VTrans Flow Restoration Plan

MS4 GENERAL PERMIT REQUIREMENT (IV.C.1)

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A. Disclaimer

The intent of this plan is to present the data collected, evaluations, analysis, designs, and cost estimates for the Vermont Agency of Transportation (VTrans). This document provides information for stormwater retrofit projects proposed to meet VTrans flow restoration obligations in watersheds subject to a Flow Restoration Plan (FRP) under the National Pollutant Discharge Elimination System (NPDES) General Permit 3-9014 (VTDEC 2012). This plan should be considered to be the regulatory document for VTrans to meet FRP obligations under General Permit 3-9014. If VTrans is included in FRPs submitted by other MS4s, the information contained in this plan should supersede that information. In addition, retrofit projects identified in this plan have not been fully assessed for feasibility or completely design. The work completed has been done at a planning level, and will be subject to change based on site conditions, permitting, budgetary constraints and other unforeseen issues.

B. Executive Summary

This Flow Restoration Plan (FRP) for the 10 stormwater impaired watersheds where the Vermont Agency of Transportation (VTrans) owns impervious cover was developed in accordance with requirements in the Municipal Separate Storm Sewer System (MS4) General Permit #3-9014 (2012). Components of this FRP include the identification of retrofits to existing BMPs, identification of new BMP controls, an implementation schedule, a financial plan, and a regulatory analysis. Once approved by the Vermont Department of Environmental Conservation (VT DEC), this FRP will become part of the Stormwater Management Plans (SWMP) for VTrans for these watersheds. The purpose of the FRP is to provide a planning tool for VTrans to implement stormwater BMPs over a 20-year timeframe from the date of permit issuance (December, 2012) in the effort to restore these impaired watersheds to their attainment conditions.

Vermont developed Total Maximum Daily Load (TMDL) documents for these stormwater impaired watersheds using flow as a surrogate for pollutant loading. The basis for the TMDL development was the comparison of modeled Flow Duration Curves (FDCs) between impaired and attainment watersheds. The Program for Predicting Polluting Particles Passage through Pits, Puddles, and Ponds, Urban Catchment Model (P8) was used to model gauged and ungauged watersheds in Vermont and develop Flow Duration Curves (FDC) from which a normalized high flow and low flow per drainage area (cfs/mi^2) were extracted. An FDC is a curve displaying the percentage of time during a period that flow exceeds a certain value, with the “low” flow represented by the 95th percentile (Q 95%) of the curve and the “high” flow represented by the 5th percentile (Q 0.3%). The high and low flow values from the FDCs were then compared between impaired watersheds and similar attainment watersheds to determine a percent change (reduction of high flow and increase of low flow). In addition to the modeled flows, future non-jurisdictional growth predictions were made for each watershed and used to predict the flow reductions needed 20 years in the future. The percent change was reported in the Environmental Protection Agency (EPA) approved TMDL for each impaired watershed. In certain watersheds, the future growth prediction was modified as it was deemed excessive based on further review. The flow targets were modified in three watersheds to account for these changes.

The TMDLs for the 10 watersheds discussed in this report were approved between 2006 and 2009. They require high flow reductions ranging by watershed from 1.3% in Indian Brook to 63.0% in Centennial Brook. The TMDLs also suggest an increase in stream flow during base flow conditions. These range by watershed from 1.1% in Indian Brook to 24.3% in Stevens Brook.

As a part of the FRP development, an assessment was completed to determine to what extent current stormwater controls have reduced high flows from the Pre-2002 condition to the current (Post-2002) condition. The Vermont Best Management Practice Decision Support System (BMPDSS) model, a GIS-based hydrologic model used to assess the impact of various stormwater Best Management Practice (BMP) scenarios, was used for the assessment. The model was created by VT DEC and its partners as part of the initial TMDL development. By watershed, the BMPDSS estimated that between 3.8% (Stevens Brook) and 213.8% (Sunderland Brook) of the total high-flow reduction target was met with existing BMPs designed to meet the Vermont 2002 Stormwater Design Standards when compared to the Pre-2002 condition. The reduction for the VTrans portion of the impervious area ranged from 0% in Centennial Brook and Moon Brook to 377.4% in Sunderland Brook, averaging 49.7% per watershed. In all watersheds except Sunderland Brook, additional BMPs are required to meet 100% of the actionable flow target.

For Sunderland Brook, even though modeled flow targets for the Post-2002 condition model exceeded TMDL flow targets, additional BMPs were also identified for potential future implementation. The MS4 entities are not required to implement any new stormwater controls under the MS4 permit requirement IV.C.1. However, the FRP document provides the MS4s with a list of possible projects that could be constructed in the event that future biomonitoring of the stream reveals non-compliance with Vermont water quality standards.

After the existing model scenarios were reviewed, new BMPs were identified, inspected, and assessed in the BMPDSS. The final proposed BMP list includes 54 projects—31 median filters, 12 detention basins, 5 gravel wetlands, 4 underground detention systems, and 2 infiltration systems. There are also several additional projects several watersheds that manage minimal amounts of VTrans owned impervious areas, but these projects are not considered to be the responsibility of VTrans.

By watershed, the BMPDSS estimated that between 23% (Moon Brook) and 482% (Sunderland Brook) of the total high-flow target was met with the proposed BMP scenario (Credit model). The high flow reduction target met for the VTrans portion of each watershed ranged from 44% in Potash Brook to 847% in Sunderland Brook, averaging 196% per watershed (Appendix D). VTrans flow reduction targets were met at over 100% in six of the 10 watersheds. Although the VTrans portion of the high flow target was not met fully in the remaining four watersheds, the proposed BMP implementation plan presented represents the most feasible and effective watershed-wide approach to meeting flow reduction targets. The planning level cost for implementation of the 56 BMPs presented in this FRP is $6,522,000.

A ranking was developed to prioritize the proposed projects based on the percentage of VTrans impervious area managed, runoff channel protection volume storage, VTrans high flow target managed, and cost. The ranking is a tool for VTrans to use to prioritize projects for implementation (Appendix F). The prioritization was also used to aid in the development of a Design and Construction Schedule (D&C), for long term implementation of the plan.

C. Background

The purpose of the FRP is to outline a plan for the retrofit of existing unmanaged VTrans impervious cover with stormwater BMPs to meet the VTrans allocated portion of the TMDL flow targets. The modeled high-flow (Q 0.3%) included flows occurring less than 0.3% of the time, determined to be relatively equivalent to the 1-year design storm flow. As such, BMPs are designed to Channel Protection volume (CP_v) storage standard to address the high-flow reduction target. These BMPs can include detention basins, bioretention filters, infiltration basins, and other management strategies. The TMDLs set forth that watershed hydrology must be controlled in each of the stormwater impaired watersheds to reduce high flow discharges and increase base flow in order to restore degraded water quality and achieve compliance with the Vermont Water Quality Standards.

The 10 stormwater impaired watersheds analyzed in this FRP are primarily located in Chittenden County. Stevens Brook and Rugg Brook are located in Franklin County, and Moon Brook is located in Rutland County. Watersheds range in size from 751 acres to 6230 acres, with impervious area covering from 6% to 31% of these watersheds and averaging 16% coverage by watershed (Table C1). Each of these watersheds requires a collaborate effort to meet flow reduction targets as each has impervious area owned by a minimum of two and a maximum of five MS4 entities. VTrans impervious cover makes up between 0.5% (Moon Brook) and 16% (Rugg Brook) of the total impervious cover within each watershed.

Table C 1 Watershed characteristics for each of the 10 watersheds assessed in this FRP

Watershed Name	Total Watershed Area (acres)	Total Impervious Cover (acres)	Total Impervious Cover (%)	VTrans Impervious Cover (acres)	VTrans Impervious Cover (% of Total Impervious Cover)	MS4 Impervious Owners
Allen Brook	6230	401	6%	49	12%	Williston, VTrans
Bartlett Brook	751	138	18%	5	4%	Town of Shelburne, South Burlington, VTrans
Centennial Brook	879	270	31%	13	5%	UVM, BTV, South Burlington, VTrans, Burlington
Indian Brook	4587	410	9%	31	8%	Town of Essex, Village of Essex Junction, VTrans
Moon Brook [1]	5032	503	16%	2	0.5%	Rutland City, Rutland Town, VTrans
Munroe Brook	3466	269	8%	13	5%	Shelburne, VTrans, South Burlington
Potash Brook	4510	924	20%	76	8%	UVM, BTV, South Burlington, VTrans, Burlington
Rugg Brook	1759	205	12%	32	16%	St. Albans City, St. Albans Town, VTrans

Stevens Brook	1735	309	18%	21	7%	St. Albans City, St. Albans Town, VTrans
Sunderland Brook	1426	314	22%	10	3%	Town of Essex, Village of Essex Junction, Town of Colchester, VTrans

[1] Summaries included in this table include area within the Town of Mendon despite the fact that this town is not an MS4 community. Later tables exclude this area.

D. Allen Brook

1. *Allen Brook TMDL Flow Targets*

In the effort to restore Allen Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and suggested increases in stream low or base flows (Q 95%). These flow targets (Table D1) serve as the basis for this section (Section D) of the Flow Restoration Plan (FRP).

Table D 1 Allen Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-3.3%	**7.4%**

In Table D1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. The VT DEC, in cooperation with the Town of Williston, estimated a future growth of 35 acres in the watershed based on local development and projected growth for Allen Brook. The approved TMDL flow targets for Allen Brook are shown in Table D1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

Approximately 87.7% of the impervious cover in the Allen Brook Watershed is within the town of Williston and the remaining 12.3% is owned by VTrans (Table D2). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where the town of Williston is responsible for a 2.89% high flow reduction and VTrans is responsible for a 0.41% high flow reduction.

Table D 2 Allen Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
Williston	6013.2	351.3	87.7%	-2.89%	6.49%
VTrans	217.2	49.3	12.3%	-0.41%	0.91%
Watershed Total	**6230.4**	400.6		**-3.30%**	**7.40%**

2. *Allen Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. Both the Post-2002 and Credit models are compared to the Pre-2002 model on a percent change basis to determine changes in high and low flows.

2.1. BMPDSS Pre-2002 Model

The VT DEC developed a Pre-2002 condition model for Allen Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The VT DEC also developed a Post-2002 or existing condition model for the watershed. This model scenario included all known existing BMPs designed to the VT Stormwater Standards and providing credit toward the flow target. The Allen Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place managing the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 3.3% in the watershed, current BMPs reduced high flows by 0.29%, which equates to 8.8% of the total required flow reduction (Table D3). Of that reduction, 2% of the VTrans allocation was addressed, reducing high flows by 0.01% of the 0.41% required reduction. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow reduction target.

Table D 3 Allen Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Williston	-2.89%	-0.28%	-2.61%	9.7%
VTrans	-0.41%	-0.01%	-0.40%	2.0%
Watershed Total	**-3.30%**	**-0.29%**	**-3.01%**	**8.8%**

3. Allen Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final modeled BMP list used for the BMPDSS Credit run included six proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 102.7% of the modified high-flow target. The Credit model showed a high flow reduction of 0.28% for the VTrans allocation for the Allen

Brook Watershed, which equates to 68.9% of the total VTrans required high flow reduction (Table D4). Progress was not made towards the increase in low flow.

At this time, VTrans has identified seven additional BMPs within the Allen Brook Watershed that have been added to the list of final proposed BMPs. The high flow target reductions shown in Table D4 do not reflect the addition of these seven proposed median filters, though additional tables do include these BMPs (Table D5, Appendix A and B). VTrans will request another BMPDSS model run be completed with the addition of these BMPs. It is expected that further progress towards meeting the VTrans high flow reduction target will be met when the model is re-run. These BMPs should also increase the overall watershed high flow reductions and provide a further factor of safety.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table D4.

Table D 4 Allen Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Williston	-2.89%	-3.11%	0.22%	107.5%
VTrans	-0.41%	-0.28%	-0.13%	68.9%
Watershed Total	**-3.30%**	**-3.39%**	**0.09%**	**102.7%**

3.2. VTrans Proposed BMPs

There are 13 proposed VTrans BMPs summarized in Table D5 and further described in Appendix B (see Appendix A for a map of all 13 BMPs). Of these 13 BMPs, six were included in the BMPDSS Credit model. As the VTrans allocated high flow reduction was only 68.9% of their required flow reduction, VTrans has proposed an additional seven BMPs in the Allen Brook Watershed. BMPs named VTrans Median A, B, and E through I are the seven projects that are not yet modeled in the BMPDSS (Table D5). These projects are designed as median filters between the northbound and southbound lanes of I-89. The BMPDSS model will be re-run for Allen Brook incorporating these seven new projects, but this model iteration has not yet been completed. These BMPs are presented in this FRP document because VTrans has committed to moving forward with design and construction of these BMPs and as such they should be accounted for within the design and construction plan for this watershed. It is expected that the overall watershed high flow reduction will increase with this model run and that the VTrans allocated portion of the high flow reduction will also increase.

Of the total 13 proposed BMPs, 12 were designed as median filters between the northbound and southbound lanes of I-89. Each of these BMPs manage impervious area entirely owned by VTrans and treats that impervious area on VTrans owned property. CPv volumes will be retained in the swale system and Water Quality Volumes (WQv) will be captured and filtered through the subsurface sand medium prior to discharge to the underdrain. WCA-1, WCA-4, and the Town Office BMPs provide overbank flood protection and will either be partially retained and infiltrated or partially bypassed through a raised outlet structure. Extreme storm events will pass safely through the system. It is not possible to accommodate the recharge volume in the median without compromising the interstate select gravel subbase.

The remaining VTrans BMP consists of a retrofit of the existing detention pond at the Williston Rest Area. The rest area was developed by the Vermont Department of Buildings and General Services through a land lease from VTrans. As such, implementation of this BMP will need to be a collaborate effort. As proposed, the pond design is in full compliance with the CPv requirement. Additionally, the design ensures that the 1-year 24-hour storm is released over 24 hours as the pond appears to drain to a wetland area, and thus a warm water habitat. The calculated CPv based on the modeling analysis is 29,172 cf. The 10-year storm peak discharge will be reduced by 30% and the pond will provide adequate free board and safely pass the extreme storm events (100-year storm). The pond retrofit does not address groundwater recharge, though recharge is currently provided on site via grass swales and vegetated disconnections.

The remaining 6.5 acres of managed VTrans impervious cover is managed by 9 additional BMPs. While these BMPs manage small amounts of VTrans impervious area, they are not determined to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 68.9% of the VTrans high flow target was met by these six proposed BMPs. The single largest contributor to this target attainment was the Williston Rest Area pond retrofit, which met 22.3% of the VTrans high flow target. The five median filters contribute additional progress towards the high flow target (Table D5). However, as noted, the remaining seven median filter BMPs are not included in the BMPDSS model run at this time and as such the VTrans high flow target managed was not calculated for these BMPs. All 13 BMPS are summarized in Table D5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B. Preliminary design concept plans for the Town Office and the WCA-1, -2, -3, and -4 projects can be found in Appendix H-1.

Table D 5 VTrans final proposed BMPs for the Allen Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Rest Area Pond Retrofit	VTrans / Town	VTrans	Detention Basin	NP	26.8	4.4	16.5%	4.4	100%	0.670	22.3%	$158,000
Town Office	VTrans	VTrans	Median Filter	NP	2.2	0.4	16.6%	0.4	100%	0.061	1.9%	$32,000
WCA_1	VTrans	VTrans	Median Filter	NP	4.2	0.7	16.1%	0.7	100%	0.175	3.4%	$92,000
WCA_2	VTrans	VTrans	Median Filter	NP	2.5	0.4	17.3%	0.4	100%	0.043	2.2%	$25,000
WCA_3	VTrans	VTrans	Median Filter	NP	2.3	0.6	23.9%	0.6	100%	0.030	2.8%	$25,000
WCA_4	VTrans	VTrans	Median Filter	NP	3.3	0.7	21.8%	0.7	100%	0.101	3.6%	$53,000
VTrans Median A *	VTrans	VTrans	Median Filter	NP	1.3	0.3	23.6%	0.3	100%	0.116	TBD	$60,000
VTrans Median B *	VTrans	VTrans	Median Filter	NP	0.7	0.2	28.7%	0.2	100%	0.078	TBD	$41,000
VTrans Median E *	VTrans	VTrans	Median Filter	NP	1.2	0.3	25.6%	0.3	100%	0.084	TBD	$44,000
VTrans Median F *	VTrans	VTrans	Median Filter	NP	1.1	0.2	18.9%	0.2	100%	0.085	TBD	$44,000
VTrans Median G *	VTrans	VTrans	Median Filter	NP	1.5	0.3	20.6%	0.3	100%	0.117	TBD	$61,000

VTrans Median H *	VTrans	VTrans	Median Filter	NP	1.3	0.2	18.9%	0.2	100%	0.113	TBD	$59,000
VTrans Median I *	VTrans	VTrans	Median Filter	NP	1.7	0.4	22.2%	0.4	100%	0.134	TBD	$70,000
Other non-VTrans dominated BMPs	*Town/ VTrans*	*Non-VTrans*	*Assorted*	--				*6.5*		--	32.8%	
Watershed Total:								**15.6 ****			**68.9%**	**$764,000**

* This BMP is included in this FRP as VTrans plans to move forward with construction and design of these projects to make further progress towards their allocated high flow reduction target. However, at this time, these BMPs are not modeled in the Credit run of the BMPDSS and as such the flow reduction progress shown does not reflect the addition of these seven BMPs.

** The VTrans impervious cover managed total shown here is representative of all 13 proposed BMPs.

E. Bartlett Brook

1. Bartlett Brook TMDL Flow Targets

In the effort to restore Bartlett Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table E1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table E 1 Bartlett Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-33.2%	13.2%

In Table E1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the Pre-2002 condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the Pre-2002 condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

The VT DEC added a future growth factor to the TMDL flow targets to account for future non-jurisdictional impervious growth. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, this type of growth is important to account for within the 20 year stormwater management plan.

The original TMDL assumed a non-jurisdictional impervious growth of 50 acres, whereas a study completed by the Chittenden County Regional Planning Commission (CCPRC) estimated that a more realistic future growth estimate was 5.7 acres based on the actual non-jurisdictional growth rate from 2003 to 2010. The future growth rate was calculated as follows:

$$\text{Growth Rate} = \left(\left(\frac{Non-Jurisdictional\ Impervious, 2010}{Non-Jurisdictional\ Impervious, 2003}\right)^{\left(\frac{1}{years}\right)} - 1\right) * 100$$

The revised future growth reduced the high-flow target (Q 0.3%) reduction from 33.0% to 11.6%, which was calculated as shown in the following equation.

Modified Flow Target = $(Target\ \%\ with\ no\ FG) + (\ Target\ \%\ from\ FG) * (\frac{Revised\ FG\ acres}{Original\ FG\ acres})$

The modified TMDL flow targets with a revised future growth for Bartlett Brook are shown in Table E2.

Table E 2 Bartlett Brook TMDL flow restoration targets with a modified future growth target of 5.7 acres

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-11.6%	**9.3%**

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads. Additionally, the University of Vermont (UVM) owns land within the Bartlett Brook Watershed, used for the operation of the UVM Horticulture Farm. However, agricultural impervious area is not subject to FRPs. As such, UVM was determined to not be an eligible MS4 for Bartlett Brook.

Approximately 1.9% of the impervious cover in the Bartlett Brook Watershed is within the Town of Shelburne, 3.8% is owned by VTrans, and the remaining 94.2% within the City of South Burlington (Table E3). The TMDL flow targets were allocated to each MS4 based on their relative impervious ownership in the watershed where the Town of Shelburne is responsible for a 0.22% high flow reduction, VTrans is responsible for a 0.44% high flow reduction, and the City of South Burlington is responsible for the remaining 10.93% high flow reduction.

Table E 3 Bartlett Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
University of Vermont	----	----	----	NA	NA
Town of Shelburne	60.6	2.7	1.9%	-0.22%	0.18%
VTrans	9.5	5.2	3.8%	-0.44%	0.35%
South Burlington	680.5	129.7	94.2%	-10.93%	8.76%
Watershed Total	**750.7**	**137.6**		**-11.60%**	**9.30%**

2. Bartlett Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. Both the Post-2002 and Credit models are compared to the Pre-2002 model on a percent change basis to determine changes in high and low flows.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Bartlett Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Bartlett Brook Post-2002 (existing condition) model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 11.6% in the watershed, current BMPs reduced high flows by 2.54%, which equates to 21.9% of the total required flow reduction (Table E4). Of that reduction, 54.7% of the VTrans allocation was addressed, reducing high flows by 0.24% of the 0.44% required reduction. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table E 4 Bartlett Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Town of Shelburne	-0.22%	0.00%	-0.22%	0.0%
VTrans	-0.44%	-0.24%	-0.20%	54.7%
South Burlington	-10.93%	-2.30%	-8.63%	21.0%
Watershed Total	**-11.60%**	**-2.54%**	**-9.06%**	**21.9%**

3. Bartlett Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

The final watershed-wide BMP scenario includes the implementation of 18 stormwater BMPs including five retrofits to existing BMPs with expired permits, four new detention systems, three new infiltration systems, and six green stormwater infrastructure (GSI) systems. Credit toward the flow target is also provided by nine existing (Post-2002) stormwater structures. The VTrans proposed BMPs are summarized in Table E6, including the impervious cover treated, drainage area, and CPv volume storage estimated by the HydroCAD design model. A map of the proposed BMP locations is included in Appendix A.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 2 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 194.5% of the modified high-flow target, providing a 94.5% factor of safety. The Credit model showed a high flow reduction of 1.18% for the VTrans allocation of the Bartlett Brook Watershed, which equates to 267.2% of the total VTrans required high flow reduction and a 167.2% factor of safety (Table E5). The factor of safety is included in the recommended BMP list to provide the MS4s with additional options in the event the list has to be modified or as conditions in the watershed change from present day. In the event a proposed project becomes infeasible after further design and construction planning or must be downscaled, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. Of the suggested 9.3% increase in low flow, 47% of the target was achieved (4.35% low flow increase).

The ultimate determination for implementation of projects within the watershed providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4’s allocated responsibility of the flow targets, summarized in Table E5.

Table E 5 Bartlett Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Town of Shelburne	-0.22%	0.00%	-0.22%	0.0%
VTrans	-0.44%	-1.18%	0.74%	267.2%
South Burlington	-10.93%	-21.38%	10.44%	195.5%
Watershed Total	**-11.60%**	**-22.56%**	**10.96%**	**194.5%**

3.2. VTrans Proposed BMPs

There are two proposed VTrans BMPs in the Bartlett Brook Watershed, which are summarized in Table E6. Both of these BMPs were designed as underground detention structures within the VTrans right-of-way (ROW). The Bartlett Bay Treatment System (BBTS) Expansion manages 9.2 acres of impervious cover, 20.4% (1.9 acres) of which is owned by VTrans. The underground detention proposed for 1690 Shelburne Rd. manages 0.4 acres of impervious area, 100% of which is owned by VTrans. The remaining 2.7 acres of treated VTrans impervious cover is managed by an existing Post-2002 BMP that currently detains the CPv.

The existing BBTS was designed in 2002 to provide water quality treatment for runoff from a portion of Route 7 and several buildings along Green Mountain Dr. A 15” pipe was installed with the original system to plan for future connections from Route 7. The BBTS expansion would route an additional 15.86 acres to the BBTS system via a new stormline connection on Route 7 from a portion of Route 7 and Harborview Dr. The expansion would involve implementing a new forebay for the additional connection in front of the Oil N Go property and expanding the southeast portion of the wetland. The existing access road would also need to be repositioned.

An underground detention chamber is proposed to detain just the 1-year storm volume (CPv) from the existing Route 7 stormline, via a flow splitter. There is an existing outfall from Shelburne Rd, parallel to the Oil N Go property, that would need to be reset to make room for the chamber. Further analysis needs to be completed to determine if the detention chamber will encroach on the flood plain for the Bartlett Brook culvert or if any other utility conflicts exist.

The percent of the VTrans high-flow target mitigated by these three BMPs was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 267.2% of the VTrans high flow target was met by these three BMPs. The single largest contributor to this target attainment was the existing Post-2002 BBTS BMP, which meets 145% of the VTrans high flow target. This differs from the earlier Post-2002 model summary as the BMPDSS is an aggregate watershed-wide model and proposed BMPs in other sections of the watershed impact flow reductions. The BBTS Expansion and the 1690 Shelburne Rd. projects meet an additional 122.2% of the VTrans high-flow target (100% and 22.2% respectively; Table E6).

The proposed BMPs are summarized in Table E6. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B. Preliminary design concept plans for the 1690 Shelburne Rd project and a section of the BBTS Expansion project can be found in Appendix H-2.

Table E 6 VTrans final proposed BMPs for the Bartlett Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Bartlett Bay Treatment System (BBTS) Expansion	VTrans/ South Burlington	South Burlington	Underground Detention Chamber in ROW	5625-9010, 2-0180, 2-0153	16.1	9.2	57.2%	1.9	20.4%	0.55	100.0%	$378,000
1690 Shelburne Rd	VTrans/ South Burlington	VTrans/ Developer-Pizzagalli	Underground Detention Chamber in ROW	5625-9010	0.8	0.4	51.3%	0.4	100%	0.04	22.2%	$199,000
Existing BBTS (Post-2002) BMP	*Town / City/ VTrans*	*Non-VTrans*	*Detention*	--	--	--		*2.7*		--	145.0%	
Watershed Total:								**5.0**			**267.2%**	**$577,000**

F. Centennial Brook

1. Centennial Brook TMDL Flow Targets

In the effort to restore Centennial Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table F1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table F 1 Centennial Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-63.0%	23.0%

In Table F1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the Pre-2002 condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the Pre-2002 condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the BMP identification for this study.

1.1. Future Growth Target

The VT DEC added a future growth factor to the TMDL flow targets to account for future non-jurisdictional impervious growth. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, this type of growth is important to account for within the 20 year stormwater management plan.

The original TMDL assumed a non-jurisdictional impervious growth of 50 acres, whereas a 2013 study completed by the Chittenden County Regional Planning Commission (CCPRC) estimated that a more realistic future growth estimate of 5 acres based on the actual non-jurisdictional growth rate. The future growth rate was calculated as follows:

$$\text{Growth Rate} = \left(\left(\frac{Non-Jurisdictional\ Impervious,later\ date}{Non-Jurisdictional\ Impervious,earlier\ date}\right)^{\left(\frac{1}{years}\right)} - 1\right) * 100$$

The revised future growth reduced the high-flow target (Q 0.3%) reduction from 63.0% to 51.1%, which was calculated as shown in the following equation.

Modified Flow Target = $(Target\ \%\ with\ no\ FG) + (\,Target\ \%\ from\ FG) * (\frac{Revised\ FG\ acres}{Original\ FG\ acres})$

The modified flow targets for Centennial Brook were used for this FRP and are shown in Table F2.

Table F 2 Centennial Brook TMDL flow restoration targets with modified future growth

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-51.5%	**23.0%**

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

The majority of the impervious cover in Centennial Brook Watershed is owned by the City of South Burlington (45.7%), though the University of Vermont and the City of Burlington own significant impervious areas (34.1% and 14.3% respectively). The remaining impervious cover is owned by VTrans (4.7%) and the Burlington International Airport (BTV; 1.1%). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where VTrans is responsible for a 2.43% reduction in high flows and the remaining four MS4s are responsible for the remaining 49.07% flow reduction (Table F3).

Table F 3 Centennial Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
BTV	23.4	3.1	1.1%	-0.59%	0.26%
VTrans	56.9	12.7	4.7%	-2.43%	1.08%
Burlington	94.9	38.6	14.3%	-7.37%	3.29%
UVM	298.4	92.1	34.1%	-17.58%	7.85%
South Burlington	405.6	123.2	45.7%	-23.53%	10.51%
Watershed Total	**879.2**	**269.7**		**-51.50%**	**23.00%**

2. Centennial Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis to determine changes in high and low flows.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Centennial Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Centennial Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 51.5% in the watershed, current BMPs reduced high flows by 14.8%, which equates to 28.7% of the total required flow reduction (Table F4). Of that reduction, 0% of the VTrans allocation was addressed and a required 2.43% high flow reduction remains. As such, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table F 4 Centennial Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
BTV	-0.59%	0.00%	-0.59%	0.0%
VTrans	-2.43%	0.00%	-2.43%	0.0%
Burlington	-7.37%	-3.60%	-3.77%	48.8%
UVM	-17.58%	-9.65%	-7.93%	54.9%
South Burlington	-23.53%	-1.55%	-21.98%	6.6%
Watershed Total	**-51.50%**	**-14.80%**	**-36.70%**	**28.7%**

3. Centennial Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 2 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses only 85.8% of the modified high-flow target. It has proven difficult to meet the 51.5% high flow reduction target required in Centennial Brook. The Credit condition presented below reflects management of 90% of the impervious cover in the watershed including all potential retrofits identified and evaluated by the MS4s. A low flow increase of 1.8% was modeled, which equates to 8% of the suggested low flow increase target.

The Credit model showed a high flow reduction of 1.44% for the VTrans allocation for the Centennial Brook Watershed, which equates to 59.1% of the VTrans required high flow reduction (Table F5). The high flow reduction for the watershed was only 85.8% of the modified high flow reduction target. Additional retrofits were not deemed feasible.

Table F 5 Centennial Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
BTV	-0.59%	-0.29%	-0.30%	48.5%
VTrans	-2.43%	-1.44%	-0.99%	59.1%
Burlington	-7.37%	-6.67%	-0.70%	90.5%
UVM	-17.58%	-16.07%	-1.51%	91.4%
South Burlington	-23.53%	-19.74%	-3.79%	83.9%
Watershed Total	**-51.50%**	**-44.20%**	**-7.30%**	**85.8%**

3.2. VTrans Proposed BMPs

There are two proposed VTrans BMPs in the Centennial Brook Watershed, which are summarized in Table F6. These BMPs include one underground detention chamber and one detention basin. The underground detention, I-89 cloverleaf (NE), manages 5 acres of VTrans impervious cover, 36.1% of the total impervious cover managed by the BMP. The detention basin, I-89 Outfall, manages 2.8 acres of VTrans impervious cover, 98.2% of the total impervious cover managed by this BMP.

The proposed I-89 Cloverleaf (NE) underground detention chambers would be located between the I-89 northbound lane and off-ramp. The proposed BMP would require a new control structure to meet CPv storage standards. An existing 48” culvert outlet pipe is easily accessible for construction and maintenance. Additional feasibility analysis is needed to ensure that this project would not impact nearby wetlands.

The I-89 Outfall detention basin location is flexible depending on constraints found during further evaluation. Most downstream locations would be across from the drainage outlet and below the water main, which would be the best location to maximize storage. Some feasibility issues in these locations include impacts to the water main ROW and acquisition of a section of private property. Keeping all of the work within VTrans jurisdiction is an alternative by moving the embankment up gradient to limit the I-89 ROW and reduce available storage.

In addition, one BMP, Patchen Rd. depression, also manages a small amount of VTrans impervious area (0.3 acres). VTrans impervious makes up 4.8% of the impervious area managed by this BMP. The remainder is located in the City of South Burlington. This BMP was determined not to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 59.1% of the VTrans high flow target was met by these BMPs, the majority of which are a result of the I-89 Cloverleaf (NE) and I-89 Outfall BMPs (57.1% cumulatively; Table F6). Although the VTrans high flow reduction target was not met in this watershed, the BMPs proposed were determined to be the most feasible for the watershed-wide scenario. The two proposed VTrans BMPs are summarized in Table F6. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B.

Table F 6 VTrans final proposed BMPs for the Centennial Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
I-89 Cloverleaf (NE)	VTrans	VTrans	Underground Detention Chamber	NP	39.2	13.8	35.2%	5.0	36.1%	2.36	36.7%	$432,000
I-89 Outfall	VTrans	VTrans	Detention Basin	NP	13.1	2.8	21.6%	2.8	98.2%	2.87	20.4%	$1,419,000
Other non-VTrans dominated BMPs	*Town / City/ VTrans*	*Non-VTrans*	*Assorted*	--	--	--		*0.3*		--	*1.9%*	
Watershed Total:								**8.0**			**59.1%**	**$1,851,000**

G. Indian Brook

1. Indian Brook TMDL Flow Targets

In the effort to restore Indian Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table G1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table G 1 Indian Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-1.3%	1.1%

In Table G1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 18 acres in the watershed based on local development and projected growth for Indian Brook. The approved TMDL flow targets for Indian Brook are shown in Table G1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

Three MS4s own impervious cover within Indian Brook Watershed: the Village of Essex Junction (53.3%), the Town of Essex (39.1%), and VTrans (7.6%). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where the Village of Essex Junction is responsible for a 0.7% flow reduction, the Town of Essex is responsible for a 0.5% flow reduction, and VTrans is responsible for the remaining 0.1% flow reduction (Table G2).

Table G 2 Indian Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
Village of Essex Junction	952.6	218.3	53.3%	-0.69%	0.59%
Town of Essex	3492.7	160.1	39.1%	-0.51%	0.43%
VTrans	141.9	31.3	7.6%	-0.10%	0.08%
Watershed Total	**4587.3**	409.7		**-1.30%**	**1.10%**

2. *Indian Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis to determine changes in high and low flows.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Indian Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Indian Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 1.3% in the watershed, current BMPs reduced high flows by 0.54%, which equates to 41.5% of the total required flow reduction (Table G3). Of that reduction, 1.9% of the VTrans allocation was addressed, reducing high flows by 0.002% of the required 0.10% reduction. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table G 3 Indian Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Village of Essex Junction	-0.69%	-0.27%	-0.42%	39.5%
Town of Essex	-0.51%	-0.26%	-0.24%	52.1%
VTrans	-0.10%	-0.002%	-0.10%	1.9%
Watershed Total	**-1.30%**	**-0.54%**	**-0.76%**	**41.5%**

3. Indian Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 3 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 211.5% of the modified high-flow target, providing a 111.5% factor of safety (Table G4). The factor of safety is included in the recommended BMP list to provide the MS4s with additional options in the event the list has to be modified or as conditions in the watershed change from present day. A low flow increase of 0.64% was modeled, which equates to 58% of the suggested low flow increase target.

The Credit model showed a high flow reduction of 0.06% for the VTrans allocation for the Indian Brook Watershed, which equates to 56.6% of the total VTrans required high flow reduction (Table G4). Although this plan does not address 100% of the VTrans high flow allocation, the proposed scenario was determined to be the most feasible watershed-wide plan.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table G4.

Table G 4 Indian Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Village of Essex Junction	-0.69%	-1.55%	0.86%	223.5%
Town of Essex	-0.51%	-1.15%	0.64%	225.6%
VTrans	-0.10%	-0.06%	-0.04%	56.6%
Watershed Total	**-1.30%**	**-2.75%**	**1.45%**	**211.5%**

3.2. VTrans Proposed BMPs

There are three proposed VTrans BMPs in the Indian Brook Watershed, which are summarized in Table G5. These BMPs include one retrofit of an existing natural detention area into a terraced detention basin and two sand filter systems. The terraced detention basin, Fairview Dr, manages 0.7 acres of VTrans impervious cover, 17.4% of the total impervious cover managed. The two sand filter systems proposed in the median on the North and South side of the Route 15, manage 0.9 and 0.8 acres of VTrans impervious cover respectively. This impervious cover is entirely owned by VTrans.

The Fairview Dr retrofit proposes to convert a natural depression to a gravel wetland with water quality treatment bays. This retrofit will benefit the high flow target and provide water quality treatment. Runoff from the northwest side of Route 15 (Main St.) would be intercepted and directed into the system through a new culvert, represented as the "Fairview Dr Add-on" drainage. This would eliminate most runoff to the highly eroded outfall. Runoff would exit the system back under Route 15 via an upgraded pipe (12" to 30").

The I-289/Route 15 Exit Ramp was identified as a potential opportunity to manage runoff from primarily VTrans owned impervious. Two sand filter systems were proposed in the median on the North and South side of the Route 15 overpass. The proposed practice is an approximately 4' deep sand filter, with a 4" underdrain, and 1.5' surface ponding depth before passing over a weir. The system is designed to provide CPv storage. The low-flow orifice and sand filter provide extended filtration and thus water quality benefit.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

The proposed BMPs are summarized in Table G5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B. Preliminary design concept plans for the three proposed projects can be found in Appendix H-3.

Table G 5 VTrans final proposed BMPs for the Indian Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Fairview Dr/Fairview Dr Add-on	Village/ VTrans/ Town	Village	Gravel Wetland	1-1074 SN002	29.4	4.1	14.0%	0.7	17.4%	0.67	17.4%	$290,000
I-289/Route 15 North	VTrans	VTrans ROW	Median Filter	NP	2.8	0.9	30.6%	0.9	100%	0.12	20.7%	$34,000
I-289/Route 15 South	VTrans	VTrans ROW	Median Filter	NP	2.2	0.8	35.3%	0.8	100%	0.10	18.5%	$29,000
Watershed Total:								**2.3**			**56.6%**	**$353,000**

H. Moon Brook

1. Moon Brook TMDL Flow Targets

In the effort to restore Moon Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table H1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table H 1 Moon Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-11.9%	23.9%

In Table H1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 25 acres in the watershed based on local development and projected growth for Moon Brook. The approved TMDL flow targets for Moon Brook are shown in Table H1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas. Additionally, the Town of Mendon owns land within the Moon Brook Watershed, but this town is not designated as an MS4 and is thus not included in the allocation.

Rutland City owns the majority of impervious cover within Moon Brook Watershed (76.8%) while Rutland Town owns 23.7% and VTrans owns the remaining 0.5%. The TMDL flow targets were allocated to each MS4 based on their impervious ownership where Rutland City is responsible for a 9.02% flow reduction, Rutland Town is responsible for a 2.82% flow reduction, and VTrans is responsible for the remaining 0.06% flow reduction (Table H2).

Table H 2 Moon Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
Mendon	2041.8	35.8	----	----	----
Rutland City	1415.3	353.8	75.8%	-9.02%	18.12%
Rutland Town	1556.4	110.6	23.7%	-2.82%	5.66%
VTrans	18.7	2.3	0.5%	-0.06%	0.12%
Watershed Total	**2990.4**	**466.7**		**-11.90%**	**23.90%**

2. *Moon Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Moon Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Moon Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 11.9% in the watershed, current BMPs reduced high flows by 0.71%, which equates to 6% of the total required flow reduction (Table H3). Of that reduction, 0% of the VTrans allocation was addressed and a required 0.06% flow reduction remains. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table H 3 Moon Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Rutland City	-9.02%	-0.52%	-8.50%	5.8%
Rutland Town	-2.82%	-0.19%	-2.63%	6.6%
VTrans	-0.06%	0.00%	-0.06%	0.0%
Watershed Total	**-11.90%**	-0.71%	-11.19%	6.0%

3. Moon Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 1 proposed VTrans BMP. The watershed-wide proposed FRP scenario addresses 23% of the modified high-flow target. The minimal high flow reduction is due to the non-participation of the City of Rutland in the FRP process at this time. The Credit model showed a high flow reduction of 0.11% for the VTrans allocation for the Moon Brook Watershed, which equates to 189.5% of the total VTrans required high flow reduction (Table H4). No progress was made towards the suggested increase in low flow.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table H4.

Table H 4 Moon Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Rutland City	-9.02%	-0.7%	-8.3%	8.0%
Rutland Town	-2.82%	-1.9%	-0.9%	66.9%
VTrans	-0.06%	-0.11%	0.05%	189.5%
Watershed Total	**-11.90%**	-2.72%	-9.18%	22.9%

3.2. VTrans Proposed BMPs

The one proposed VTrans BMP in the Moon Brook Watershed, which is summarized in Table H5. This BMP is a gravel wetland collecting runoff from a drainage ditch. The gravel wetland manages 2.3 acres of VTrans impervious cover, 20.9% of the total impervious cover managed by this BMP.

The proposed BMP, located behind the new ALDI Store along Route 7 and Cold River Rd., could potentially be an ideal solution to reduce peak-flows and sediment loading to Moon Brook from a 23-acre drainage area, 47.4% of which is impervious. The proposed gravel wetland will provide flow detention as well as water quality benefits. The Randbury Road site is located on private property, which would need to be acquired by the Town of Rutland in order for this site to be a feasible retrofit location. The site currently consists of a wooded undeveloped area with a highly eroded drainage ditch. The retrofit BMP could collect runoff from this drainage ditch, which has been formed from the high volume of runoff originating from the Route 7 outfall. Based on field observation, the site is underlain by sandy soils so infiltration of runoff may be possible. Additionally, the existing drainage ditch was assessed by the State Fisheries Biologist, and determined to be void of fisheries resources. As such, alterations to the existing ditch would be feasible. This BMP location is of particular interest as the project could align with the Town's re-development goals for the area, which will include a new access road to ease traffic on Route 7. This project would require a new stormwater management system regardless of this FRP (see Appendix H-4 for a design concept plan).

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 189.5% of the VTrans high flow target was met by this BMP at the Randbury Rd. site. The proposed BMPs are summarized in Table H5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP location is included in Appendix A and details about the proposed BMP is located in Appendix B. A preliminary design has been created for this project and is included in Appendix H-4.

Table H 5 VTrans final proposed BMPs for the Moon Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Randbury Rd	VTrans/ Town of Rutland	VTrans/ Town of Rutland/ Private	Gravel Wetland	NP/ New Road Project (Construction Permit)	23.1	11.0	47.4%	2.3	20.9%	0.83	189.5%	$279,000
Watershed Total:								**2.3**			**189.5%**	**$279,000**

I. Munroe Brook

1. Munroe Brook TMDL Flow Targets

In the effort to restore Munroe Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table I1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table I 1 Munroe Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-5.2%	7.4%

In Table I1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 20 acres in the watershed based on local development and projected growth for Munroe Brook. The approved TMDL flow targets for Munroe Brook are shown in Table I1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

Shelburne owns the majority of impervious cover within the Munroe Brook Watershed (87.9%) while the City of South Burlington owns 7.1% and VTrans owns the remaining 5.0%. The TMDL flow targets were allocated to each MS4 based on their impervious ownership where Shelburne is responsible for a 4.57% flow reduction, the City of South Burlington is responsible for a 0.37% flow reduction, and VTrans is responsible for the remaining 0.26% flow reduction (Table I2).

Table I 2 Munroe Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
Shelburne	3145.2	236.2	87.9%	-4.57%	6.50%
South Burlington	297.8	19.1	7.1%	-0.37%	0.53%
VTrans	23.0	13.5	5.0%	-0.26%	0.37%
Watershed Total	**3466.0**	**268.7**		**-5.20%**	**7.40%**

2. Munroe Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Munroe Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Munroe Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 5.2% in the watershed, current BMPs reduced high flows by 2.6%, which equates to 50% of the total required flow reduction (Table I3). Of that reduction, 0.04% of the VTrans allocation was addressed, which equates to 15.1% of the VTrans allocation. A 0.22% flow reduction for VTrans remains. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table I 3 Munroe Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Shelburne	-4.57%	-1.93%	-2.64%	42.2%
South Burlington	-0.37%	-0.63%	0.26%	170.8%
VTrans	-0.26%	-0.04%	-0.22%	15.1%
Watershed Total	**-5.20%**	**-2.60%**	**-2.60%**	**50.0%**

3. Munroe Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included three proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 100% of the modified high-flow target. The Credit model showed a high flow reduction of 0.36% for the VTrans allocation for the Munroe Brook Watershed, which equates to 137.5% of the total VTrans required high flow reduction (Table I4). The factor of safety is included in the recommended VTrans BMP list to provide for additional options in the event the list has to be modified or as conditions in the watershed change from present day. In the event a proposed project becomes infeasible after further design and construction planning or must be downscaled, VTrans will still be able to meet their allocated target for Munroe Brook without seeking out additional projects. No progress was made towards the suggested low flow increase target.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table I4.

Table I 4 Munroe Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Shelburne	-4.57%	-4.15%	-0.42%	90.8%
South Burlington	-0.37%	-0.69%	0.32%	187.5%
VTrans	-0.26%	-0.36%	0.10%	137.5%
Watershed Total	**-5.20%**	**-5.20%**	**0.30%**	**100.0%**

3.2. VTrans Proposed BMPs

There are three proposed VTrans BMPs in the Munroe Brook Watershed, which are summarized in Table I5. These BMPs include an underground detention chamber, a retrofit of an existing detention pond, and a gravel wetland.

The proposed underground detention, by Danform Shoes, manages 2.1 acres of VTrans impervious cover, 74.9% of the total impervious cover managed. This detention area would collect drainage from the west side of Shelburne Rd (Route 7) from the Munroe Brook Watershed boundary to the area in front of Danform Shoes. The underground storage would be located primarily within the VTrans ROW.

A retrofit of an existing pond, the Executive Dr (M08) Detention Pond, would continue to manage 2.7 acres of VTrans impervious cover. However, the retrofit of the pond would increase detention and provide for pre-treatment within a forebay. This pond has a large drainage area (approximately 91 acres) and collects stormwater from over 21 acres of impervious cover, 12.7% of which is owned by VTrans.

The final VTrans BMP proposed for the watershed is across Shelburne Rd (Route 7) from the Tractor Supply building. This proposed gravel wetland would manage 2.8 acres of VTrans impervious cover, 75.6% of the total impervious cover managed, and would be located along Shelburne Rd primarily in the VTrans ROW. In total, this BMP would collect and treat stormwater from 6.8 acres, 3.8 acres of which is impervious cover. The design of this BMP would provide for detention of the CPv as well as significant water quality treatment.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 137.5% of the VTrans high flow target was met by these BMPs. The proposed BMPs are summarized in Table I5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B.

Table I 5 VTrans final proposed BMPs for the Munroe Brook FRP Credit BMPDSS model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
M08 Executive Dr Pond	Town/ VTrans	Non-VTrans	Detention Pond	1-1291	91.1	21.3	23.4%	2.7	12.7%	0.54	49.0%	$25,000
By Danform Shoes	Town/ VTrans	VTrans	Underground Detention	NP	4.9	2.8	58.0%	2.1	74.9%	0.145	38.4%	$102,000
Across from Tractor Supply	Town/ VTrans	VTrans	Gravel Wetland	NP	6.8	3.8	55.5%	2.8	75.6%	0.544	51.5%	$480,000
Watershed Total:								**7.6**			**137.5%**	**$607,000**

J. Potash Brook

1. Potash Brook TMDL Flow Targets

In the effort to restore Potash Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table J1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table J 1 Potash Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-16.5%	11.2%

In Table J1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 30 acres in the watershed based on local development and projected growth for Potash Brook. The approved TMDL flow targets for Potash Brook are shown in Table J1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

The City of South Burlington owns the majority of impervious cover within the Potash Brook Watershed (84.7%) and thus is responsible for the majority of high flow reductions (13.98%). The remaining impervious area is owned by VTrans (8.3%), while BTV owns 3.5%, the City of

Burlington owns 3%, and UVM owns the remaining 0.5%. The TMDL flow targets were allocated to each MS4 based on their impervious ownership where VTrans is responsible for a 1.37% high flow reduction (Table J2). These summaries are representative of the watershed condition following updates to the watershed boundary completed in the Post-2002 and Credit model runs.

Table J 2 Potash Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
South Burlington	3662.1	778.5	84.7%	-13.98%	9.49%
VTrans	317.0	76.3	8.3%	-1.37%	0.93%
BTV	72.1	32.0	3.5%	-0.57%	0.39%
Burlington	105.8	27.3	3.0%	-0.49%	0.33%
UVM	338.2	5.1	0.5%	-0.09%	0.06%
Watershed Total	**4495.2**	919.2		**-16.50%**	**11.20%**

2. *Potash Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Potash Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Potash Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 16.5% in the watershed, current BMPs reduced high flows by 4.5%, which equates to 27.3% of the total required high flow reduction (Table J3). Of that reduction, 8% of the VTrans allocation was addressed as a reduction of 0.11% was achieved. A 1.2% VTrans flow reduction remains. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table J 3 Potash Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
South Burlington	-13.98%	-4.35%	-9.64%	31.1%
VTRANS	-1.37%	-0.11%	-1.25%	8.0%
BTV	-0.57%	0.00%	-0.57%	0.0%
Burlington	-0.49%	-0.04%	-0.45%	8.1%
UVM	-0.09%	0.00%	-0.09%	0.0%
Watershed Total	**-16.50%**	**-4.50%**	**-12.00%**	**27.3%**

3. *Potash Brook Required Controls Identification*

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 107 BMPs, 6 of which are the responsibility of VTrans. The watershed-wide proposed FRP scenario addresses 100% of the modified high-flow target. No progress was made towards the suggested low flow increase target.

The Credit model showed a high flow reduction of 0.6% for the VTrans allocation for the Potash Brook Watershed, which equates to 43.7% of the total VTrans required high flow reduction

(Table J4). Although this plan does not address 100% of the VTrans high flow allocation, the proposed scenario was determined to be the most feasible watershed-wide plan.

The ultimate determination for when the watershed has returned to its attainment condition will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table J4.

Table J 4 Potash Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
South Burlington	-13.98%	-15.28%	1.31%	109.4%
VTRANS	-1.37%	-0.60%	-0.77%	43.7%
BTV	-0.57%	-0.02%	-0.56%	3.0%
Burlington	-0.49%	-0.56%	0.07%	114.2%
UVM	-0.09%	-0.04%	-0.05%	43.8%
Watershed Total	**-16.50%**	**-16.50%**	**0.00%**	**100.0%**

3.2. VTrans Proposed BMPs

There are six proposed VTrans BMPs in the Potash Brook Watershed, which are summarized in Table J5. These BMPs include one median filter, two gravel wetlands, and three detention basins.

The proposed I-89 Swale median filter would be located between I-89 North and South lanes west of Hinesburg Road in South Burlington. The proposed BMP would be a constructed median filter in the depressed area between the interstate lanes and would manage 1.8 acres of VTrans impervious cover, 100% of the total impervious cover managed. Several existing culverts could be rerouted to this median filter.

Gravel wetlands are proposed at sites Exit 13 and Exit 14 in South Burlington. These wetlands would be constructed in the depressed triangle greenspace between ramps and receive stormwater from several rerouted culverts. The gravel wetlands at Exit 13 and Exit 14, manage 4.8 and 1.8 acres retrospectively, 100% of the total impervious cover managed by these BMPs.

The proposed BMP at the 189 Cloverleaf is a detention pond that will manage 3.5 acres of VTrans impervious cover, 30% of the total impervious cover managed. An outlet structure added to this already depressed area will detain stormwater once stormlines from Shelburne Road are rerouted. Wetlands are the only known feasibility concern for this proposed BMP.

A detention pond is proposed at the Dorset St/189 Ramps site that will detain stormwater from a large section of Dorset Street, managing 1.1 acres of VTrans impervious cover (19.6% of the total impervious cover managed). The stormline near Kennedy Drive can be intercepted to reroute discharge to the area between the 189 ramps. This BMP location will need significant earthwork as the area is currently elevated.

At Queen City Park Rd, a detention basin is proposed to add detention to an exciting depressed area where stormlines already outfall to manage 0.4 acres of VTrans impervious cover, 14.7% of the total impervious cover managed. The drainage from Shelburne Road is assumed to be rerouted to a larger depression to the north at site 189 Cloverleaf because of limiting space.

The remaining 8.2 acres of managed VTrans impervious cover is managed by 18 additional BMPs. While these BMPs manage small amounts of VTrans impervious area, they are not determined to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 43.7% of the VTrans high flow target was met by these BMPs, the majority of which are a result of the six specific BMPs described in Table J5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B.

Table J 5 VTrans final proposed BMPs for the Potash Brook FRP Credit BMPDSS model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Exit 13	VTrans	VTrans	Gravel Wetland	NP	16.7	4.8	28.6%	4.8	100%	0.567	9.7%	$219,000
189 Cloverleaf	VTrans / Town	VTrans	Detention Basin	NP	21.3	11.5	54.3%	3.5	30%	1.129	7.0%	$59,000
I-89 Swale	VTrans	VTrans	Median Filter	NP	6.3	1.8	28.6%	1.8	100%	0.531	3.6%	$129,000
Exit 14	VTrans	VTrans	Gravel Wetland	NP	4.9	1.8	36.9%	1.8	100%	0.294	3.7%	$131,000
Dorset St / 189 Ramps	VTrans / Town	VTrans	Detention Basin	NP	9.4	5.6	59.5%	1.1	19.6%	0.348	2.2%	$101,000
Queen City Pk Rd	VTrans / Town	VTrans	Detention Basin	NP	6.5	2.9	44.9%	0.4	14.7%	0.452	0.9%	$99,000
Other non-VTrans dominated BMPs	*Town/ VTrans*	*Non-VTrans*	*Assorted*	--				*8.2*		--	*16.6%*	
Watershed Total:								**21.5**			**43.7%**	**$738,000**

K. Rugg Brook

1. Rugg Brook TMDL Flow Targets

In the effort to restore Rugg Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table K1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table K 1 Rugg Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-16.0%	**16.8%**

In Table K1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

The VT DEC added a future growth factor to the TMDL flow targets to account for future non-jurisdictional impervious growth. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, this type of growth is important to account for within the 20 year stormwater management plan.

The original TMDL assumed a non-jurisdictional impervious growth of 15 acres, whereas a 2013 study completed by the Chittenden County Regional Planning Commission (CCPRC) estimated a more likely future growth estimate of 4.54 acres based on the actual non-jurisdictional growth rate from 2003 to 2014. The future growth rate was calculated as follows:

$$\text{Growth Rate} = \left(\left(\frac{Non-Jurisdictional\ Impervious, 2014}{Non-Jurisdictional\ Impervious, 2003}\right)^{\left(\frac{1}{years}\right)} - 1\right) * 100$$

The revised future growth reduced the high-flow target (Q 0.3%) reduction from 16.0% to 15.3%, which was calculated as shown in the following equation.

Modified Flow Target = $(Target\ \%\ with\ no\ FG) + (Target\ \%\ from\ FG) * (\frac{Revised\ FG\ acres}{Original\ FG\ acres})$

The modified flow targets for Rugg Brook were used for this FRP and are shown in Table K2.

Table K 2 Rugg Brook TMDL flow restoration targets with modified future growth

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-15.3%	**16.8%**

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

St. Albans Town owns the majority of impervious cover within the Rugg Brook Watershed (73.9%). VTrans and St. Albans City on the remainder of the impervious cover in the watershed (15.7% and 10.4% respectively). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where St. Albans Town is responsible for 11.3% of the flow reduction, VTrans is responsible for 2.4% of the flow reduction, and St. Albans City is responsible for the remaining 1.6% of the flow reduction (Table K3).

Table K 3 Rugg Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
St. Albans Town	1556.4	151.4	73.9%	-11.30%	12.41%
VTrans	131.8	32.2	15.7%	-2.40%	2.64%
St. Albans City	70.5	21.4	10.4%	-1.60%	1.75%
Watershed Total	**1758.8**	**204.9**		**-15.30%**	**16.80%**

2. Rugg Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Rugg Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Rugg Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 15.3% in the watershed, current BMPs reduced high flows by 2.5%, which equates to 16.3% of the total required flow reduction (Table K4). Of that reduction, 12.1% of the VTrans allocation was addressed as a reduction of 0.29% was achieved. A 2.11% flow reduction from the VTrans MS4 remains. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table K 4 Rugg Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
St. Albans Town	-11.30%	-1.19%	-10.11%	10.5%
VTrans	-2.40%	-0.29%	-2.11%	12.1%
St. Albans City	-1.60%	-1.02%	-0.58%	63.9%
Watershed Total	**-15.30%**	**-2.50%**	**-12.80%**	**16.3%**

3. Rugg Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 13 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 114.1% of the modified high-flow target, providing a 14.1% factor of safety. The Credit model showed a high flow reduction of 3.42% for the VTrans allocation for the Rugg Brook Watershed, which equates to 142.4% of the total VTrans required high flow reduction (Table K5). The factor of safety is included in the recommended BMP list to provide the MS4s with additional options in the event the list has to be modified or as conditions in the watershed change from present day. In the event a proposed project becomes infeasible after further design and construction planning or must be downscaled, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. No progress was made towards the suggested low flow increase target.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table K5.

Table K 5 Rugg Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
St. Albans Town	-11.30%	-12.41%	1.11%	109.8%
VTrans	-2.40%	-3.42%	1.02%	142.4%
St. Albans City	-1.60%	-1.63%	0.03%	101.9%
Watershed Total	**-15.30%**	**-17.46%**	**2.16%**	**114.1%**

3.2. VTrans Proposed BMPs

There are 13 proposed VTrans BMPs in the Rugg Brook Watershed, which are summarized in Table K6. These BMPs include an infiltration basin, four detention areas, and eight median filters.

The infiltration site, I-89 / Holyoke Farm, manages 0.2 acres of VTrans impervious cover, 49.9% of the total impervious cover managed. The proposed BMP would be located on land owned by an active farm, adjacent to I-89, located off Holyoke Farm Rd. The BMP would be a 15,000 sq-ft infiltration basin that has the potential to increase baseflow to the stream via infiltration, which addresses both the high-flow and low-flow TMDL targets.

The proposed detention basins will treat a total of 7.9 acres of VTrans impervious cover between the four sites. In three of the four locations the BMPs are located on both private and VTrans land. The Exit 19 site is the only detention basin located fully on VTrans land in the center median between the on ramp and the Interstate Access Rd.

Eight median sites were identified that would detain and treat runoff from I-89 in the existing highway median. The structures would be considered equivalent to dry swales as defined in the 2002 Vermont Stormwater Management Manual. The structures would be located in existing vegetated stormwater conveyances in the I-89 median. Key features of the structures include earthen check dams designed to create up to 1.5’ of ponding depth behind each dam, amended soils consisting of a 50/50 blend of sand and native soil at the surface, and a pure sand filter below. A perforated underdrain wrapped in stone would be located below the sand filter, which would be connected to the outlet structure or day lighted.

The remaining 8.1 acres of managed VTrans impervious cover is managed by 12 additional BMPs. While these BMPs manage small amounts of VTrans impervious area, they are not determined to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 142.4% of the VTrans high flow target was met by these BMPs, the majority of which are a result of thirteen specific BMPs (83.4% cumulatively). The proposed BMPs are summarized in Table K6. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B.

Preliminary design concept plans for the Access Rd East, Access Rd West, Exit 19, I-89 Holyoke Farm, and SDC 280 median filter projects can be found in Appendix H-5.

Table K 6 VTrans final proposed BMPs for the Rugg Brook FRP Credit BMPDSS model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Exit 19 South	VTrans	VTrans	Detention	NP	57.9	3.8	6.5%	3.7	97.2%	2.070	26.7%	$270,000
Access Rd. East	VTrans	VTrans/ Private	Detention	NP	85.1	2.8	3.2%	2.4	87.8%	1.820	17.6%	$197,000
Access Rd. West	VTrans	VTrans/ Private	Detention	Drains Portion of 1-1428	13.7	0.6	4.0%	0.6	100%	0.652	4.0%	$40,000
SASH / Federal St Connector	City/ VTrans	VTrans/ Private	Detention	NP	21.1	4.9	23.1%	1.2	24.5%	0.36	8.7%	$39,000
SDC87	VTrans	VTrans	Median Filter	NP	4.9	0.9	18.8%	0.9	100%	0.128	6.7%	$36,000
SDC83b	VTrans	VTrans	Median Filter	NP	1.8	0.4	20.1%	0.4	100%	0.077	2.6%	$22,000
SDC27	VTrans	VTrans	Median Filter	NP	1.6	0.4	26.4%	0.4	100%	0.063	3.1%	$18,000
SDC280	VTrans	VTrans	Median Filter	NP	2.1	0.4	17.4%	0.4	100%	0.063	2.7%	$18,000
SDC347	VTrans	VTrans	Median Filter	NP	1.4	0.3	21.7%	0.3	100%	0.060	2.2%	$17,000
SDC83a	VTrans	VTrans	Median Filter	NP	1.7	0.3	15.8%	0.3	100%	0.058	2.0%	$16,000
SDC342	VTrans	VTrans	Median Filter	NP	1.6	0.3	19.4%	0.3	100%	0.054	2.3%	$15,000

SDC29	VTrans	VTrans	Median Filter	NP	2.2	0.4	18.2%	0.4	100%	0.054	3.0%	$15,000
I-89 / Holyoke Farm	Town / VTrans	Private	Infiltration	NP	61.8	0.5	0.8%	0.2	49.9%	1.426	1.8%	$130,000
Other non-VTrans dominated BMPs	*Town / City/ VTrans*	*Non-VTrans*	*Assorted*	--	*124.1*	*29.9*	*24.1%*	*8.1*	*27.1%*	--	*59.0%*	
Watershed Total:								**19.6**			**142.4%**	**$833,000**

L. Stevens Brook

1. Stevens Brook TMDL Flow Targets

In the effort to restore Stevens Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table L1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table L 1 Stevens Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-24.4%	24.3%

In Table L1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 15 acres in the watershed based on local development and projected growth for Stevens Brook. The approved TMDL flow targets for Stevens Brook are shown in Table L1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

St. Albans City owns the majority of impervious cover within the Stevens Brook Watershed (70.6%) and thus is responsible for the majority of high flow reductions (17.23%). The remaining impervious area is owned by St. Albans Town (22.7%) and VTrans (6.7%). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where St. Albans Town is responsible for a 5.53% flow reduction and VTrans is responsible for the remaining 1.64% flow reduction (Table L2).

Table L 2 Stevens Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
St. Albans City	585.4	218.0	70.6%	-17.23%	17.16%
St. Albans Town	1081.8	70.0	22.7%	-5.53%	5.51%
VTrans	67.7	20.7	6.7%	-1.64%	1.63%
Watershed Total	**1734.9**	**308.7**		**-24.40%**	**24.30%**

2. *Stevens Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Stevens Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Condition Model

The Stevens Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 24.4% in the watershed, current BMPs reduced high flows by 0.92%, which equates to 3.8% of the total required flow reduction (Table L3). Of that reduction, 14.8% of the VTrans allocation of 1.52% was addressed and a required 1.4% flow reduction remains. Based on the model results, additional CPv stormwater controls will be required to meet the required TMDL high-flow target.

Table L 3 Stevens Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
St. Albans City	-17.80%	-0.24%	-16.99%	1.4%
St. Albans Town	-5.09%	-0.44%	-5.09%	8.0%
VTrans	-1.52%	-0.24%	-1.40%	14.8%
Watershed Total	**-24.40%**	**-0.92%**	**-23.48%**	**3.8%**

3. Stevens Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 10 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 115.2% of the modified high-flow target, providing a 15.2% factor of safety. The Credit model showed a high flow reduction of 2.25% for the VTrans allocation for the Stevens Brook Watershed, which equates to 148.5% of the total VTrans required high flow reduction (Table L4). The factor of safety is included in the recommended BMP list to provide the MS4s with additional options in the event the list has to be modified or as conditions in the watershed change from present day. In the event a proposed project becomes infeasible after further design and construction planning or must be downscaled, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. No progress was made towards the suggested low flow increase target.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table L4.

Table L 4 Stevens Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
St. Albans City	-17.80%	-16.52%	-1.28%	92.8%
St. Albans Town	-5.09%	-9.33%	4.25%	183.5%
VTrans	-1.52%	-2.25%	0.74%	148.5%
Watershed Total	**-24.40%**	**-28.10%**	**3.70%**	**115.2%**

3.2. VTrans Proposed BMPs

There are 10 proposed VTrans BMPs in the Stevens Brook Watershed, which are summarized in Table L5. These BMPs include two detention basins and eight median filters.

The proposed location for the Upper Fairfield Hill Rd. retrofit site is off Fairfield Hill Road (VT-36, VTrans-owned) on a private parcel within the Town. It captures approximately 34 acres of drainage from VT-36 as well as neighboring homes and driveways. A water quality treatment/flow control basin is proposed. Private land would need to be acquired in order to implement the BMP. The land, as of November 2013, is advertised for sale. The benefit of the proposed facility location is the ability to control flow at the top of the watershed before stormwater flows enter the main stream channel and gain velocity and erosive strength.

A water quality/flow detention retrofit is proposed at the Fairfield Rd./I-89 retrofit site, designed to capture runoff from a 28.9 acre-area including a portion of Fairfield Road (VT-36) and Town residences along the road. The structure will need to be designed according to Federal Highway Administration (FHWA) guidelines for safety. A new culvert under Fairfield Road would be required to route flow from the north side of VT-36 into the facility. The proposed BMP would treat runoff from VTrans and Town-impervious cover, and therefore a cost-share is recommended.

Eight sites within the VTrans I-89 ROW were identified as potential sites for water quality/flow detention BMPs to detain and treat runoff from I-89. The sites are all located in existing vegetated stormwater conveyances within the I-89 median. Key features of the structures include earthen check dams designed to create up to 1.5 feet of ponding depth behind each dam, amended soils consisting of a 50/50 blend of sand and native soil at the surface, and a pure sand filter below. The structures are designed with a perforated underdrain to be located below the sand filter, connected to the nearest downstream, outlet structure or daylighted. The sites are all on VTrans land. Environmental permitting including primarily potential wetland impacts needs to be considered for each site. Designs are required to comply with FHWA safety standards for the interstate system.

The remaining 2 acres of managed VTrans impervious cover is managed by 4 additional BMPs. While these BMPs manage small amounts of VTrans impervious area, they are not determined to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 148.5% of the VTrans high flow target was met by these BMPs (Table L5).

The proposed BMPs are summarized in Table L5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B. Preliminary design concept plans for three of the proposed projects can be found in Appendix H-6 (Fairfield Rd I-89, SDC105b, and Upper Fairfield Hill Rd).

Table L 5 VTrans final proposed BMPs for the Stevens Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Upper Fairfield Hill Rd	VTrans	VTrans/ Private	Detention Basin	NP	34.3	3.4	9.8%	1.2	34.4%	1.28	22.7%	$164,000
Fairfield Rd. / I-89	VTrans	VTrans	Detention Basin	NP	28.9	2.1	7.2%	0.8	40.8%	0.68	16.6%	$109,000
SDC118	VTrans	VTrans	Median Filter	NP	1.1	0.5	50.9%	0.5	100%	0.06	10.7%	$28,000
Median A1	VTrans	VTrans	Median Filter	NP	0.9	0.4	46.4%	0.4	100%	0.06	8.2%	$27,000
SDC140b	VTrans	VTrans	Median Filter	NP	1.0	0.5	50.4%	0.5	100%	0.05	9.9%	$26,000
SDC408	VTrans	VTrans	Median Filter	NP	0.9	0.5	50.0%	0.5	100%	0.05	9.2%	$23,000
SDC98b	VTrans	VTrans	Median Filter	NP	0.9	0.4	49.0%	0.4	100%	0.05	8.2%	$22,000
Median A2	VTrans	VTrans	Median Filter	NP	0.7	0.3	45.5%	0.3	100%	0.04	5.8%	$21,000
SDC105b	VTrans	VTrans	Median Filter	NP	1.0	0.5	53.3%	0.5	100%	0.05	10.4%	$26,000

SDC105c	VTrans	VTrans	Median Filter	NP	0.8	0.4	52.1%	0.4	100%	0.04	8.6%	$20,000
Other non-VTrans dominated BMPs	*Town / City/ VTrans*	*Non-VTrans*	*Assorted*	--	--	--		*2.0*		--	*38.3%*	
Watershed Total:								**7.6**			**148.5%**	**$466,000**

M. Sunderland Brook

1. Sunderland Brook TMDL Flow Targets

In the effort to restore Sunderland Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table M1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table M 1 Sunderland Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-3.7%	3.6%

In Table M1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 8 acres in the watershed based on local development and projected growth for Sunderland Brook. The approved TMDL flow targets for Sunderland Brook are shown in Table M1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas. The University of Vermont (UVM) owns land at the Fort Ethan Allen, but as a non-traditional MS4 the VT DEC did not consider UVM to be a jurisdictional MS4 within the Sunderland Brook Watershed. It is thus not included as a contributing MS4 to the Sunderland Brook TMDL.

The Town of Essex and the Town of Colchester own the majority of impervious cover in the Sunderland Brook Watershed (35.7% and 35.6% respectively). The remaining impervious cover is owned by the Village of Essex Junction and VTrans (25.5% and 3.2% respectively). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where the Town of Essex and the Town of Colchester are both responsible for 1.32% flow reductions. The Village of Essex Junction is responsible for 0.94% of the flow reduction, and VTrans is responsible for the remaining 0.12% flow reduction (Table M2).

Table M 2 Sunderland Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
University of Vermont	----	----	----	----	----
Town of Essex	318.3	111.8	35.7%	-1.32%	1.28%
Town of Colchester	916.6	111.6	35.6%	-1.32%	1.28%
Village of Essex Junction	173.6	80.1	25.5%	-0.94%	0.9%
VTrans	17.8	10.1	3.2%	-0.12%	0.12%
Watershed Total	**1426.3**	**313.6**		**-3.70%**	**3.60%**

2. Sunderland Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Sunderland Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Sunderland Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 3.7% in the watershed, current BMPs reduced high flows by 7.91%, which equates to 213.8% of the total required flow reduction (Table M3). Of that reduction, 377.4% of the VTrans allocation of 0.12% was addressed and a no required flow reduction remains. VTrans high flow reductions exceeded the target by 0.33%. Based on the model results, no additional CPv stormwater controls will be required to meet the TMDL high-flow target. However, as noted, even though modeled flow targets exceed TMDL flow targets, additional BMPs were identified in the event that future biomonitoring of the stream reveals non-compliance with Vermont water quality standards.

Table M 3 Sunderland Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Town of Essex	-1.32%	-3.99%	2.67%	302.0%
Town of Colchester	-1.32%	-3.37%	2.06%	256.2%
Village of Essex Junction	-0.94%	-0.10%	-0.84%	10.8%
VTrans	-0.12%	-0.45%	0.33%	377.4%
Watershed Total	**-3.70%**	**-7.91%**	**4.21%**	**213.8%**

3. Sunderland Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 1 proposed VTrans BMP. The watershed-wide proposed FRP scenario addresses 482.4% of the modified high-flow target, providing retrofit options for the MS4s well above the required high flow reduction. The factor of safety is included in the recommended BMP list to provide the MS4s with options in the event that biomonitoring of Sunderland Brook reveals non-compliance with Vermont water quality standards. A low flow increase of 8.3% was modeled, which equates to 58% of the suggested target.

The Credit model showed a high flow reduction of 1.01% for the VTrans allocation for the Sunderland Brook Watershed, which equates to 847.3% of the total VTrans required high flow reduction (Table M4).

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table M4.

Table M 4 Sunderland Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Town of Essex	-1.32%	-10.02%	8.71%	759.6%
Town of Colchester	-1.32%	-5.23%	3.91%	397.1%
Village of Essex Junction	-0.94%	-1.59%	0.64%	168.0%
VTrans	-0.12%	-1.01%	0.89%	847.3%
Watershed Total	**-3.70%**	**-17.85%**	**14.15%**	**482.4%**

3.2. VTrans Proposed BMPs

There is one proposed VTrans BMP in the Sunderland Brook Watershed, which is summarized in Table M5. This BMP includes one infiltration trench that manages 2.3 acres of VTrans impervious cover, 59.4% of the total impervious cover managed.

Tracy Rd. located in the Town of Colchester, was identified as a retrofit opportunity. The BMP retrofit would involve a retrofit of the existing grass swale on the VTrans site along Tracy Road. The existing grass swale and attached stormwater system collects drainage from the VTrans garage site and also from Barnes/Troy Ave. The existing swale would be expanded and a 2-foot-deep stone infiltration gallery would be added under the surface. The surface would remain as grass and riser pipes would connect drainage into the deeper stone gallery for easier maintenance. The existing fence would need to be moved closer to the road. This project would benefit high and low flow targets as well as improve water quality discharge from the site. Since the contributing drainage comes from the Town of Colchester and VTrans impervious, a cost share could be set up to allocate resources. On a runoff volume basis, the Town of Colchester contributes 0.195 ac-ft versus 0.23 ac-ft from VTrans owned land. The split is about 46%/54%.

The Fort Ethan Allen Offset Project manages the remaining 4.5 acres of VTrans impervious cover, 14.2% of the total impervious cover managed in this drainage area. This BMP manages a small amount of VTrans impervious area through the construction of a micropool extended detention pond, it is not determined to be the responsibility of VTrans.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 847.3% of the VTrans high flow target was met by these BMPs, the majority of which are a result of the existing Fort Ethan Allen existing Post-2002 BMP. The proposed Tracy Rd. BMP manages the remaining 288% of the high flow target (Table M5).

The proposed BMPs are summarized in Table M5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMP is located in Appendix B. A preliminary design concept plans for the Tracy Rd project can be found in Appendix H-7.

Table M 5 VTrans final proposed BMPs for the Sunderland Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Tracy Rd.	VTrans/ Colchester	VTrans/ Colchester	Infiltration Trench	6363-INDS	5.0	3.9	78.3%	2.3	59.4%	0.43	287.9%	$54,000
Existing Fort Ethan Allen (Post-2002) BMP	*Town / City/ VTrans*	*Non-VTrans*	*Assorted*	*5598-INDO*	*46.5*	*31.8*	*68.3%*	*4.5*	*14.2%*	--	*559.4%*	
Watershed Total:								**6.8**			**847.3%**	**$54,000**

N. Design and Construction Schedule

A design and construction (D&C) schedule was developed to provide a long term plan for the implementation of the VTrans FRP. The 54 projects were spaced out over a 16-year timeframe in seven separate phases. The timeline provides for design, acquisition of necessary permits, regulatory approvals, acquisition of necessary land, and construction. The flow restoration targets are subject to adjustment by the Secretary based on biological monitoring data or other confounding information concerning high flow reduction progress. Adjustments to the flow targets may impact the schedule and full implementation of the proposed projects. The D&C is a working document and will be revised based on new information regarding the projects and stream conditions. A complete implementation schedule summary can be found in Appendix E. A summary of the number of projects to be constructed and the total cost by implementation phase is included below (Table N1). A workbook has been developed to track these projects (Appendix F).

Table N 1 Summary of project implementation costs and the number of projects to be constructed in each implementation phase

	Phase 1 (2017-2019)	**Phase 2 (2020-2022)**	**Phase 3 (2023-2025)**	**Phase 4 (2026-2027)**	**Phase 5 (2028-2029)**	**Phase 6 (2030-2031)**	**Phase 7 (2032)**	**Total**
# of Projects	13	18	7	5	5	3	3	**54**
Total Cost (Rounded to Nearest $1,000)	$764,000	729,000	$1,033,000	570,000	$1,067,000	$1,334,000	$1,752,000	**$6,522,000**

O. Financial Plan

Planning level costs were estimated for each project using a consistent spreadsheet-based method for all projects. As such, some cost estimates may differ slightly from those presented in other FRP documents. The total estimated implementation cost for all 54 BMPs is $6,522,000. VTrans will request state and federal funding for the appropriate amount to implement the BMPs as outlined in the D&C (see Table N1). For those projects that will require a joint effort with another municipality, VTrans will request funding for their portion of the cost share. In watersheds where VTrans is either not meeting or exceeding their allocated target, there may be cost sharing between MS4s.

a. BMP Cost Estimates

A spreadsheet-based method, originally developed by the Horsley-Witten (HW) Group, was used to develop planning level costs for all proposed BMPs. The methodology was used in the development of the Centennial Brook FRP and provides consistent cost estimates across watersheds (see HW Memo in Appendix G). It is expected that these costs will change as further designs are completed and site conditions and constraints are better understood. Cost estimates are based on limited site investigation, but are useful for planning purposes. All estimates presented are based on 2014 dollars.

The BMP cost estimation is based on the design control volume as determined by HydroCAD models developed for each site, unit costs that take into account the type of BMP, a site adjustment factor that takes into account the difficulty of construction based on present development at a location, a factor for the design and permitting of the BMP, and a land acquisition cost.

Base unit costs were dependent on the type of BMP proposed, as well as the area of the BMP. For example, a detention basin's base cost would be \$2 per ft^3 (Table O1 upper). Depending on the type of site where the BMP will be constructed, a cost multiplier was used with more constricted and developed sites assumed to increase construction complexity and cost (Table O1 lower).

Table O 1 Unit costs and adjustment factors for each BMP type

BMP Type	Base Cost (\$/ft^3)
Detention Basin	\$2
Infiltration Basin	\$4
Underground Chamber (infiltration or detention)	\$12
Bioretention	\$10
Green Infrastructure/ Underground Chamber Combo	\$22
Site Type	Cost Multiplier
Existing BMP retrofit	0.25
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Adjustment factor for large aboveground basin projects	0.5

Final costs were also influenced by a number of other factors. These include:

- Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.
- Permits and Engineering Costs: A cost multiplier of either 20% for large storage volume projects, or 35% for small or complex projects was applied.

- Land Acquisition Costs (modified from the HW method): For projects that require the acquisition of private land, a variation from the HW method was applied. An approximate land acquisition cost of $120,000 was used per acre required for the BMP. It should be noted that this value is based on a limited estimate and not necessarily an expected cost per acre.
- Total Project Cost: The total project cost was calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs. This cost was then rounded to the nearest $1,000.
- Minimum Cost Adjustment: This methodology tends to underestimate the cost of small retrofits, so a minimum project cost of $10,000 was applied for a simple, small projects such as an outlet retrofit, and a minimum cost of $25,000 was applied for more complex projects.

Cost estimates are summarized by watershed for VTrans BMPs below (Table O2). Cost estimates by BMP are located in Appendix C.

Table O 2 Cost estimate summary by watershed for all proposed VTrans BMPs

Watershed Name	# of VTrans BMPs	Estimated Cost
Allen Brook	13	$764,000
Bartlett Brook	2	$577,000
Centennial Brook	2	$1,851,000
Indian Brook	3	$353,000
Moon Brook	1	$279,000
Munroe Brook	3	$607,000
Potash Brook	6	$738,000
Rugg Brook	13	$833,000
Stevens Brook	10	$466,000
Sunderland Brook	1	$54,000
VTrans Total:	**54**	**$6,522,000**

P. Regulatory Analysis

BMPs presented in this FRP document will be implemented over the 16-year timeframe detailed in D&C. In several watersheds, the proposed BMP implementation scenario manages >100% of the VTrans high flow reduction target and thus includes a robust factor of safety (i.e., Sunderland Brook, Bartlett Brook; Appendix D). This factor of safety is included so that if one or more proposed projects become infeasible after further design and construction planning, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. The proposed BMP implementation plan will serve as a guide for VTrans, but is subject to change as more information becomes available. Each of the BMPs is either on land owned by VTrans, on land controlled by VTrans, or on land controlled by another municipality. For the BMPs that fall into the third category, VTrans is prepared to work with the appropriate municipality to implement the BMP.

Q. Glossary of Terms

A glossary of relevant terms is provided below.

Best Management Practice (BMP)- Generally, BMPs are defined as, "schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State and waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage" (MS4 Permit, 2012). In the context of the FRP, BMPs include prescribed stormwater flow control practices as defined in the computer-based BMPDSS model, in which various BMPs scenarios can be assessed.

Best Management Practice Decision Support System (BMPDSS)- A computer-based hydrologic model used to assess the impact of various stormwater BMP scenarios. This tool was developed by a private consultant for the VT DEC to use as the assessment tool for compliance with the Stormwater TMDLs.

Channel Protection Volume (CPv)- The stormwater volume generated from the 1-year, 24-hour rainfall event. The Vermont Stormwater CPv Design Standard requires 24 hours of extended detention storage of the CPv in warm water fish habitat and 12 hours for cold water fish habitat as a means to reduce channel erosion.

Detention BMP- A BMP (e.g. detention pond) which stores stormwater for a defined length of time before it eventually drains to the receiving water body. Stormwater is not retained in the practice long term. The objective with a detention BMP is to reduce the peak discharge (Q_p) from the basin in the effort to reduce channel erosion and settle out pollutants from the stormwater.

Flow Duration Curve (FDC)- An FDC is a curve displaying the percentage of time during a period that flow exceeds a certain value, with the low flow represented by the 95th percentile (Q 95%) of the curve, and the high flow represented by the 5th percentile (Q 0.3%).

Flow Restoration Plan (FRP)- The FRP is a required element of the MS4 General Permit #3-9014, under section IV. C. 1., for stormwater discharges to impaired waters. The FRP is a 20-year implementation plan of stormwater flow control BMPs to meet the TMDL high flow target and return the impaired water to its attainment condition. The FRP is required to include a list of stormwater BMP controls, as well as modeling results from the VT BMPDSS model demonstrating compliance of the approved TMDL flow target with the proposed BMP list.

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

Non-Jurisdictional Impervious- Non-jurisdictional impervious area is impervious cover that does not require a stormwater permit and is not managed by a stormwater BMP (impervious growth < 1 acre).

Residual Designation Authority (RDA)- The RDA permit is separate from the MS4 permit, held by the private landowner.

Stormwater Management Plan (SWMP)- A comprehensive program to manage stormwater discharges from the Municipal Separated Storm Sewer System as mandated by the MS4 General Permit #3-9014.

Stormwater TMDL- Vermont developed stormwater Total Maximum Daily Loads (TMDLs) for impaired watersheds using stormwater flow as a surrogate for pollutants. The basis for the flow-based TMDL is the understanding that stormwater is the source of pollutant loading. Therefore, minimizing stormwater flows will reduce pollutant loading to the streams and Lake Champlain. The approved TMDL requires a reduction in high flows, defined as greater than the 1-year storm event. The TMDL also includes a non-actionable (not enforced) low flow target, which is measured by an increase in stream baseflow (groundwater flow to streams).

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

TMDL High Flow Target- The TMDL target defined as the percent change between the Pre-2002 (baseline) condition and the Post-2002 (existing) high flow. The high flow is the flow rate in the stream that is exceeded 0.3% of the time (Q 0.3%) over a 10-year simulation period. The Q 0.3% has been equated to the 1-year design storm runoff.

TMDL Low Flow Target- The non-actionable TMDL target defined as the percent change between the Pre-2002 (baseline) condition and the Post-2002 (existing) low flow. The low flow is the flow rate in the stream that is exceeded 95% of the time (Q 95%), over a 10-year simulation period. The Q 95% is considered baseflow, which is the flow in a stream fed by groundwater.

R. Appendices

N
0 0.5 1 Miles

Proposed Stormwater BMPs

Allen Brook Watershed
Williston, VT 05496

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

N

0 0.2 0.4 Miles

Proposed Stormwater BMPs

Bartlett Brook Watershed

South Burlington, VT 05403

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

Proposed Stormwater BMPs

Centennial Brook Watershed

South Burlington, VT 05403

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

Proposed Stormwater BMPs

Indian Brook Watershed

Essex Junction, VT 05452

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

Proposed Stormwater BMPs

Moon Brook Watershed

Rutland, VT 05701

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

Proposed Stormwater BMPs

Munroe Brook Watershed

Shelburne, VT 05482

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

Proposed Stormwater BMPs

Potash Brook Watershed

South Burlington, VT 05403

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

N

0 0.25 0.5 Miles

Proposed Stormwater BMPs

Rugg Brook Watershed

St Albans City, VT 05478

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

N

0 0.25 0.5 Miles

Proposed Stormwater BMPs

Stevens Brook Watershed

St Albans City, VT 05478

WATERSHED CONSULTING ASSOCIATES, LLC

Map Produced: 9/29/2016

N
0 0.25 0.5 Miles

Proposed Stormwater BMPs

Sunderland Brook Watershed

Colchester, VT 05446

WATERSHED CONSULTING ASSOCIATES, LLC

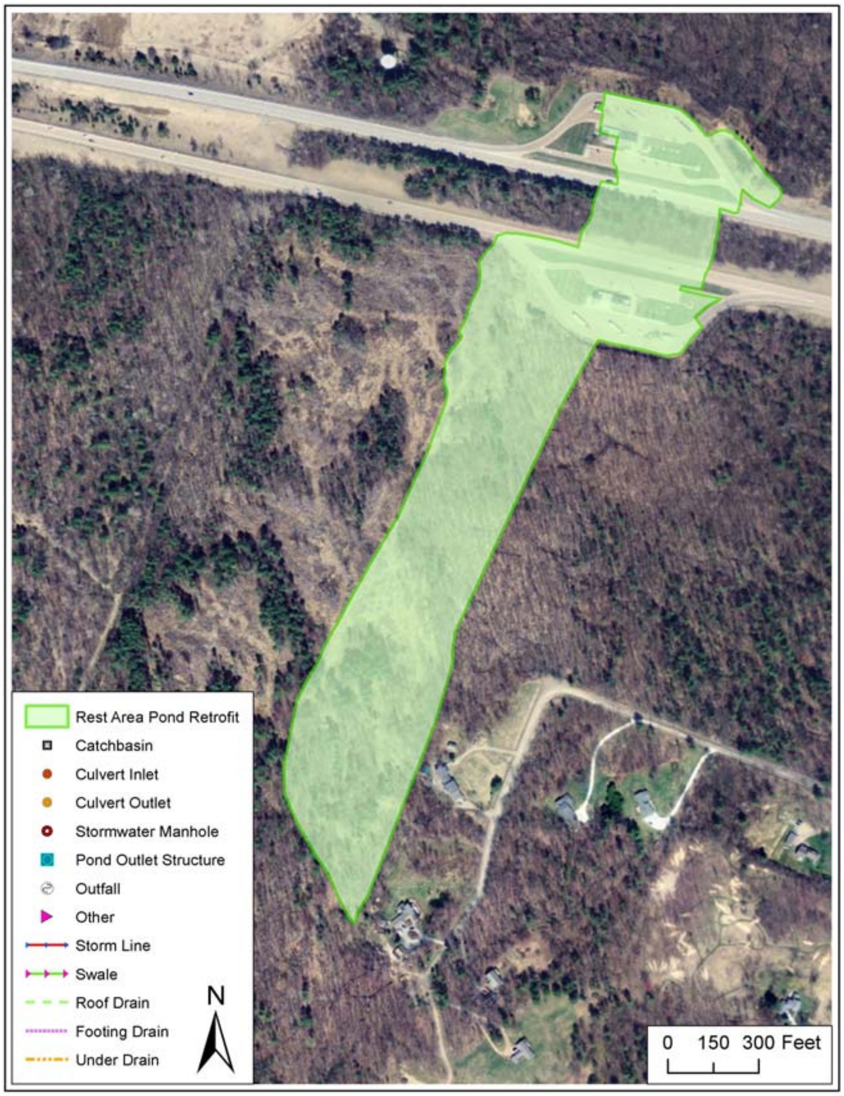
Map Produced: 9/29/2016

VTRANS FRP BMP Summary Sheet

Site name: Rest Area Pond Retrofit **Watershed: Allen Brook**

Approximate address:	Willistion Information Center I-89 Williston, VT 05495	**MS4 Impervious Owner(s):**	VTrans / Town of Williston	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Detention Basin				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$158,000
Drainage area (acres)	26.80
Total impervious cover managed by BMP (acres)	4.42
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	4.42
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.67
Percent of VTrans High-Flow Target Managed (%)	0.26%
Cost Notes	--

BMP Description

Retrofit existing pond to meet CPv standards.

VTRANS FRP BMP Summary Sheet

Site name: Town Office		Watershed: Allen Brook			
Approximate address:	I-89 South of Rest Area Williston, VT 05496	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$32,000
Drainage area (acres)	2.22
Total impervious cover managed by BMP (acres)	0.37
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.37
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.06
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: WCA_1	Watershed: Allen Brook				
Approximate address:	I-89 South of Oak Hill Rd Williston, VT 05495	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$92,000
Drainage area (acres)	4.25
Total impervious cover managed by BMP (acres)	0.68
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.68
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.18
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: WCA_2		Watershed: Allen Brook			
Approximate address:	I-89 North of Rest Area Williston, VT 05496	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$25,000
Drainage area (acres)	2.51
Total impervious cover managed by BMP (acres)	0.44
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.44
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.04
Percent of VTrans High-Flow Target Managed (%)	0.03%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: WCA_3		Watershed: Allen Brook			
Approximate address:	I-89 North of Rest Area Williston, VT 05496	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$25,000
Drainage area (acres)	2.32
Total impervious cover managed by BMP (acres)	0.55
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.55
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.03
Percent of VTrans High-Flow Target Managed (%)	0.03%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: WCA_4	Watershed: Allen Brook				
Approximate address:	I-89 North of Rest Area Williston, VT 05496	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$53,000
Drainage area (acres)	3.25
Total impervious cover managed by BMP (acres)	0.71
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.71
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.10
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet			
Site name: VTrans Median A	**Watershed: Allen Brook**		

Approximate address:	I-89 South of Route 2 Williston, VT 05498	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$60,000
Drainage area (acres)	1.28
Total impervious cover managed by BMP (acres)	0.30
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.30
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.12
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: VTrans Median B		Watershed: Allen Brook			
Approximate address:	I-89 South of Route 2 Williston, VT 05498	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$41,000
Drainage area (acres)	0.73
Total impervious cover managed by BMP (acres)	0.21
Total impervious cover managed by BMP (% of drainage area)	0.3%
VTRANS impervious cover managed (acres)	0.21
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.08
Percent of VTrans High-Flow Target Managed (%)	0.01%
Cost Notes	--

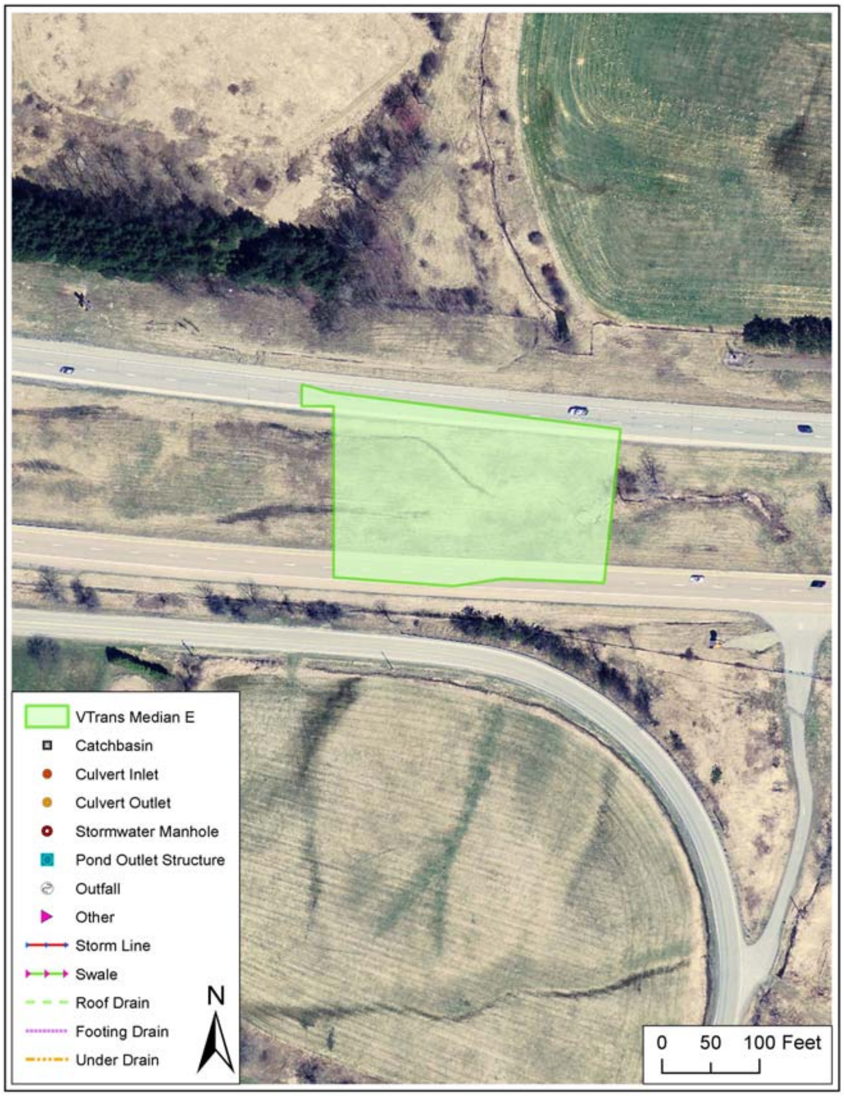
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: VTrans Median E		Watershed: Allen Brook			
Approximate address:	I-89 South of Oak Hill Rd Williston, VT 05495	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$44,000
Drainage area (acres)	1.17
Total impervious cover managed by BMP (acres)	0.30
Total impervious cover managed by BMP (% of drainage area)	0.3%
VTRANS impervious cover managed (acres)	0.30
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.08
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

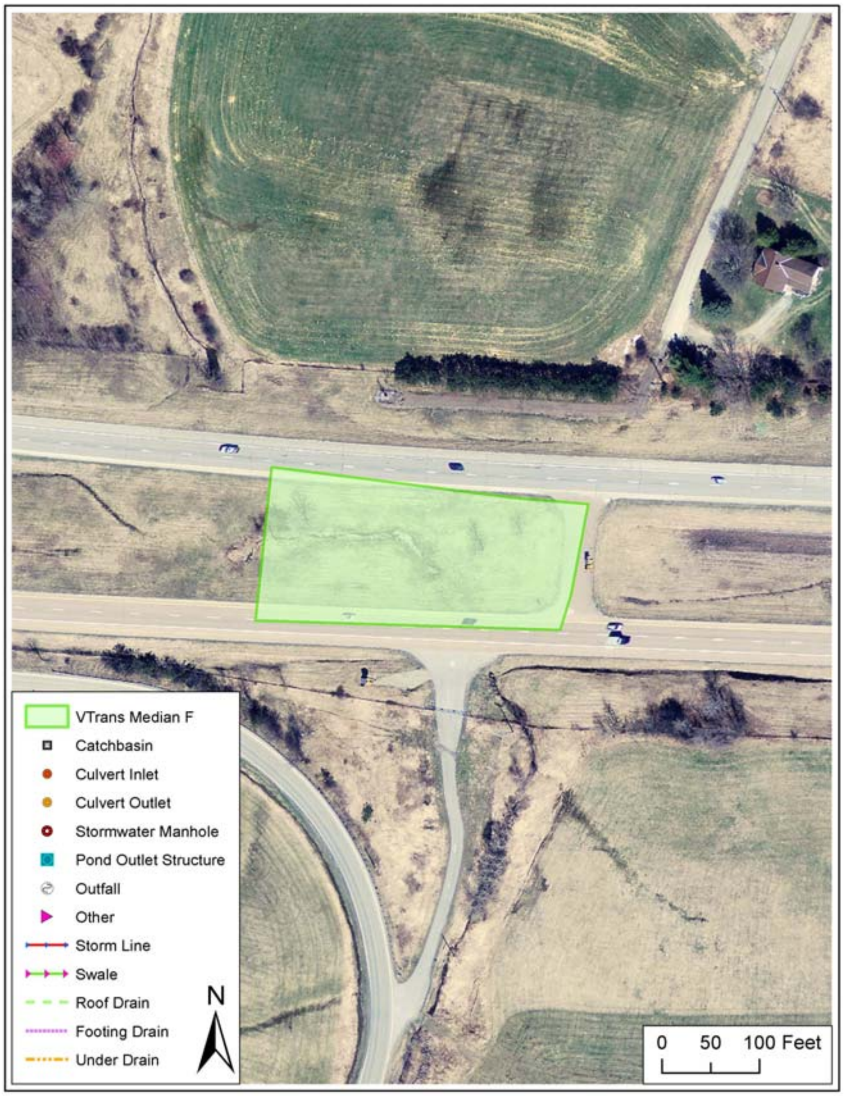
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: VTrans Median F		Watershed: Allen Brook			
Approximate address:	I-89 South of Oak Hill Rd Williston, VT 05495	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$44,000
Drainage area (acres)	1.07
Total impervious cover managed by BMP (acres)	0.20
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.20
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.09
Percent of VTrans High-Flow Target Managed (%)	0.01%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: VTrans Median G		Watershed: Allen Brook			
Approximate address:	I-89 South of Oak Hill Rd Williston, VT 05495	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$61,000
Drainage area (acres)	1.54
Total impervious cover managed by BMP (acres)	0.32
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.32
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.12
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: VTrans Median H		Watershed: Allen Brook			
Approximate address:	I-89 South of Oak Hill Rd Williston, VT 05495	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$59,000
Drainage area (acres)	1.30
Total impervious cover managed by BMP (acres)	0.25
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.25
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.11
Percent of VTrans High-Flow Target Managed (%)	0.01%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: VTrans Median I		Watershed: Allen Brook			
Approximate address:	I-89 South of Oak Hill Rd Williston, VT 05495	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$70,000
Drainage area (acres)	1.65
Total impervious cover managed by BMP (acres)	0.37
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.37
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.13
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

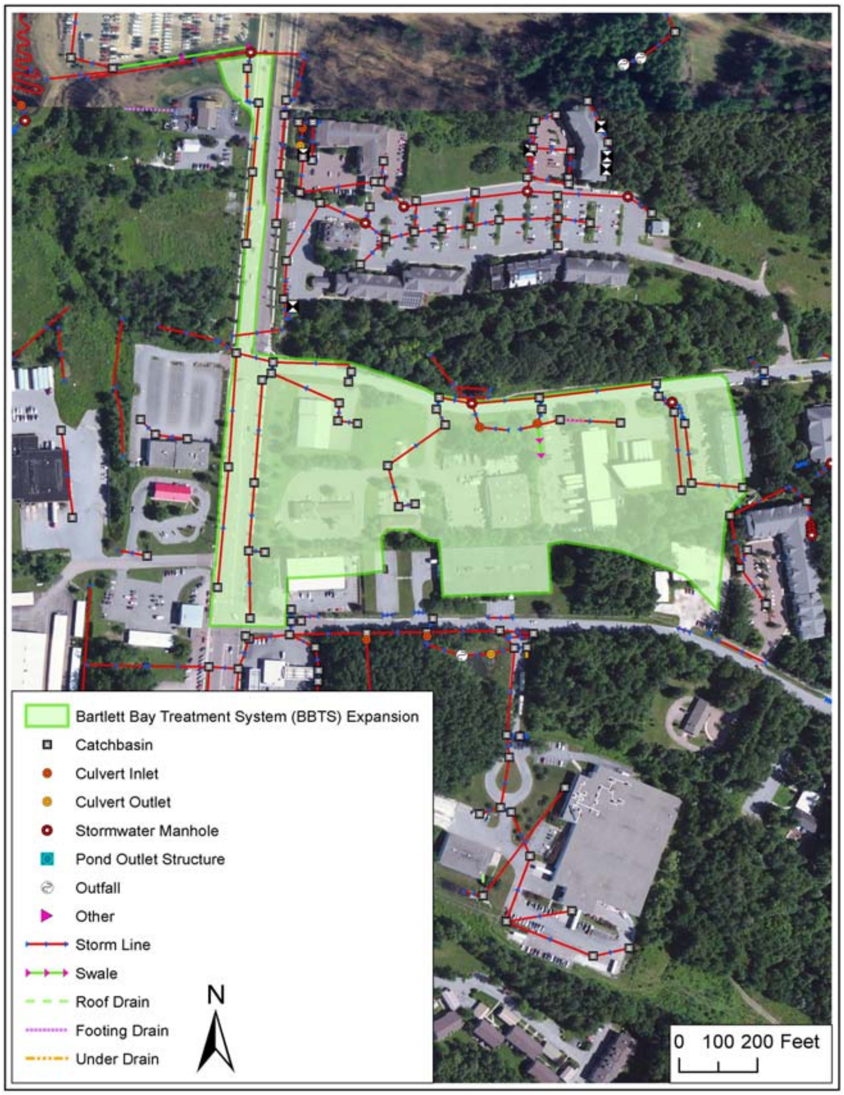
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: Bartlett Bay Treatment System (BBTS) Expansion			**Watershed: Bartlett Brook**		
Approximate address:	Shelburne Rd / Harbor View Rd South Burlington, VT 05403	**MS4 Impervious Owner(s):**	VTrans/ South Burlington	**Ownership of Land where BMP is located:**	South Burlington
Proposed BMP type:	Underground Detention Chamber in ROW				

Site Map



Proposed BMP details

Permit #	5625-9010, 2-0180, 2-0153
Estimated project cost (rounded to nearest $1,000)	$378,000
Drainage area (acres)	16.06
Total impervious cover managed by BMP (acres)	9.18
Total impervious cover managed by BMP (% of drainage area)	0.6%
VTRANS impervious cover managed (acres)	1.88
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.2%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.55
Percent of VTrans High-Flow Target Managed (%)	1.02%
Cost Notes	Cost share with City

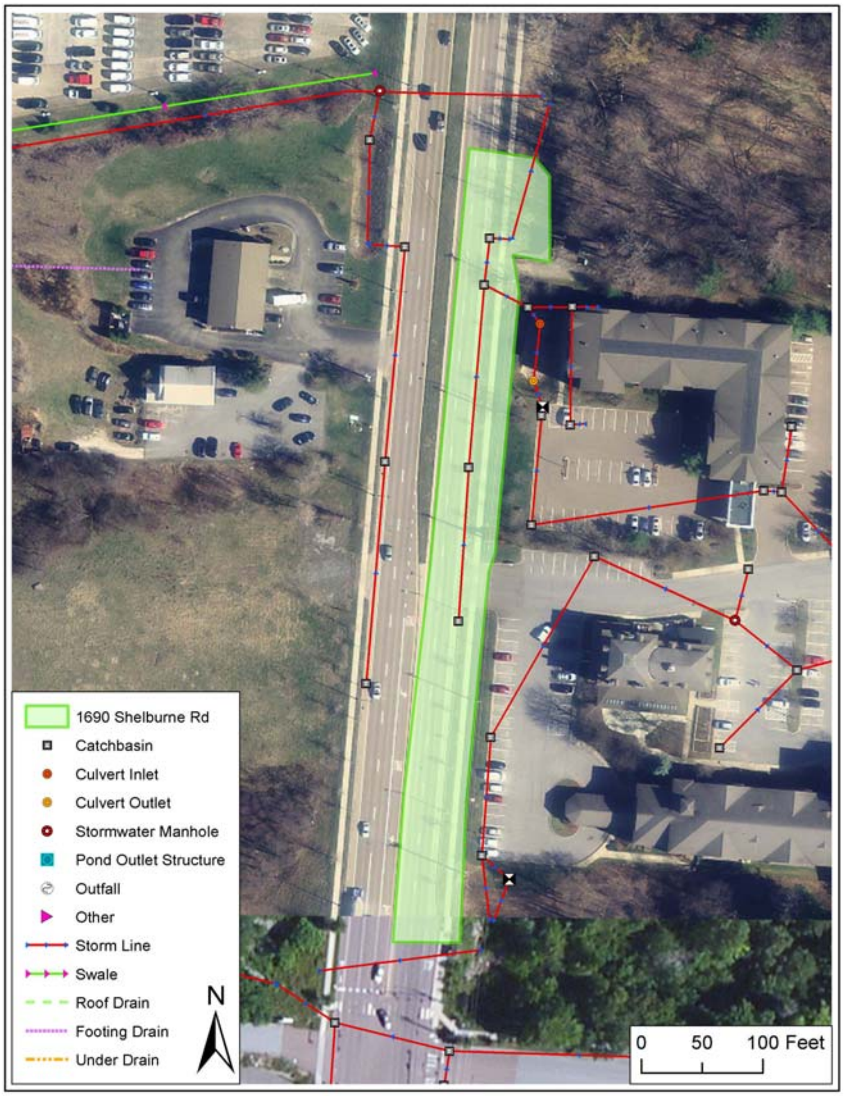
BMP Description

Route CPv storm to BBTS Wetland, and add forebay.

VTRANS FRP BMP Summary Sheet

Site name: 1690 Shelburne Rd			Watershed: Bartlett Brook		
Approximate address:	1690 Shelburne Rd South Burlington, VT 05403	**MS4 Impervious Owner(s):**	VTrans/ South Burlington	**Ownership of Land where BMP is located:**	VTrans/ Developer-Pizzagalli
Proposed BMP type:	Underground Detention Chamber in ROW				

Site Map



Proposed BMP details

Permit #	5625-9010
Estimated project cost (rounded to nearest $1,000)	$199,000
Drainage area (acres)	0.81
Total impervious cover managed by BMP (acres)	0.42
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.42
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.04
Percent of VTrans High-Flow Target Managed (%)	0.23%
Cost Notes	--

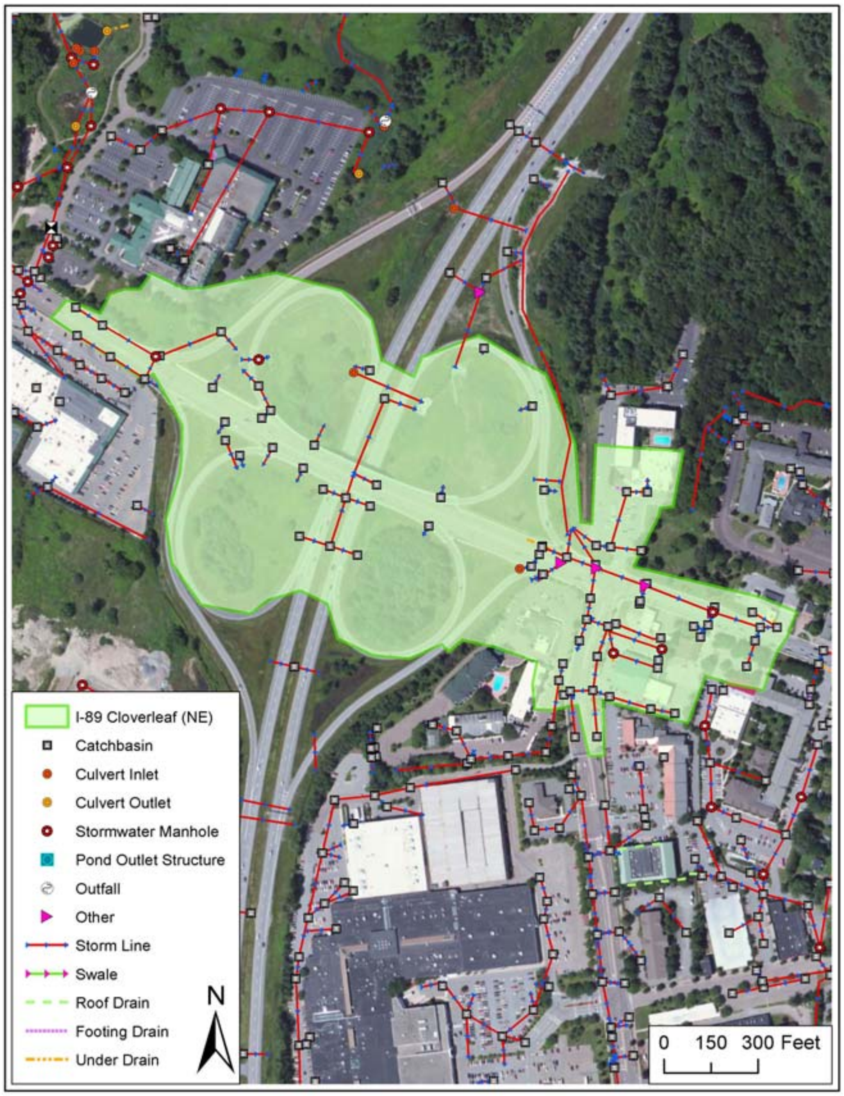
BMP Description

Detain unmanaged portion of Route 7 with underground detention in ROW.

VTRANS FRP BMP Summary Sheet

Site name: I-89 cloverleaf (NE)		Watershed: Centennial Brook			
Approximate address:	I-89 Cloverleaf South Bulrlington, VT 05403	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Underground Detention Chamber				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$432,000
Drainage area (acres)	39.17
Total impervious cover managed by BMP (acres)	13.80
Total impervious cover managed by BMP (% of drainage area)	0.4%
VTRANS impervious cover managed (acres)	4.98
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.4%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	2.36
Percent of VTrans High-Flow Target Managed (%)	0.37%
Cost Notes	--

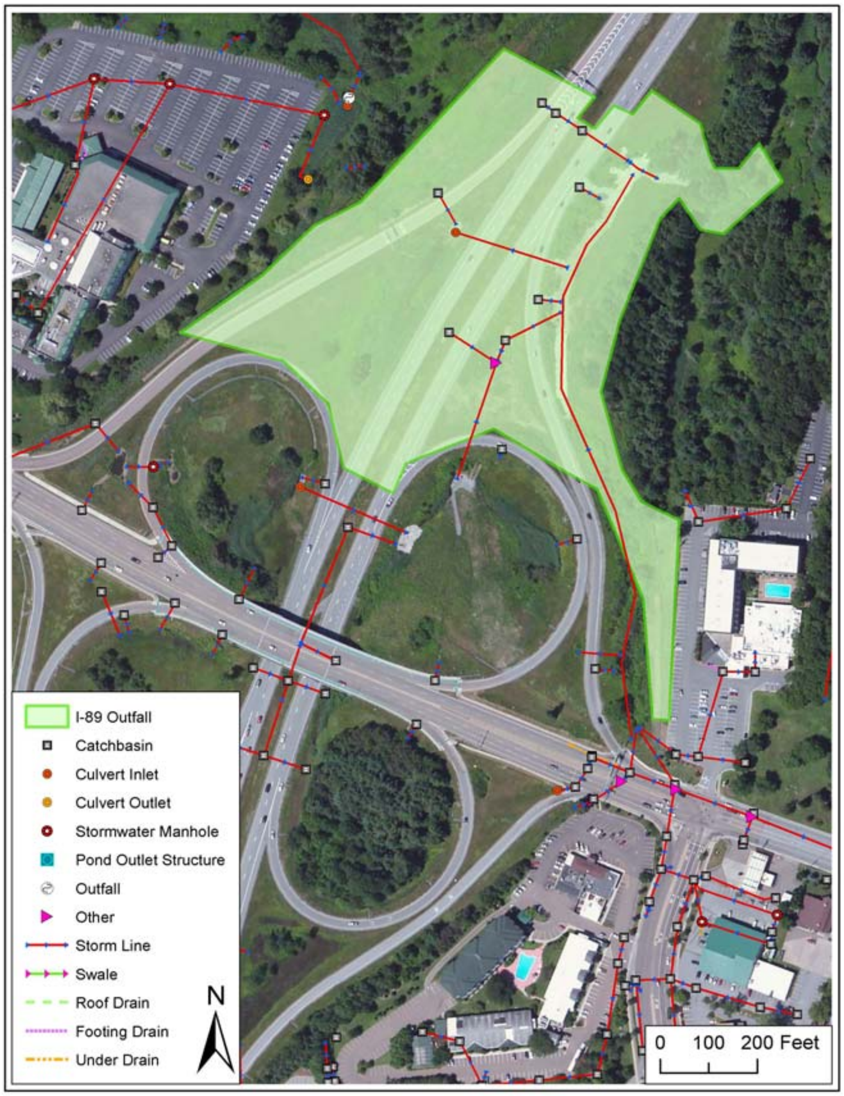
BMP Description

Create new underground detention chambers. Max det. time=48.8 hrs; max. ponding depth=8'

VTRANS FRP BMP Summary Sheet

Site name: I-89 Outfall			Watershed: Centennial Brook		
Approximate address:	I-89 North of Cloverleaf South Bulrlington, VT 05403	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Detention Basin				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$1,419,000
Drainage area (acres)	13.07
Total impervious cover managed by BMP (acres)	2.82
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	2.77
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	2.87
Percent of VTrans High-Flow Target Managed (%)	0.20%
Cost Notes	Requires private land easement

BMP Description

Create new detention basin. Max det. time= 46.6 hr; max. ponding depth=12'

VTRANS FRP BMP Summary Sheet

Site name: Fairview Dr | **Watershed: Indian Brook**

Approximate address:	Main Street and Athens Drive Essex Junction, VT 05452	**MS4 Impervious Owner(s):**	Essex Junction Village/ VTrans/ Town of Essex	**Ownership of Land where BMP is located:**	Village
Proposed BMP type:	Gravel Wetland				

Site Map

Proposed BMP details

Permit #	1-1074 SN002
Estimated project cost (rounded to nearest $1,000)	$290,000
Drainage area (acres)	29.40
Total impervious cover managed by BMP (acres)	4.13
Total impervious cover managed by BMP (% of drainage area)	0.1%
VTRANS impervious cover managed (acres)	0.72
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.2%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.67
Percent of VTrans High-Flow Target Managed (%)	0.12%
Cost Notes	Cost share with Village and Town

BMP Description

Regrade existing detention area, add terraced WQ bays, and replace existing culvert. Stabilize eroded outfall on North side of Main St. Install new culvert under Main St. to direct North side of Main St. to basin.

VTRANS FRP BMP Summary Sheet

Site name: I-289/Route 15 North **Watershed: Indian Brook**

Approximate address:	I-289 / Route 15 North Essex Junction, VT 05452	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans ROW
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$34,000
Drainage area (acres)	2.78
Total impervious cover managed by BMP (acres)	0.85
Total impervious cover managed by BMP (% of drainage area)	0.3%
VTRANS impervious cover managed (acres)	0.85
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.12
Percent of VTrans High-Flow Target Managed (%)	0.14%
Cost Notes	--

BMP Description

Retrofit existing median swale with CPv volume control sand filter.

VTRANS FRP BMP Summary Sheet

Site name: I-289/Route 15 South | **Watershed: Indian Brook**

Approximate address:	I-289 / Route 15 South Essex Junction, VT 05452	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans ROW
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$29,000
Drainage area (acres)	2.15
Total impervious cover managed by BMP (acres)	0.76
Total impervious cover managed by BMP (% of drainage area)	0.4%
VTRANS impervious cover managed (acres)	0.76
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.10
Percent of VTrans High-Flow Target Managed (%)	0.13%
Cost Notes	--

BMP Description

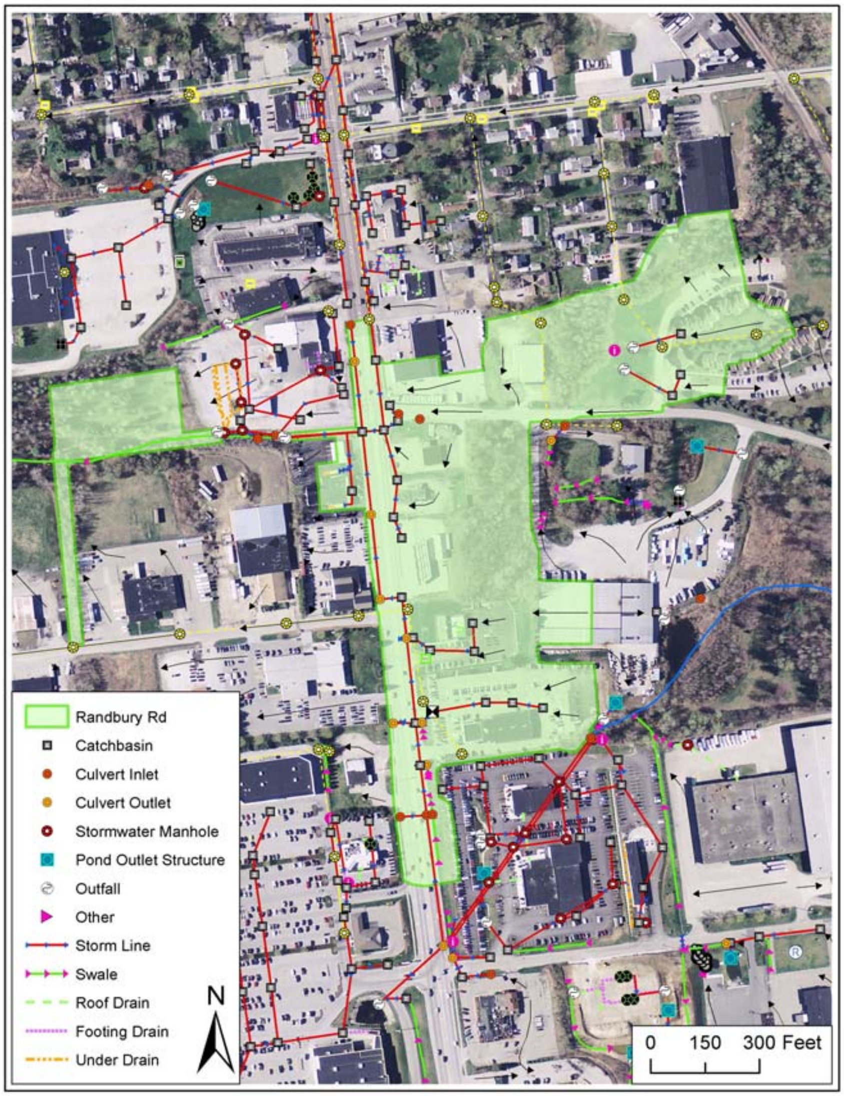
Retrofit existing median swale with CPv volume control sand filter.

VTRANS FRP BMP Summary Sheet

Site name: Randbury Rd — Watershed: Moon Brook

Approximate address:	Randbury Rd Rutland, VT 05701	**MS4 Impervious Owner(s):**	VTrans/ Town of Rutland	**Ownership of Land where BMP is located:**	VTrans/ Town/Priv
Proposed BMP type:	Gravel Wetland				

Site Map



Proposed BMP details

Permit #	NP/ New Road Project (Construction Permit)
Estimated project cost (rounded to nearest $1,000)	$279,000
Drainage area (acres)	23.10
Total impervious cover managed by BMP (acres)	10.95
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	2.29
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.2%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.83
Percent of VTrans High-Flow Target Managed (%)	1.05%
Cost Notes	Cost share with Town

BMP Description

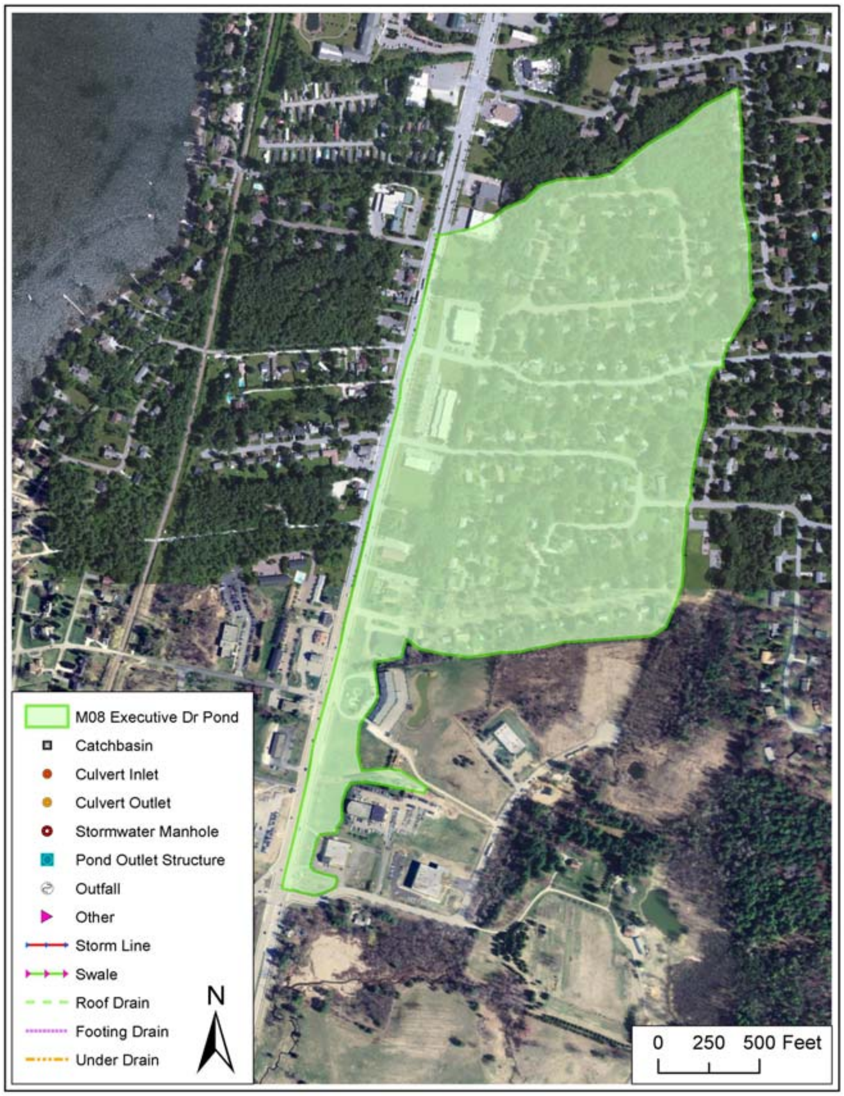
Create new gravel wetland. Possible landfill waste site (infiltration restrictions). Redevelopment will involve new road, which needs to be accounted for in design.

VTRANS FRP BMP Summary Sheet

Site name: M08 Executive Dr Pond   Watershed: Munroe Brook

Approximate address:	Executive Dr Shelburne, VT 05482	MS4 Impervious Owner(s):	Town of Shelburne/ VTrans	Ownership of Land where BMP is located:	Non-VTrans
Proposed BMP type:	Retrofit Detention Pond				

Site Map



Proposed BMP details

Permit #	1-1291
Estimated project cost (rounded to nearest $1,000)	$25,000
Drainage area (acres)	91.10
Total impervious cover managed by BMP (acres)	21.34
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	2.71
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.1%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.54
Percent of VTrans High-Flow Target Managed (%)	0.47%
Cost Notes	--

BMP Description

Reduce pond outlet orifice size. BMP Drainage area of pond M08 (Executive Dr Pond) was modified to reduce the need for expansion. Proposed drainage area modified by WCA.

VTRANS FRP BMP Summary Sheet					
Site name: By Danform Shoes			**Watershed: Munroe Brook**		
Approximate address:	Shelburne Rd Shelburne, VT 05482	**MS4 Impervious Owner(s):**	Town of Shelburne/ VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Underground Detention				

Site Map

Proposed BMP details

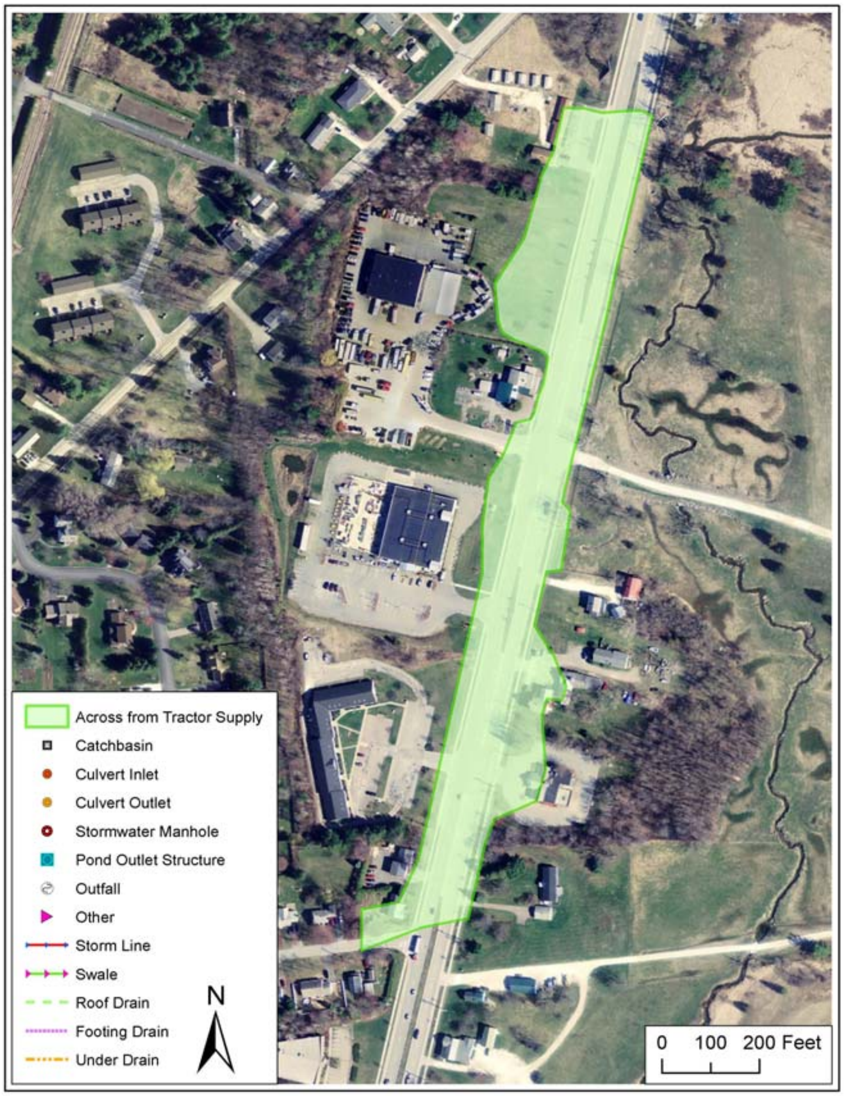
Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$102,000
Drainage area (acres)	4.89
Total impervious cover managed by BMP (acres)	2.84
Total impervious cover managed by BMP (% of drainage area)	0.6%
VTRANS impervious cover managed (acres)	2.12
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.7%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.14
Percent of VTrans High-Flow Target Managed (%)	0.37%
Cost Notes	--

BMP Description

Create new underground detention chambers. Reroute drainge from west side of Shelburne Rd to this grassed area mostly in ROW.

VTRANS FRP BMP Summary Sheet					
Site name: Across from Tractor Supply			**Watershed: Munroe Brook**		
Approximate address:	Shelburne Rd Shelburne, VT 05482	**MS4 Impervious Owner(s):**	Town of Shelburne/ VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Gravel Wetland				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$480,000
Drainage area (acres)	6.78
Total impervious cover managed by BMP (acres)	3.77
Total impervious cover managed by BMP (% of drainage area)	0.6%
VTRANS impervious cover managed (acres)	2.85
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.8%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.54
Percent of VTrans High-Flow Target Managed (%)	0.50%
Cost Notes	--

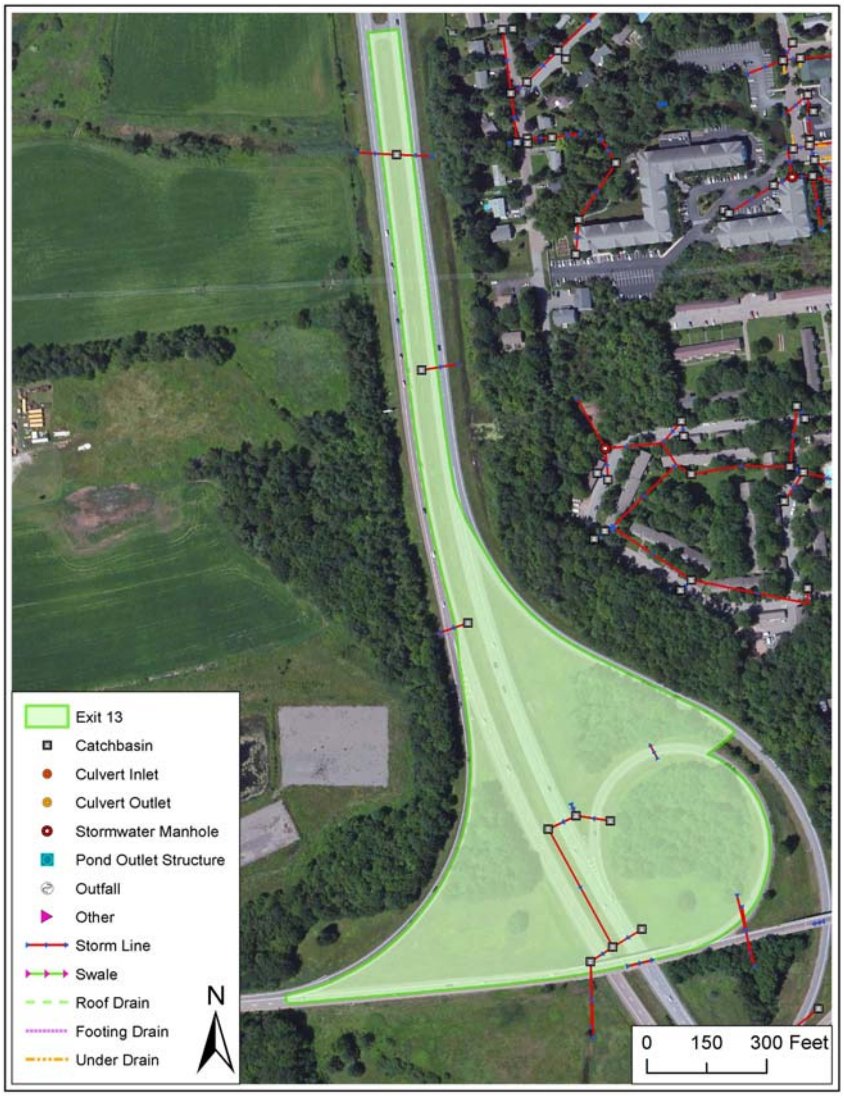
BMP Description

Create new linear gravel wetland primarily in ROW across Shelburne Rd from Tractor Supply. Reroute short stretch of stormlines that drain to the north of this area.

VTRANS FRP BMP Summary Sheet

Site name: Exit 13 Gravel Wetland		Watershed: Potash Brook			
Approximate address:	I-89 Exit 13 South Burlington, VT 05403	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Gravel Wetland				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$219,000
Drainage area (acres)	16.72
Total impervious cover managed by BMP (acres)	4.77
Total impervious cover managed by BMP (% of drainage area)	0.3%
VTRANS impervious cover managed (acres)	4.77
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.57
Percent of VTrans High-Flow Target Managed (%)	0.10%
Cost Notes	--

BMP Description

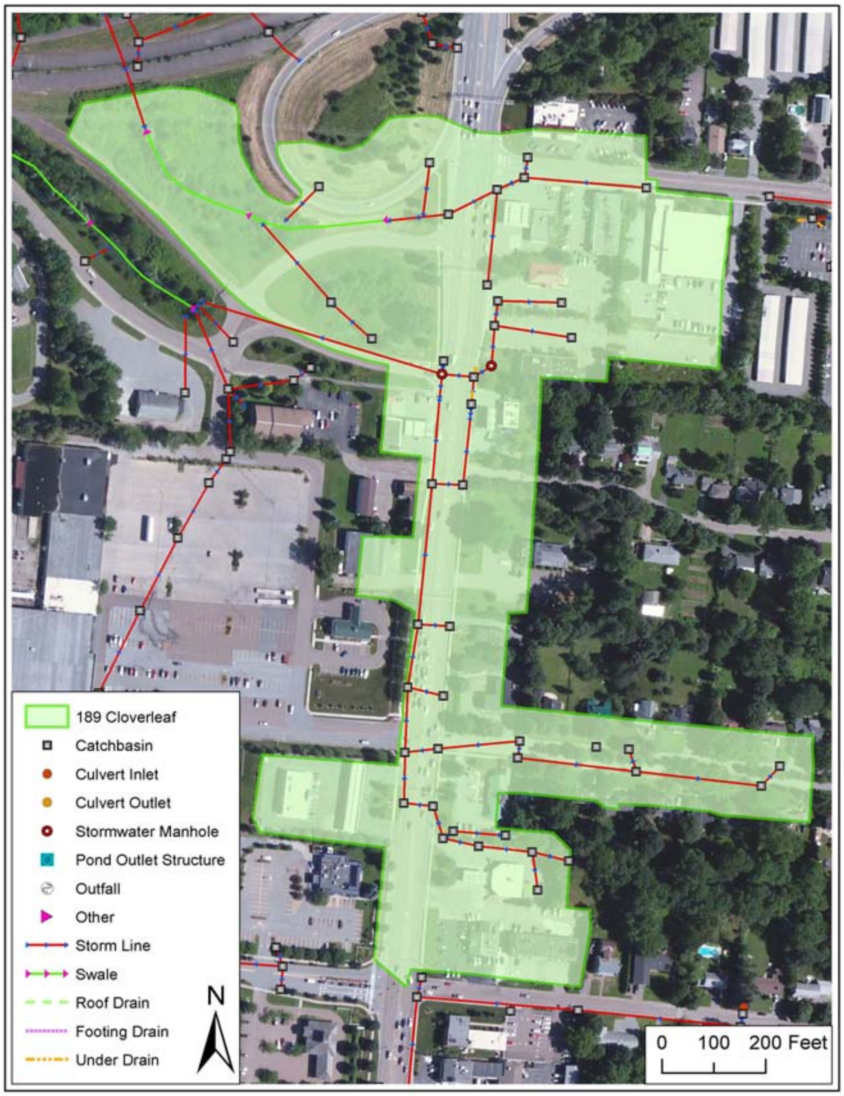
Propose new gravel wetland in depressed triangle greenspace between ramps. Reroute several culverts to this area.

VTRANS FRP BMP Summary Sheet

Site name: 189 Cloverleaf | **Watershed: Potash Brook**

Approximate address:	I-189 and Shelburne Rd South Burlington, VT 05403	**MS4 Impervious Owner(s):**	VTrans/ City of South Burlington	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Detention Basin				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$59,000
Drainage area (acres)	21.25
Total impervious cover managed by BMP (acres)	11.53
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	3.46
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.3%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	1.13
Percent of VTrans High-Flow Target Managed (%)	0.07%
Cost Notes	--

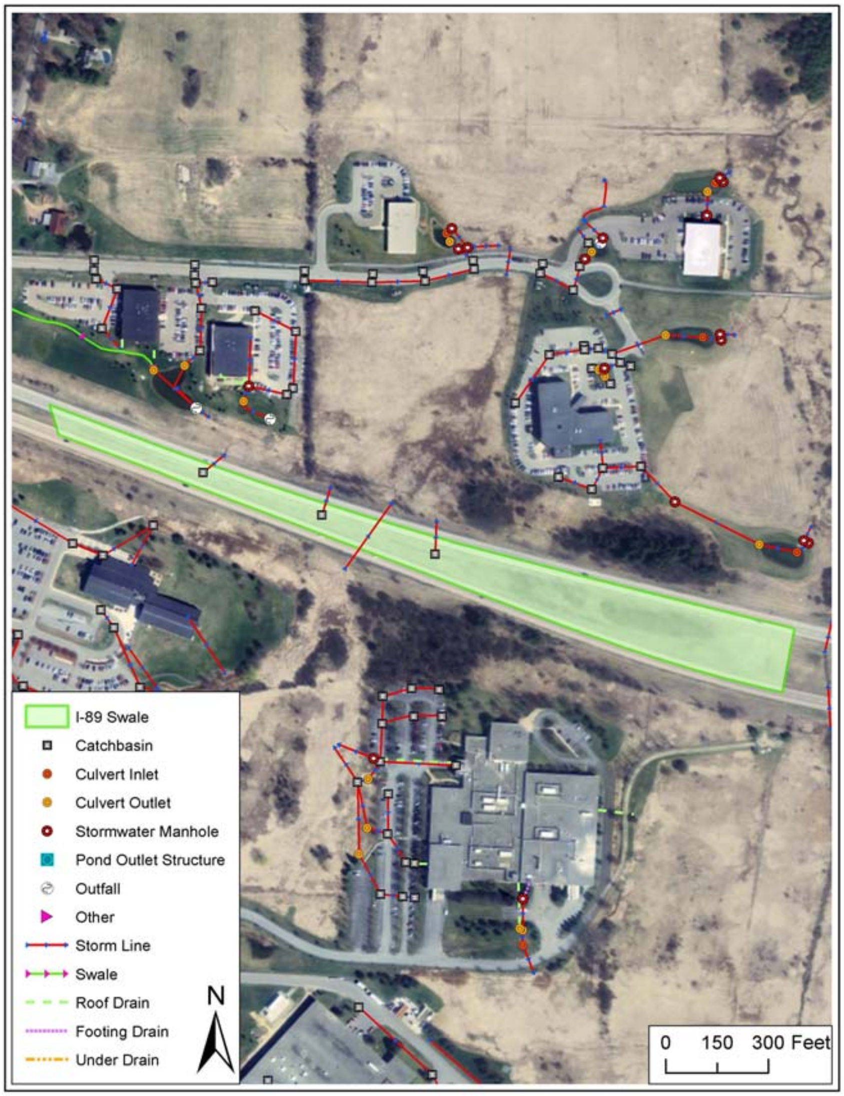
BMP Description

Add outlet structure to area that is already depressed to detain stormwater. Reroute stormline from Shelburne Rd to this area.

VTRANS FRP BMP Summary Sheet

Site name: I-89 Swale		Watershed: Potash Brook			
Approximate address:	I-89 North of Hinesburg Rd South Burlington, VT 05403	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$129,000
Drainage area (acres)	6.28
Total impervious cover managed by BMP (acres)	1.80
Total impervious cover managed by BMP (% of drainage area)	0.3%
VTRANS impervious cover managed (acres)	1.80
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.53
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

BMP Description

Construct median filter in depressed area between north and south I-89 lanes. Reroute several culverts.

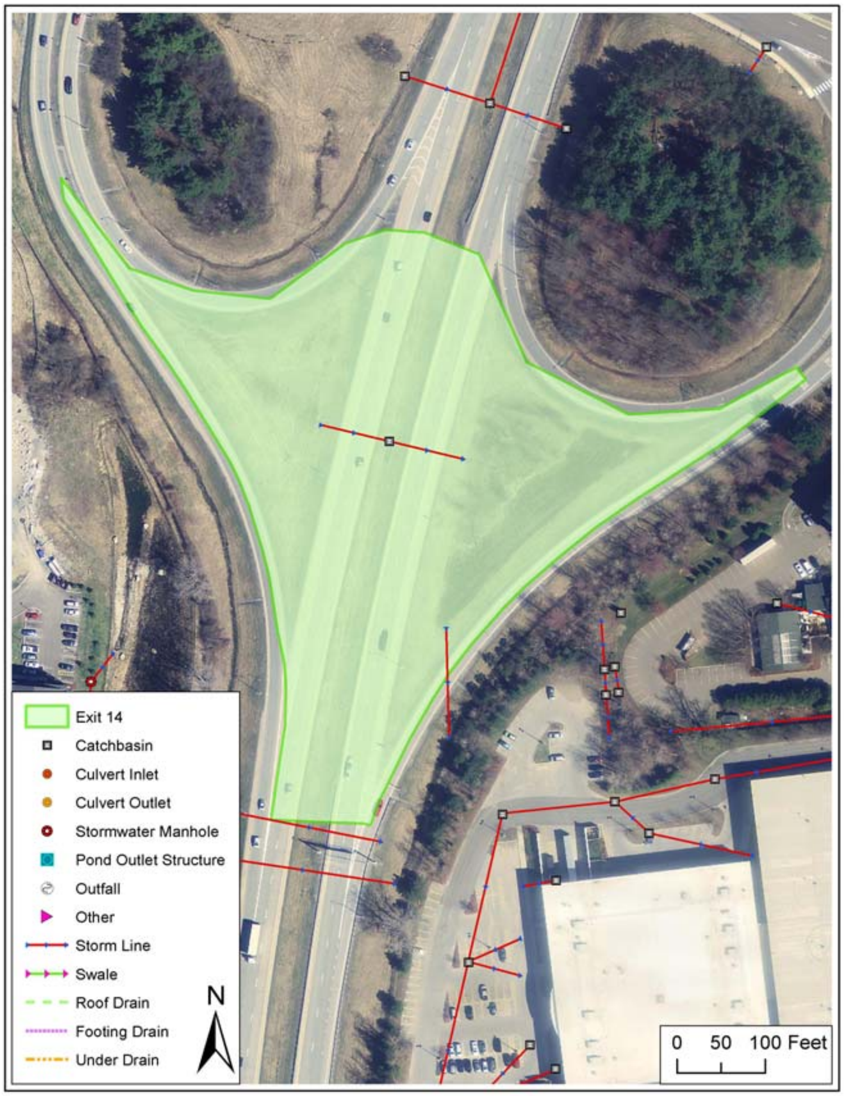
VTRANS FRP BMP Summary Sheet

Site name: Exit 14 Gravel Wetland   Watershed: Potash Brook

Approximate address:	I-89 Exit 14 South Burlington, VT 05403	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans

Proposed BMP type:	Gravel Wetland

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$131,000
Drainage area (acres)	4.91
Total impervious cover managed by BMP (acres)	1.81
Total impervious cover managed by BMP (% of drainage area)	0.4%
VTRANS impervious cover managed (acres)	1.81
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.29
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

BMP Description

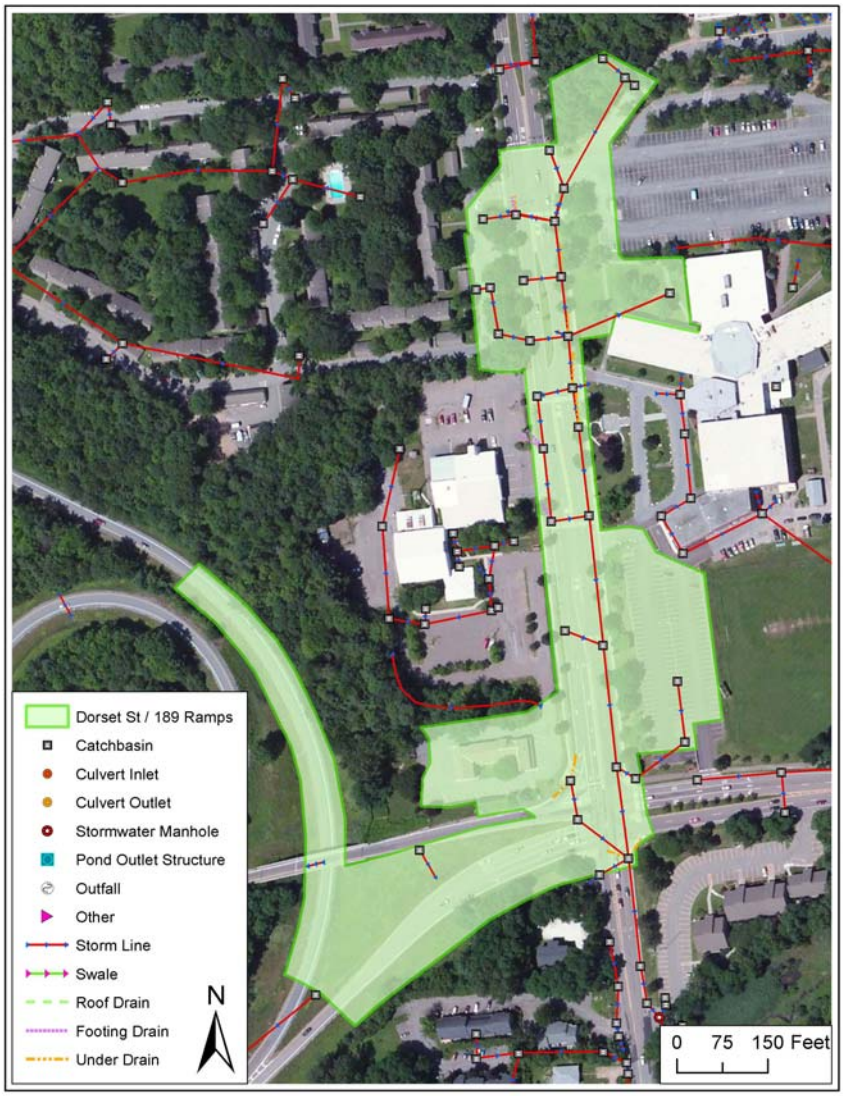
Propose new gravel wetland in depressed triangle greenspace between ramps. Reroute several culverts to this area.

VTRANS FRP BMP Summary Sheet

Site name: 189 Ramp Detention Pond   Watershed: Potash Brook

Approximate address:	Dorset St / Kennedy Dr South Burlington, VT 05403	**MS4 Impervious Owner(s):**	VTrans/ City of South Burlington	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Detention Basin				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$101,000
Drainage area (acres)	9.36
Total impervious cover managed by BMP (acres)	5.57
Total impervious cover managed by BMP (% of drainage area)	0.6%
VTRANS impervious cover managed (acres)	1.09
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.2%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.35
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

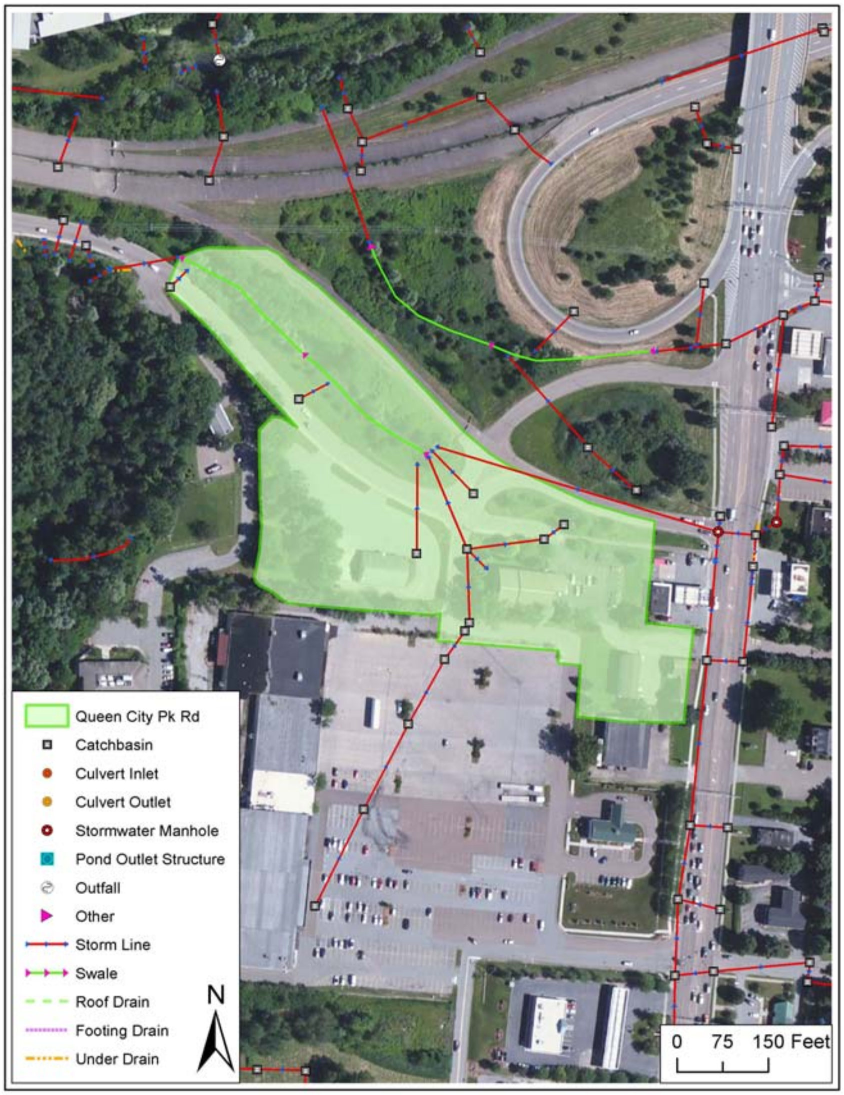
BMP Description

Detain stormwater from a large section of Dorset St. Intercept stormline near Kennedy Dr and reroute to the area between 189 ramps.

VTRANS FRP BMP Summary Sheet

Site name: Queen City Park Road Detention Pond			Watershed: Potash Brook		
Approximate address:	Queen City Park Rd South Burlington, VT 05403	**MS4 Impervious Owner(s):**	VTrans/ City of South Burlington	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Detention Basin				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$99,000
Drainage area (acres)	6.51
Total impervious cover managed by BMP (acres)	2.92
Total impervious cover managed by BMP (% of drainage area)	0.4%
VTRANS impervious cover managed (acres)	0.43
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.1%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.45
Percent of VTrans High-Flow Target Managed (%)	0.01%
Cost Notes	--

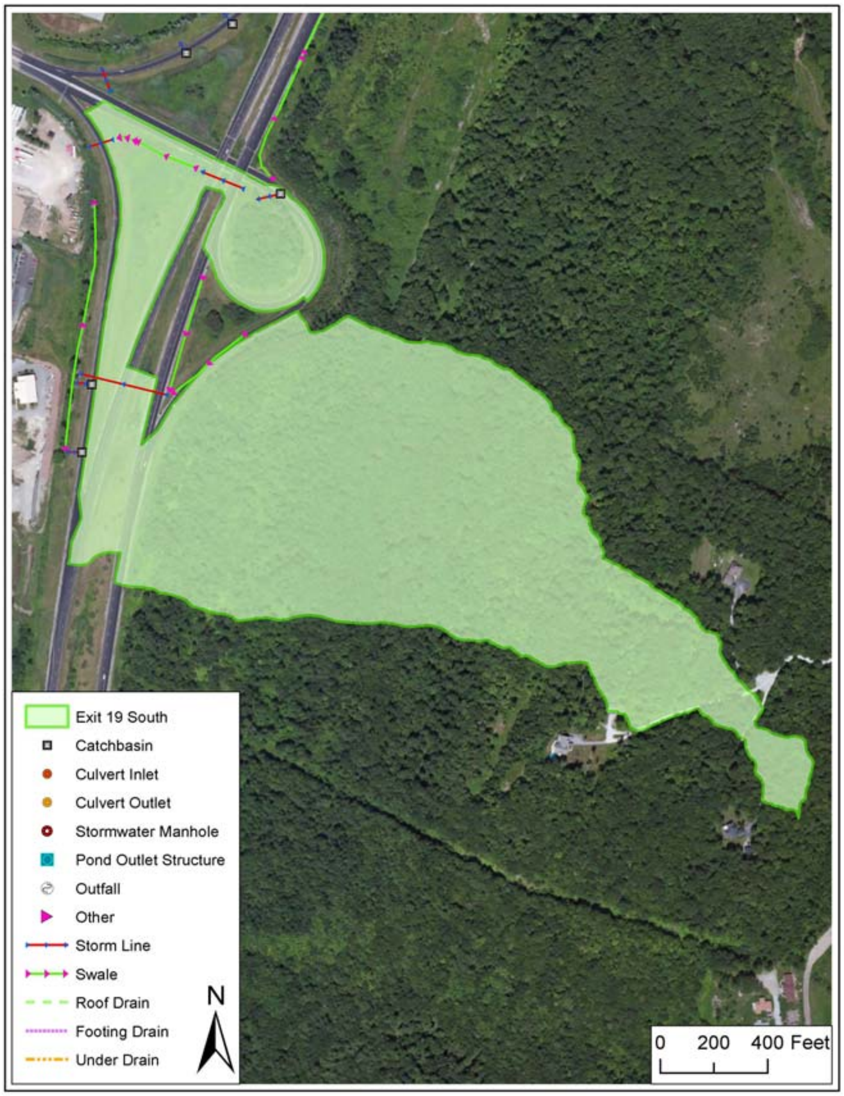
BMP Description

Add detention to existing depressed area where stormlines already outfall. Drainage from Shelburne Rd is assumed to be already rerouted to larger depression to the north (see project entitled 189 Cloverleaf).

VTRANS FRP BMP Summary Sheet

Site name: Exit 19 South		Watershed: Rugg Brook			
Approximate address:	I-89 Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Detention				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$270,000
Drainage area (acres)	57.94
Total impervious cover managed by BMP (acres)	3.78
Total impervious cover managed by BMP (% of drainage area)	0.1%
VTRANS impervious cover managed (acres)	3.67
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	2.07
Percent of VTrans High-Flow Target Managed (%)	0.27%
Cost Notes	Joint MS4 (75% Share)

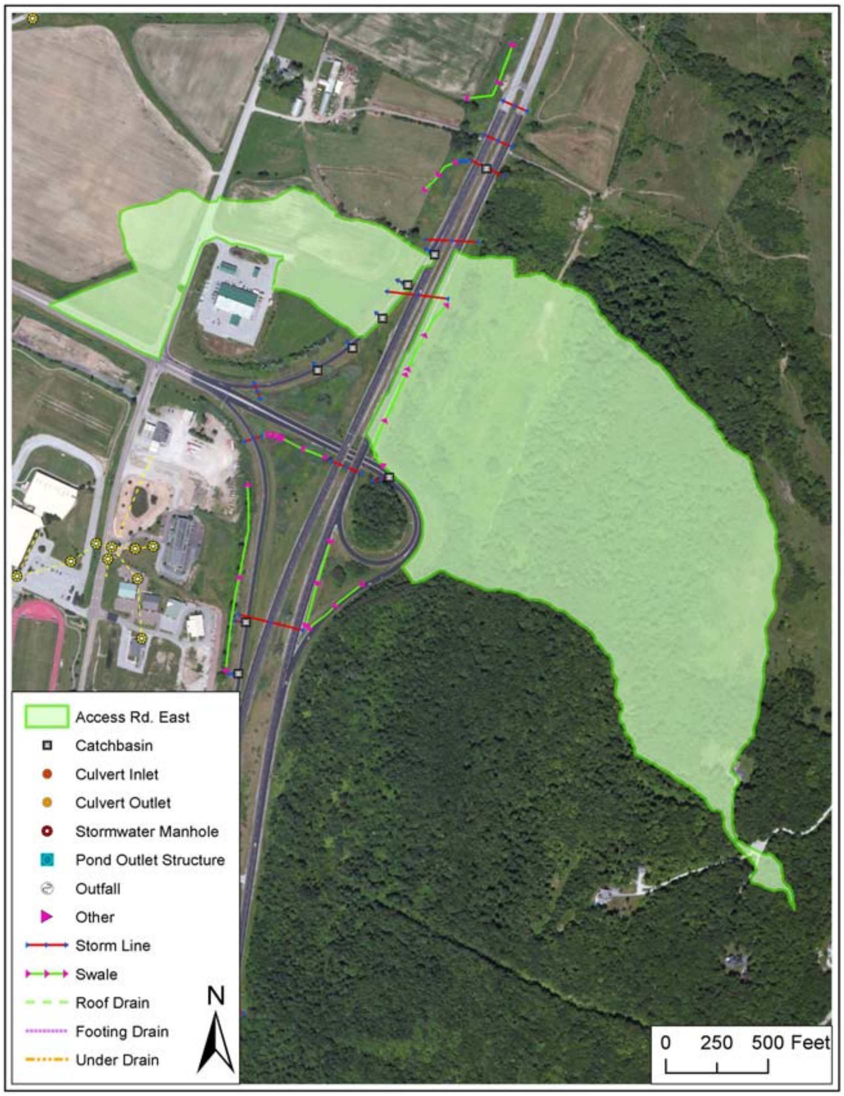
BMP Description

Proposed a new stormwater detention pond in ROW with approximately 2.0 ac-ft of storage.

VTRANS FRP BMP Summary Sheet

Site name: Access Rd. East			Watershed: Rugg Brook		
Approximate address:	I-89 Exit 19 Access Road East St Albans City, VT 05478	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans/ Private
Proposed BMP type:	Detention				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$197,000
Drainage area (acres)	85.13
Total impervious cover managed by BMP (acres)	2.75
Total impervious cover managed by BMP (% of drainage area)	0.0%
VTRANS impervious cover managed (acres)	2.42
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.9%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	1.82
Percent of VTrans High-Flow Target Managed (%)	0.18%
Cost Notes	Joint MS4 (50% share)

BMP Description

Propose a new a new stormwater detention basin with a stone bed and micropool to improve water quality benefits. The location of the proposed BMP is on land that is currently owned by a local farmer and within the VTrans ROW

VTRANS FRP BMP Summary Sheet

Site name: Access Rd. West		Watershed: Rugg Brook			
Approximate address:	I-89 Exit 19 Access Road West St Albans City, VT 05478	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans/ Private
Proposed BMP type:	Detention				

Site Map

Proposed BMP details

Permit #	Drains Portion of 1-1428
Estimated project cost (rounded to nearest $1,000)	$40,000
Drainage area (acres)	13.70
Total impervious cover managed by BMP (acres)	0.55
Total impervious cover managed by BMP (% of drainage area)	0.0%
VTRANS impervious cover managed (acres)	0.55
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.65
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	Joint MS4 (50% share)

BMP Description

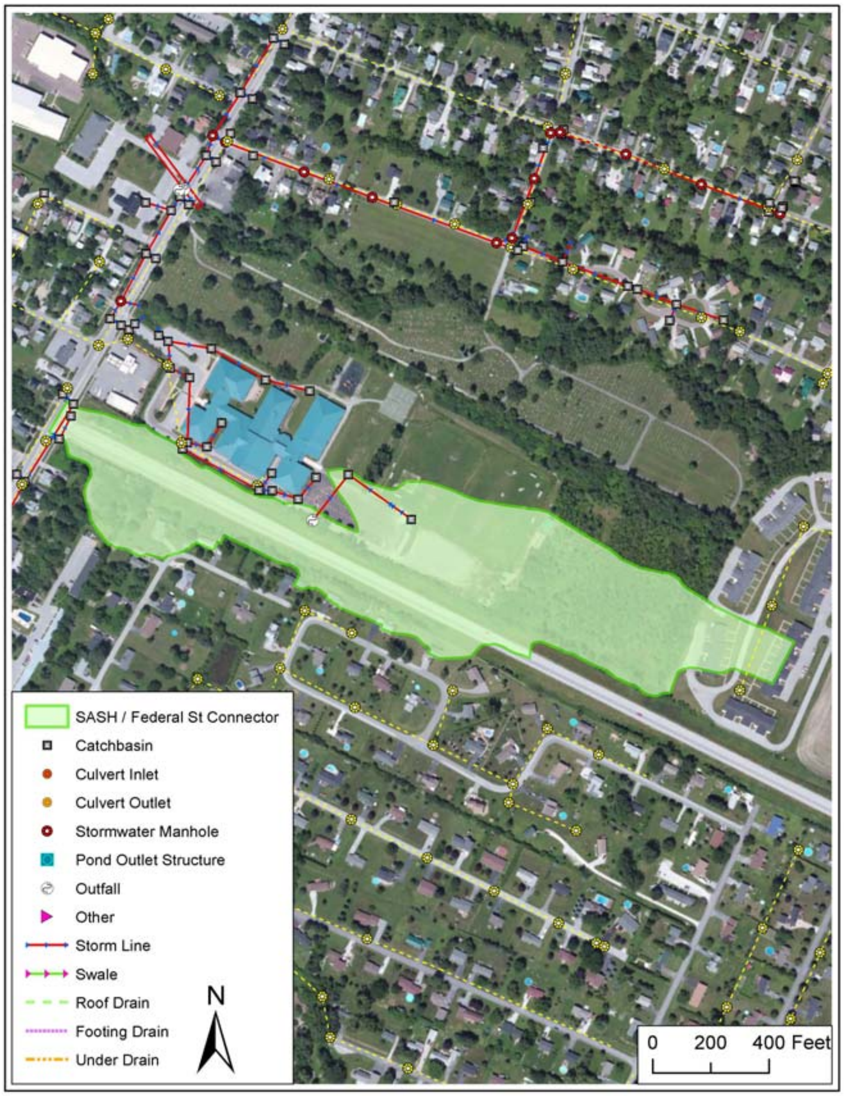
Create new detention BMP to collect drainage from the roadway and the upslope field before draining to a culvert under the Access Rd. BMP will provide CPv storage and water quality treatment. Project located within the VTrans ROW, but has potential for cost-sharing as the BMP would treat drainage from privately owned cropland within the Town.

VTRANS FRP BMP Summary Sheet

Site name: SASH / Federal St Connector **Watershed: Rugg Brook**

Approximate address:	St Albans State Hwy St Albans City, VT 05478	**MS4 Impervious Owner(s):**	St. Albans City/ VTrans	**Ownership of Land where BMP is located:**	VTrans/ Private
Proposed BMP type:	Detention				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$39,000
Drainage area (acres)	21.12
Total impervious cover managed by BMP (acres)	4.89
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	1.20
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.2%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.36
Percent of VTrans High-Flow Target Managed (%)	0.09%
Cost Notes	Joint MS4 (25% Share)

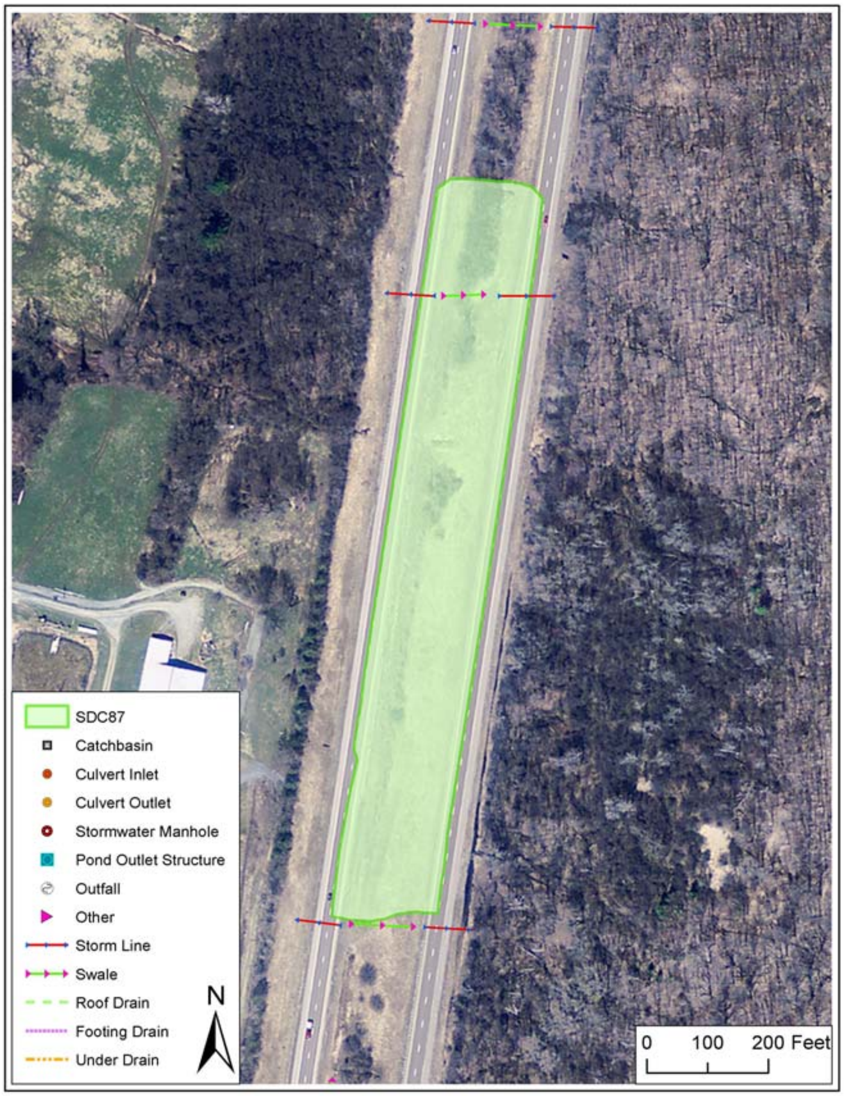
BMP Description

Incorporate detention of SASH runoff with Federal Street Connector Project.

VTRANS FRP BMP Summary Sheet

Site name: SDC87	Watershed: Rugg Brook				
Approximate address:	I-89 Median South of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$36,000
Drainage area (acres)	4.92
Total impervious cover managed by BMP (acres)	0.92
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.92
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.13
Percent of VTrans High-Flow Target Managed (%)	0.07%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC83b			Watershed: Rugg Brook		
Approximate address:	I-89 Median South of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$22,000
Drainage area (acres)	1.80
Total impervious cover managed by BMP (acres)	0.36
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.36
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.08
Percent of VTrans High-Flow Target Managed (%)	0.03%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC27		Watershed: Rugg Brook			
Approximate address:	I-89 Median South of Exit 19 St Albans City, VT 05478	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$18,000
Drainage area (acres)	1.61
Total impervious cover managed by BMP (acres)	0.43
Total impervious cover managed by BMP (% of drainage area)	0.3%
VTRANS impervious cover managed (acres)	0.43
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.06
Percent of VTrans High-Flow Target Managed (%)	0.03%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC280		Watershed: Rugg Brook			
Approximate address:	I-89 Median South of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$18,000
Drainage area (acres)	2.13
Total impervious cover managed by BMP (acres)	0.37
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.37
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.06
Percent of VTrans High-Flow Target Managed (%)	0.03%
Cost Notes	--

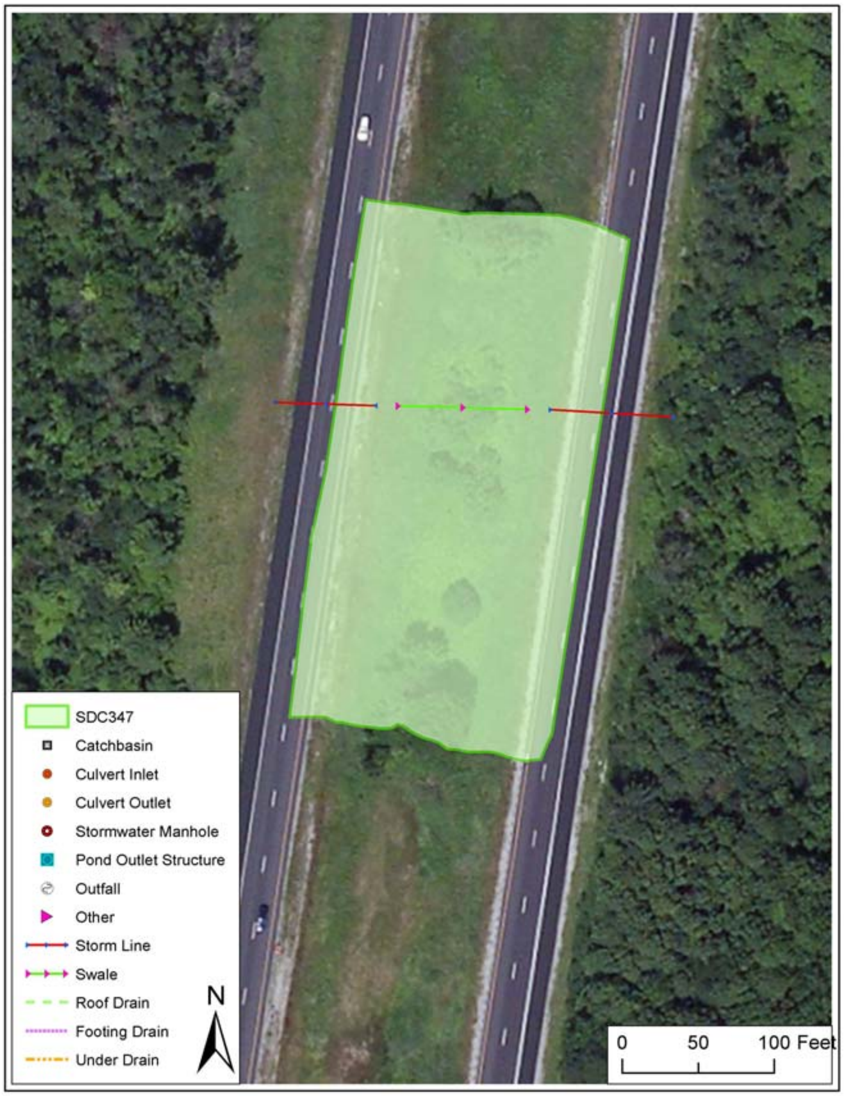
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC347		Watershed: Rugg Brook			
Approximate address:	I-89 Median South of Exit 19 St Albans City, VT 05478	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$17,000
Drainage area (acres)	1.40
Total impervious cover managed by BMP (acres)	0.30
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.30
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.06
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

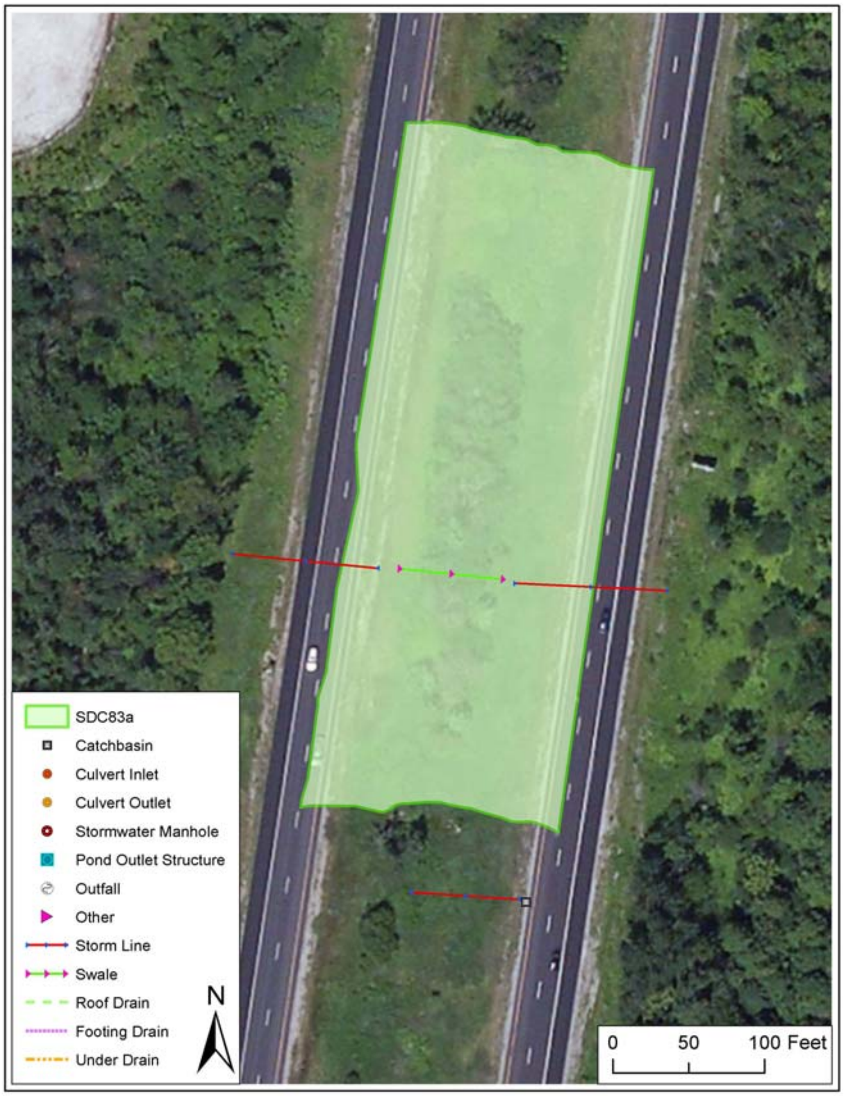
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC83a		Watershed: Rugg Brook			
Approximate address:	I-89 Median South of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$16,000
Drainage area (acres)	1.71
Total impervious cover managed by BMP (acres)	0.27
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.27
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.06
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC342		Watershed: Rugg Brook			
Approximate address:	I-89 Median South of Exit 19 St Albans City, VT 05478	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map

Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$15,000
Drainage area (acres)	1.60
Total impervious cover managed by BMP (acres)	0.31
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.31
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.05
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	--

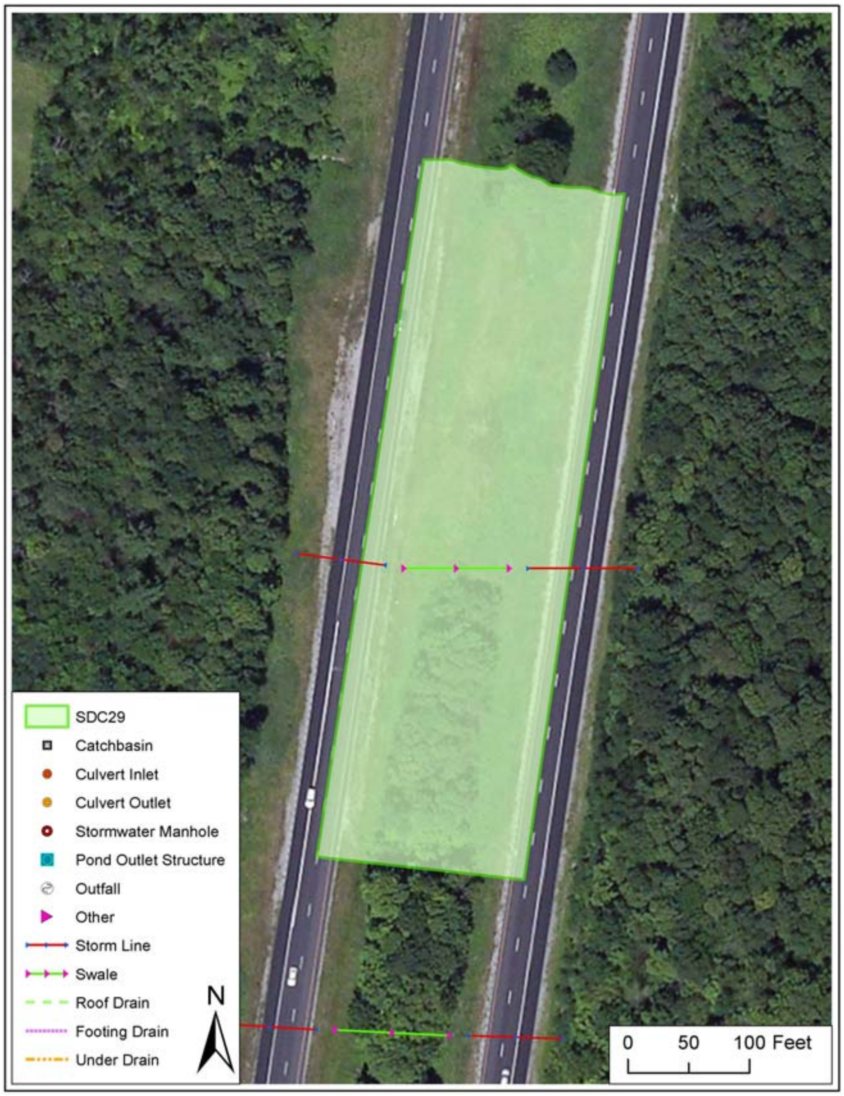
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC29	Watershed: Rugg Brook				
Approximate address:	I-89 Median South of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$15,000
Drainage area (acres)	2.25
Total impervious cover managed by BMP (acres)	0.41
Total impervious cover managed by BMP (% of drainage area)	0.2%
VTRANS impervious cover managed (acres)	0.41
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.05
Percent of VTrans High-Flow Target Managed (%)	0.03%
Cost Notes	--

BMP Description

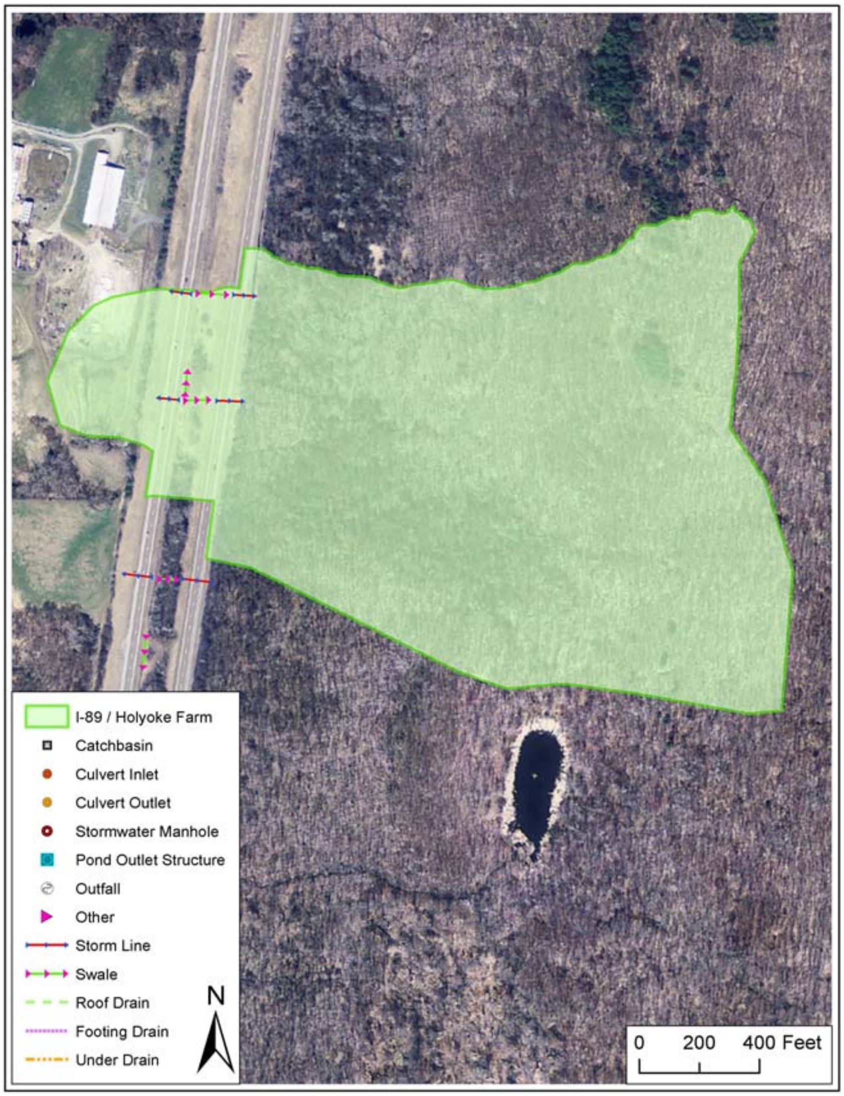
Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: I-89 / Holyoke Farm **Watershed: Rugg Brook**

Approximate address:	Holyoke Farm Dr St Albans City, VT 05478	MS4 Impervious Owner(s):	St. Albans City / VTrans	Ownership of Land where BMP is located:	Private
Proposed BMP type:	Infiltration				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$130,000
Drainage area (acres)	61.83
Total impervious cover managed by BMP (acres)	0.50
Total impervious cover managed by BMP (% of drainage area)	0.0%
VTRANS impervious cover managed (acres)	0.25
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.5%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	1.43
Percent of VTrans High-Flow Target Managed (%)	0.02%
Cost Notes	Joint MS4 (50% share)

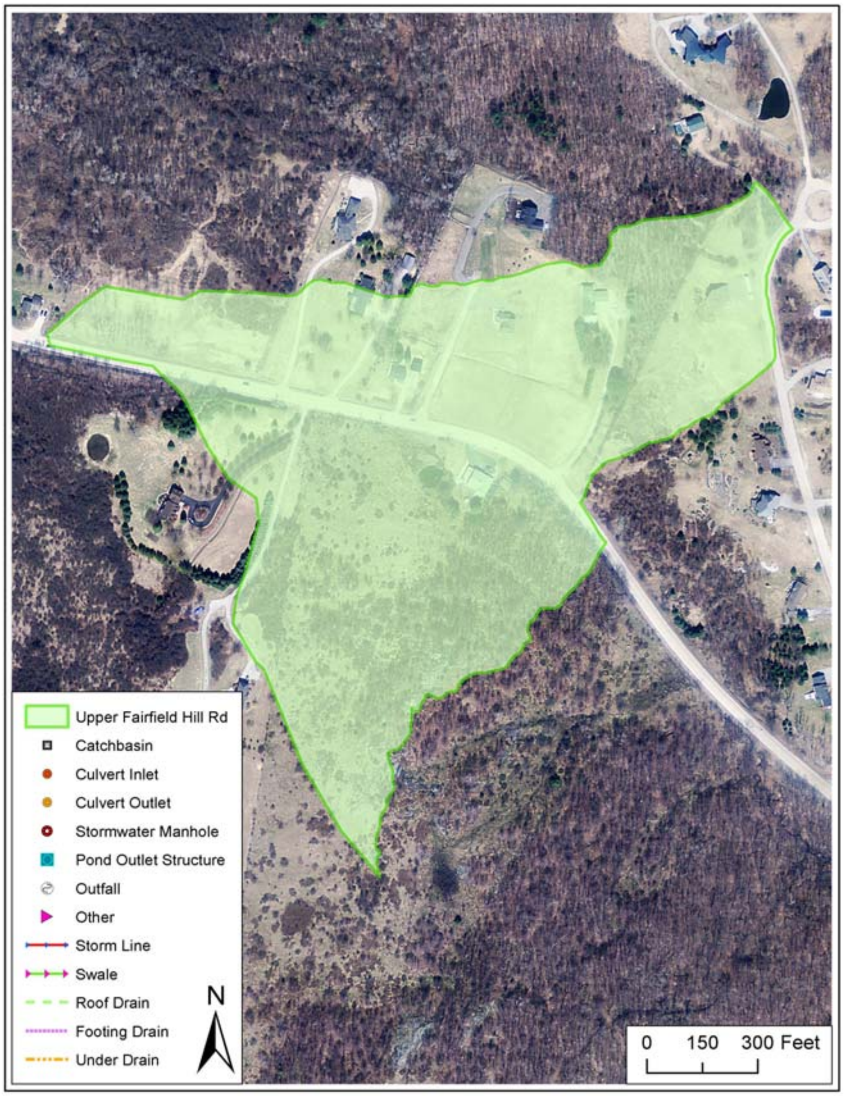
BMP Description

Create new 15,000 sq-ft infiltration basin. Reseed surface with grass for ease of maintenance. Below the surface would be 3 feet of drain stone on top of the native soil. The basin will detain and filter the 1-year design storm volume (CPv).

VTRANS FRP BMP Summary Sheet

Site name: Upper Fairfield Hill Rd		Watershed: Stevens Brook			
Approximate address:	Fairfield Hill Rd St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans/ Private
Proposed BMP type:	Detention Basin				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$164,000
Drainage area (acres)	34.26
Total impervious cover managed by BMP (acres)	3.36
Total impervious cover managed by BMP (% of drainage area)	0.1%
VTRANS impervious cover managed (acres)	1.15
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.3%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	1.28
Percent of VTrans High-Flow Target Managed (%)	0.10%
Cost Notes	Cost share with Town

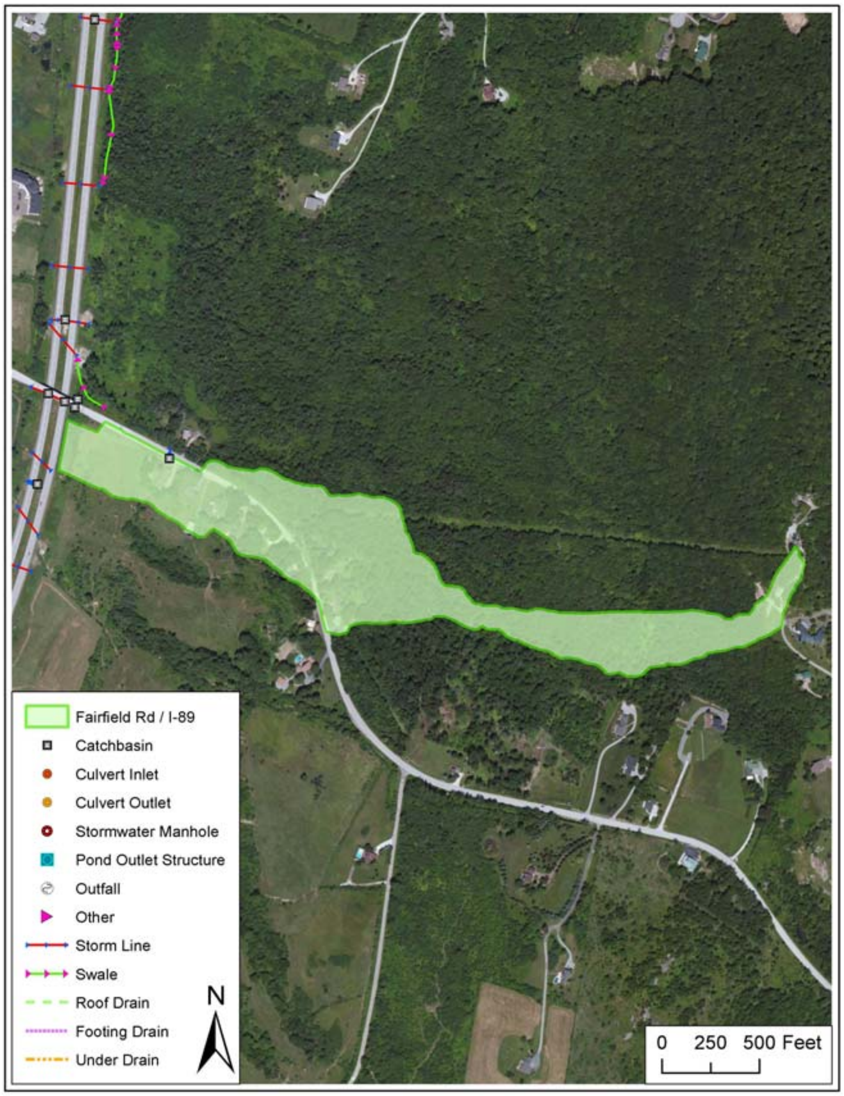
BMP Description

Create new detention basin on private parcel within the Town to capture and detain a 34 acre drainage area. Private land would need to be acquired in order to implement the BMP. Project will require new culvert to capture drainage on south side of Fairfield.

VTRANS FRP BMP Summary Sheet

Site name: Fairfield Rd / I-89		Watershed: Stevens Brook			
Approximate address:	Fairfield Hill Rd St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Detention Basin				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$109,000
Drainage area (acres)	28.92
Total impervious cover managed by BMP (acres)	2.07
Total impervious cover managed by BMP (% of drainage area)	0.1%
VTRANS impervious cover managed (acres)	0.85
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.4%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.68
Percent of VTrans High-Flow Target Managed (%)	0.07%
Cost Notes	Cost share with Town

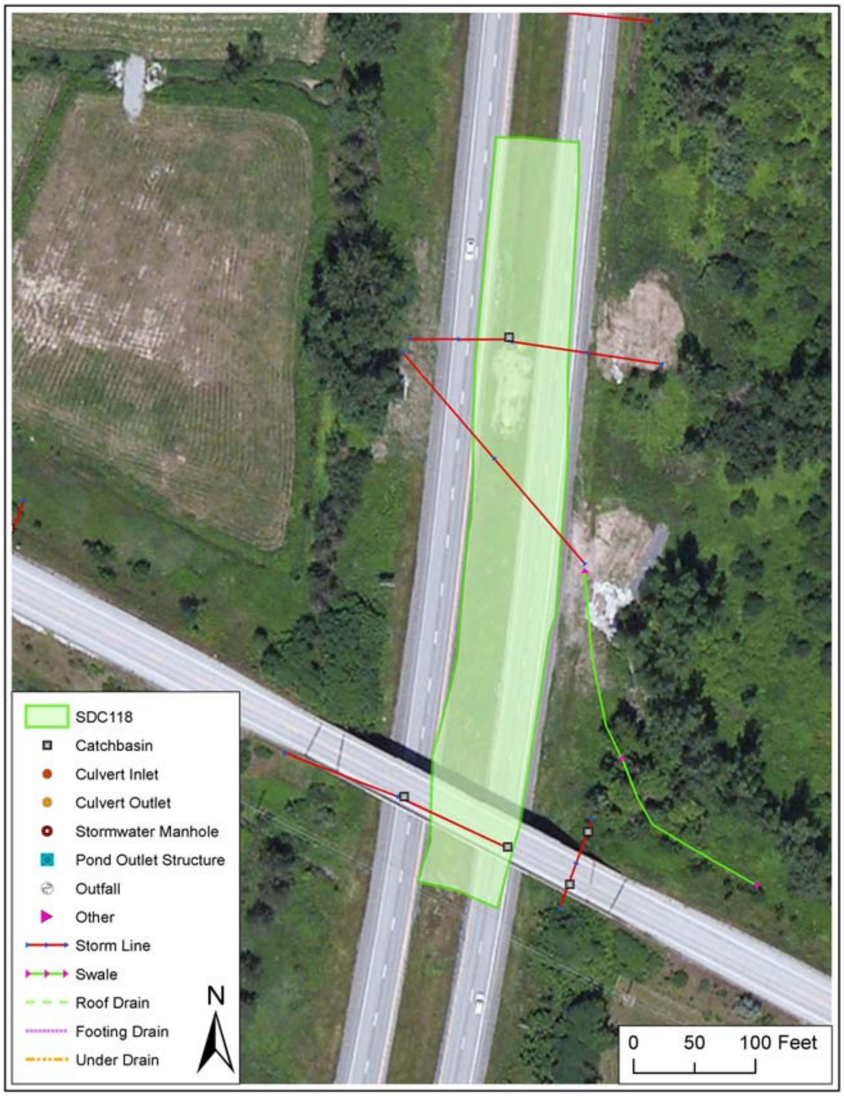
BMP Description

A water quality/flow detention retrofit is proposed within the I-89 ROW designed to capture runoff from a 28 ac area including a portion of Fairfield Rd (VT-36) and Town residences along the road. Project requires a new culvert under Fairfield Rd to route flow from the north side of VT-36 into the facility.

VTRANS FRP BMP Summary Sheet

Site name: SDC118		Watershed: Stevens Brook			
Approximate address:	I-89 Median North of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$28,000
Drainage area (acres)	1.08
Total impervious cover managed by BMP (acres)	0.55
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.55
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.06
Percent of VTrans High-Flow Target Managed (%)	0.05%
Cost Notes	--

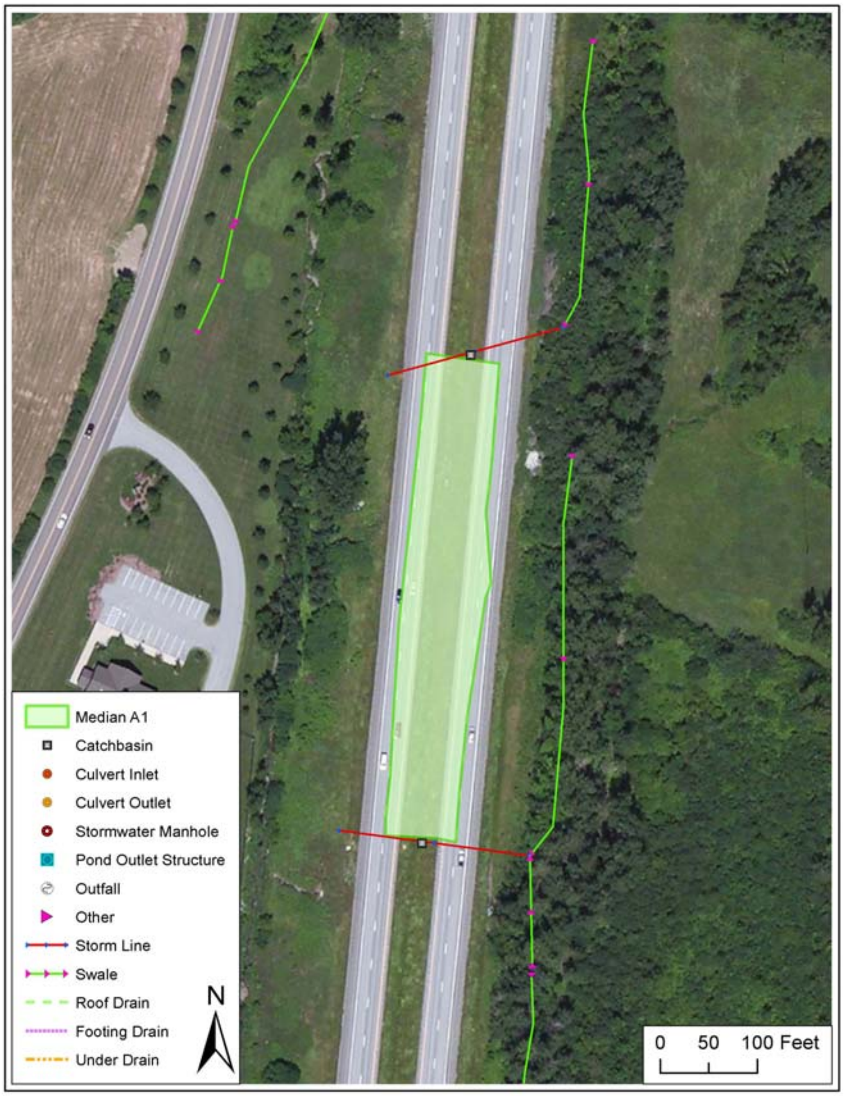
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: Median A1		Watershed: Stevens Brook			
Approximate address:	I-89 Median North of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$27,000
Drainage area (acres)	0.90
Total impervious cover managed by BMP (acres)	0.42
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.42
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.06
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

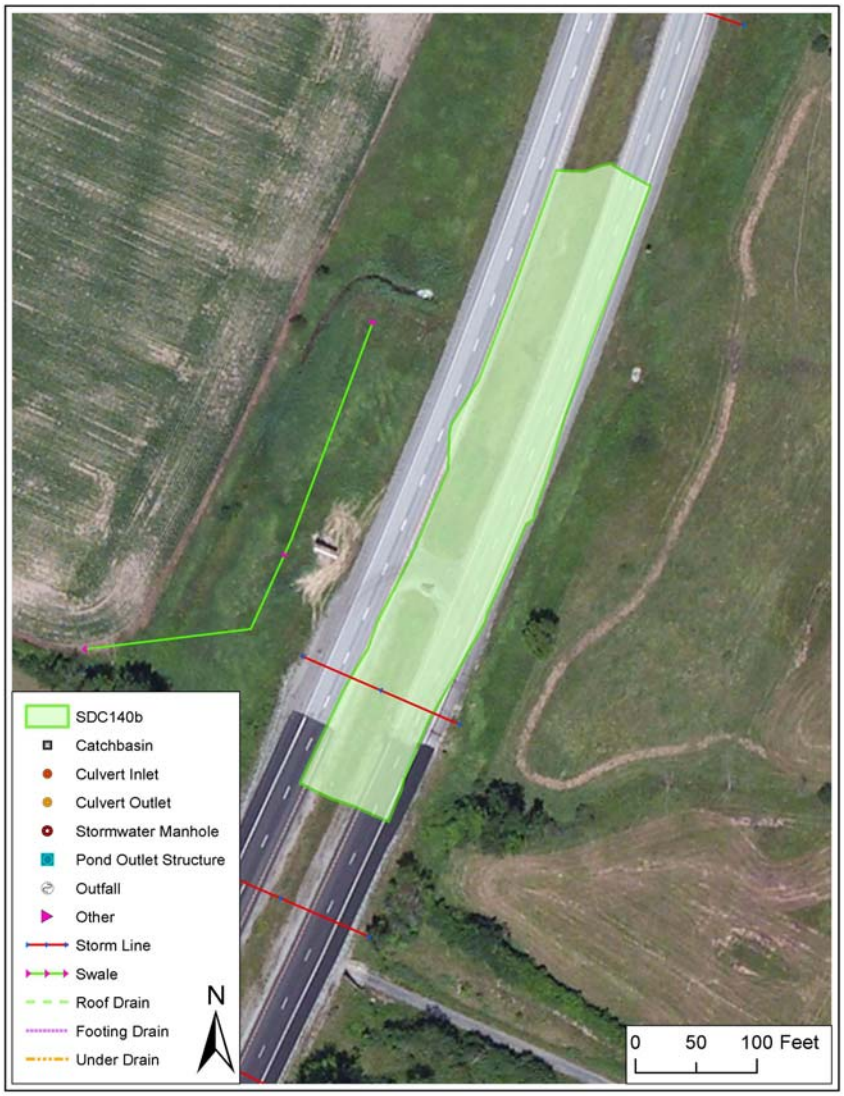
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC140b		Watershed: Stevens Brook			
Approximate address:	I-89 Median North of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$26,000
Drainage area (acres)	1.00
Total impervious cover managed by BMP (acres)	0.50
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.50
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.05
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

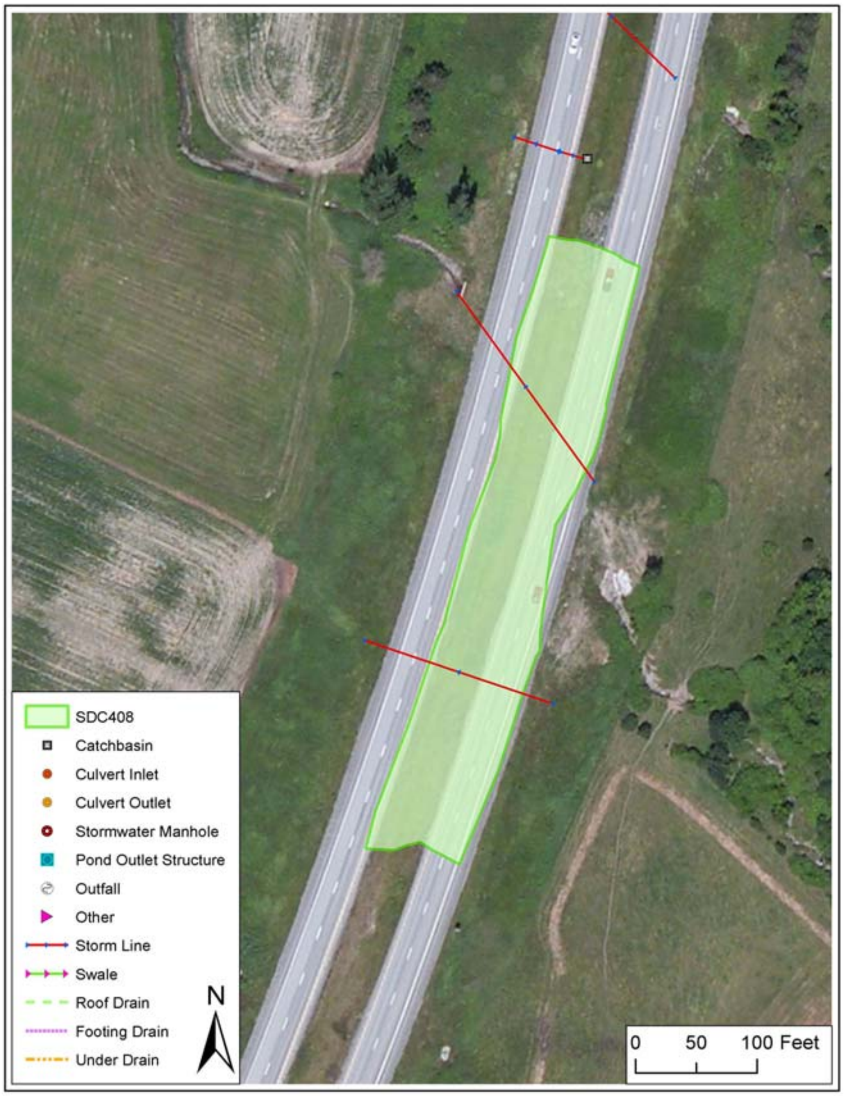
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC408			Watershed: Stevens Brook		
Approximate address:	I-89 Median North of Exit 19 St Albans City, VT 05478	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$23,000
Drainage area (acres)	0.94
Total impervious cover managed by BMP (acres)	0.47
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.47
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.05
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

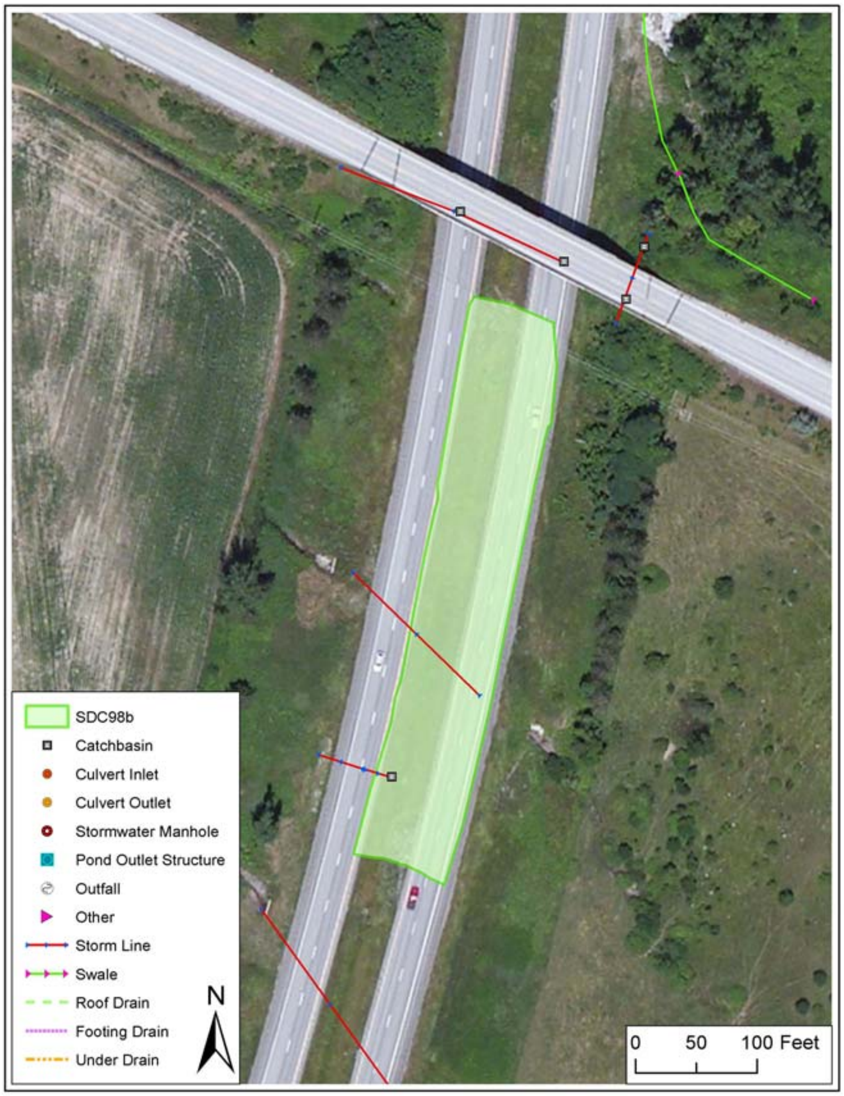
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC98b		Watershed: Stevens Brook			
Approximate address:	I-89 Median North of Exit 19 St Albans City, VT 05478	MS4 Impervious Owner(s):	VTrans	Ownership of Land where BMP is located:	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$22,000
Drainage area (acres)	0.85
Total impervious cover managed by BMP (acres)	0.42
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.42
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.05
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

BMP Description

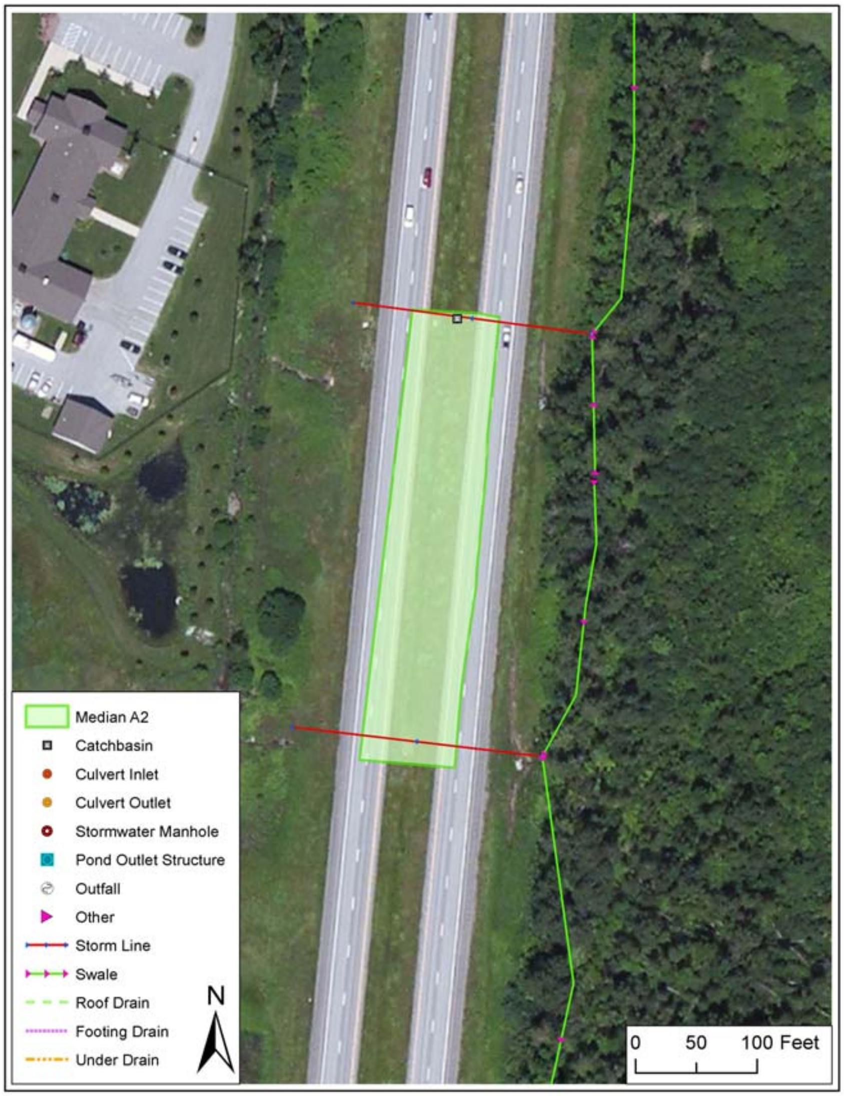
Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: Median A2 **Watershed: Stevens Brook**

Approximate address:	I-89 Median North of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$21,000
Drainage area (acres)	0.65
Total impervious cover managed by BMP (acres)	0.30
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.30
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.04
Percent of VTrans High-Flow Target Managed (%)	0.03%
Cost Notes	--

BMP Description

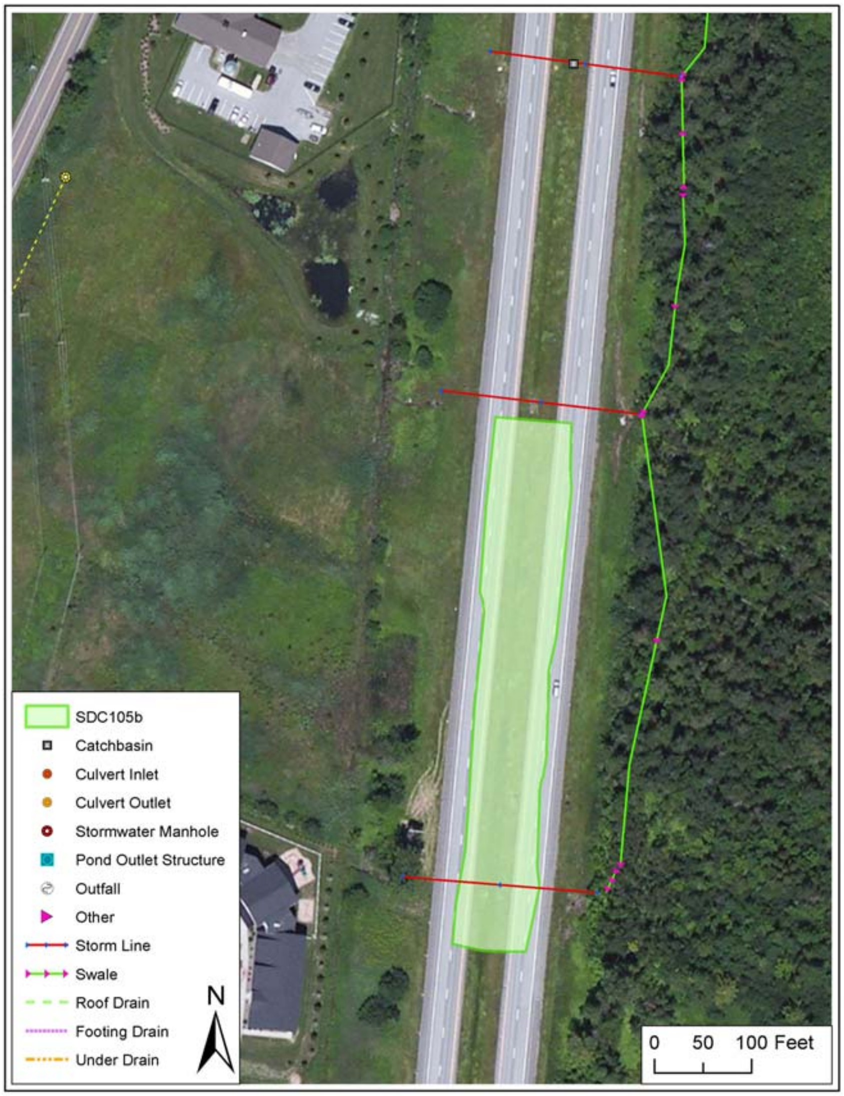
Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC105b — Watershed: Stevens Brook

Approximate address:	I-89 Median North of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$26,000
Drainage area (acres)	0.99
Total impervious cover managed by BMP (acres)	0.53
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.53
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.05
Percent of VTrans High-Flow Target Managed (%)	0.05%
Cost Notes	--

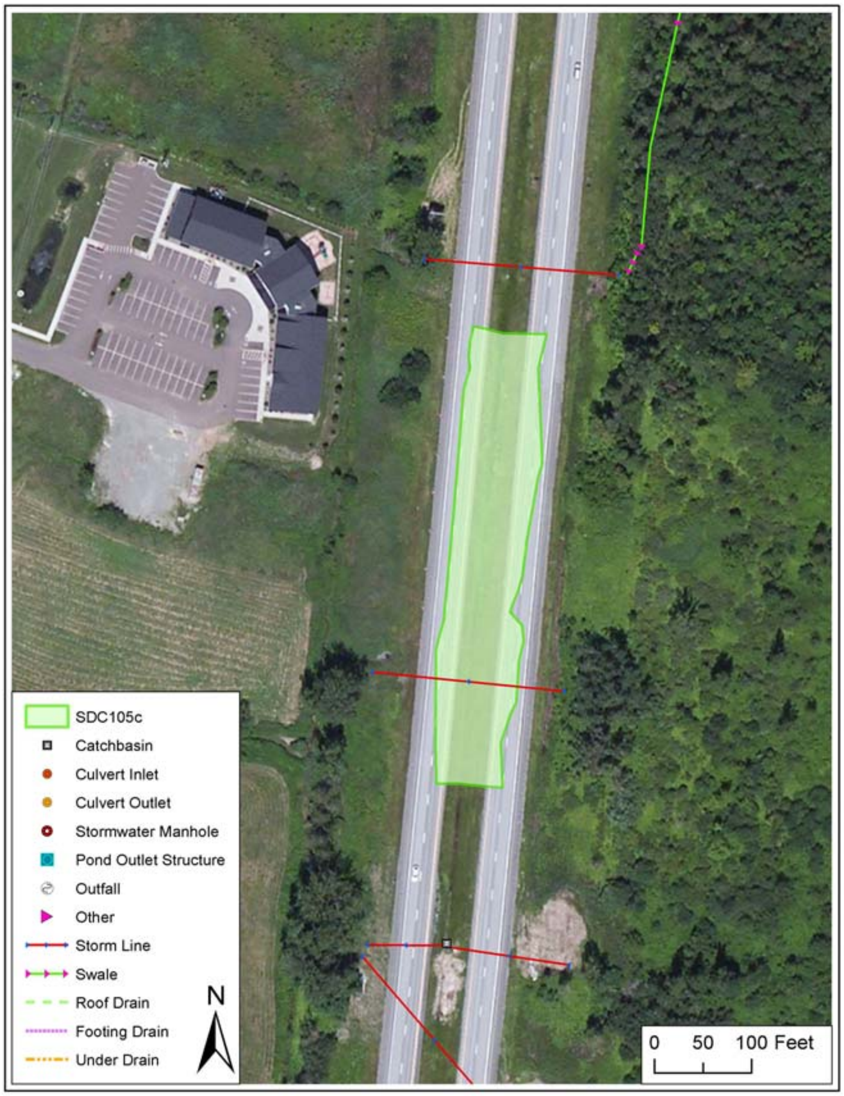
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: SDC105c		Watershed: Stevens Brook			
Approximate address:	I-89 Median North of Exit 19 St Albans City, VT 05478	**MS4 Impervious Owner(s):**	VTrans	**Ownership of Land where BMP is located:**	VTrans
Proposed BMP type:	Median Filter				

Site Map



Proposed BMP details

Permit #	NP
Estimated project cost (rounded to nearest $1,000)	$20,000
Drainage area (acres)	0.84
Total impervious cover managed by BMP (acres)	0.44
Total impervious cover managed by BMP (% of drainage area)	0.5%
VTRANS impervious cover managed (acres)	0.44
Managed impervious cover owed by VTrans (% of total managed impervious cover)	1.0%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.04
Percent of VTrans High-Flow Target Managed (%)	0.04%
Cost Notes	--

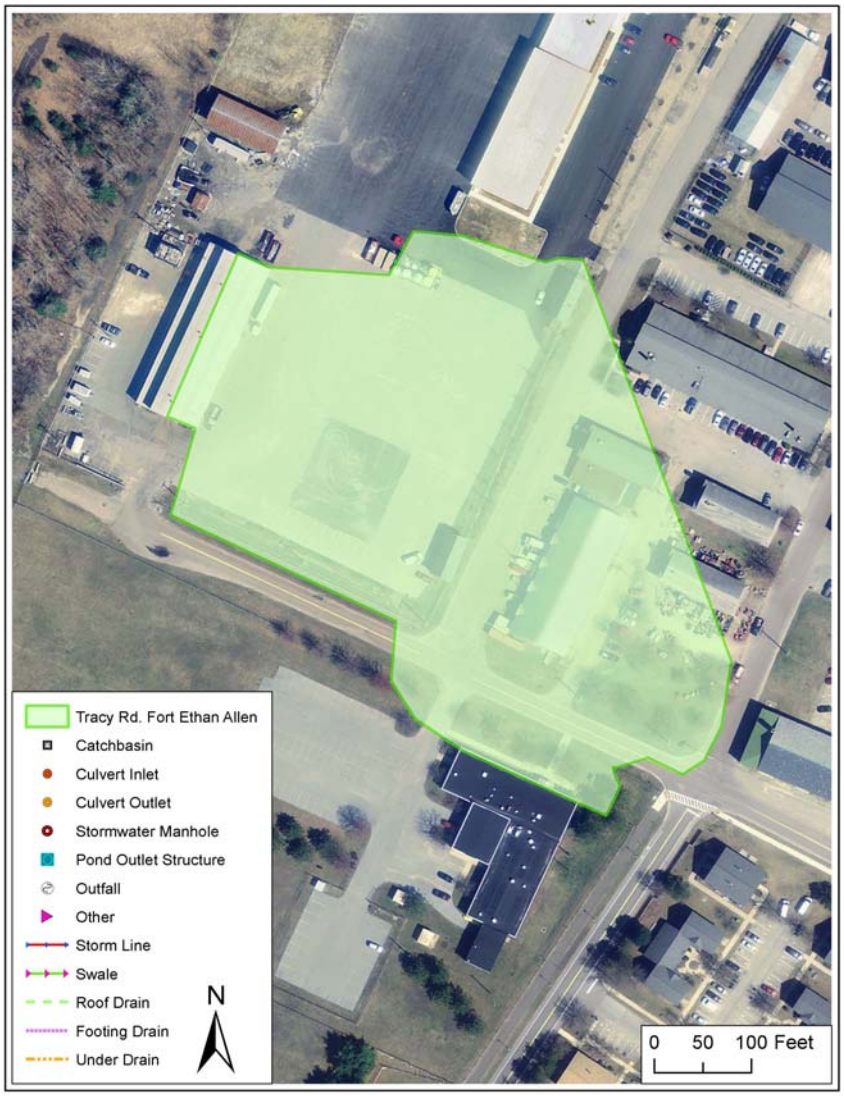
BMP Description

Create new median filter with subsurface sand medium to detain the CPv.

VTRANS FRP BMP Summary Sheet

Site name: Tracy Rd		Watershed: Sunderland Brook			
Approximate address:	Tracy Rd Colchester, VT 05446	**MS4 Impervious Owner(s):**	VTrans/ Colchester	**Ownership of Land where BMP is located:**	VTrans/ Colchester
Proposed BMP type:	Infiltration Trench				

Site Map



Proposed BMP details

Permit #	6363-INDS
Estimated project cost (rounded to nearest $1,000)	$54,000
Drainage area (acres)	4.97
Total impervious cover managed by BMP (acres)	3.89
Total impervious cover managed by BMP (% of drainage area)	0.8%
VTRANS impervious cover managed (acres)	2.31
Managed impervious cover owed by VTrans (% of total managed impervious cover)	0.6%
Runoff Channel Protection Volume (CPv) Storage (ac-ft)	0.43
Percent of VTrans High-Flow Target Managed (%)	2.51%
Cost Notes	Cost share with Town

BMP Description

Retrofit existing grass swale on the VTrans site along Tracy Road. Expand existing swale, add a 2 foot deep stone subsurface infiltration gallery. The surface would remain as grass and riser pipes would connect drainage into the deeper stone gallery for easier maintenance. Move existing fence closer to the road. The contributing drainage comes from the Town of Colchester and VTrans impervious; a cost share is recommended. On a runoff volume basis, the Town of Colchester contributes 0.195 ac-ft versus 0.23 ac-ft from VTrans owned land.

VTrans FRP
9/29/2016
Appendix C. VTrans FRP BMP Summary Table

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Cost Notes
Allen	Rest Area Pond Retrofit	VTrans / VT BGS	VTrans	Detention Basin	NP	26.8	4.4	16.5%	4.4	100%	0.670	22.3%	$158,000	
Allen	Town Office	VTrans	VTrans	Median Filter	NP	2.2	0.4	16.6%	0.4	100%	0.061	1.9%	$32,000	
Allen	WCA_1	VTrans	VTrans	Median Filter	NP	4.2	0.7	16.1%	0.7	100%	0.175	3.4%	$92,000	
Allen	WCA_2	VTrans	VTrans	Median Filter	NP	2.5	0.4	17.3%	0.4	100%	0.043	2.2%	$25,000	
Allen	WCA_3	VTrans	VTrans	Median Filter	NP	2.3	0.6	23.9%	0.6	100%	0.030	2.8%	$25,000	
Allen	WCA_4	VTrans	VTrans	Median Filter	NP	3.3	0.7	21.8%	0.7	100%	0.101	3.6%	$53,000	
Allen	VTrans Median A	VTrans	VTrans	Median Filter	NP	1.3	0.3	23.6%	0.3	100%	0.116	TBD	$60,000	
Allen	VTrans Median B	VTrans	VTrans	Median Filter	NP	0.7	0.2	28.7%	0.2	100%	0.078	TBD	$41,000	
Allen	VTrans Median E	VTrans	VTrans	Median Filter	NP	1.2	0.3	25.6%	0.3	100%	0.084	TBD	$44,000	
Allen	VTrans Median F	VTrans	VTrans	Median Filter	NP	1.1	0.2	18.9%	0.2	100%	0.085	TBD	$44,000	
Allen	VTrans Median G	VTrans	VTrans	Median Filter	NP	1.5	0.3	20.6%	0.3	100%	0.117	TBD	$61,000	
Allen	VTrans Median H	VTrans	VTrans	Median Filter	NP	1.3	0.2	18.9%	0.2	100%	0.113	TBD	$59,000	
Allen	VTrans Median I	VTrans	VTrans	Median Filter	NP	1.7	0.4	22.2%	0.4	100%	0.134	TBD	$70,000	
Allen	Other non-VTrans dominated BMPs	Town/ VTrans	Non-VTrans	Assorted	--				6.5		--	32.8%		--
	Watershed Total:								**15.6**			**68.9%**	**$764,000**	
Watershed	**Site Name**	**MS4 Impervious Owner**	**Ownership of Land where BMP is Located**	**BMP Type**	**Permit #**	**Drainage Area (acres)**	**Impervious Cover Managed (acres)**	**Impervious Cover Managed (% of Drainage Area)**	**VTrans Impervious Cover Managed (acres)**	**VTrans Impervious Cover Managed (% of Total Impervious Cover)**	**Runoff Channel Protection Volume (CPv) Storage (ac-ft)**	**VTrans High-Flow Target Managed (%)**	**Estimated Cost (Rounded to Nearest $1,000)**	**Cost Notes**
Bartlett	Bartlett Bay Treatment System (BBTS) Expansion	VTrans/ South Burlington	South Burlington	Underground Detention Chamber in ROW	5625-9010, 2-0180, 2-0153	16.1	9.2	57.2%	1.9	20.4%	0.55	100.0%	$378,000	Cost share with City
Bartlett	1690 Shelburne Rd	VTrans/ South Burlington	VTrans/ Developer-Pizzagalli	Underground Detention Chamber in ROW	5625-9010	0.8	0.4	51.3%	0.4	100%	0.04	22.2%	$199,000	
Bartlett	Existing BBTS (Post-2002) BMP	Town / City/ VTrans	Non-VTrans	Detention	--	--	--		2.7		--	145.0%		--
	Watershed Total:								**5.0**			**267.2%**	**$577,000**	
Watershed	**Site Name**	**MS4 Impervious Owner**	**Ownership of Land where BMP is Located**	**BMP Type**	**Permit #**	**Drainage Area (acres)**	**Impervious Cover Managed (acres)**	**Impervious Cover Managed (% of Drainage Area)**	**VTrans Impervious Cover Managed (acres)**	**VTrans Impervious Cover Managed (% of Total Impervious Cover)**	**Runoff Channel Protection Volume (CPv) Storage (ac-ft)**	**VTrans High-Flow Target Managed (%)**	**Estimated Cost (Rounded to Nearest $1,000)**	**Cost Notes**
Centennial	I-89 Cloverleaf (NE)	VTrans	VTrans	Underground Detention Chamber	NP	39.2	13.8	35.2%	5.0	36.1%	2.36	36.7%	$432,000	
Centennial	I-89 Outfall	VTrans	VTrans	Detention Basin	NP	13.1	2.8	21.6%	2.8	98.2%	2.87	20.4%	$1,419,000	Requires private land easement
Centennial	Other non-VTrans dominated BMPs	Town / City/ VTrans	Non-VTrans	Assorted	--	--	--		0.3		--	1.9%		--
	Watershed Total:								**8.0**			**59.1%**	**$1,851,000**	

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Cost Notes
Indian	Fairview Dr	Village/ VTrans/ Town	Village	Gravel Wetland	1-1074 SN002	29.4	4.1	14.0%	0.7	17.4%	0.67	17.4%	$290,000	Cost share with Village and Town of Essex
Indian	I-289/Route 15 North	VTrans	VTrans ROW	Median Filter	NP	2.8	0.9	30.6%	0.9	100%	0.12	20.7%	$34,000	
Indian	I-289/Route 15 South	VTrans	VTrans ROW	Median Filter	NP	2.2	0.8	35.3%	0.8	100%	0.10	18.5%	$29,000	
	Watershed Total:								2.3			56.6%	$353,000	

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Cost Notes
Moon	Randbury Rd	VTrans/ Town of Rutland	VTrans/ Town of Rutland/ Private	Gravel Wetland	NP/ New Road Project (Construction Permit)	23.1	11.0	47.4%	2.3	20.9%	0.83	189.5%	$279,000	*Need to estimate cost share with Town of Rutland
	Watershed Total:								2.3			189.5%	$279,000	

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Cost Notes
Munroe	M08 Executive Dr Pond	Town/ VTrans	Non-VTrans	Detention Pond	1-1291	91.1	21.3	23.4%	2.7	12.7%	0.54	49.0%	$25,000	--
Munroe	By Danform Shoes	Town/ VTrans	VTrans	Underground Detention	NP	4.9	2.8	58.0%	2.1	74.9%	0.145	38.4%	$102,000	
Munroe	Across from Tractor Supply	Town/ VTrans	VTrans	Gravel Wetland	NP	6.8	3.8	55.5%	2.8	75.6%	0.544	51.5%	$480,000	
	Watershed Total:								7.6			137.5%	$607,000	

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Cost Notes
Potash	Exit 13	VTrans	VTrans	Gravel Wetland	NP	16.7	4.8	28.6%	4.8	100%	0.567	9.7%	$219,000	
Potash	189 Cloverleaf	VTrans / Town	VTrans	Detention Basin	NP	21.3	11.5	54.3%	3.5	30%	1.129	7.0%	$59,000	Cost share with City
Potash	I-89 Swale	VTrans	VTrans	Median Filter	NP	6.3	1.8	28.6%	1.8	100%	0.531	3.6%	$129,000	--
Potash	Exit 14	VTrans	VTrans	Gravel Wetland	NP	4.9	1.8	36.9%	1.8	100%	0.294	3.7%	$131,000	--
Potash	Dorset St / 189 Ramps	VTrans / Town	VTrans	Detention Basin	NP	9.4	5.6	59.5%	1.1	19.6%	0.348	2.2%	$101,000	Cost share with City
Potash	Queen City Pk Rd	VTrans / Town	VTrans	Detention Basin	NP	6.5	2.9	44.9%	0.4	14.7%	0.452	0.9%	$99,000	
Potash	Other non-VTrans dominated BMPs	Town/ VTrans	Non-VTrans	Assorted	--				8.2		--	16.6%		--
	Watershed Total:								21.5			43.7%	$738,000	

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Cost Notes
Rugg	Exit 19 South	VTrans	VTrans	Detention	NP	57.9	3.8	6.5%	3.7	97.2%	2.070	26.7%	$270,000	Joint MS4 (75% Share)
Rugg	Access Rd. East	VTrans	VTrans/ Private	Detention	NP	85.1	2.8	3.2%	2.4	87.8%	1.820	17.6%	$197,000	Joint MS4 (50% share)
Rugg	Access Rd. West	VTrans	VTrans/ Private	Detention	Drains Portion of 1-1428	13.7	0.6	4.0%	0.6	100%	0.652	4.0%	$40,000	Joint MS4 (50% share)
Rugg	SASH / Federal St Connector	City/ VTrans	VTrans/ Private	Detention	NP	21.1	4.9	23.1%	1.2	24.5%	0.36	8.7%	$39,000	Joint MS4 (25% Share)
Rugg	SDC87	VTrans	VTrans	Median Filter	NP	4.9	0.9	18.8%	0.9	100%	0.128	6.7%	$36,000	
Rugg	SDC83b	VTrans	VTrans	Median Filter	NP	1.8	0.4	20.1%	0.4	100%	0.077	2.6%	$22,000	
Rugg	SDC27	VTrans	VTrans	Median Filter	NP	1.6	0.4	26.4%	0.4	100%	0.063	3.1%	$18,000	
Rugg	SDC280	VTrans	VTrans	Median Filter	NP	2.1	0.4	17.4%	0.4	100%	0.063	2.7%	$18,000	
Rugg	SDC347	VTrans	VTrans	Median Filter	NP	1.4	0.3	21.7%	0.3	100%	0.060	2.2%	$17,000	
Rugg	SDC83a	VTrans	VTrans	Median Filter	NP	1.7	0.3	15.8%	0.3	100%	0.058	2.0%	$16,000	
Rugg	SDC342	VTrans	VTrans	Median Filter	NP	1.6	0.3	19.4%	0.3	100%	0.054	2.3%	$15,000	
Rugg	SDC29	VTrans	VTrans	Median Filter	NP	2.2	0.4	18.2%	0.4	100%	0.054	3.0%	$15,000	
Rugg	I-89 / Holyoke Farm	Town / VTrans	Private	Infiltration	NP	61.8	0.5	0.8%	0.2	49.9%	1.426	1.8%	$130,000	Joint MS4 (50% share)
Rugg	Other non-VTrans dominated BMPs	Town / City/ VTrans	Non-VTrans	Assorted	--	124.1	29.9	24.1%	8.1	27.1%	--	59.0%		--
	Watershed Total:								**19.6**			**142.4%**	**$833,000**	

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Cost Notes
Stevens	Upper Fairfield Hill Rd	VTrans	VTrans/ Private	Detention Basin	NP	34.3	3.4	9.8%	1.2	34.4%	1.28	22.7%	$164,000	Cost Share with Town
Stevens	Fairfield Rd / I-89	VTrans	VTrans	Detention Basin	NP	28.9	2.1	7.2%	0.8	40.8%	0.68	16.6%	$109,000	Cost Share with Town
Stevens	SDC118	VTrans	VTrans	Median Filter	NP	1.1	0.5	50.9%	0.5	100%	0.06	10.7%	$28,000	
Stevens	Median A1	VTrans	VTrans	Median Filter	NP	0.9	0.4	46.4%	0.4	100%	0.06	8.2%	$27,000	
Stevens	SDC140b	VTrans	VTrans	Median Filter	NP	1.0	0.5	50.4%	0.5	100%	0.05	9.9%	$26,000	
Stevens	SDC408	VTrans	VTrans	Median Filter	NP	0.9	0.5	50.0%	0.5	100%	0.05	9.2%	$23,000	
Stevens	SDC98b	VTrans	VTrans	Median Filter	NP	0.9	0.4	49.0%	0.4	100%	0.05	8.2%	$22,000	
Stevens	Median A2	VTrans	VTrans	Median Filter	NP	0.7	0.3	45.5%	0.3	100%	0.04	5.8%	$21,000	
Stevens	SDC105b	VTrans	VTrans	Median Filter	NP	1.0	0.5	53.3%	0.5	100%	0.05	10.4%	$26,000	
Stevens	SDC105c	VTrans	VTrans	Median Filter	NP	0.8	0.4	52.1%	0.4	100%	0.04	8.6%	$20,000	
Stevens	Other non-VTrans dominated BMPs	Town / City/ VTrans	Non-VTrans	Assorted	--	--	--		2.0		--	38.3%		--
	Watershed Total:								**7.6**			**148.5%**	**$466,000**	

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Cost Notes
Sunderland	Tracy Rd.	VTrans/ Colchester	VTrans/ Colchester	Infiltration Trench	6363-INDS	5.0	3.9	78.3%	2.3	59.4%	0.43	287.9%	$54,000	Cost Share with Town of Colchester (46% / 54%)
Sunderland	Other non-VTrans dominated BMPs	Town / City/ VTrans	Non-VTrans	Assorted	--	--	--		4.5		--	559.4%		--
	Watershed Total:								**6.8**			**847.3%**	**$54,000**	

TOTAL FRP Implementation Cost: **$ 6,522,000**

Appendix D. BMPDSS Results Summary Table

Watershed Name	Target High Flow Q 0.3 (± %) Reduction Watershed Total	Target High Flow Q 0.3 (± %) Reduction VTRANS	Target High Flow Q 0.3 (± %) Reduction Achieved (%) Watershed Total	Target High Flow Q 0.3 (± %) Reduction Achieved (%) VTRANS	% of Watershed High Flow Reduction Addressed Watershed Total	% of Watershed High Flow Reduction Addressed VTRANS
Allen Brook	-3.30%	-0.41%	-3.39%	-0.28%	102.7%	68.9%
Bartlett Brook	-11.60%	-0.44%	-22.56%	-1.20%	194.5%	267.2%
Centennial Brook	-51.50%	-2.43%	-44.20%	-1.44%	85.8%	59.1%
Indian Brook	-1.30%	-0.10%	-2.75%	-0.06%	211.5%	56.6%
Moon Brook	-11.90%	-0.06%	-2.72%	-0.11%	22.9%	189.5%
Munroe Brook	-5.20%	-0.26%	-5.20%	-0.36%	100.0%	137.5%
Potash Brook	-16.50%	-1.37%	-16.50%	-0.60%	100.0%	43.7%
Rugg Brook	-15.30%	-2.40%	-17.46%	-3.42%	114.1%	142.4%
Stevens Brook	-24.40%	-1.52%	-28.10%	-2.25%	115.2%	148.5%
Sunderland Brook	-3.70%	-0.12%	-17.85%	-1.01%	482.4%	847.3%

In several watersheds (as shown above), the proposed BMP implementation scenario manages >100% of the VTrans high flow reduction target and thus includes a robust factor of safety (i.e., Sunderland Brook, Bartlett Brook). This factor of safety is included so that if one or more proposed projects becomes infeasible after further design and construction planning, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. The proposed BMP implementation plan will serve as a guide for VTrans, but is subject to change as more information becomes available.

Appendix E. VTrans FRP BMP Implementation Schedule

Watershed	Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)	Implementation Schedule
Allen	Rest Area Pond Retrofit	VTrans / VT BGS	VTrans	Detention Basin	NP	26.8	4.4	16.5%	4.4	100%	0.670	22.3%	$158,000	2017-2019
Allen	Town Office	VTrans	VTrans	Median Filter	NP	2.2	0.4	16.6%	0.4	100%	0.061	1.9%	$32,000	2017-2019
Allen	WCA_1	VTrans	VTrans	Median Filter	NP	4.2	0.7	16.1%	0.7	100%	0.175	3.4%	$92,000	2017-2019
Allen	WCA_2	VTrans	VTrans	Median Filter	NP	2.5	0.4	17.3%	0.4	100%	0.043	2.2%	$25,000	2017-2019
Allen	WCA_3	VTrans	VTrans	Median Filter	NP	2.3	0.6	23.9%	0.6	100%	0.030	2.8%	$25,000	2017-2019
Allen	WCA_4	VTrans	VTrans	Median Filter	NP	3.3	0.7	21.8%	0.7	100%	0.101	3.6%	$53,000	2017-2019
Allen	VTrans Median A	VTrans	VTrans	Median Filter	NP	1.3	0.3	23.6%	0.3	100%	0.116	TBD	$60,000	2017-2019
Allen	VTrans Median B	VTrans	VTrans	Median Filter	NP	0.7	0.2	28.7%	0.2	100%	0.078	TBD	$41,000	2017-2019
Allen	VTrans Median E	VTrans	VTrans	Median Filter	NP	1.2	0.3	25.6%	0.3	100%	0.084	TBD	$44,000	2017-2019
Allen	VTrans Median F	VTrans	VTrans	Median Filter	NP	1.1	0.2	18.9%	0.2	100%	0.085	TBD	$44,000	2017-2019
Allen	VTrans Median G	VTrans	VTrans	Median Filter	NP	1.5	0.3	20.6%	0.3	100%	0.117	TBD	$61,000	2017-2019
Allen	VTrans Median H	VTrans	VTrans	Median Filter	NP	1.3	0.2	18.9%	0.2	100%	0.113	TBD	$59,000	2017-2019
Allen	VTrans Median I	VTrans	VTrans	Median Filter	NP	1.7	0.4	22.2%	0.4	100%	0.134	TBD	$70,000	2017-2019
Total Cost for Implementation Phase 1													**$764,000**	
Rugg	Exit 19 South	VTrans	VTrans	Detention	NP	57.9	3.8	6.5%	3.7	97.2%	2.070	26.7%	$270,000	2020-2022
Rugg	SDC87	VTrans	VTrans	Median Filter	NP	4.9	0.9	18.8%	0.9	100%	0.128	6.7%	$36,000	2020-2022
Rugg	SDC83b	VTrans	VTrans	Median Filter	NP	1.8	0.4	20.1%	0.4	100%	0.077	2.6%	$22,000	2020-2022
Rugg	SDC27	VTrans	VTrans	Median Filter	NP	1.6	0.4	26.4%	0.4	100%	0.063	3.1%	$18,000	2020-2022
Rugg	SDC280	VTrans	VTrans	Median Filter	NP	2.1	0.4	17.4%	0.4	100%	0.063	2.7%	$18,000	2020-2022
Rugg	SDC347	VTrans	VTrans	Median Filter	NP	1.4	0.3	21.7%	0.3	100%	0.060	2.2%	$17,000	2020-2022
Rugg	SDC83a	VTrans	VTrans	Median Filter	NP	1.7	0.3	15.8%	0.3	100%	0.058	2.0%	$16,000	2020-2022
Rugg	SDC342	VTrans	VTrans	Median Filter	NP	1.6	0.3	19.4%	0.3	100%	0.054	2.3%	$15,000	2020-2022
Rugg	SDC29	VTrans	VTrans	Median Filter	NP	2.2	0.4	18.2%	0.4	100%	0.054	3.0%	$15,000	2020-2022
Stevens	Fairfield Rd / I-89	VTrans	VTrans	Detention Basin	NP	28.9	2.1	7.2%	0.8	40.8%	0.68	7.5%	$109,000	2020-2022
Stevens	SDC118	VTrans	VTrans	Median Filter	NP	1.1	0.5	50.9%	0.5	100%	0.06	4.8%	$28,000	2020-2022
Stevens	Median A1	VTrans	VTrans	Median Filter	NP	0.9	0.4	46.4%	0.4	100%	0.06	3.7%	$27,000	2020-2022
Stevens	SDC140b	VTrans	VTrans	Median Filter	NP	1.0	0.5	50.4%	0.5	100%	0.05	4.4%	$26,000	2020-2022
Stevens	SDC408	VTrans	VTrans	Median Filter	NP	0.9	0.5	50.0%	0.5	100%	0.05	4.1%	$23,000	2020-2022
Stevens	SDC98b	VTrans	VTrans	Median Filter	NP	0.9	0.4	49.0%	0.4	100%	0.05	3.7%	$22,000	2020-2022
Stevens	Median A2	VTrans	VTrans	Median Filter	NP	0.7	0.3	45.5%	0.3	100%	0.04	2.6%	$21,000	2020-2022
Stevens	SDC105b	VTrans	VTrans	Median Filter	NP	1.0	0.5	53.3%	0.5	100%	0.05	4.6%	$26,000	2020-2022
Stevens	SDC105c	VTrans	VTrans	Median Filter	NP	0.8	0.4	52.1%	0.4	100%	0.04	3.9%	$20,000	2020-2022
Total Cost for Implementation Phase 2													**$729,000**	
Centennial	I-89 Cloverleaf (NE)	VTrans	VTrans	Underground Detention Chamber	NP	39.2	13.8	35.2%	5.0	36.1%	2.36	36.7%	$432,000	2023-2025
Indian	I-289/Route 15 North	VTrans	VTrans ROW	Median Filter	NP	2.8	0.9	30.6%	0.9	100%	0.12	20.7%	$34,000	2023-2025
Indian	I-289/Route 15 South	VTrans	VTrans ROW	Median Filter	NP	2.2	0.8	35.3%	0.8	100%	0.10	18.5%	$29,000	2023-2025
Potash	Exit 13	VTrans	VTrans	Gravel Wetland	NP	16.7	4.8	28.6%	4.8	100%	0.567	9.7%	$219,000	2023-2025
Potash	189 Cloverleaf	VTrans / Town	VTrans	Detention Basin	NP	21.3	11.5	54.3%	3.5	30%	1.129	7.0%	$59,000	2023-2025
Potash	I-89 Swale	VTrans	VTrans	Median Filter	NP	6.3	1.8	28.6%	1.8	100%	0.531	3.7%	$129,000	2023-2025
Potash	Exit 14	VTrans	VTrans	Gravel Wetland	NP	4.9	1.8	36.9%	1.8	100%	0.294	3.7%	$131,000	2023-2025
Total Cost for Implementation Phase 3													**$1,033,000**	

Rugg	Access Rd. East	VTrans	VTrans/ Private	Detention	NP	85.1	2.8	3.2%	2.4	87.8%	1.820	17.6%	$197,000	2026-2027
Rugg	Access Rd. West	VTrans	VTrans/ Private	Detention	Drains Portion of 1-1428	13.7	0.6	4.0%	0.6	100%	0.652	4.0%	$40,000	2026-2027
Rugg	SASH / Federal St Connector	City/ VTrans	VTrans/ Private	Detention	NP	21.1	4.9	23.1%	1.2	24.5%	0.36	8.7%	$39,000	2026-2027
Rugg	I-89 / Holyoke Farm	Town / VTrans	Private	Infiltration	NP	61.8	0.5	0.8%	0.2	49.9%	1.426	1.8%	$130,000	2026-2027
Stevens	Upper Fairfield Hill Rd	VTrans	VTrans/ Private	Detention Basin	NP	34.3	3.4	9.8%	1.2	34.4%	1.28	10.2%	$164,000	2026-2027
Total Cost for Implementation Phase 4													**$570,000**	
Bartlett	Bartlett Bay Treatment System (BBTS) Expansion	VTrans/ South Burlington	South Burlington	Underground Detention Chamber in ROW	5625-9010, 2-0180, 2-0153	16.1	9.2	57.2%	1.9	20.4%	0.55	122.4%	$378,000	2028-2029
Bartlett	1690 Shelburne Rd	VTrans/ South Burlington	VTrans/ Developer-Pizzagalli	Underground Detention Chamber in ROW	5625-9010	0.8	0.4	51.3%	0.4	100%	0.04	27.2%	$199,000	2028-2029
Indian	Fairview Dr	Village/ VTrans/ Town	Village	Gravel Wetland	1-1074 SN002	29.4	4.1	14.0%	0.7	17.4%	0.67	17.4%	$290,000	2028-2029
Potash	Dorset St / 189 Ramps	VTrans / Town	VTrans	Detention Basin	NP	9.4	5.6	59.5%	1.1	19.6%	0.348	2.2%	$101,000	2028-2029
Potash	Queen City Pk Rd	VTrans / Town	VTrans	Detention Basin	NP	6.5	2.9	44.9%	0.4	14.7%	0.452	0.9%	$99,000	2028-2029
Total Cost for Implementation Phase 5													**$1,067,000**	
Munroe	M08 Executive Dr Pond	Town/ VTrans	Non-VTrans	Detention Pond	1-1291	91.1	21.3	23.4%	2.7	12.7%	0.54	47.1%	$25,000	2030-2031
Munroe	By Danform Shoes	Town/ VTrans	VTrans	Underground Detention	NP	4.9	2.8	58.0%	2.1	74.9%	0.145	36.9%	$102,000	2030-2031
Munroe	Across from Tractor Supply	Town/ VTrans	VTrans	Gravel Wetland	NP	6.8	3.8	55.5%	2.8	75.6%	0.544	49.5%	$480,000	2030-2031
Total Cost for Implementation Phase 6													**$607,000**	
Centennial	I-89 Outfall	VTrans	VTrans	Detention Basin	NP	13.1	2.8	21.6%	2.8	98.2%	2.87	20.4%	$1,419,000	2032
Moon	Randbury Rd	VTrans/ Town of Rutland	VTrans/ Town of Rutland/ Private	Gravel Wetland	New Road Project (Construction Permit)	23.1	11.0	47.4%	2.3	20.9%	0.83	104.6%	$279,000	2032
Sunderland	Tracy Rd.	VTrans/ Colchester	VTrans/ Colchester	Infiltration Trench	6363-INDS	5.0	3.9	78.3%	2.3	59.4%	0.43	287.9%	$54,000	2032
Total Cost for Implementation Phase 7													**$1,752,000**	

TOTAL FRP Implementation Cost: **$ 6,522,000**

VTrans FRP BMP Implementation

Plan   Actual

ACTIVITY	PERCENT COMPLETE	Phase 1			Phase 2			Phase 3			Phase 4		Phase 5		Phase 6		Phase 7
		Implementation Year															
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Allen Brook	0%																
Rugg Brook	0%																
Stevens Brook	0%																
Potash Brook	0%																
Centennial Brook	0%																
Indian Brook	0%																
Municipal/VTrans - 1	0%																
Municipal/VTrans - 2	0%																
Municipal/VTrans - 3	0%																
Municipal/VTrans - 4	0%																

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MEMORANDUM

DATE: January 9, 2014

TO: Dan Albrecht; Megan Moir; Tom DiPietro; Jennifer Callahan; Bill Nedde, Linda Seavey, and Lani Ravin

FROM: Horsley Witten Group, Inc.

RE: Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information

This memorandum describes the basic approach used to model potential stormwater retrofits for the Centennial Brook Flow Restoration Plan (FRP) using the VT BMPDSS model. Modeling efforts have proven that is it difficult to meet the **63.0%** high flow reduction target required by the Centennial Brook TMDL. In fact, the percent flow reduction achieved under the proposed restoration scenario is **44.2%**. This reduction reflects management of 90% of the watershed impervious cover using all retrofits identified in the field and vetted with the MS4s. Under this scenario, UVM's existing Main St. and North Campus ponds would be modified from their current configuration to improve performance while maintaining 12-hr detention times and storage capacity for future development activities (only the proposed Colchester Ave. watershed expansion is incorporated into the model at this time).

Table 1 summarizes high flow reduction targets established by the TMDL, a revised target based on an analysis of future impervious cover, and the percent reduction achieved under the currently modeled VTBMPDSS restoration scenario. Figures 1-3 show impervious cover and drainage area maps for the proposed restoration scenario, including a zoom in of the proposed Colchester Avenue expansion.

Table 1. Summary of Percent Flow Reductions Achieved

Description		% High Flow Reduction	Managed IA (acres)	Planning Level Cost[5]
TMDL Reduction Targets	TMDL baseline with no agriculture.	49.9	--	--
	TMDL with no agriculture and 40 acres future, unmanaged impervious cover.	63.0	--	--
	TMDL with no agriculture and revised 5 acres of future, unmanaged impervious cover.[1]	51.5[2]	--	--
Current Conditions	All existing BMPs (revised ANR BMPDSS Credit Model)	14.8	106.1[3]	--
Proposed Flow Restoration Scenario	All primary and secondary retrofits; existing UVM facilities meeting 12-hr detention criteria and maintaining future use allocations; Colchester Ave watershed expansion included.[4]	44.2	243.7	$9,740,000

[1] Based on 2013 analysis conducted by CCRPC for Burlington and South Burlington.
[2] 51.5% = 49.9% baseline target + 5/40 acres future IA * 13.1% reduction target associated with future IA
[3] IA managed by post-2002 BMPs, which does not include Main Street and Queensbury ponds (based on most recently available GIS)
[4] One surface detention facility proposed in the VTrans right-of-way is designed to exceed 24-hr detention time.
[5] See cost section for more detail on planning level assumptions and costing analysis.

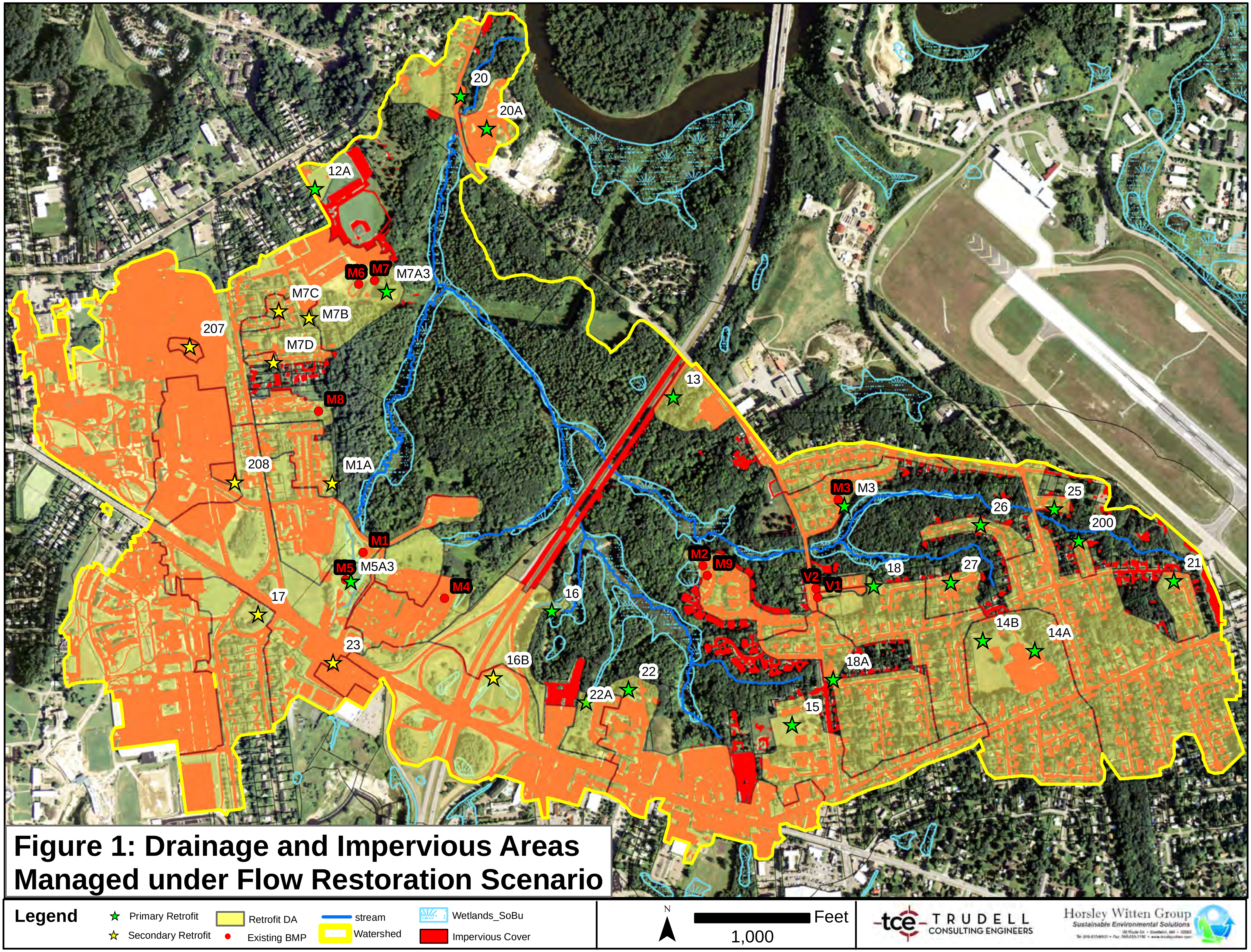

Figure 1: Drainage and Impervious Areas Managed under Flow Restoration Scenario

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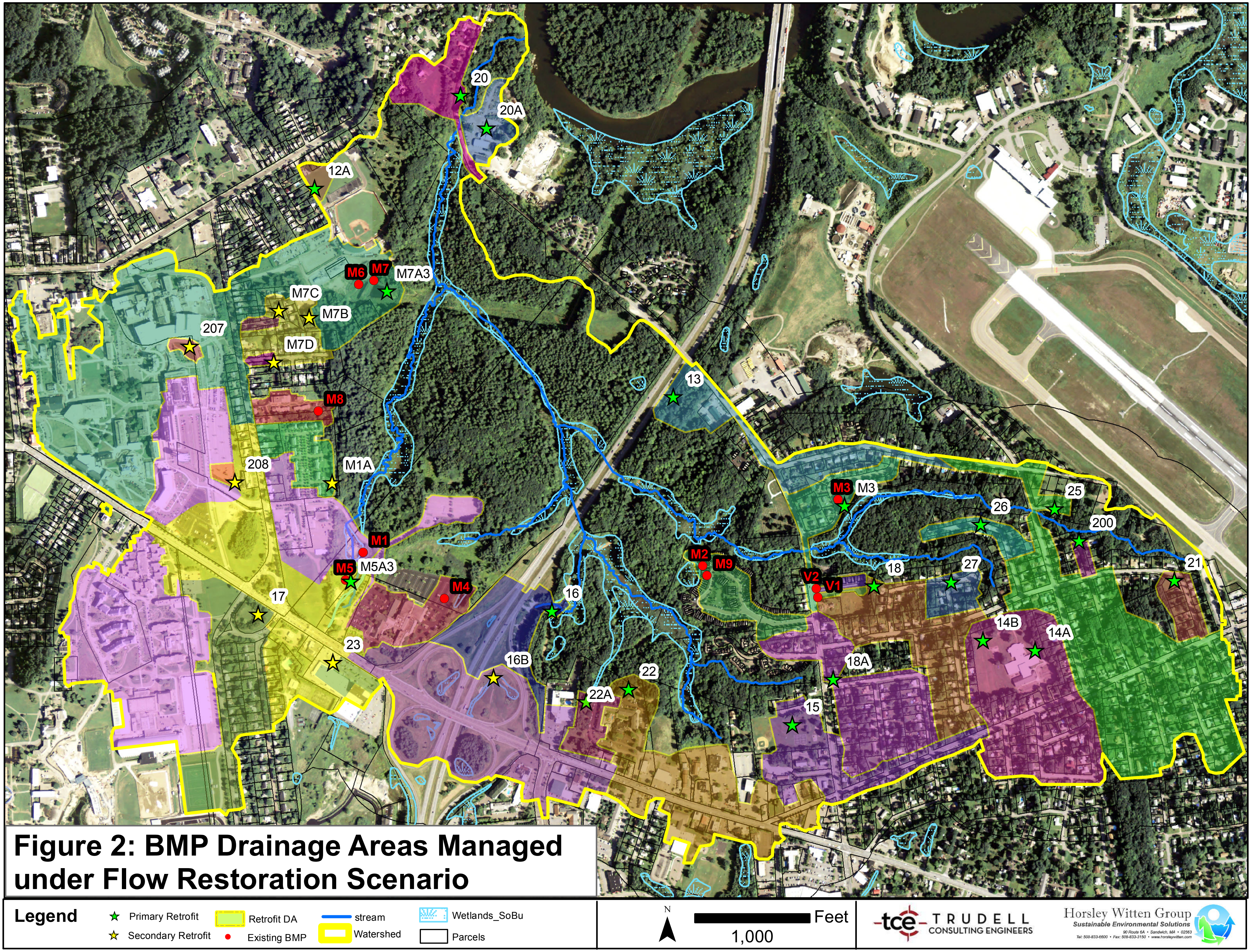

Figure 2: BMP Drainage Areas Managed under Flow Restoration Scenario

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Figure 3. Colchester Ave. Proposed Watershed Expansion

Legend

Colchester Ave Area

Impervious Cover

Existing Watershed Boundary

N

Feet

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General Conclusions

The restoration scenario presented here is not intended to represent the optimal implementation scenario proposed by the MS4s, rather it represents the maximum reduction all MS4s agree is achievable, regardless of cost considerations. Prior to moving forward with finalizing the flow restoration plan for Centennial Brook, the MS4s and the VT Agency of Natural Resources (ANR) may want to consider the following:

1. A detailed analysis was conducted by Chittenden County Regional Planning Commission in July, 2013 that refined the estimate of future, unregulated impervious cover to a more realistic estimate of 5 acres, rather than the 40 acres assumed in the TMDL. This change, if approved by ANR, would lower the high flow TMDL target from 63.0% to 51.5%.
2. Restoration activities other than the implementation of structural stormwater retrofits, such as tree planting, buffer enhancement, impervious cover reduction, or more stringent development requirements could potentially bridge the remaining gap for meeting the reduction target if a crediting mechanism was established.
3. Higher flow reductions are possible if surface detention time (center of mass) are relaxed in Centennial Brook; although modeling suggests that detention times >24 hrs for retrofits of existing and new ponds still cannot meet the 63% reduction target. If increased detentions times were allowed, future permitting of proposed development projects draining to those retrofitted facilities would also need to be considered.
4. The proposed retrofits with the most influence on flow reduction modeled at the watershed outlet include: Best Western (#22 at 13.6% relative reduction); North Campus Pond (M7A3 at 7.7%); Chamberlain School (#14 at 5.9%); and Picard Circle (#25 at 4.3%). The East Campus Pond (M1) contributes to 13.4% of the achieved flow reduction, though no retrofit of this facility is proposed. The Main St. pond retrofit's (M5A3) relative reduction was 3.4%. These "regional" storage facilities manage more impervious cover than the smaller on-site BMPs, which have less of an individual influence on reductions measured at the watershed outlet. Based on the results of the VTBMPDSS, the revised 51.5% flow reduction target can be met by extending detention times of the UVM ponds beyond 24 hours; however, since over-detention in these existing facilities was reported by Krebs and Lansing to significantly reduce UVM's future development opportunities, this retrofit option is not considered practical. Regardless, the 63% target was not reached under any modeling scenarios.
5. A number of secondary BMPs (practices within the drainage areas of primary sites) were identified as backup options in case primary sites become infeasible or are down-sized. None of the secondary practices are able to completely replace the relevant primary practice, however. The I-89 clover-leaf (16B) comes the closest, but is about ½ as effective as the primary BMP proposed at I-89 outfall (16). Currently, these secondary practices are included in the proposed restoration scenario in addition to the primary facilities to show the maximum amount of flow reduction deemed achievable, regardless of cost. Removing the secondary facilities from the restoration scenario will likely result in a very modest change the flow reduction at significant cost savings.
6. The VTBMPDSS model runs for Centennial Brook do not fully depict expected increases in low flow despite a substantial increase in annual infiltration volumes from the proposed infiltration BMPs. Under the proposed restoration scenario, 94 acres of impervious cover are directed to infiltration practices designed to infiltrate the 1-year storm. Using the Burlington rainfall record, a rough analysis of recharge from the impervious area runoff should yield approximately 22 inches/year.

This recharge should augment streamflow by approximately 0.24 cfs across the entire flow duration curve; however, the model predictions of increase in low flow from infiltration practices are only 0.02 cfs (an 8% increase over baseline conditions).

7. The planning level estimate of overall capital costs for the proposed flow restoration scenario modeled is $9,740,000.

The remainder of this memorandum provides more detailed information on the modeling analyses, BMP input information, and estimated construction costs. Additional supporting information submitted separately from, but in conjunction with, this memo includes:

- VTBMPDSS model runs for the revised baseline, the revised credit, and the proposed restoration scenario.
- GIS shapefiles used in each scenario, including updated impervious cover layer, BMP footprints, and other shapefiles created during this effort.
- HydroCAD models—created for all of the revised Credit BMPs and potential retrofits using HydroCAD version 10.00 for calibrating VTBMPDSS input;
- Spreadsheets—summarizing reductions, input variables, and cost estimates.

VTBMPDSS Modeling Analysis

The VTBMPDSS model is a continuous hydrological simulation model that estimates the effect of land use changes and stormwater BMPs on streamflow. This model was applied to the Centennial Brook watershed, which has a drainage area of about 1.4 square miles. The most important inputs to the model for this study are the GIS layers of land use, impervious cover, and soil, as well as the locations, configuration, and connections of the BMPs themselves.

Establishing Baseline Conditions

The ANR Baseline Scenario represents the watershed condition prior to the Centennial TMDL (2002), which in this case reflects six existing BMPs. In coordination with ANR, a Revised Baseline Scenario was created to address an issue discovered during subsequent modeling runs involving the application of BMPs with small drainage areas. Each time one of these on-site BMPs is added, the model creates a new routing connection that increases downstream flow and reduces times of concentration in the drainage area. This phenomenon can cause the VTBMPDSS model to underestimate the reduction potential of smaller green infrastructure (GI) practices and negates some of the potential benefits of BMP treatment trains. To accurately account for this effect, the Baseline Scenario was revised to incorporate virtual outlets (VOs) and drainage areas with “dummy” connections in the same manner as in the subsequently modeled flow restoration scenario. This adjustment did not alter flow paths in the Baseline Scenario, but did slightly increase Q03 base flows. Thus, slight increases in percent reductions over baseline conditions were achieved in the restoration scenarios.

FDC Statistics and Flow Reductions

The VTBMPDSS model outputs both summary files and complete records of hourly flows for any specified control points. The outlet is the primary control point (number 16 for this model). The outlet summary file (Init_Eval.out) provides a quick way to see the control point flows for Q95 and Q03 flows (cfsm) from the current scenario. These numbers were used as a quick guide on performance.

For the final FDC flow numbers, ANR recommends that a separate FDC analysis be performed using only the last 10 years of the 12 year output record for the desired control point (Init_VirtualOutlet_16.out). The FDC spreadsheet was used to provide these numbers for all current scenarios. Only these FDC numbers are reported in this memo.

Additionally, ANR requires computation of the flow reductions percentages based on flow in cubic feet per second (cfs) not cubic feet per second per square mile (cfsm). The logic is that additional watershed area would increase flow (in cfs) and require instream morphological changes that could be detrimental, like augmenting sediment load. The flow per square mile (cfsm) might be unchanged and not reflect this impact. Only flows in cfs were reported in this memo.

Current Condition (Credit) Models

The ANR Credit Scenario reflects upgrades to four of the six ponds included in the baseline model to meet 2002 VT Stormwater Manual criteria. Updated ponds include: the East Campus Pond (M1), Sheraton Pond (M4); the North Campus Pond (M6) with sediment forebay (M7); and the Quarry Ridge Pond (M9) with sediment forebay (M2). The Queensbury Rd. Pond (M3) and the Main St. Pond (M5) remained unchanged from the baseline model. The ANR Credit Scenario was reviewed and revised to account for: 1) an error discovered in the HydroCAD and VTBMPDSS setup for the East Campus pond (M1), and 2) recent construction at Patchen Woods that added two vegetated swales (V1 and V2), increased impervious cover, and required slight changes to sub-watershed boundaries.

HydroCAD modeling of BMPs

HydroCAD models were set up for most of the proposed retrofits identified during field investigations in May, 2013. The Field Findings Memorandum (dated June 13, 2013) that documented procedures and feasible retrofit concepts has been revised to reflect subsequent changes to some of the retrofit concepts (see Revised Field Summaries Memorandum, dated October, 2013). The HydroCAD runs were saved as PDF files, marked up to show the relevant VTBMPDSS parameters used, and then the selected parameters were saved in a model input spreadsheet, thus providing full documentation of each VTBMPDSS model run. All HydroCAD models and the input spreadsheet are available for review. The following two modeling adjustments should be noted:

- HydroCAD models were based on the most updated impervious cover and soils data, which may differ slightly from what is being used in the VTBMPDSS model. ANR requested consistency in the GIS layers used for running model scenarios to ensure that results are comparable to baseline conditions; however, they agreed that the BMPs should be adequately designed using the latest data.
- Because of the differing methods that HydroCAD and the VTBMPDSS models aggregate runoff from soils and impervious areas and deal with flow lag times (time of concentration), the size of the HydroCAD designs for some infiltration practices (e.g., Jaycee Park (15) and Patchen Rd. (18A)) had to be increased to achieve maximum infiltration in the VTBMPDSS.

Flow Restoration Scenario

A number of restoration scenarios were modeled to compare various implementation options using 39 stormwater BMPs. In these scenarios, primary BMPs are defined as having an outlet directly to a stream while secondary BMPs drain to a downstream BMP. More details of the BMP concept summaries, based on GIS and field data, can be found in the revised "Centennial Brook Watershed: Retrofit Field Findings Summary Memorandum" (dated October, 2013). A few key model parameters used during the restoration scenarios include:

- The revised impervious cover used in the Revised Credit Scenario was updated slightly to account for new parking lots and buildings recently constructed/removed based on a visual inspection of the latest satellite images. Even though more recent impervious cover GIS layers were available, this approach was recommended by ANR since it allows direct comparison with the baseline scenarios without introducing differences between remote sensing technology used to develop the old and new impervious cover layers.
- The watershed boundary was changed in a few locations based on MS4 input and field verification. For example, the area north of University Avenue and west of the baseball diamond was removed because it is now connected to the combined sewer system. The UVM proposed expansion on the corner of Colchester Avenue and University Place was modeled as part of the restoration scenario presented here.
- All the stormwater practices, except for vegetated swales, were modeled as multistage ponds. The multistage pond allows the volume-stage relationship to be well represented, has more options for outlet control structures, and has all the controls represented in other model BMPs like infiltration or biofiltration. The multi-stage pond also has the added advantage in that it can be turned on/off or scaled with a multiplier (normally set to 1.0). The parameter allows the same network to be preserved for all flow restoration scenarios and is extremely useful for evaluating different scenarios and individual BMP performance.

Table 2 summarizes the base, credit, and restoration scenarios discussed above. Table 3 provides an accounting of some of the key input parameters of each proposed BMP used in the proposed restoration scenario.

Table 2. Summary of Modeling Scenarios

Model Scenario			Purpose	Q03 High Flow (cfs)	Q03 High Flow % Red.	Conclusion
Pre-TMDL	ANR Base	Six pre-2002 BMPs, 2002 land use and IA GIS layers	What were the flows at the time the TMDL was established? These flows are the baseline from which restoration/treatment is measured.	27.2	--	We were able to successfully replicate ANR's model.
Pre-TMDL	Revised Base	ANR Base + virtual outlets, DAs, and network	Add "dummy" BMP connections to allow for more accurate comparison with restoration scenarios.	27.9	--	This is the new baseline to measure achieved flow reductions.
Current	ANR Credit	ANR Base + upgrades to some existing BMPs	What is the change in baseline flow with the retrofit of 4 of 6 existing BMPs to 2002 standards?	23.1	15.2%	We were able to replicate ANR's model.
Current	Revised Credit	ANR Credit + BMP revisions/addition	Revise current conditions by correcting model inputs on East Campus Pond (M1) and adding the Patchen Woods development.	23.2	14.8%	Corrections result in a slight decrease from ANR's prediction of the current reductions.
Proposed Restoration Scenario		All primary and secondary retrofits (see Table 3)	What is the max. flow reduction achievable if all feasible retrofits are implemented with UVM-designed retrofits of the Main St. (M5A3) and North Campus (M7A3) ponds and the Colchester Ave. expansion.	15.6	44.2%	Does not meet the revised 51.5%% TMDL reduction target, and benefit of secondary practices probably not worth the additional cost.

Table 3. BMPs used in Flow Restoration Scenarios

Site ID	Site Name	BMP Type[1]	Class[2]	DA (ac)	IA (ac)[3]	% Difference in Q03[4]		Design Notes
						BMP Outlet	Watershed Outlet	
12A	University soccer field	IB	E	1.41	0.33	-100.0	0.0	--
13	Patchen Rd. depression	URC	P	14.06	5.07	-100.0	-1.2	Max. ponding depth=7'; Exfiltration = 2.41 in/hr
14A/B	Chamberlin School	URC	P	31.49	10.12	-100.0	-5.9	Field size: 97'(w) x 167'(l) x 3.5'(h); Exf. = 0.52 in/hr
15	Jaycee Park	DB	P	15.73	6.28	-100.0	-2.7	Field size: 87'(w) x 60'(l) x 3.5'(h); Exf. = 2.41 in/hr
16	I-89 outfall	DB	P	52.25	18.88	-26.4[4]	-2.1	Max det. time= 46.6 hr; max. ponding depth=12'
16B	I-89 cloverleaf (NE)	UDC	S	39.17	16.14	-83.0	-0.9	Max det. time=48.8 hrs; max. ponding depth=8'
17	Jug handle @ Spear & Main St. (east)	UDC	S	22.01	7.28	-74.9	-0.3	Field size: 144'(w) x 231'(l) x 3.5'(h)
18	Fielding Lane Condos	URC	P	18.74	5.48	-100.0	-2.3	Max. ponding depth=4'; Exf. = 2.41 in/hr
18A	Patchen Rd & Pine St	URC	P	20.41	6.00	-100.0	-1.8	Field size: 49'(w) x 81'(l) x 3.5'(h); Exf. = 2.41 in/hr
20	Grove St Parking Lot	URC	P	8.82	2.54	-100.0	-0.3	Field size: 30'(w) x 74'(l) x 3.5'(h); Exf. = 2.41 in/hr
20A	SD Ireland Property	URC	P	4.66	3.82	-100.0	-0.2	--
21	Dumont Ave (south)	URC	P	3.93	1.20	-100.0	-0.1	Field size: 21'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
22	Best Western Windjammer (N)	IB	P	29.25	21.68	-100.0	-13.6	Max. ponding depth=12'; Exf. = 2.41 in/hr
22A	Best Western Windjammer (W)	IB	P	4.09	1.24	-100.0	-0.5	Max. ponding depth=3'; Exf. = 2.41 in/hr
23A/B	Staples Plaza	UDC	S	2.50	2.43	-67.7	-0.2	Field size: 35'(w) x 259'(l) x 2.33'(h)
25	Picard Circle	URC	P	51.85	17.11	-86.7	-4.3	Field size: 49'(w) x 138'(l) x 3.5'(h); Exf. = 2.41 in/hr
26	Duval St	URC	P	3.57	1.18	-100.0	-0.1	Field size: 21'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
27	Clover St	URC	P	3.82	1.43	-100.0	0.0	Field size: 26'(w) x 31'(l) x 3.5'(h); Exf. = 2.41 in/hr
200	N Henry Court	URC	P	1.03	0.45	-100.0	0.0	Field size: 11'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
207	Fletcher Allen green space	Bio	S	0.89	0.85	-100.0	0.0	Bio surface area: 3,200 sf
208	Fletcher Allen parking lot	Bio	S	0.83	0.53	-100.0	-0.1	Bio surface area: 2,300 sf
M1A	Centennial Crt Apartments	IB	S	6.54	3.03	-100.0	-0.6	Max. ponding depth=4'; Exfiltration=0.52 in/hr

Site ID	Site Name	BMP Type[1]	Class[2]	DA (ac)	IA (ac)[3]	% Difference in Q03[4]		Design Notes
						BMP Outlet	Watershed Outlet	
M1	East Campus Pond	DB	E	80.30	49.34	-58.1	-13.4	Existing UVM design. Max. det. time= < 12 hrs. Stor. Vol. = 11.3 ac-ft
M2/ M9	Quarry Ridge	DB	E	7.44	4.2	-59.7	-1.1	Max det. time= 12.5 hrs
M3A	Queensbury Pond (modified)	IB	P	8.99	4.17	-86.5	-0.8	Max. ponding depth=10'; Exfiltration=2.41 in/hr
M4	Sheraton	DB	E	9.81	6.70	-52.4	-0.2	Max det. time= 9.9 hrs
M5A3	Main St (UVM modified)	DB	P	64.15	26.59	-39.0	-3.4	UVM design. Max. det. time= < 12 hrs. Stor. Vol. =8.5 ac-ft; with smaller low flow orifice of 5.8” than existing
M6 / M7A3	North Campus (UVM modified)	DB	P	86.36	48.22	-46.3	-7.7	UVM design. Max. det. time= < 12 hrs. Stor. Vol. =21.5 ac-ft.; perm pool elevation 236.0, with smaller low flow orifice of 7.3” than existing and raised to 9-ft embankment
M7B	Open area east of Case Pkwy	URC	S	7.04	3.19	-100.0	-0.1	Field size: 40'(w) x 74'(l) x 3.5'(h); Exf. = 2.41 in/hr
M7C	Case Pkwy center island	Bio	S	0.86	0.50	-100.0	0.1	Bio surface area: 700 sf
M7D	140 East Ave residence	Bio	S	0.63	0.36	0.0	0.0	Bio surface area: 1,550 sf
M8	Burlington COOP	DB	E	3.73	1.62	-100.0	-0.4	Max det. time= 2hrs
V1	Patchen Woods	VS	E	0.48	0.32	-50.0	-0.3	
V2	Patchen Woods	VS	E	0.91	0.81	-100.0	-0.11	

[1] Bio=bioretention; DB=detention basin, IB= infiltration basin; UDC= underground detention chamber; URC=underground recharge chambers; and VS=vegetated swale

[2] P=Primary BMP; S= Secondary BMP that drains to a primary BMP; E=Existing practice (no modification)

[3] Impervious area shown here is based on the most recent/ accurate information that was used to size potential retrofits and may not correspond exactly with GIS layers used in the VTBMPDSS model

[4] Percent difference in high flows is negative when showing a reduction. The model was run with all BMPs turned on and then with individual BMPs turned off, one at a time, to quantify differences in flow and relative performance at the outlet of individual BMPs. Differences at each BMP outlet were determined by comparing the inflows and outflows. 100% represents no surface discharge; BMPS with less than 50% at the BMP outlet could be opportunities to enhance performance. Differences in flow at the watershed outlet are intended as a relative comparison of BMP effectiveness, but are not absolute or additive. Individual BMP values do not add up to corresponding total watershed reductions due to other losses in the system.

[4] Relative performance for #16 appears low because #16B is already managing a large portion of the drainage area.

Estimated Project Costs

This section provides estimates of construction costs for the various stormwater retrofit facilities based on volume managed, the type of BMP, and the type of project site. The total cost for implementation of the restoration scenario presented here is $9,740,000.

The cost estimates were developed based on the following assumptions and design decisions:

1. **Design Control Volumes** are based on the estimated runoff volume associated with the one-year storm event for underground systems or green infrastructure-type practices. Control volumes for large, above-ground infiltration or detention basins are based on the estimated runoff associated with the one hundred year storm event plus approximately two feet of freeboard volume. Underground systems and green infrastructure-type practices were conceptually designed as off-line practices that only accept runoff from the one-year event. Runoff volumes for all storm events were determined based on HydroCAD® model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.
2. Table 4 summarizes **Unit Costs** for each BMP and **Site Adjustment Factors** that were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from our experience with actual construction. Underground detention chambers (UDC) and underground recharge chamber (URC) systems were typically designed using Stormtech SC-740™ chamber systems. A Stormtech SC-310™ system was used at Site 23A/B due to a shallow existing drainage system. Cost estimates for the retrofit sites described as "GI/URC" were calculated as bioretention treatment systems followed by Stormtech SC-740™ chambers for recharge benefits. The cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. Retrofits of existing BMPs, for example, generally cost less than new installations.

Table 4. Retrofit unit costs and adjustment factors

BMP	Base Cost ($/ft^3)
Detention Basin	$2
Infiltration Basin	$4
Underground Chamber (infiltration or detention)	$12
Bioretention	$10
Green Infrastructure/ Underground Chamber Combo	$22
Site Type	**Cost Multiplier**
Existing BMP retrofit	0.25
New BMP in undeveloped area	1.00
New BMP in partially developed area	1.50
New BMP in developed area	2.00
Adjustment factor for large aboveground basin projects	0.50

3. For certain retrofit locations, additional **Site-Specific Costs** were added to the construction costs. For example, Sites #13, #22, and M3A will require significant drainage or utility reconstruction. Site M5A3 will require ledge removal if constructed. Site M7A3 will require elevating the existing electric transmission lines to provide adequate clearance for the basin berm construction. Site-specific construction items are described in detail in the Retrofit

Summary Sheets provided as part of the Revised Field Findings Memo (dated October 14), except for the most recent retrofit concepts by UVM for M5A3 and M7A3, which were updated after submittal of the Revised Field Findings Memo. Table 3 provides information on the key design elements of M5A3 and M7A3.

4. **Base Construction Cost** is the product of the design control volume, the unit cost, and the site adjustment factor. Site-specific costs were added to this result for the applicable retrofit sites.
5. **Permits & Engineering Costs** were estimated at either 20% or 35% of the construction cost depending on the scale of the project. The largest projects (in terms of control volume) were estimated at 20% and the smaller projects at 35%. Certain large-scale projects that are likely to include high levels of engineering or permitting effort were assigned a 35% fee, despite their overall size.
6. **Land Acquisition Cost** was added to the total costs for facilities located on private, non-UVM properties. Retrofits that may require partial land acquisition fees were marked up by $150,000; retrofits possibly requiring total land acquisition were marked up by $300,000. These land acquisition estimates are considered to be place-holders at this time and may require adjustments based on current land values and the willingness of land owners to grant easements for the proposed drainage improvements. It was assumed that no land acquisition fees would be necessary for privately owned Sites 22, 22B, and 23A/B due to possible Residual Designation Authority (RDA) applicability. Site M1A was also not assigned a land acquisition fee due to possible existing agreements between UVM and the Centennial Court Apartments property management; however additional refinement of costs for UVM property may require inclusion of a land acquisition cost.
7. **Total Project Cost** is the sum of the base construction cost, permitting & engineering costs, and land acquisitions costs; it does not include operation & maintenance costs.
8. **Relative Cost** is described in terms of total project costs and represented by dollar signs. A project costing less than $100,000 is given $; a project between $100,000 and $250,000 is given $$; a project between $250,000 and $500,000 is given $$$; and a project greater than $500,000 is given $$$$.
9. **Costs per Impervious Acre** treated was calculated by dividing the sum of the construction costs and the permitting & engineering costs by the total impervious area directed to each BMP. Impervious areas used in this calculation are displayed in Table 3. Land acquisition costs and operation & maintenance costs are not included as part of this calculation.
10. **Operation & Maintenance** costs were estimated separately for each BMP, but are <u>not</u> included in the total construction costs. We assume that annual O&M is approximately 3% of project construction costs, with a cap at $10,000.

Each of the numbered descriptions above provides clarification to the corresponding columns in Table 5. The spreadsheet used to develop Table 5 is provided separately as supporting information.

Table 5. BMP Cost Summary Table

Site ID	Site Name	BMP Type	Class	Design Control Volume[1] (ft3)	Base Unit Cost[2] ($/cu.ft.)	Site Adjust. Factor[2]	Site Specific Cost[3]	Base Constr. Cost[4]	Permits & Eng.[5]	Land Cost[6]	Total Project Cost[7]	Relative Cost[8]	Cost/ Imp. Acre[9]	O&M[10]
12A	University soccer field	IB	E	2,700	-	-	-	-	-	-	-	-	-	-
13	Patchen Rd depression	URC	P	66,800	$4	0.25	$25,000	$91,800	$33,000	$150,000	$280,000	$$$	$25,000	$2,800
14A/B	Chamberlin School	URC	P	35,200	$12	1.50	$0	$633,600	$127,000	$0	$770,000	$$$$	$76,000	$10,000
15	Jaycee Park	DB	P	11,300	$12	1.50	$0	$203,400	$72,000	$0	$280,000	$$$	$48,000	$6,200
16	I-89 outfall	DB	P	566,000	$2	1.00	$0	$1,132,000	$227,000	$150,000	$1,510,000	$$$$	$72,000	$10,000
16B	I-89 cloverleaf (NE)	UDC	S	320,000	$2	0.50	$0	$320,000	$112,000	$0	$440,000	$$$	$27,000	$9,600
17	Jug handle @ Spear & Main St.	UDC	S	73,000	$12	1.50	$0	$1,314,000	$263,000	$0	$1,580,000	$$$$	$217,000	$10,000
18	Fielding Lane Condos	URC	P	21,700	$4	1.00	$0	$86,800	$31,000	$300,000	$420,000	$$$	$23,000	$2,700
18A	Patchen Rd & Pine St	URC	P	8,600	$12	1.50	$0	$154,800	$55,000	$150,000	$360,000	$$$	$35,000	$4,700
20	Grove St Parking Lot	URC	P	4,800	$12	2.00	$0	$115,200	$41,000	$0	$160,000	$$	$62,000	$3,500
20A	SD Ireland Property	URC	P	28,700	-	-	-	-	-	-	-	-	-	-
21	Dumont Ave (south)	URC	P	1,100	$12	1.50	$0	$19,800	$7,000	$0	$30,000	$	$23,000	$600
22	Best West.(N)	IB	P	181,000	$4	0.50	$50,000	$412,000	$145,000	$0	$560,000	$$$$	$26,000	$10,000
22A	Best West. (W)	IB	P	30,000	$4	0.50	$0	$60,000	$21,000	$0	$90,000	$	$75,000	$1,800
23A/B	Staples Plaza	UDC	S	11,600	$12	2.00	$0	$278,400	$56,000	$0	$340,000	$$$	$139,000	$8,400
25	Picard Circle	URC	P	14,700	$12	1.50	$0	$264,600	$53,000	$0	$320,000	$$$	$20,000	$8,000
26	Duval St	URC	P	1,100	$22	1.50	$0	$36,300	$13,000	$150,000	$200,000	$$	$42,000	$1,100
27	Clover St	URC	P	1,700	$12	1.50	$0	$30,600	$11,000	$150,000	$200,000	$$	$30,000	$1,000

Site ID	Site Name	BMP Type	Class	Design Control Volume[1] (ft3)	Base Unit Cost[2] ($/cu.ft.)	Site Adjust. Factor[2]	Site Specific Cost[3]	Base Constr. Cost[4]	Permits & Eng.[5]	Land Cost[6]	Total Project Cost[7]	Relative Cost[8]	Cost/ Imp. Acre[9]	O&M[10]
200	N Henry Court	URC	P	600	$22	1.50	$0	$19,800	$7,000	$0	$30,000	$	$60,000	$600
207	Fletcher Allen green space	Bio	S	3,700	$10	1.00	$0	$37,000	$13,000	$0	$50,000	$	$59,000	$1,200
208	Fletcher Allen parking lot	Bio	S	2,700	$10	1.00	$0	$27,000	$10,000	$0	$40,000	$	$70,000	$900
M1A	Centennial Court Apts.	IB	S	30,800	$4	1.00	$0	$123,200	$44,000	$0	$170,000	$$	$59,000	$3,700
M3A	Queensbury (modified)	IB	P	26,700	$4	0.25	$25,000	$51,700	$19,000	$150,000	$230,000	$$	$24,000	$1,600
M5A3	Main St (UVM modified)	DB	P	370,900	$2	0.50	$100,000	$470,900	$95,000	$0	$570,000	$$$$	$22,000	$10,000
M7A3	North Campus (with extra DA)	DB	P	1,008,00 0	$2	0.25	$100,000	$604,000	$121,000	$0	$730,000	$$$$	$16,000	$10,000
M7B	Open area east of Case Pkwy	URC	S	6,300	$12	1.50	$0	$113,400	$40,000	$0	$160,000	$$	$38,000	$3,500
M7C	Case Pkwy center island	Bio	S	1,000	$10	1.50	$0	$15,000	$6,000	$0	$30,000	$	$42,000	$500
M7D	140 East Ave residence	Bio	S	1,800	$10	1.50	$0	$27,000	$10,000	$150,000	$190,000	$$	$103,000	$900

See preceding text for footnotes.

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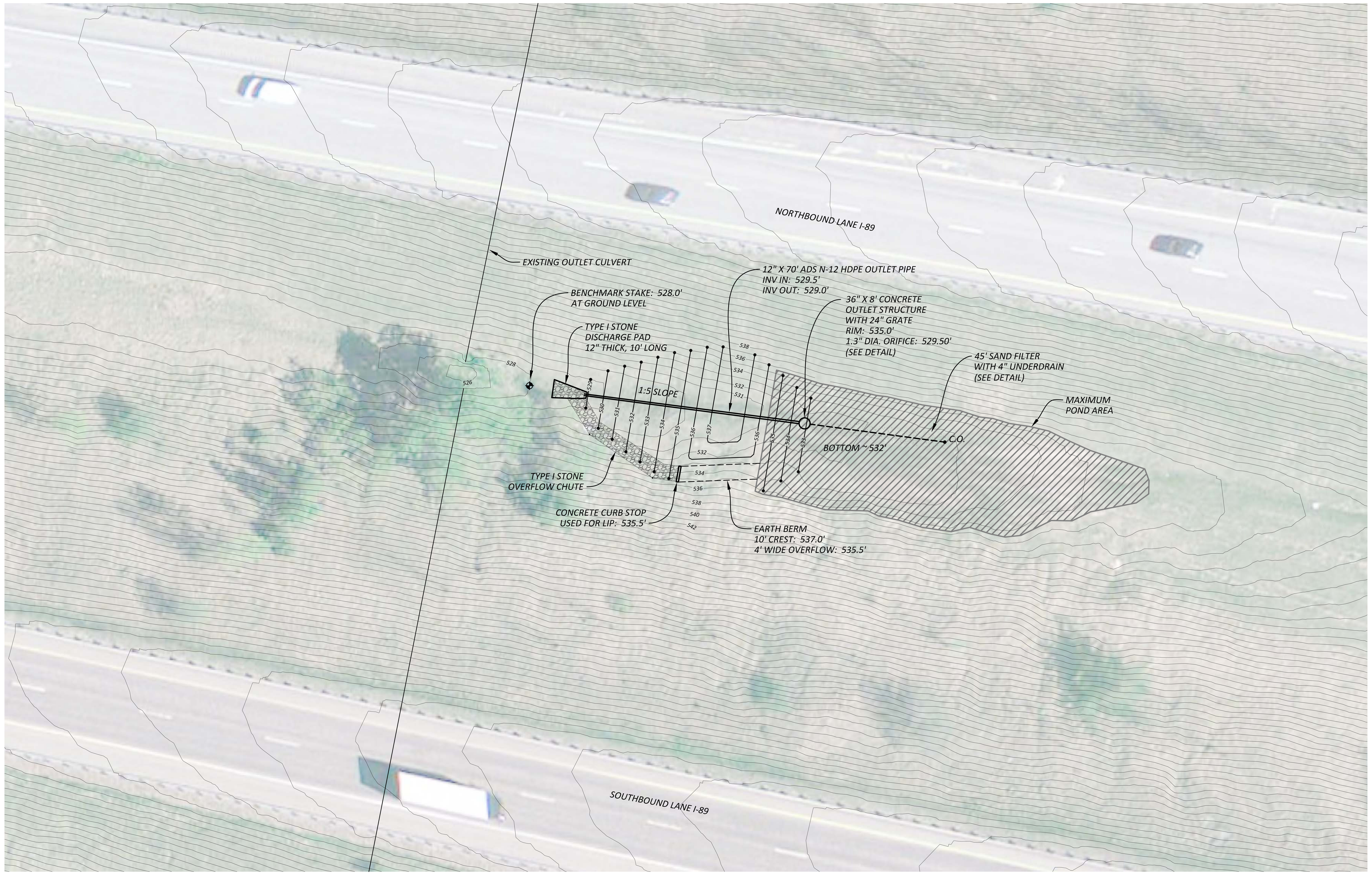

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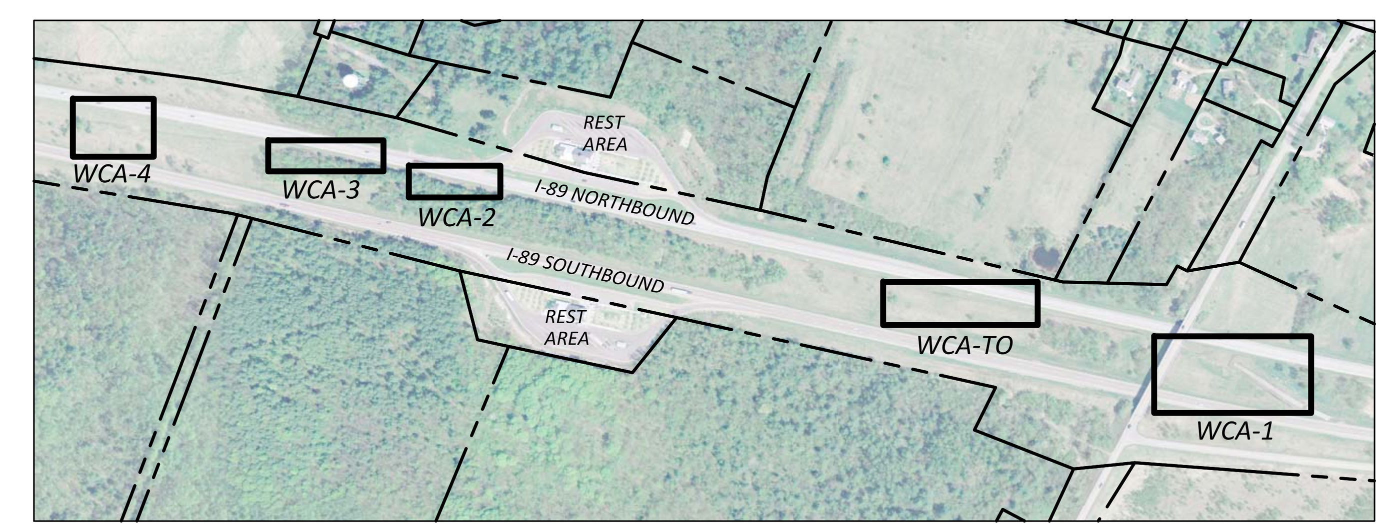
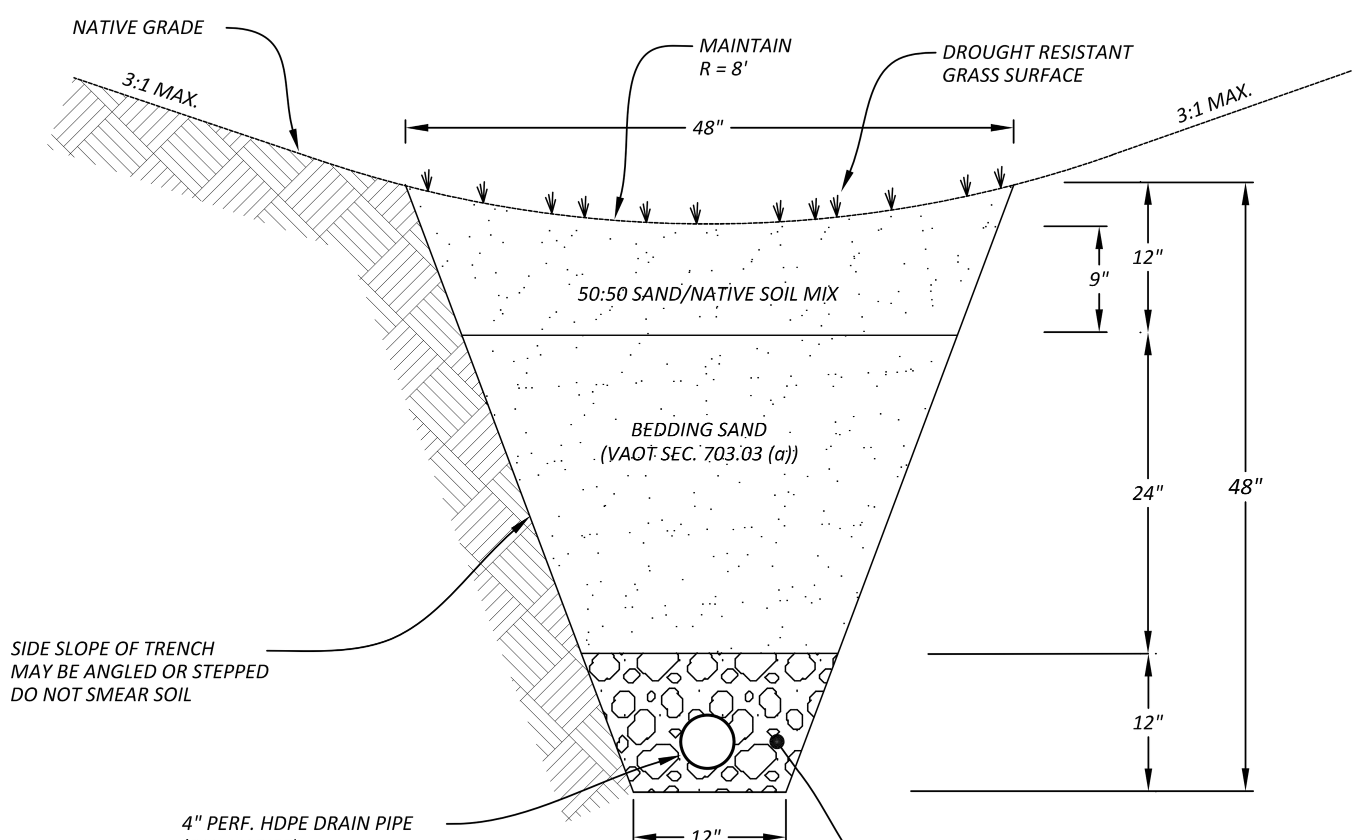
LOOKING DOWN SWALE FROM DIVIDE


OUTLET


LOOKING UP SWALE FROM OUTLET



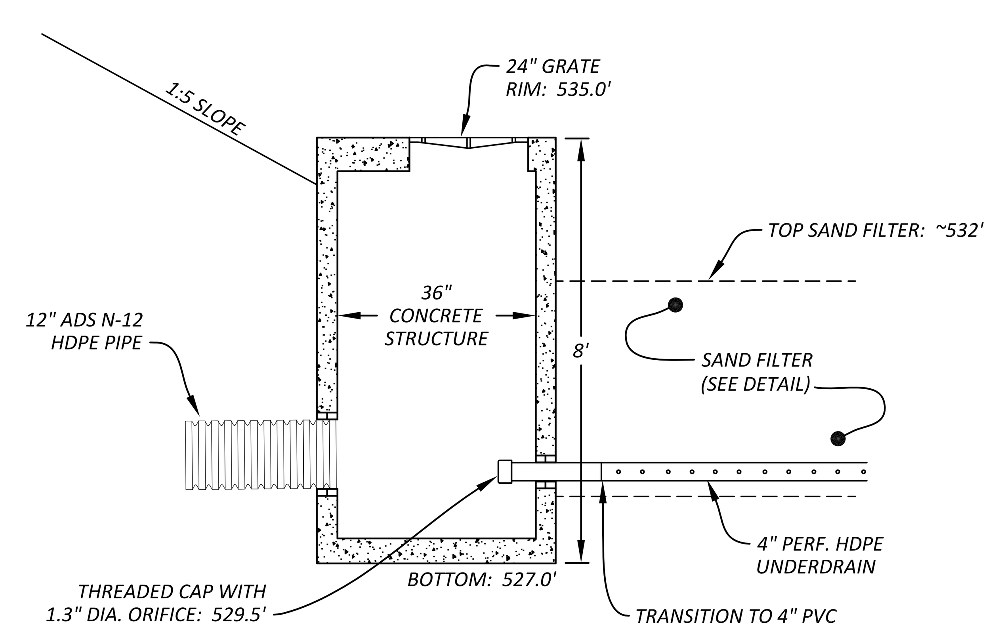
SHEET INDEX
NTS



SAND AREA = 8.5 SF
STONE AREA = 0.8 SF

SAND FILTER/UNDERDRAIN SECTION
1" = 1'

GRAPHIC SCALE
20 0 10 20 40 80
(IN FEET)
1 inch = 20 ft.



SECTION VIEW

WCA-4 OUTLET DETAIL
NTS

P:\VTRANS WILLISTON MEDIAN\BASE PLAN-FEET.dwg

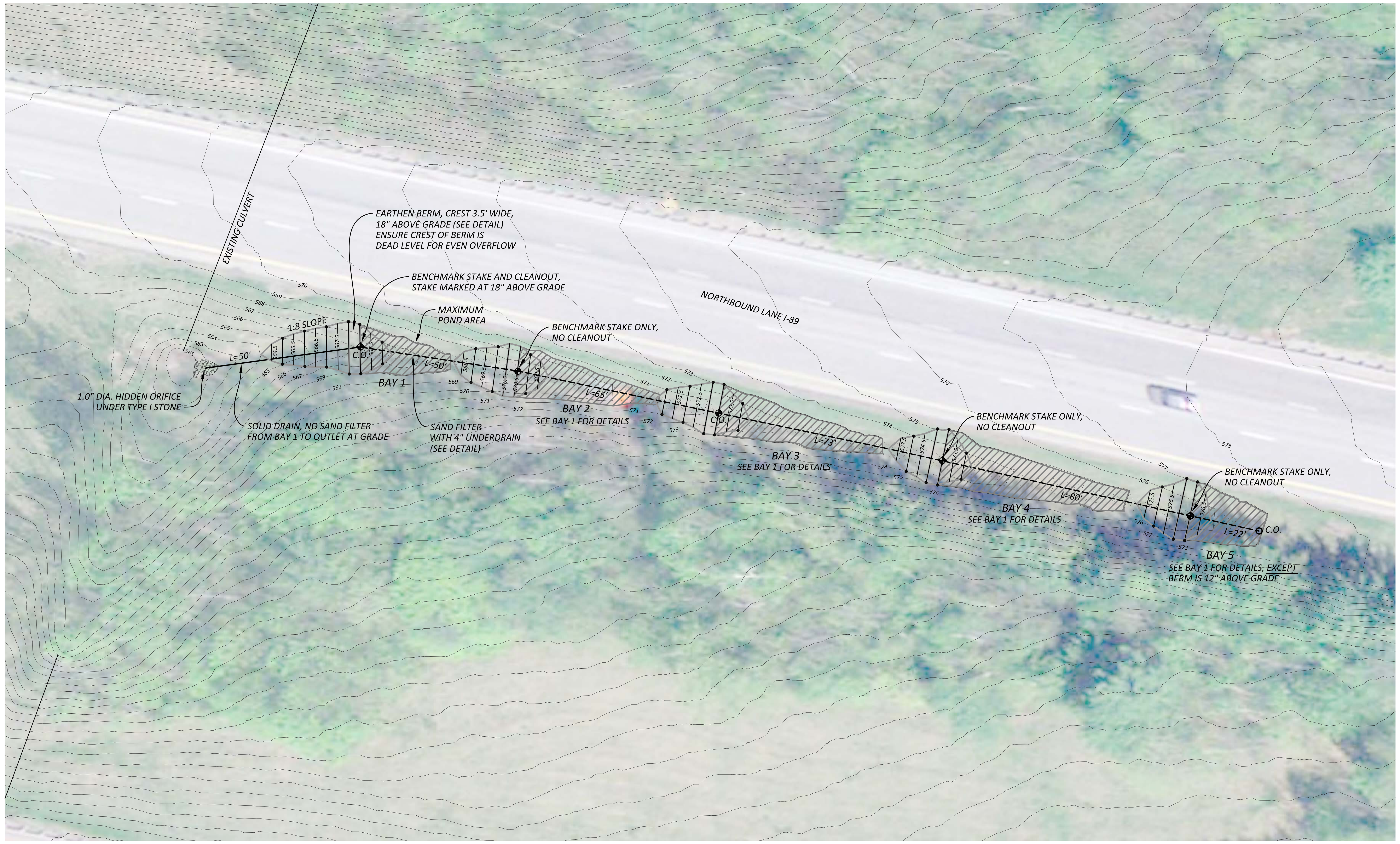
VTRANS MEDIAN STORMWATER UPGRADE
WILLISTON, VERMONT

LAYOUT PLAN - WCA-4

LAKESIDE ENVIRONMENTAL GROUP
P.O. BOX 4081
BURLINGTON, VT 05406
P: (802) 489-5214
WWW.LEGVT.COM

DRAWN BY:	SMS
CHECKED BY:	AT/ATS
APPROVED BY:	AT
DATE:	9-27-12
SCALE:	NOTED
SHEET:	1 OF

WATERSHED CONSULTING ASSOCIATES, LLC
P.O. BOX 1085
WAITSFIELD, VT 05673
P: (802) 496-5130 F: (802) 496-5131
www.watershedca.com
"specializing in stormwater management and erosion-sediment control"



N

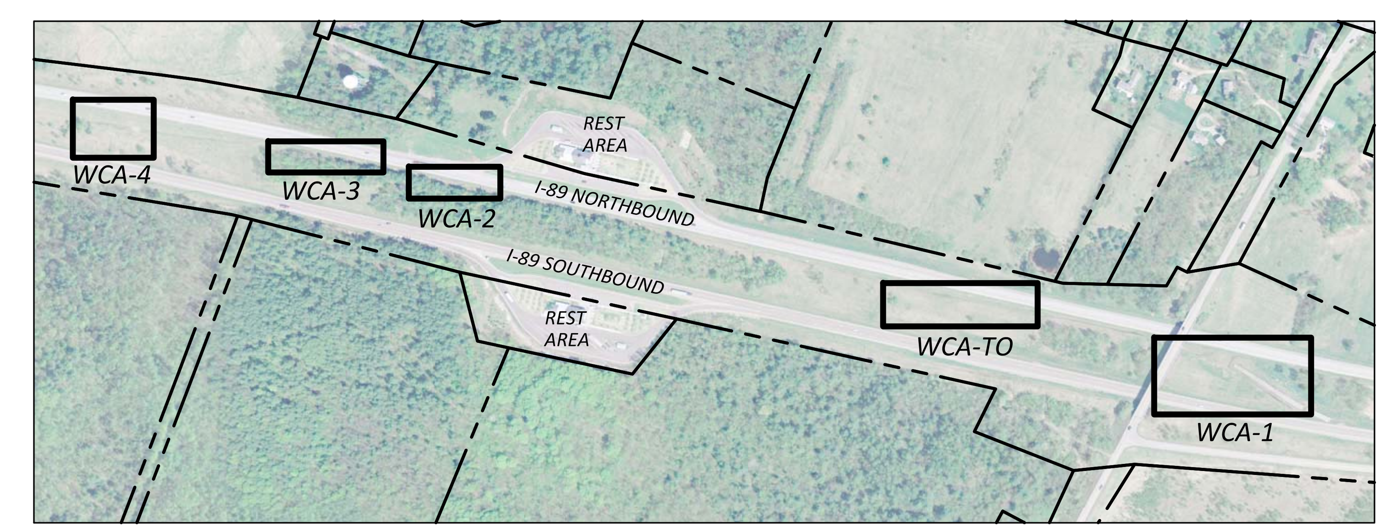
LOOKING UP SWALE FROM OUTLET

OUTLET

GRAPHIC SCALE

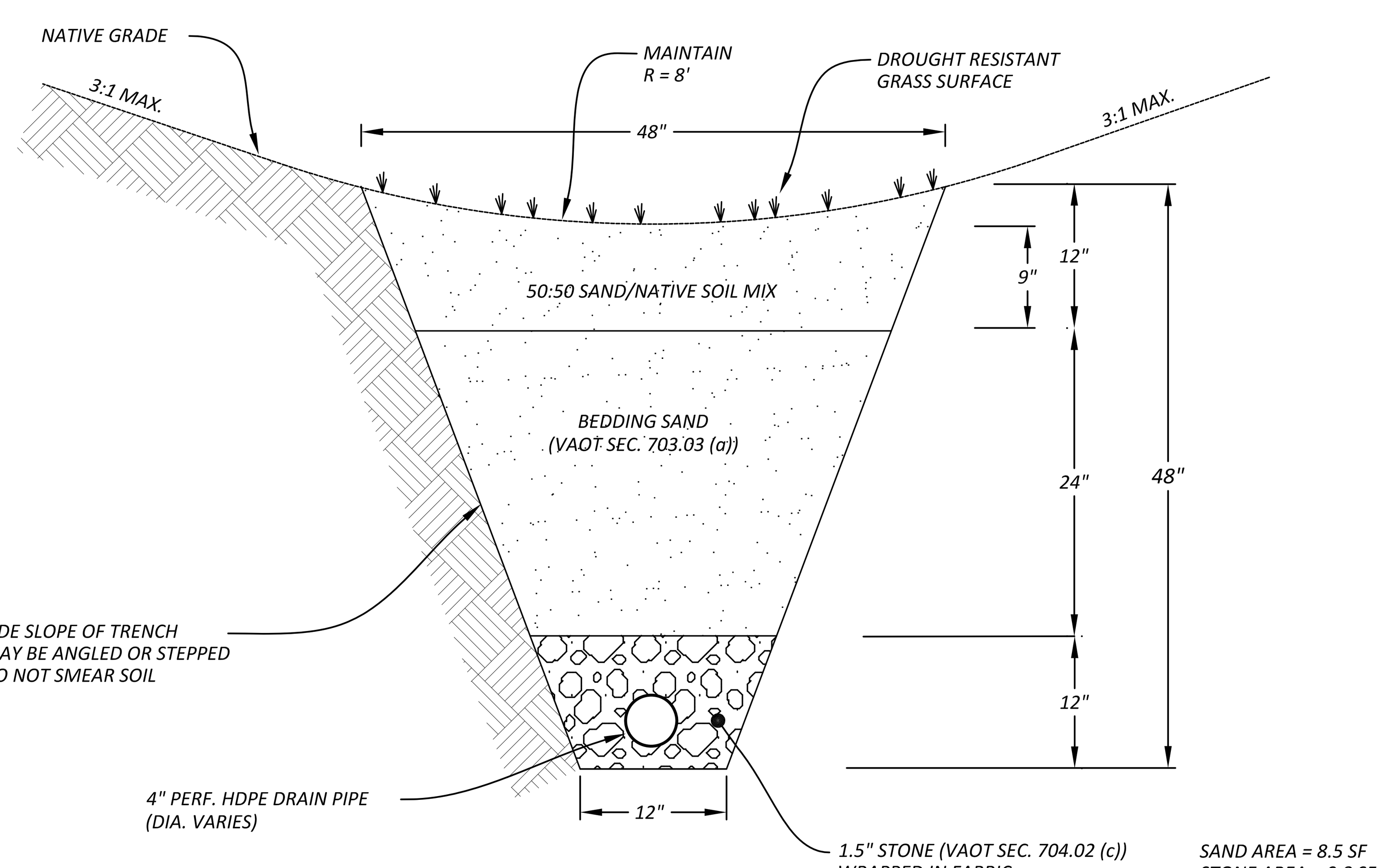
20 0 10 20 40 80

(IN FEET)
1 inch = 20 ft.



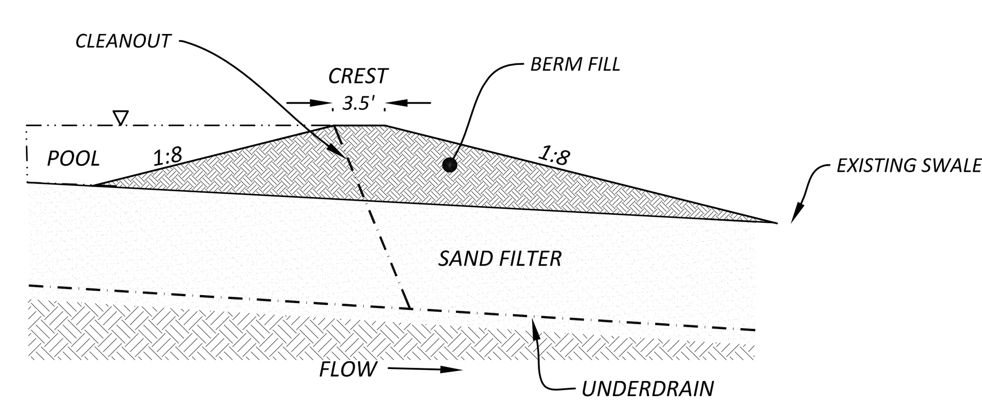
SHEET INDEX

NTS



SAND FILTER/UNDERDRAIN SECTION

1" = 1'



NOTE:
BERM FILL MUST BE COMPACTED IN 6" LIFTS TO ENSURE NO SETTLING SO AS TO MAINTAIN DEAD LEVEL LIP ON BERM.

EARTH BERM DETAIL

NTS

VTRANS MEDIAN STORMWATER UPGRADE

WILLISTON, VERMONT

LAYOUT PLAN - WCA-3

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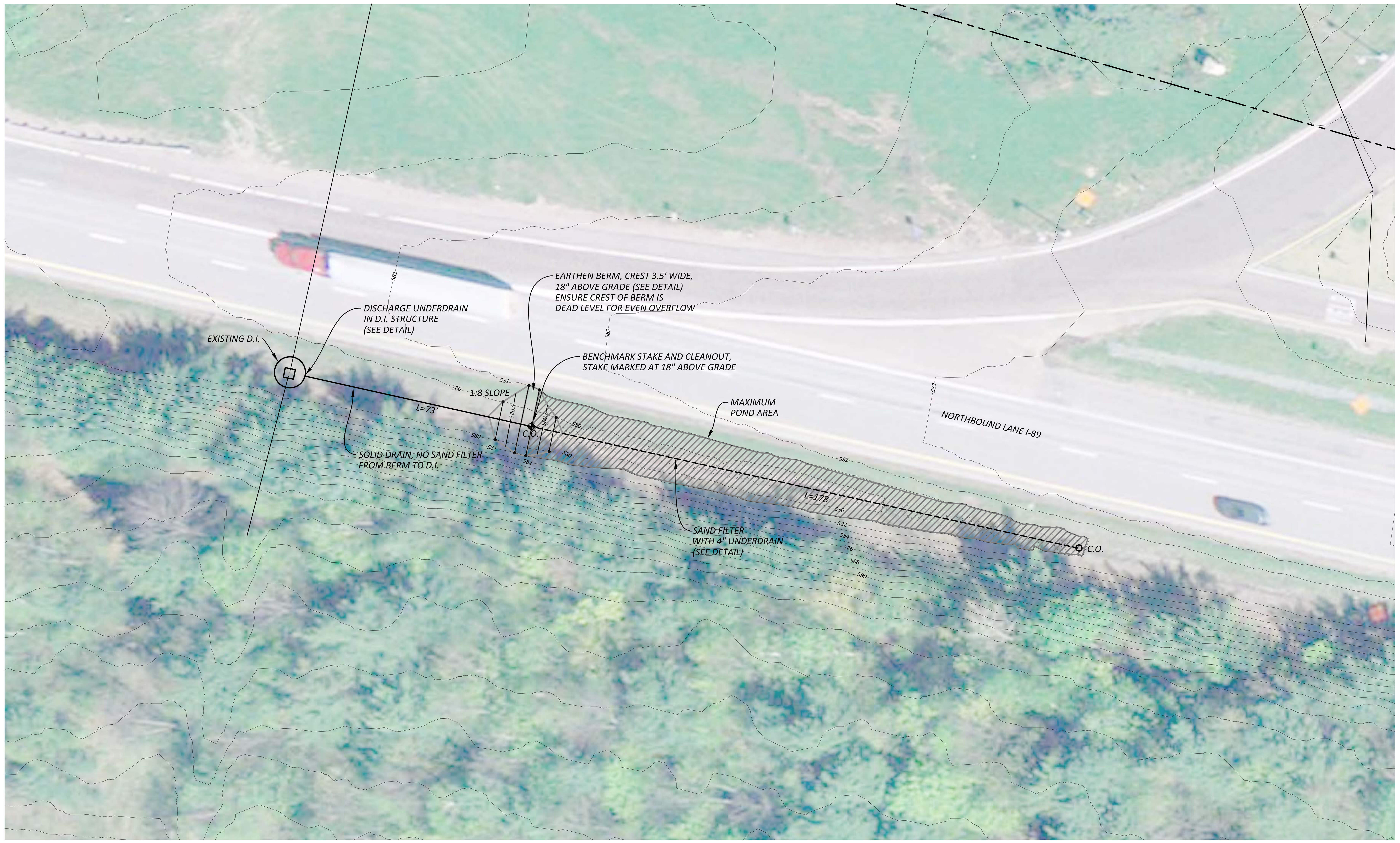
APPROVED BY:	AT
DATE:	9-27-12
SCALE:	NOTED
SHEET:	1 OF

WATERSHED CONSULTING ASSOCIATES, LLC

P.O. BOX 1085
WAITSFIELD, VT 05673
P: (802) 496-5130 F: (802) 496-5131
www.watershedca.com

"specializing in stormwater management and erosion-sediment control"

P:\VTRANS WILLISTON MEDIAN\BASE PLAN-FEET.dwg

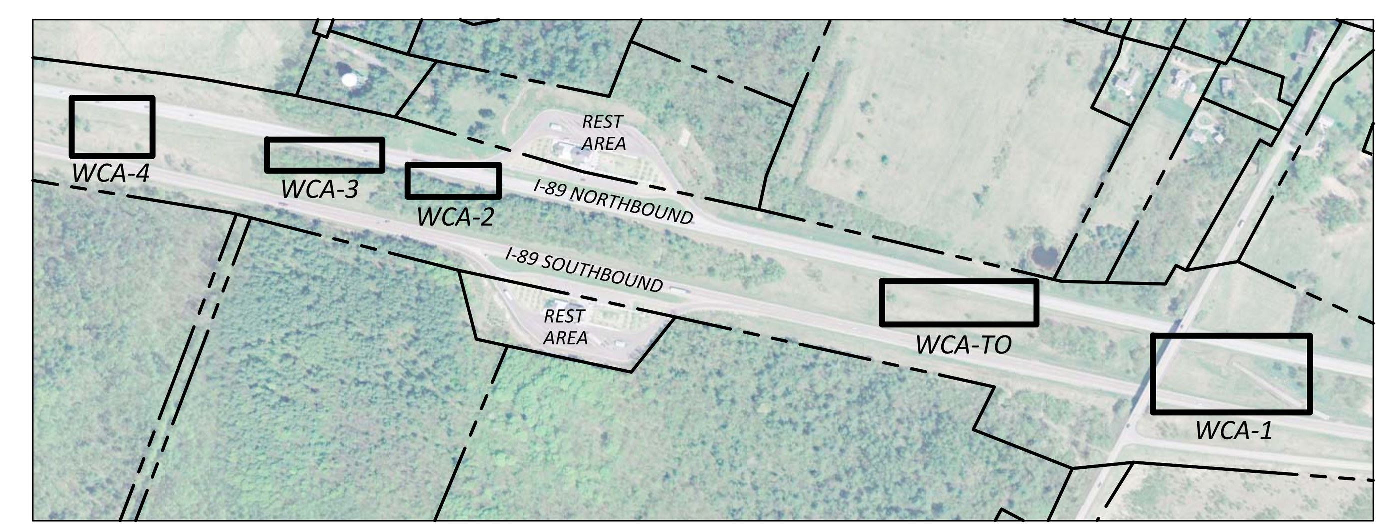


LOOKING UP SWALE FROM OUTLET

GRAPHIC SCALE

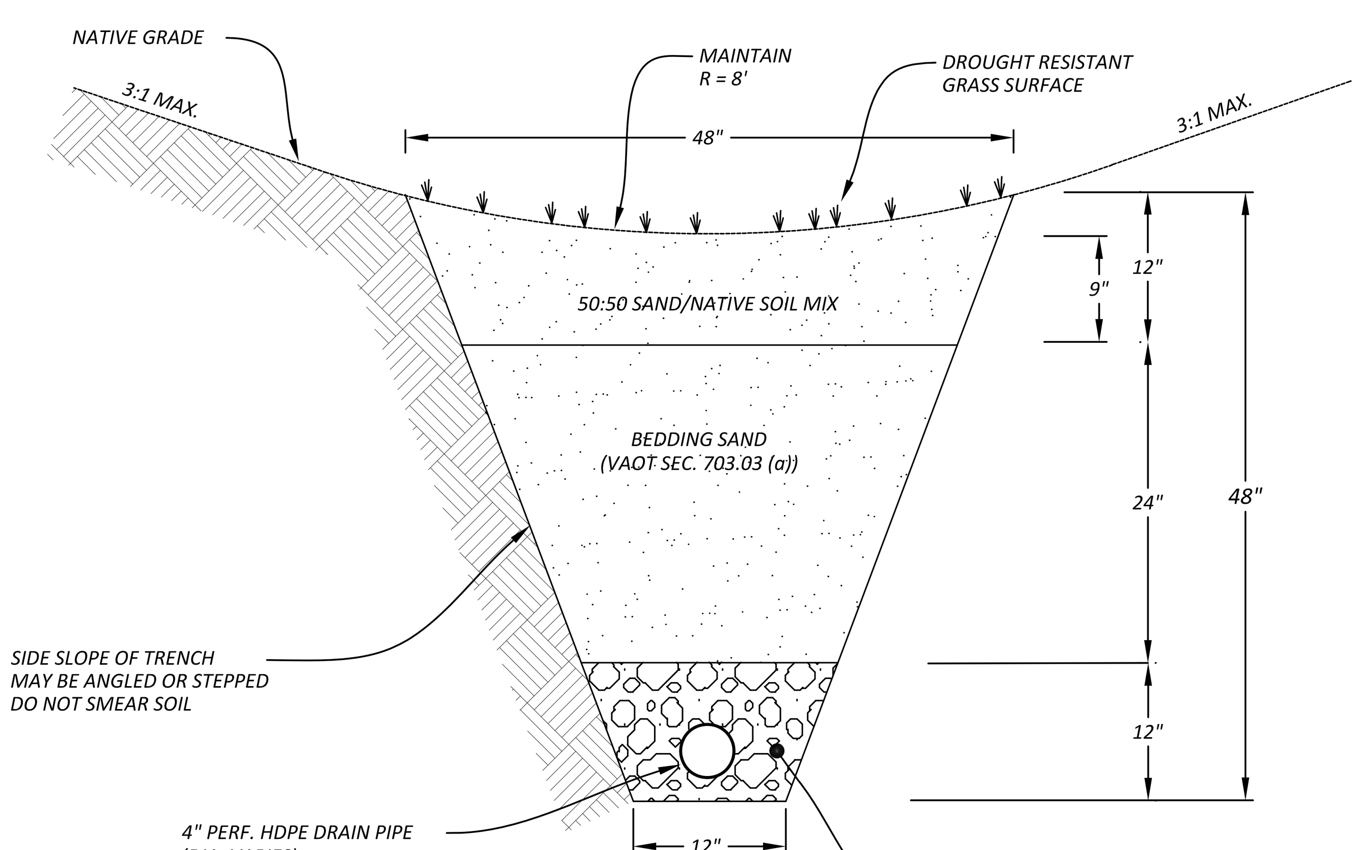
20 0 10 20 40 80

(IN FEET)
1 inch = 20 ft.



SHEET INDEX

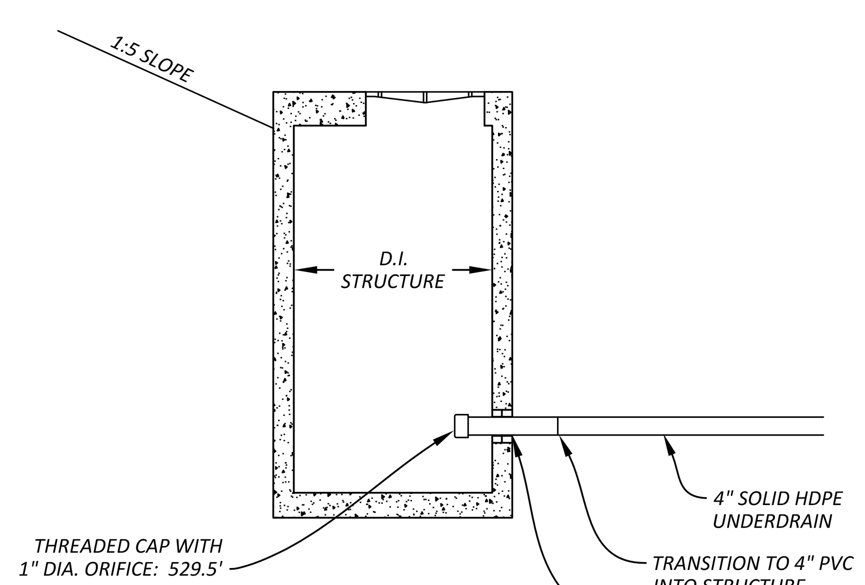
NTS



SAND AREA = 8.5 SF
STONE AREA = 0.8 SF

SAND FILTER/UNDERDRAIN SECTION

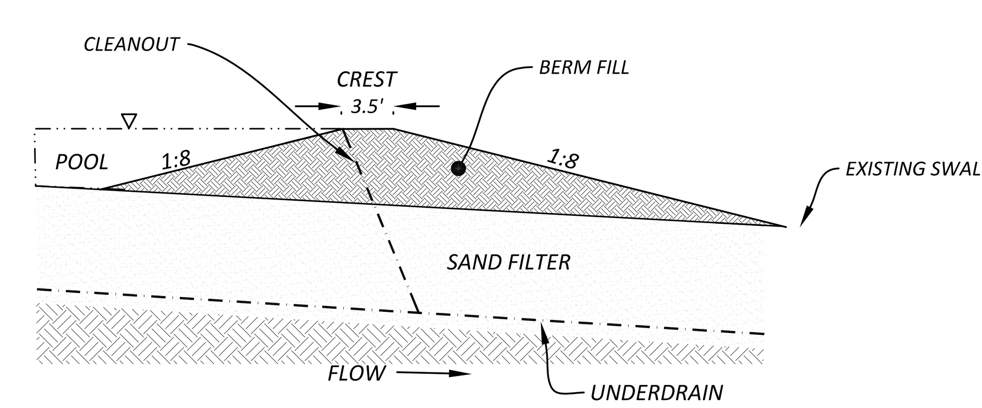
1" = 1'



SECTION VIEW

D.I. DRAIN CORING DETAIL

NTS



NOTE:
BERM FILL MUST BE COMPACTED IN 6" LIFTS TO ENSURE NO SETTLING SO AS TO MAINTAIN DEAD LEVEL LIP ON BERM.

EARTH BERM DETAIL

NTS

VTRANS MEDIAN STORMWATER UPGRADE

WILLISTON, VERMONT

LAYOUT PLAN - WCA-2

LAKESIDE ENVIRONMENTAL GROUP
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BURLINGTON, VT 05406
P: (802) 489-5214
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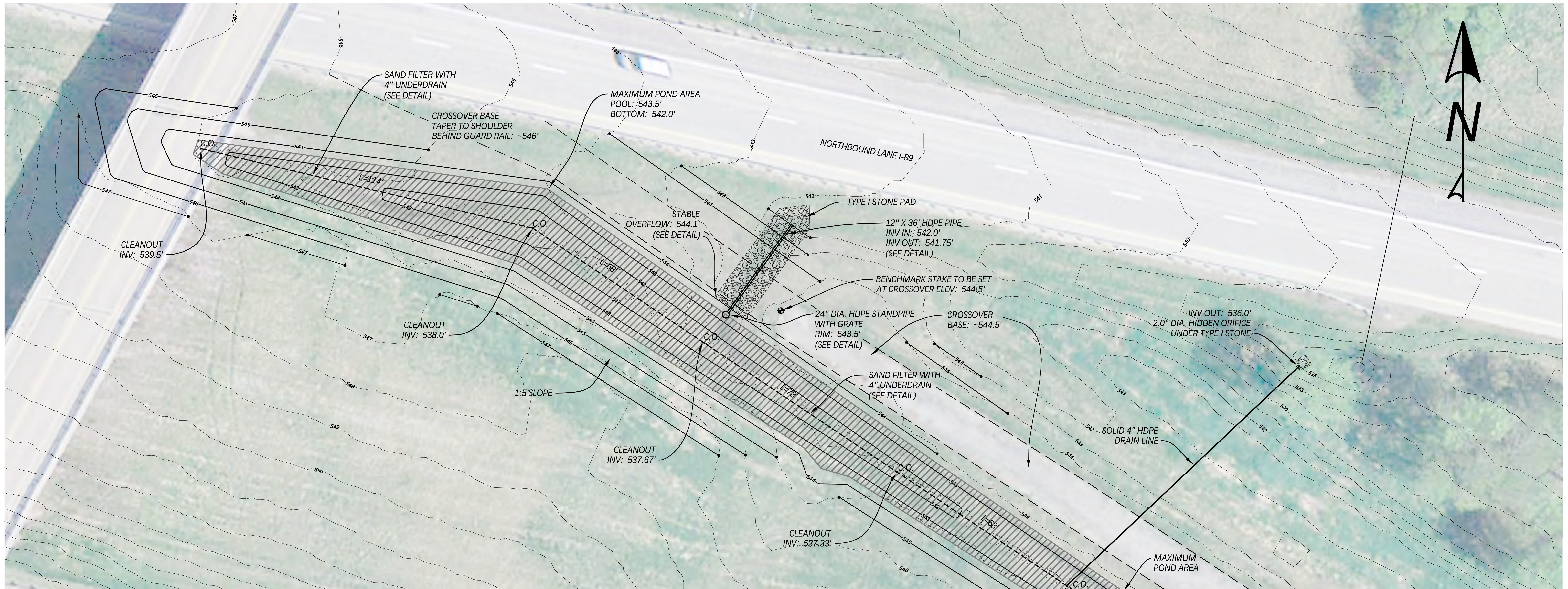
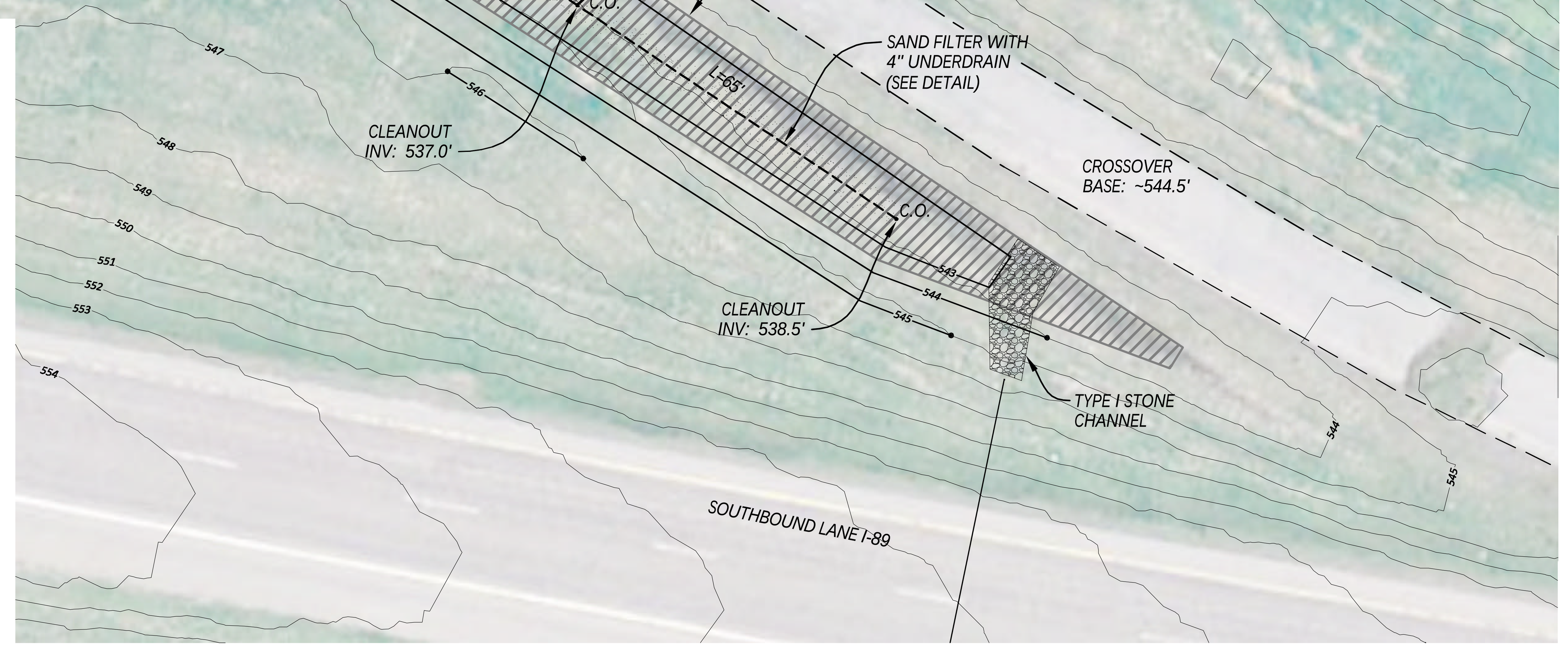
P:\VTRANS WILLISTON MEDIAN\BASE PLAN-FEET.dwg

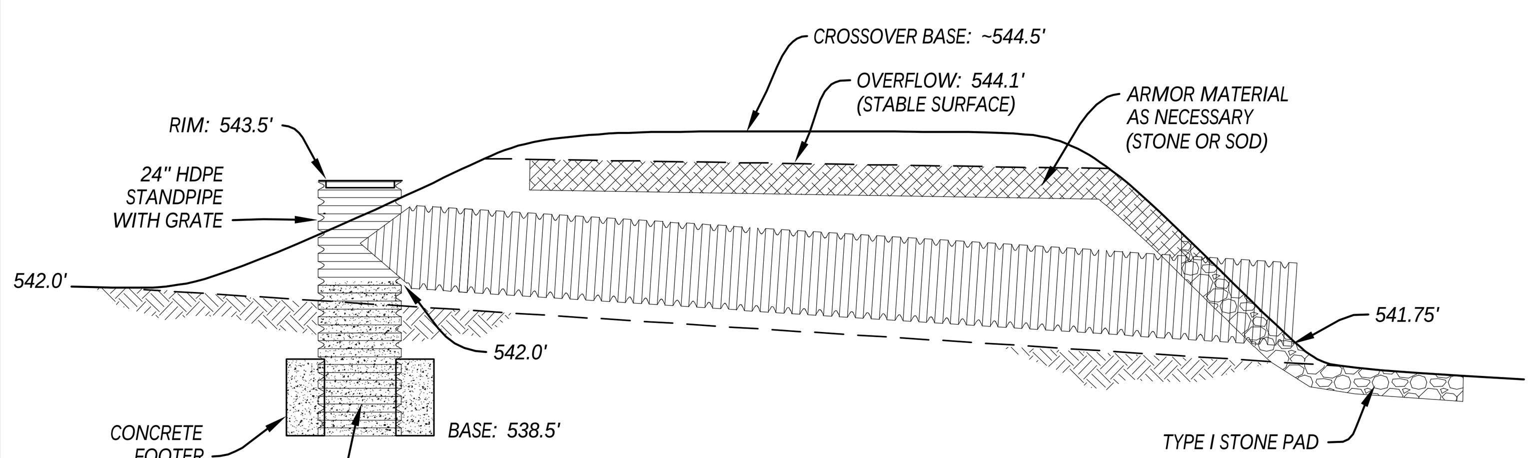




LOOKING DOWN EAST SWALE ALONG CROSSOVER

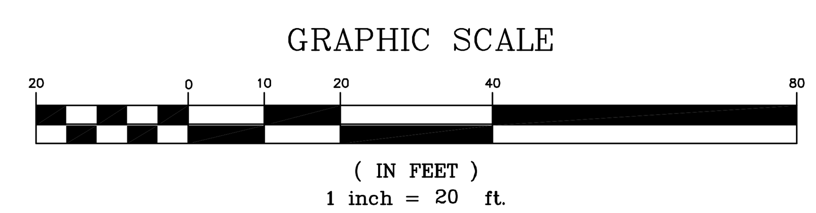
OUTLET

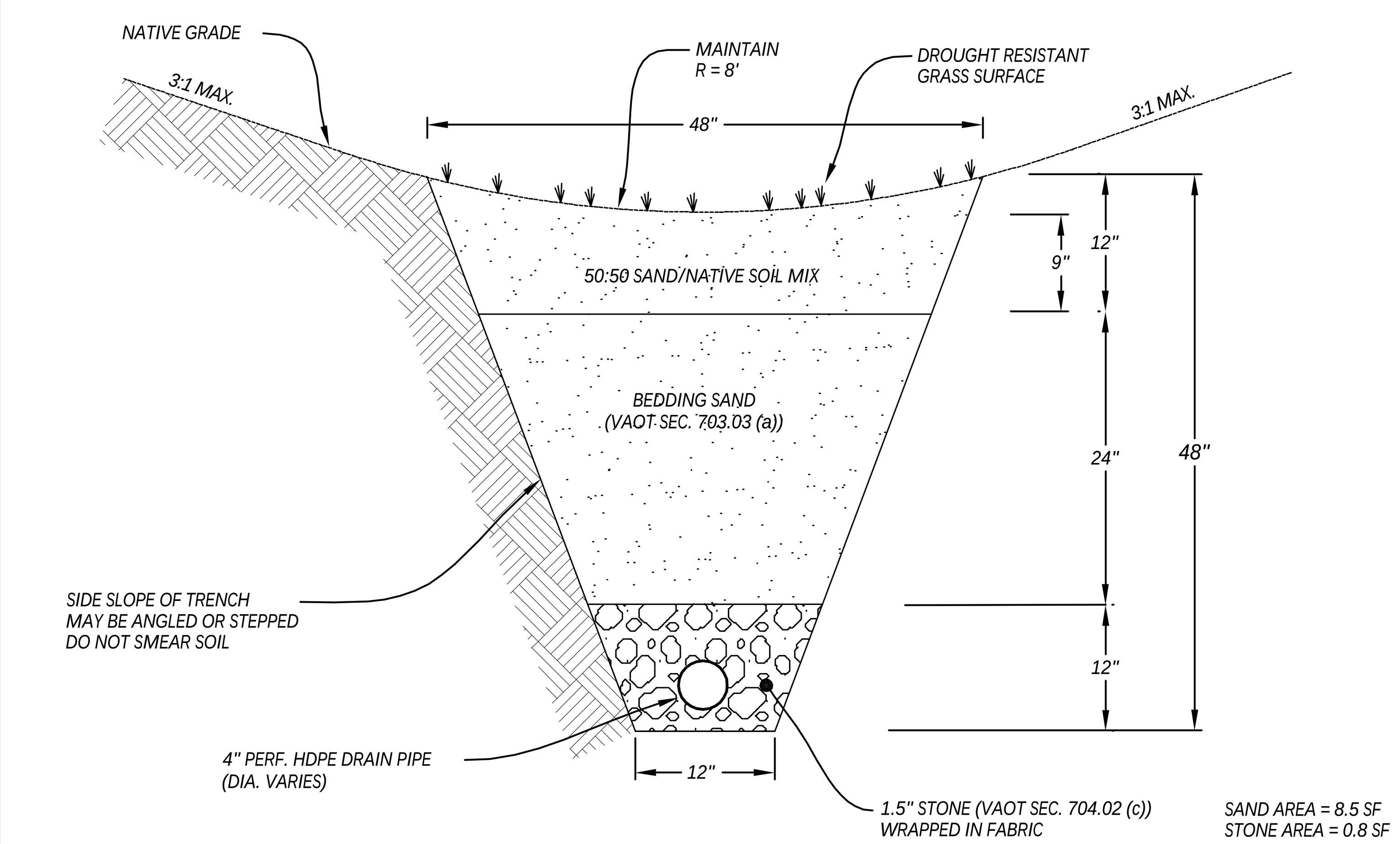
LOOKING UP WEST SWALE FROM CROSSOVER



WCA-1 OUTLET DETAIL

NTS





SAND FILTER/UNDERDRAIN SECTION

1" = 1'

SHEET INDEX

NTS

VTRANS MEDIAN STORMWATER UPGRADE

WILLISTON, VERMONT

LAYOUT PLAN - WCA-1

LAKESIDE ENVIRONMENTAL GROUP

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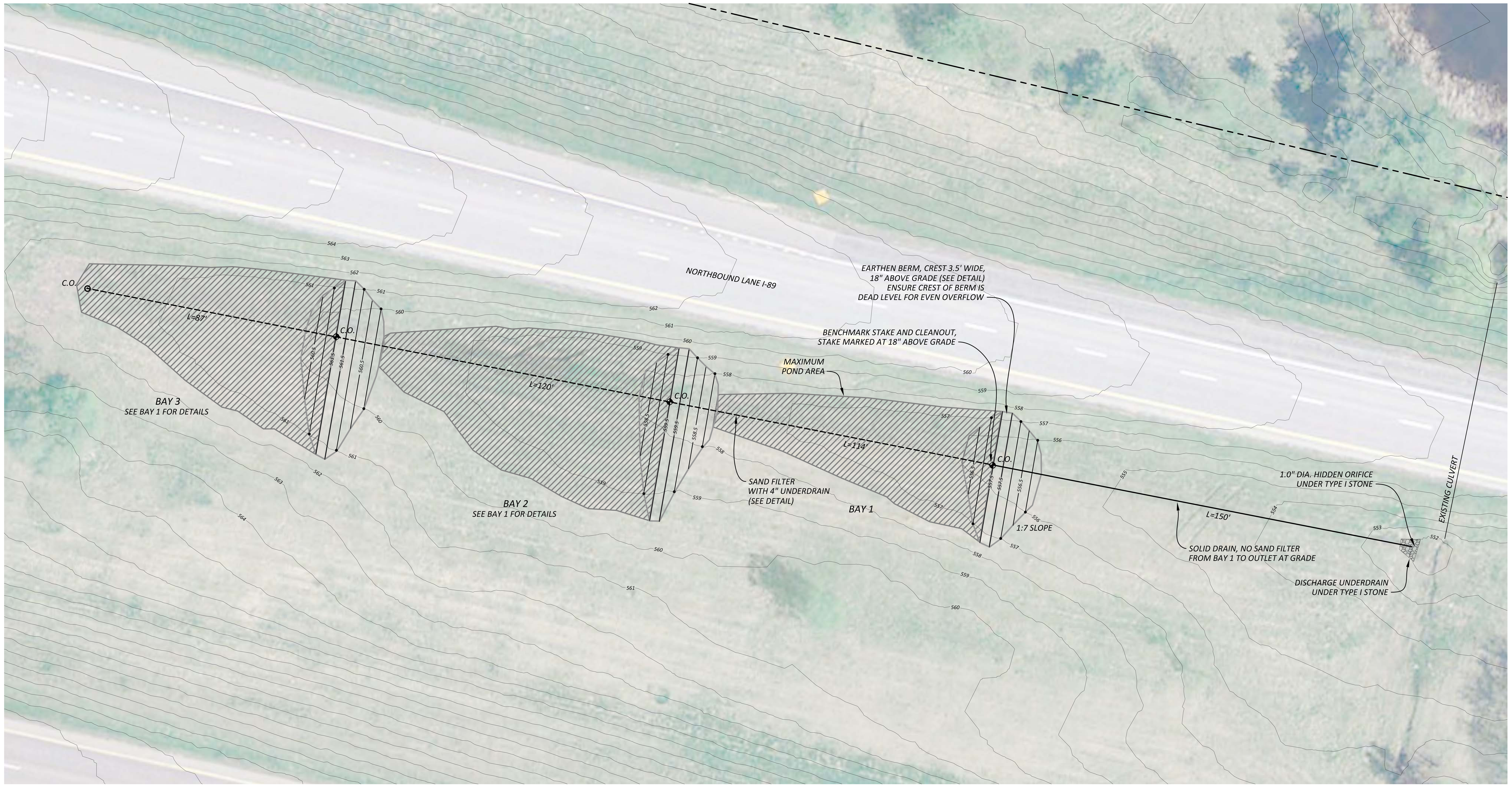
P:\VTRANS WILLISTON MEDIAN\BASE PLAN-FEET.dwg



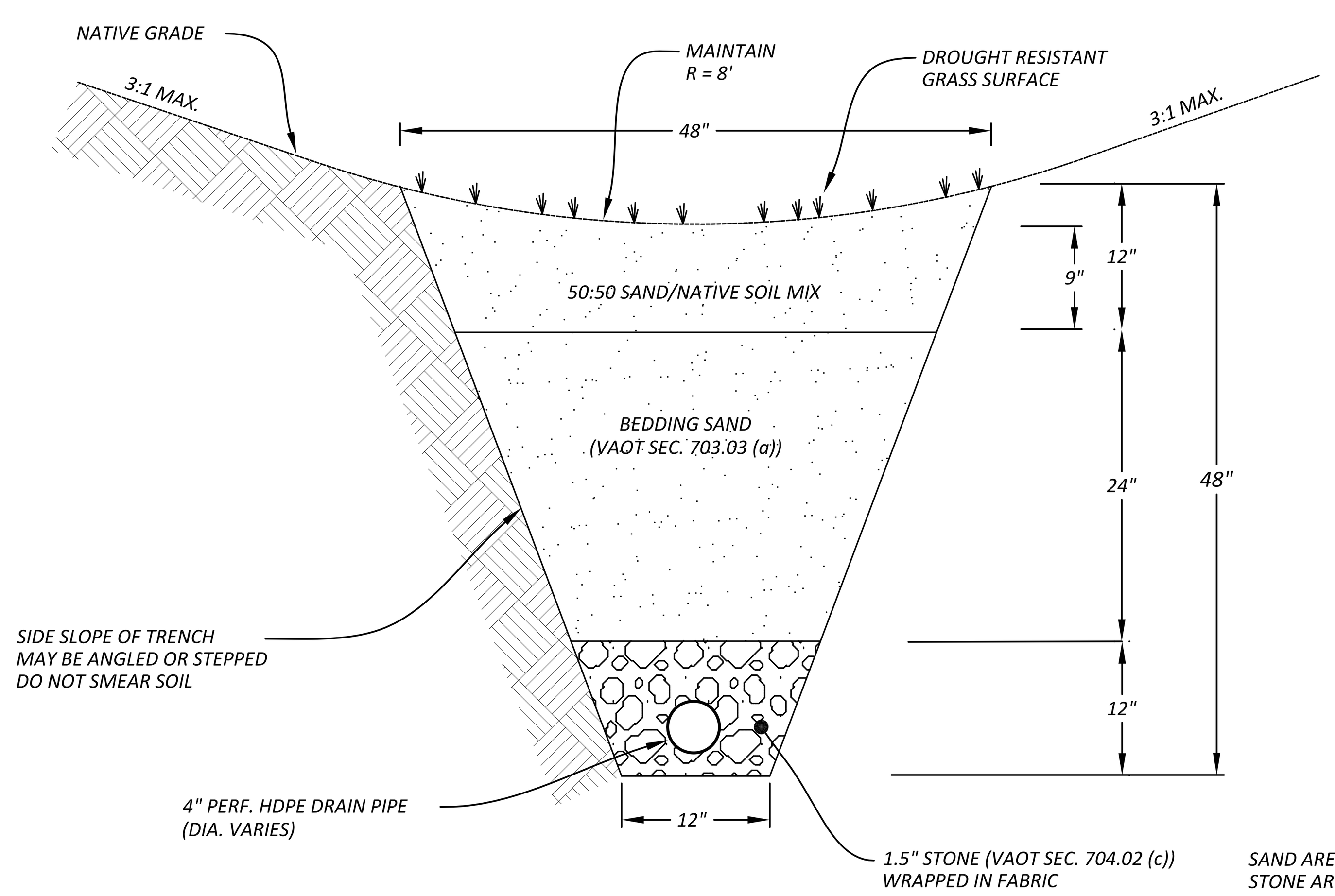
GRAPHIC SCALE

20 0 10 20 40 80

(IN FEET)
1 inch = 20 ft.

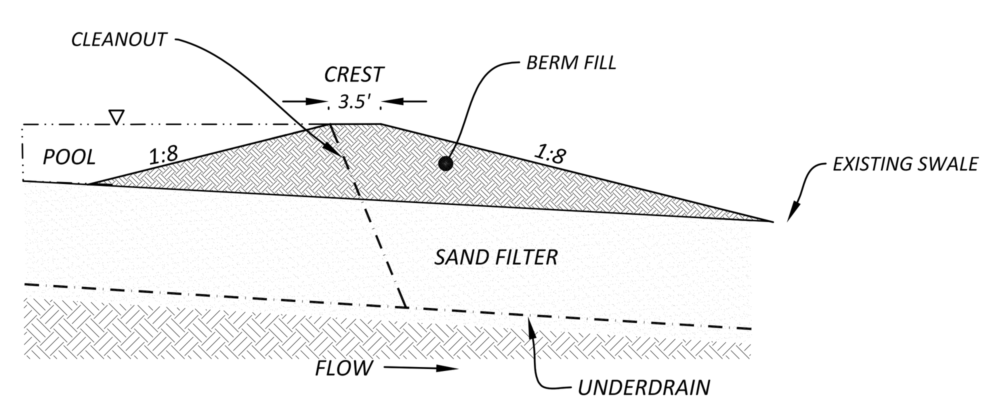
OUTLET

LOOKING UP SWALE FROM OUTLET



SAND FILTER/UNDERDRAIN SECTION

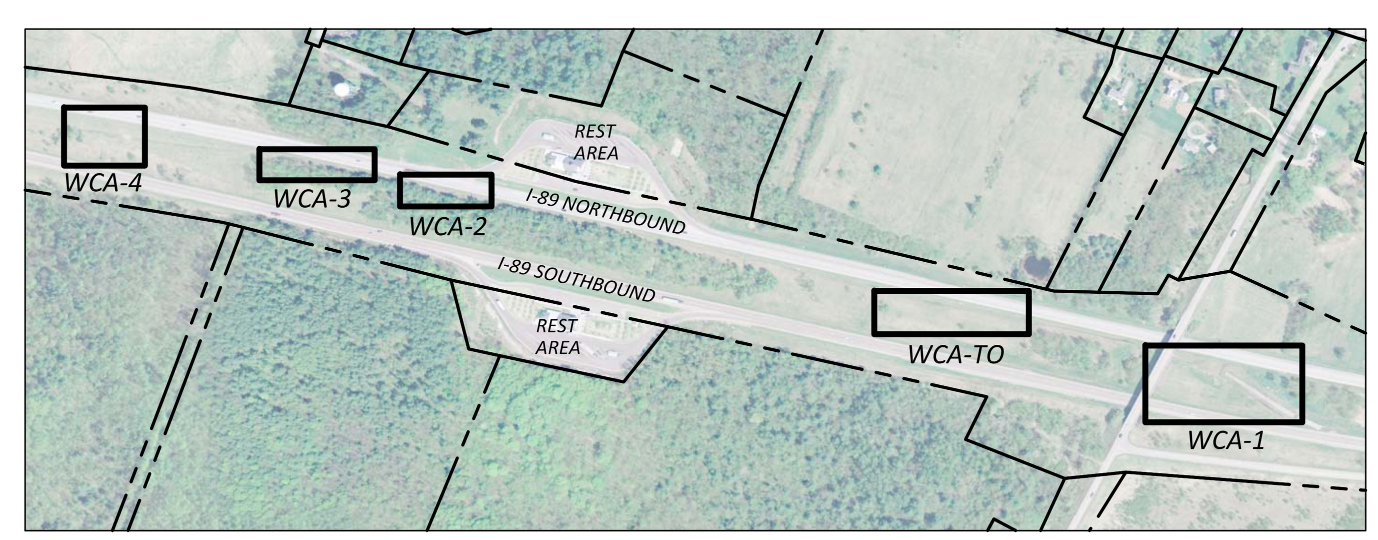
1" = 1'



NOTE:
BERM FILL MUST BE COMPACTED IN 6" LIFTS TO ENSURE NO SETTLING SO AS TO MAINTAIN DEAD LEVEL LIP ON BERM.

EARTH BERM DETAIL

NTS



SHEET INDEX

NTS

VTRANS MEDIAN STORMWATER UPGRADE

WILLISTON, VERMONT

LAYOUT PLAN - WCA-TO

LAKESIDE ENVIRONMENTAL GROUP

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DATE:	9-27-12
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SHEET: 1	OF

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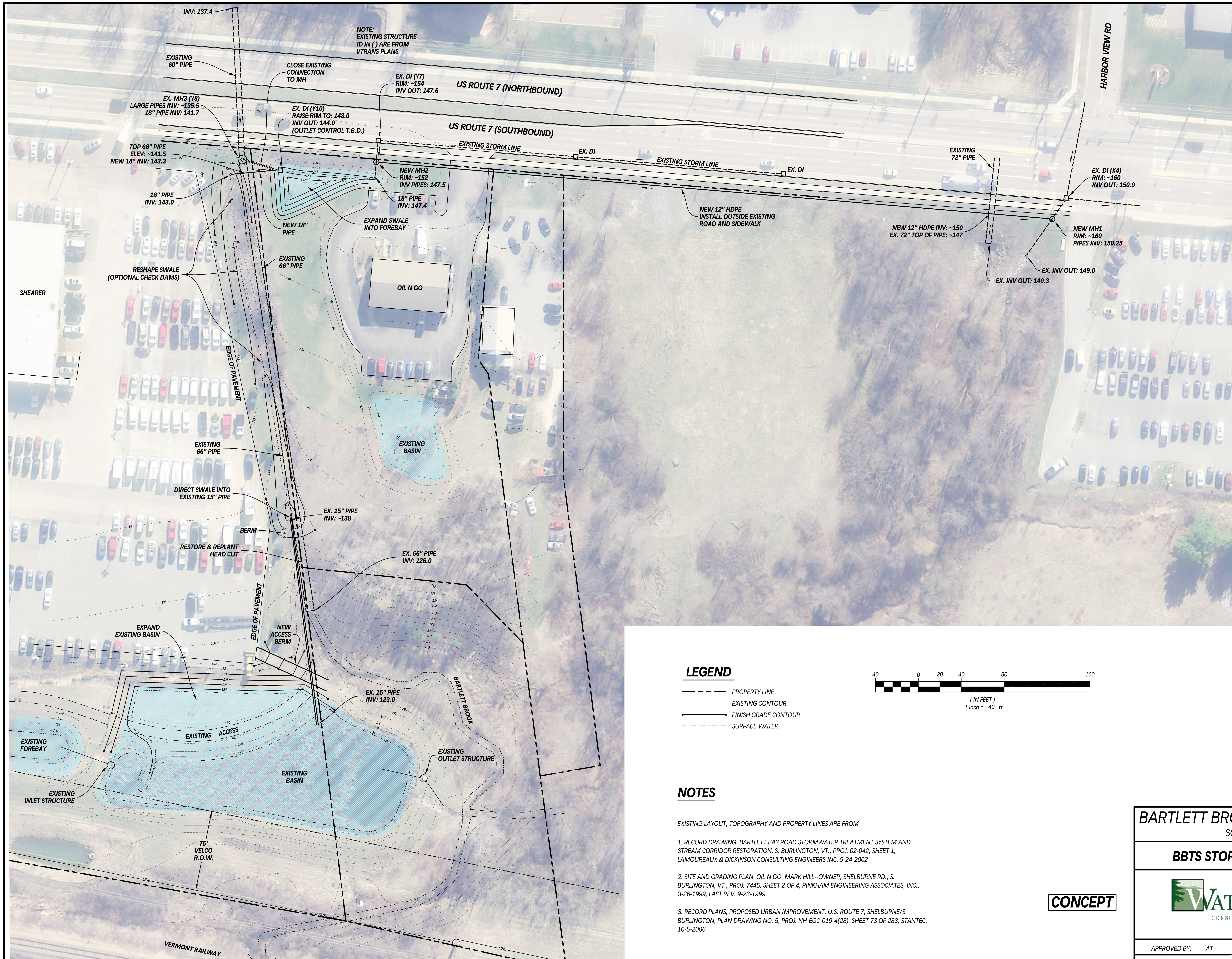

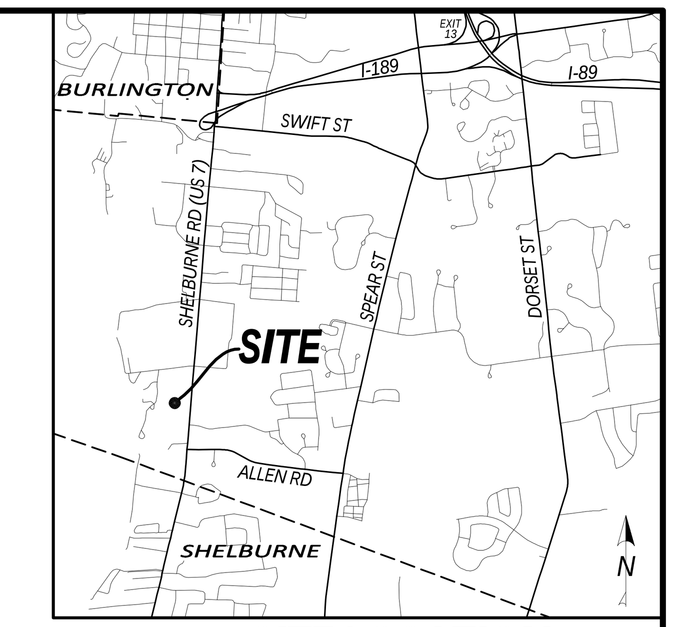

SITE LOCATION

NTS

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- FINISH GRADE CONTOUR
- SURFACE WATER

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.

NOTES

EXISTING LAYOUT, TOPOGRAPHY AND PROPERTY LINES ARE FROM

1. RECORD DRAWING, BARTLETT BAY ROAD STORMWATER TREATMENT SYSTEM AND STREAM CORRIDOR RESTORATION, S. BURLINGTON, VT., PROJ. 02-042, SHEET 1, LAMOUREAUX & DICKINSON CONSULTING ENGINEERS INC. 9-24-2002

2. SITE AND GRADING PLAN, OIL N GO, MARK HILL--OWNER, SHELBURNE RD., S. BURLINGTON, VT., PROJ. 7445, SHEET 2 OF 4, PINKHAM ENGINEERING ASSOCIATES, INC., 3-26-1999, LAST REV. 9-23-1999

3. RECORD PLANS, PROPOSED URBAN IMPROVEMENT, U.S. ROUTE 7, SHELBURNE/S. BURLINGTON, PLAN DRAWING NO. 5, PROJ. NH-EGC-019-4(28), SHEET 73 OF 283, STANTEC, 10-5-2006

CONCEPT

BARTLETT BROOK FLOW RESTORATION PLAN

SOUTH BURLINGTON, VERMONT

BBTS STORMWATER IMPROVEMENT PLAN

WATERSHED CONSULTING ASSOCIATES, LLC
Stormwater Management | Water Quality | Erosion Control
430 Shelburne Road P.O. Box 4413
Burlington, VT 05406
Mobile: 802.922.4871 | Main: 802.497.2367
www.watershedca.com

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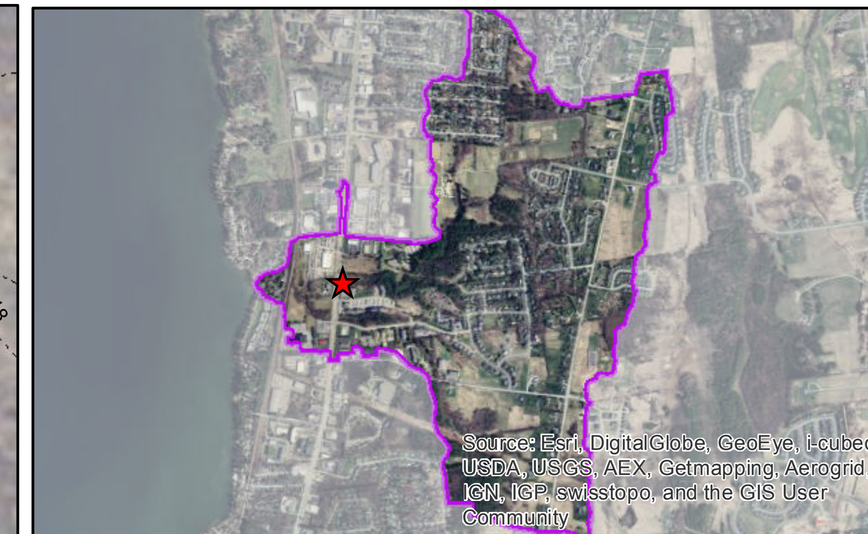
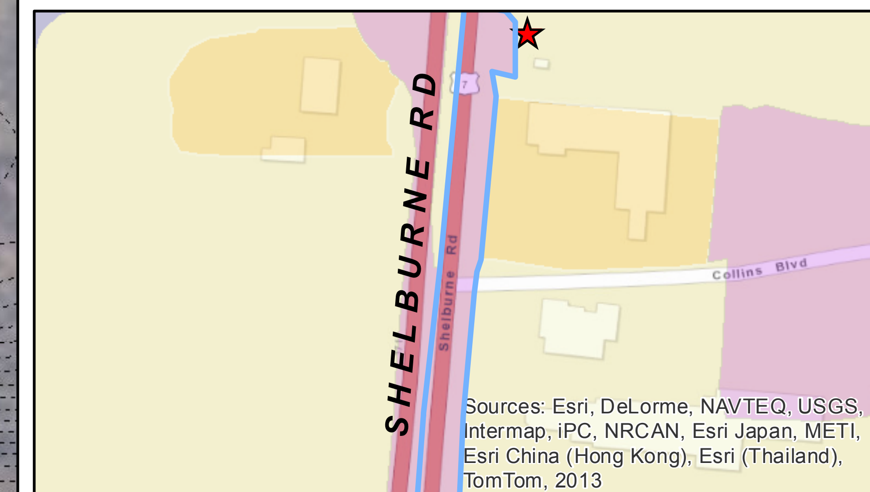
DATE:	12-15-14	CHECKED BY:	AT	SHEET:	1 OF 1





LEGEND

- PROPOSED RETROFIT SITE
- PROPOSED STORM MANHOLE
- PROPOSED OUTLET
- PROPOSED STORMLINE
- Proposed Underground Detention Chamber
- PROPERTY LINE
- EXISTING 1' CONTOUR
- CITY BOUNDARY
- Roads

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

NOTES:

The proposed Shelburne Rd/Route 7 BMP involves an underground detention chamber to mitigate the 1-year storm (CPv) volume. The existing outfall would be reset.

BARTLETT BROOK FLOW RESTORATION STUDY

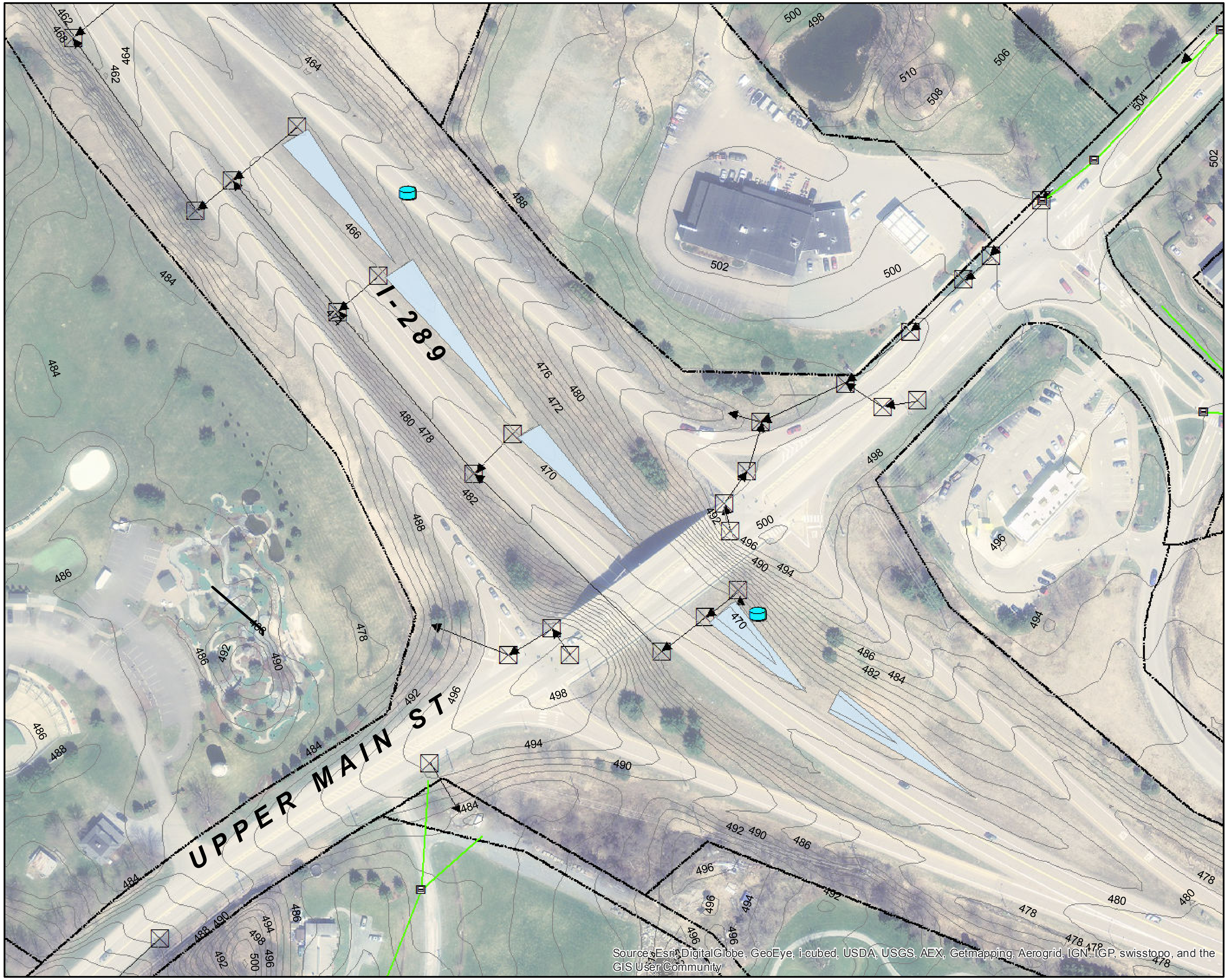
SOUTH BURLINGTON, VERMONT

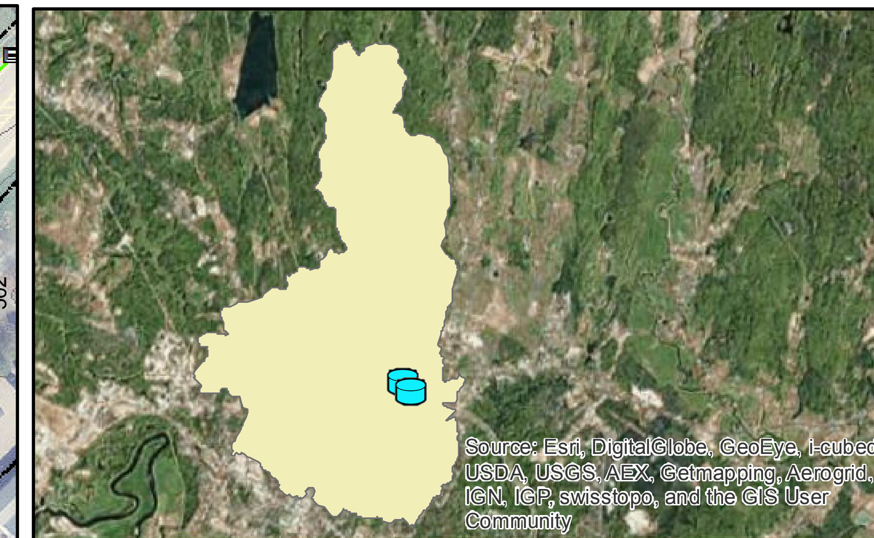
Shelburne Rd Detention Chamber BMP

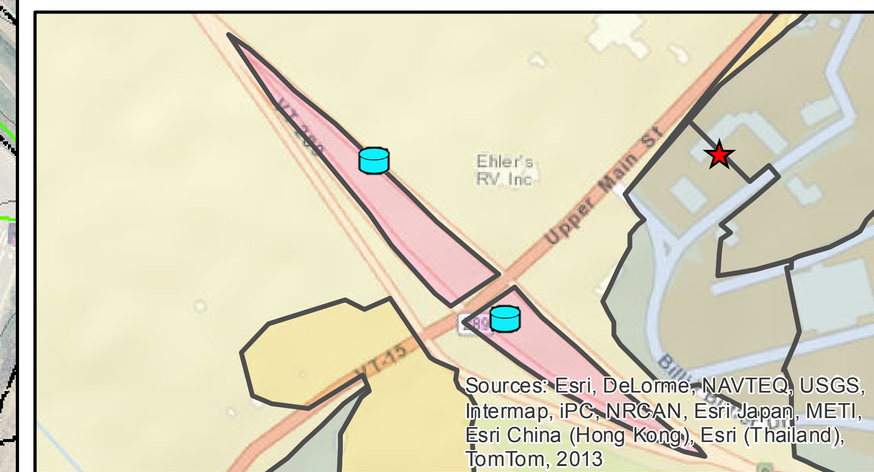
DATE: 12-12-14	DRAWN BY:JS	SCALE:NOTED

WATERSHED CONSULTING ASSOCIATES, LLC

0 40 80 Feet







LEGEND

- Proposed Retrofit
- Proposed Stormwater Sand Filter
- PROPERTY LINE
- EXISTING 2' CONTOUR
- DropInlets
- Culverts
- IssuedPermits_Indian

BMP Drainage Area

- Existing Post 2002
- Existing Pre 2002
- Proposed

NOTES:

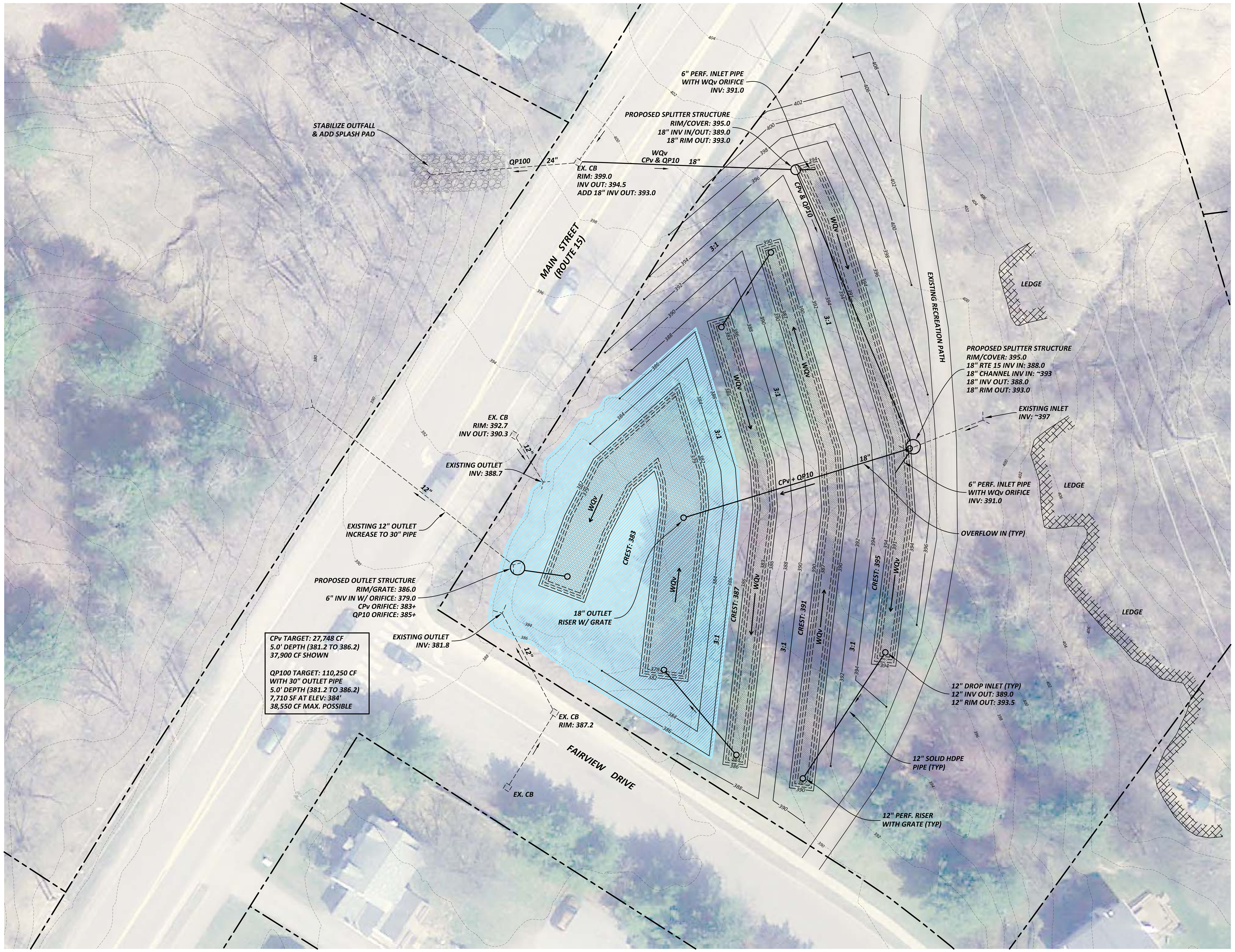
The proposed improvements include the installation of terraced sand filters, designed to provide surface ponding for the CPv storm and filtration through a 4' sand bed. A 4" underdrain controls flow from the filter. This type of filter has been installed in I-89 medians in St. Albans.

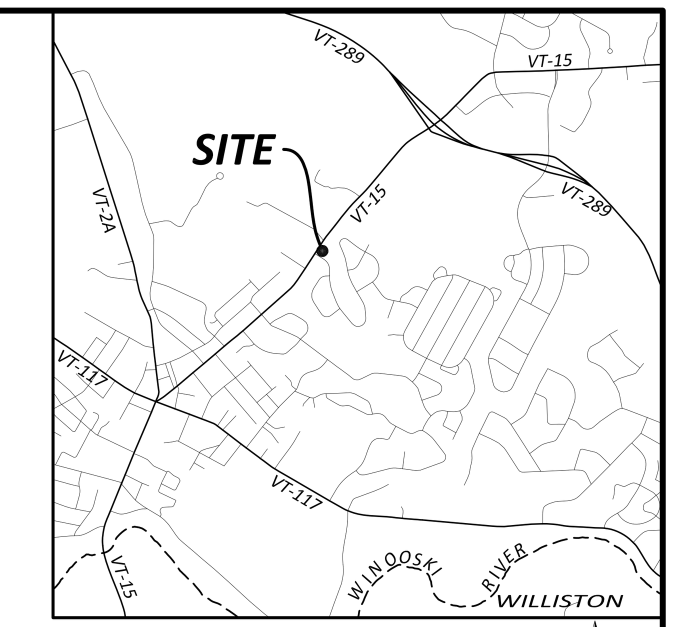
INDIAN BROOK FLOW RESTORATION STUDY		
ESSEX, VERMONT		
VTRANS I-289 Exit Ramp Stormwater Improvements		
DATE: 1-26-15	DRAWN BY:JS	SCALE:NOTED

0 40 80 160 240 320 400 480 Feet

N S

WATERSHED CONSULTING ASSOCIATES, LLC





SITE LOCATION
NTS

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- EXISTING STORM LINE
- PROPOSED STORM LINE
- DRAINAGE COURSE

NOTES

1. THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.
2. EXISTING TOPOGRAPHY WAS CREATED FROM CHITTENDEN COUNTY LiDAR (2004).

20 0 10 20 40 80
(IN FEET)
1 inch = 20 ft.

CONCEPT

INDIAN BROOK FLOW RESTORATION PLAN

ESSEX, VERMONT

FAIRVIEW DRIVE STORMWATER IMPROVEMENT PLAN

WATERSHED CONSULTING ASSOCIATES, LLC
Stormwater Management | Water Quality | Erosion Control
430 Shelburne Road P.O. Box 4413
Burlington, VT 05406
Mobile: 802.922.4871 | Main: 802.497.2367
www.watershedca.com

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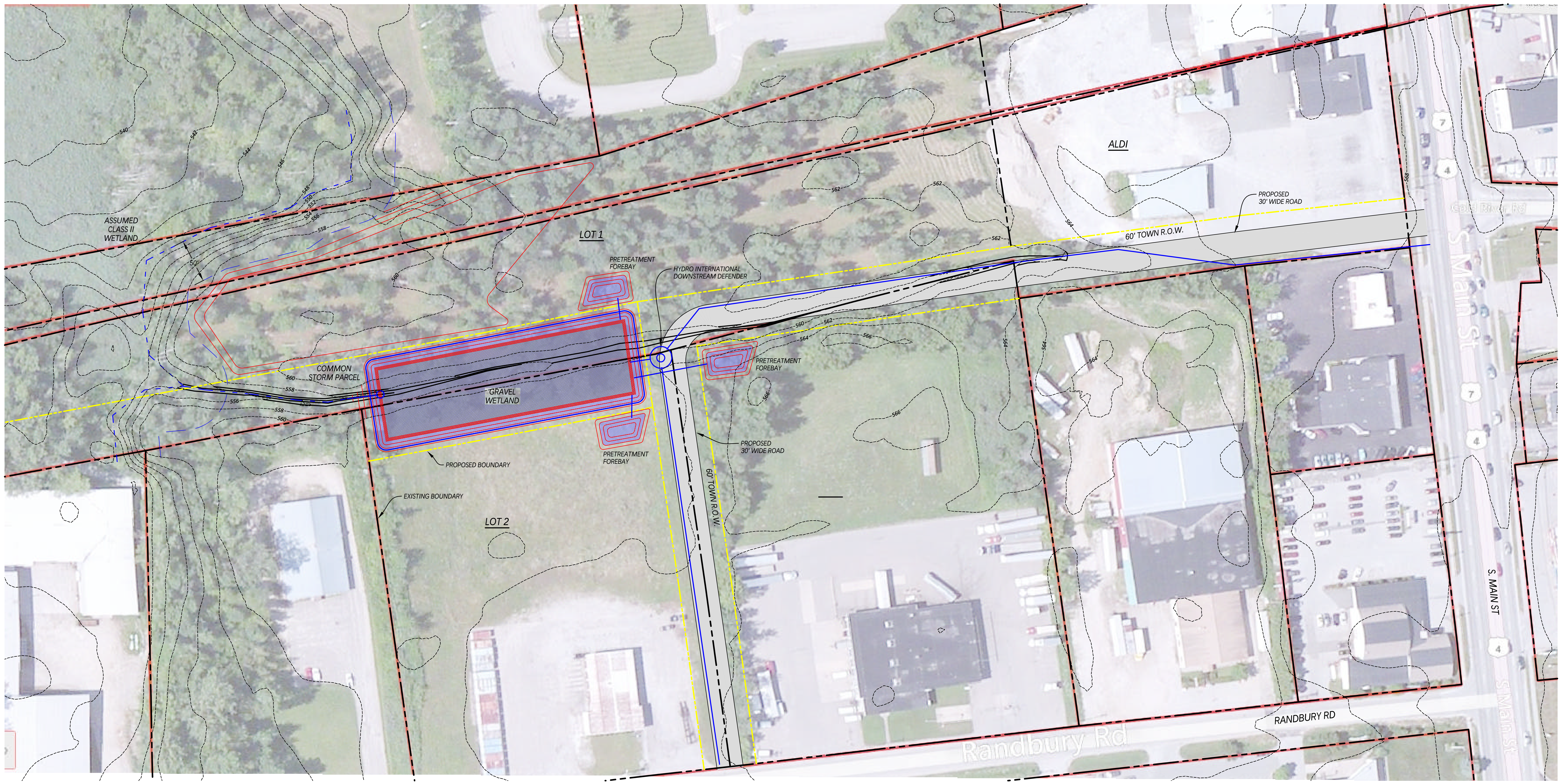
DATE: 1-28-15		CHECKED BY: AT		SHEET: 1 OF 1	



N

60 0 30 60 120 240

(IN FEET)
1 inch = 60 ft.

CONCEPT

VTRANS MOON BROOK FLOW RESTORATION PLAN

RUTLAND, VERMONT

RANDBURY ROAD BASIN

LAKESIDE ENVIRONMENTAL GROUP

P.O. BOX 4081
BURLINGTON, VT 05406
P: (802) 489-5214
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APPROVED BY:	AT
DATE:	9-26-13
SCALE:	NOTED
SHEET:	1 OF 1

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WAITSFIELD, VT 05673
P: (802) 496-5130 F: (802) 496-5131
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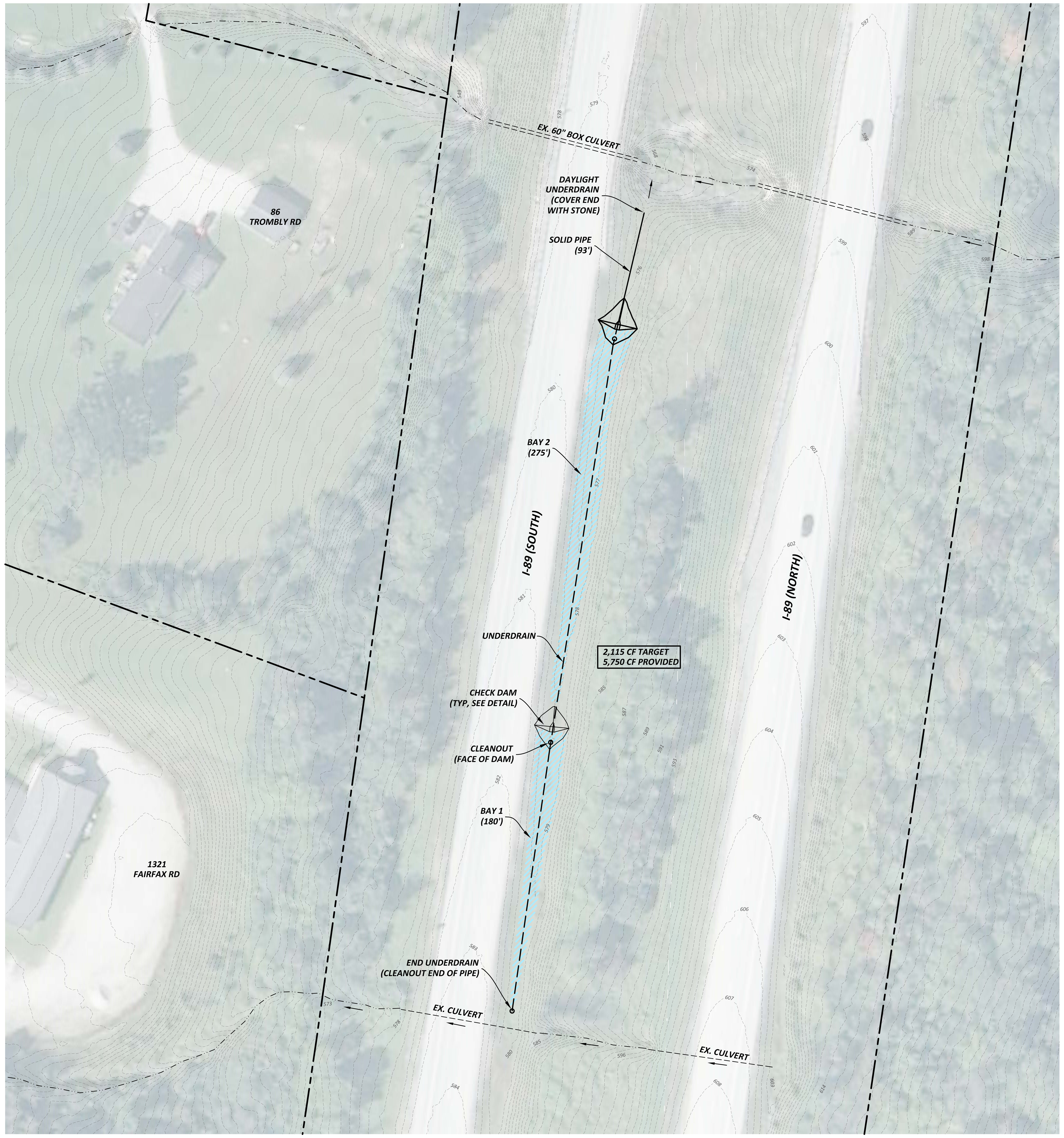
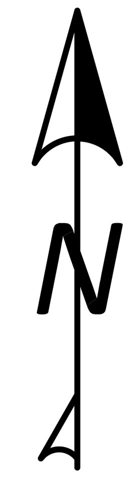
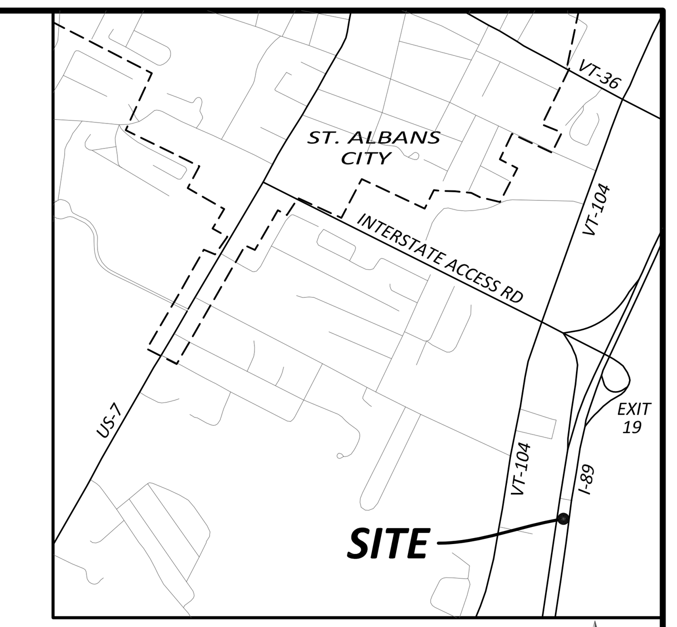
"specializing in stormwater management and erosion-sediment control"

P:\VTRANS MOON REMEDIATION\MOON BROOK.dwg

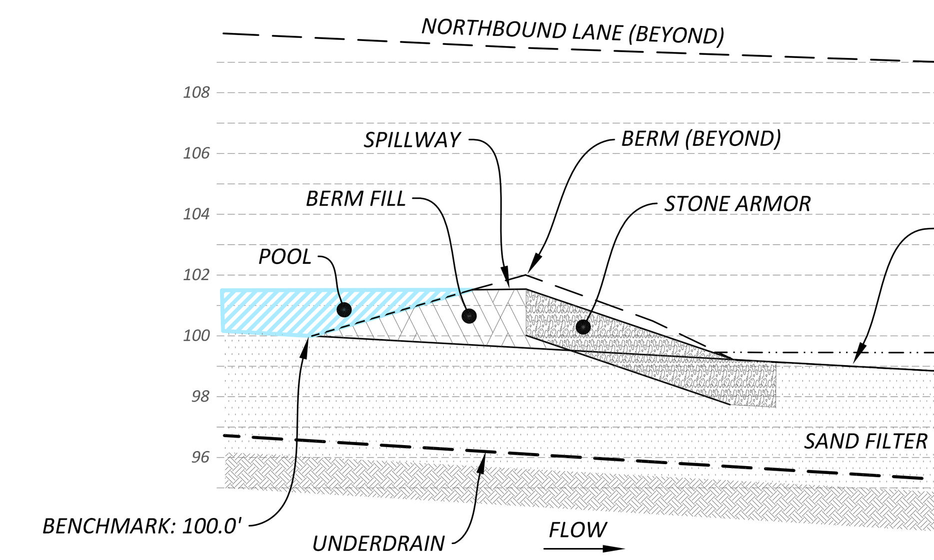




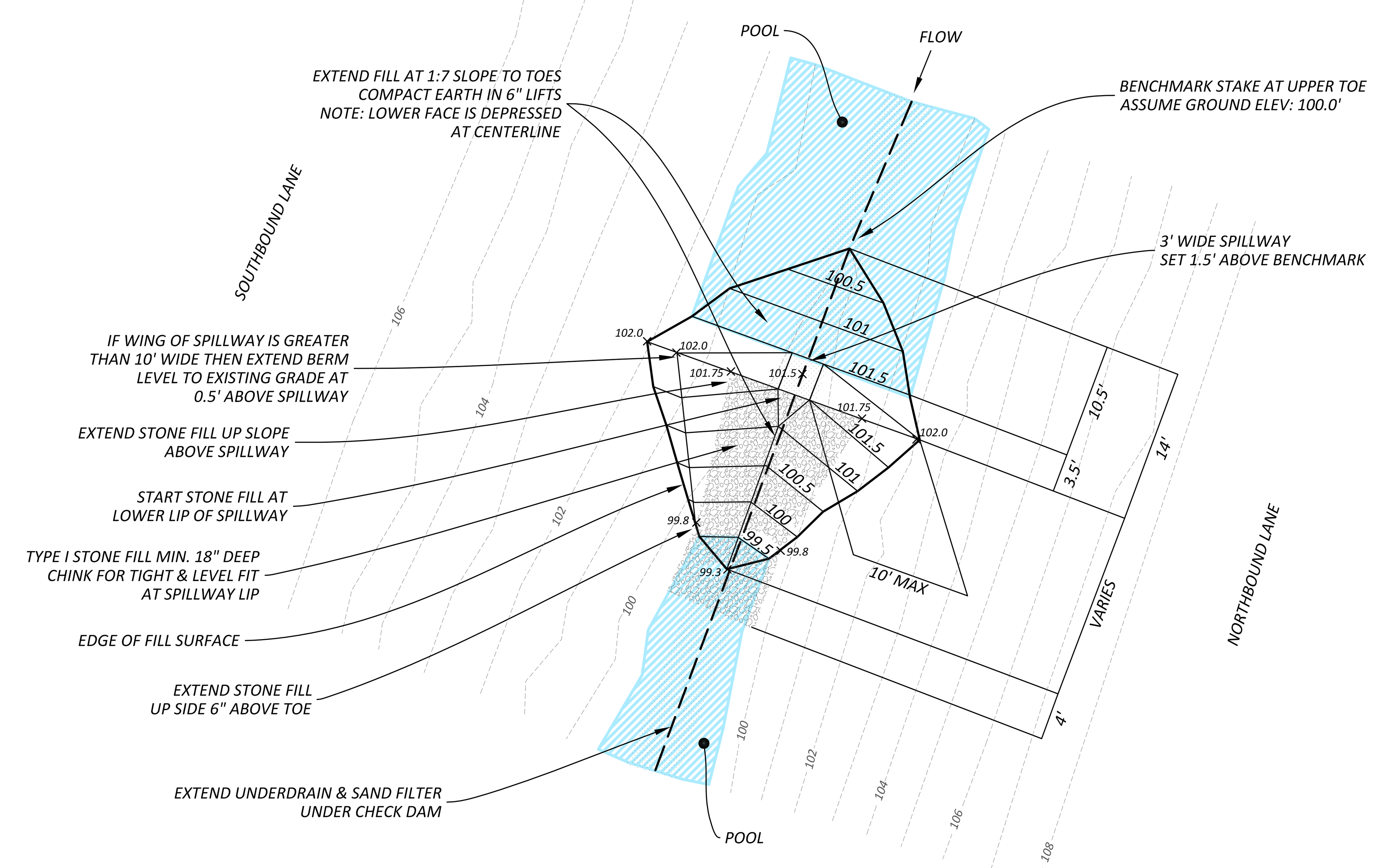


SITE LOCATION

NTS



SECTION ALONG FLOW PATH



TYPE I STONE DEFINITION:
THE LONGEST DIMENSION OF STONE SHALL VARY FROM 1-INCH TO 12-INCHES, AND AT LEAST 50 PERCENT OF THE VOLUME OF THE STONE IN PLACE SHALL HAVE AT LEAST A DIMENSION OF 4-INCHES.

PLAN VIEW

CHECK DAM DETAIL

NTS

NOTES

1. THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.
2. EXISTING TOPOGRAPHY WAS CREATED FROM ROCK RIVERLiDAR (2008).

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- EXISTING STORM LINE
- PROPOSED UNDERDRAIN
- DRAINAGE FLOW PATH

CONCEPT

RUGG BROOK FLOW RESTORATION PLAN

ST. ALBANS, VERMONT

INTERSTATE MEDIAN SITE 280 STORMWATER IMPROVEMENT PLAN

WATERSHED CONSULTING ASSOCIATES, LLC
Stormwater Management | Water Quality | Erosion Control
430 Shelburne Road P.O. Box 4413
Burlington, VT 05406
Mobile: 802.922.4871 | Main: 802.497.2367
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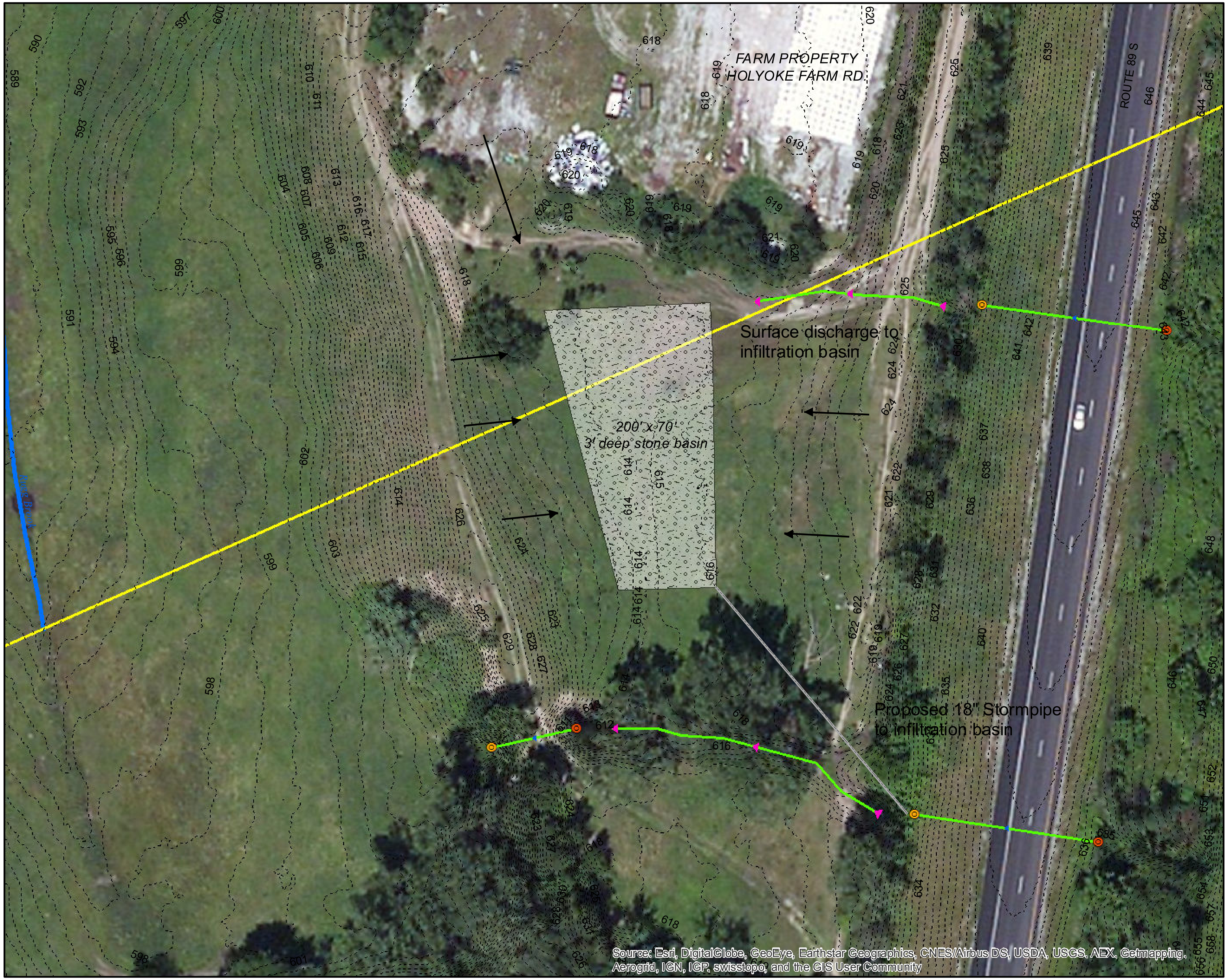
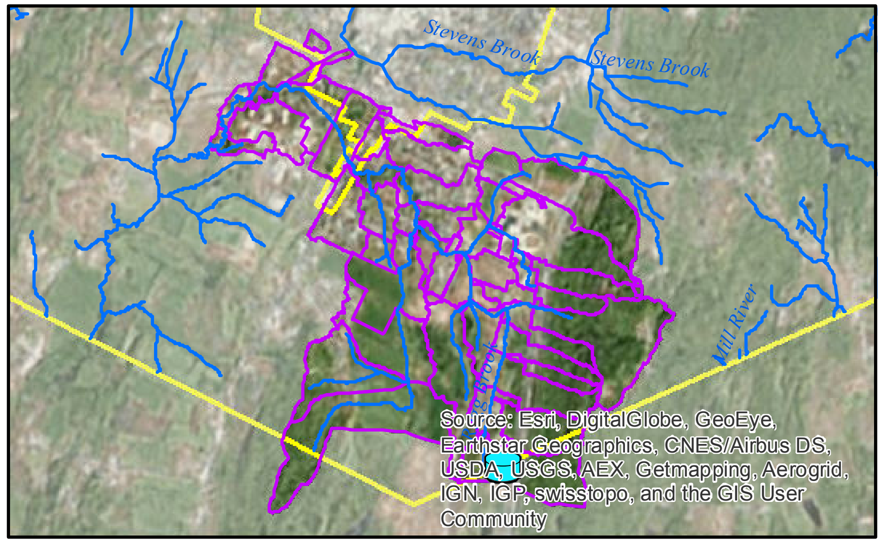
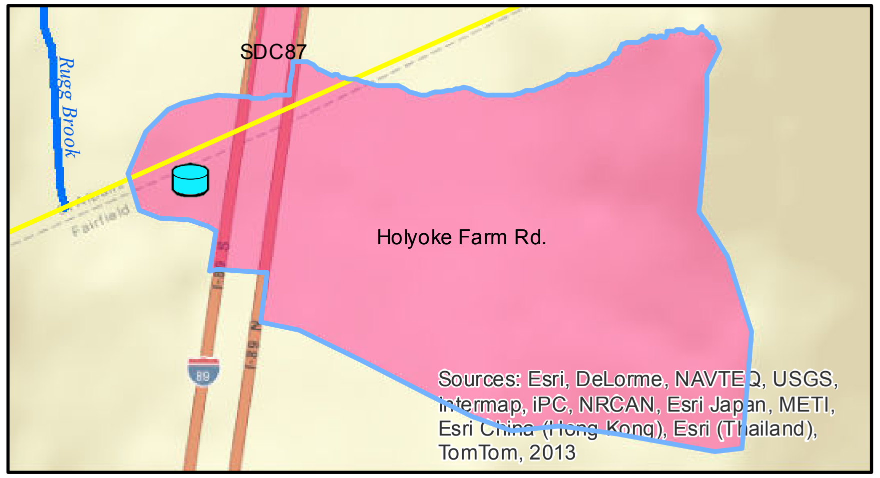






LEGEND

- Proposed Storm Pipe
- Storm line
- Swale
- EXISTING 1' CONTOUR
- Proposed Infiltration Basin
- city_town_BNDS
- Stormwater Permit

BMP Drainage Area

- Proposed Retrofit
- Proposed New
- Existing Post 2002
- Existing Pre 2002
- Rugg Brook

The proposed retrofit is an infiltration basin on the back lot of an active farm, off Holyoke Farm Rd. The BMP would mitigate runoff from two I-89 culverts, as well as a portion of the farm. The proposed basin is a 3 foot deep stone basin, with surface ponding storage. The surface could either be left as stone, or reseeded with grass for ease of maintenance. The depth to groundwater needs to be verified. This project has opportunity to also address potential BMP requirements on the Farm to comply with the Lake Champlain Phosphorus TMDL.

1 inch = 67 feet

0 40 80 160 240 Feet

N S

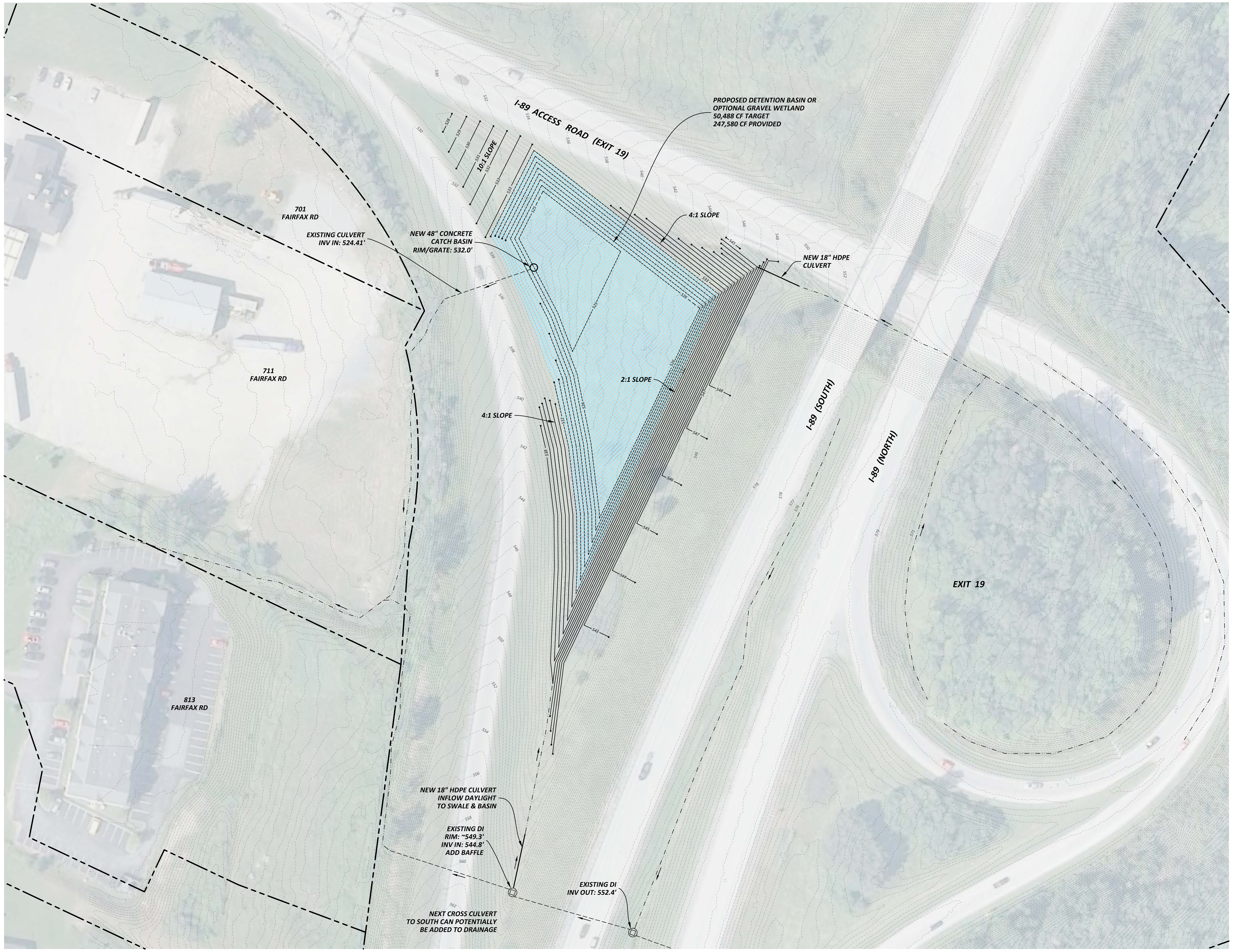
WATERSHED CONSULTING ASSOCIATES, LLC

RUGG BROOK FLOW RESTORATION STUDY

ST. ALBANS, VERMONT

I-89/Holyoke Farm Infiltration Basin

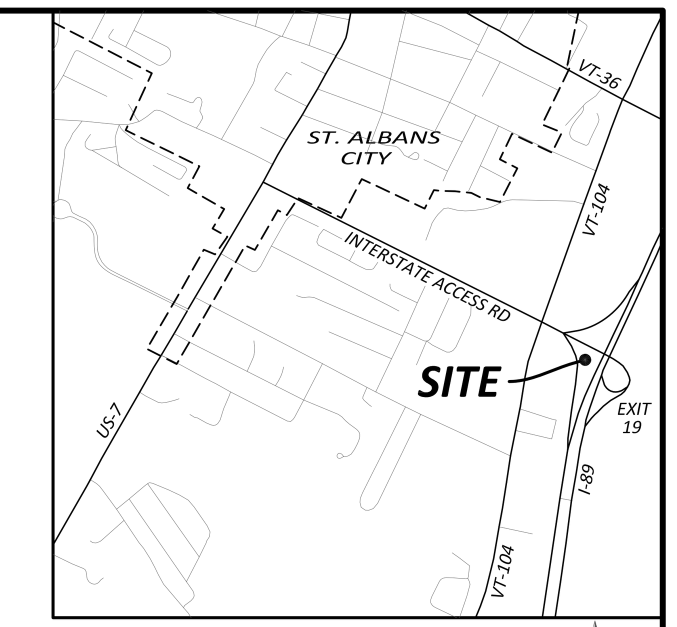
DATE: 2-17-15	DRAWN BY:JS	SCALE:NOTED



40 0 25 40 100 200

(IN FEET)
1 inch = 50 ft.

CONCEPT



SITE LOCATION

NTS

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- EXISTING STORM LINE
- PROPOSED STORM LINE
- DRAINAGE FLOW PATH

NOTES

1. THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.

2. EXISTING TOPOGRAPHY WAS CREATED FROM ROCK RIVER LiDAR (2008).

RUGG BROOK FLOW RESTORATION PLAN

ST. ALBANS, VERMONT

INTERSTATE EXIT 19 STORMWATER IMPROVEMENT PLAN

WATERSHED
CONSULTING ASSOCIATES, LLC
Stormwater Management | Water Quality | Erosion Control
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Mobile: 802.922.4871 | Main: 802.497.2367
www.watershedca.com

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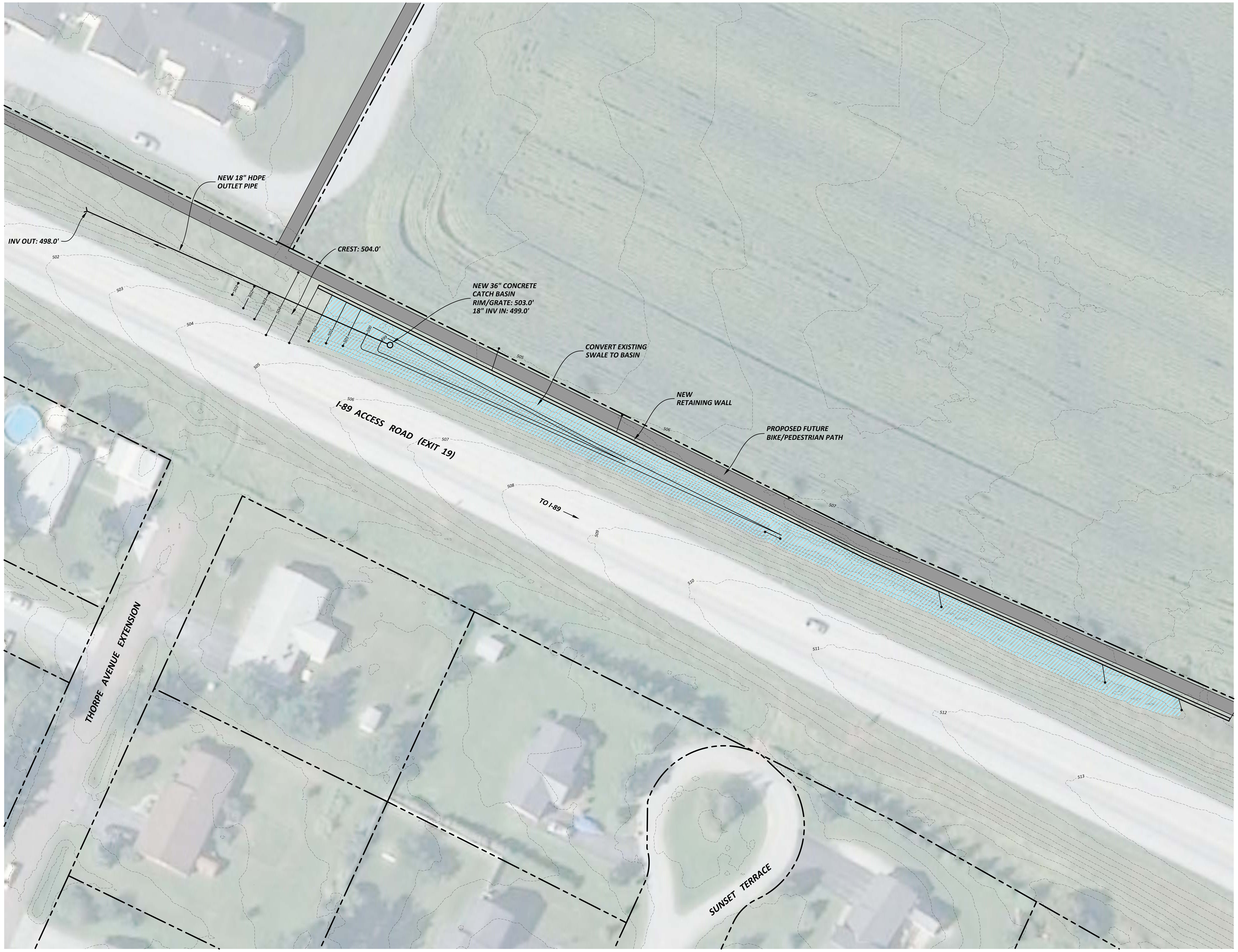
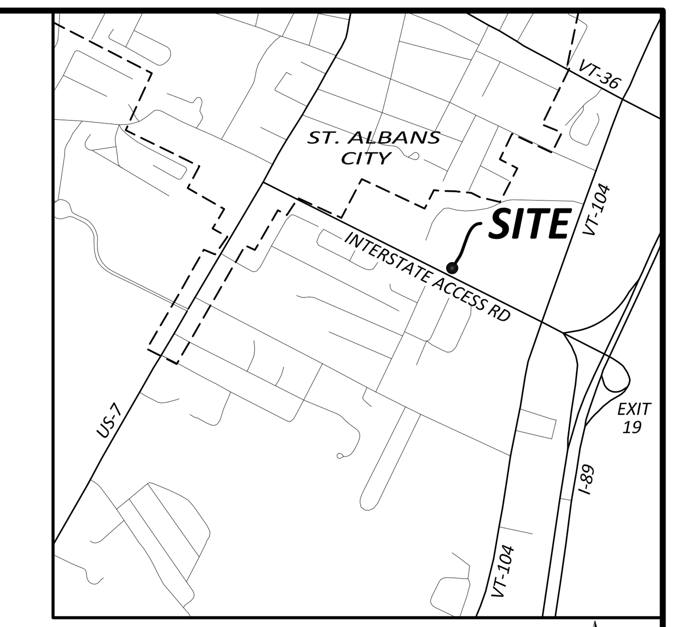
DATE:	4-17-15	CHECKED BY:	AT	SHEET:	1 OF 1





SITE LOCATION

NTS

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- PROPOSED STORM LINE

NOTES

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2. EXISTING TOPOGRAPHY WAS CREATED FROM CHITTENDEN COUNTY LiDAR (2004).

30 0 15 30 60 120
(IN FEET)
1 inch = 30 ft.

CONCEPT

RUGG BROOK FLOW RESTORATION PLAN

ST. ALBANS, VERMONT

INTERSTATE ACCESS WEST STORMWATER IMPROVEMENT PLAN

WATERSHED CONSULTING ASSOCIATES, LLC

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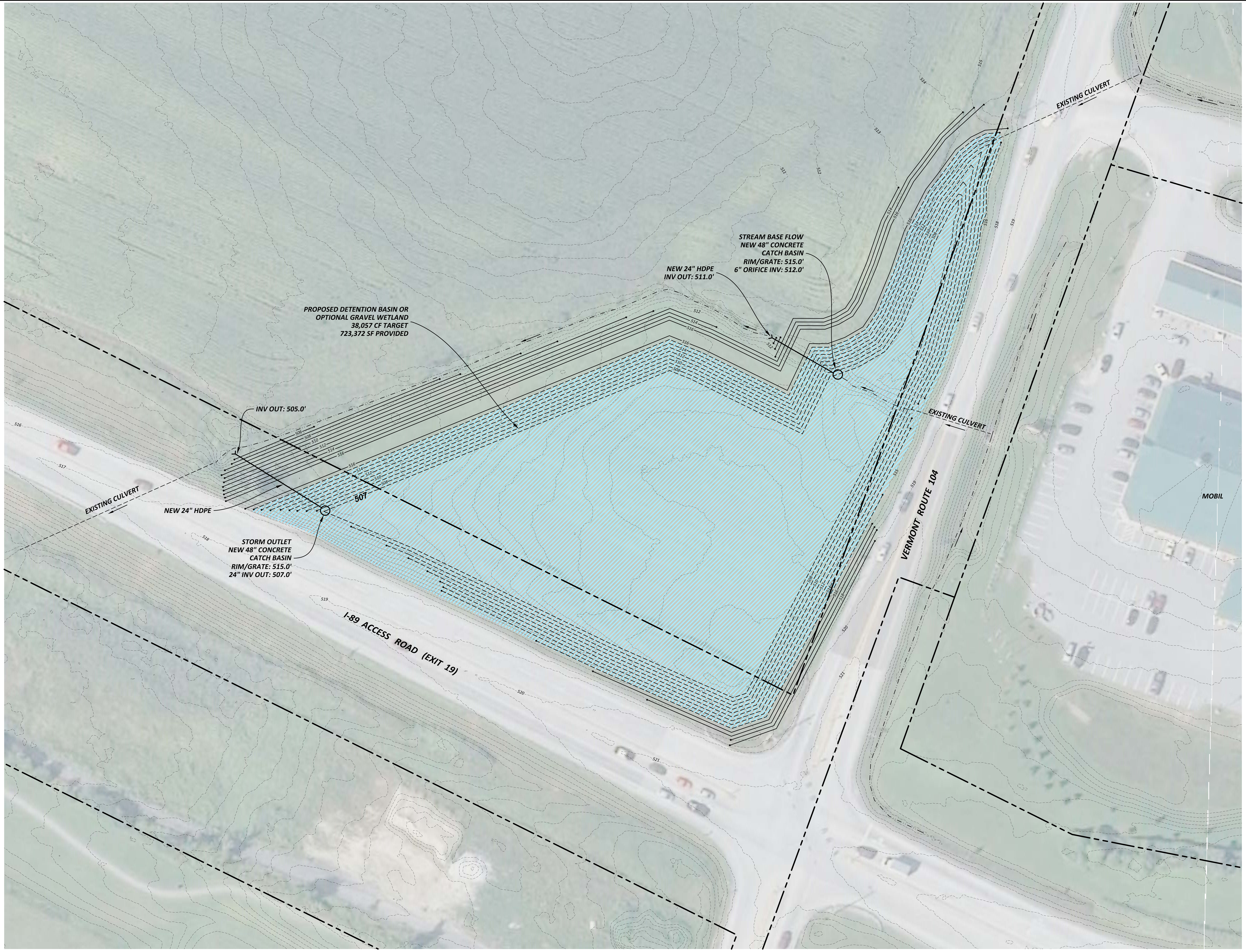
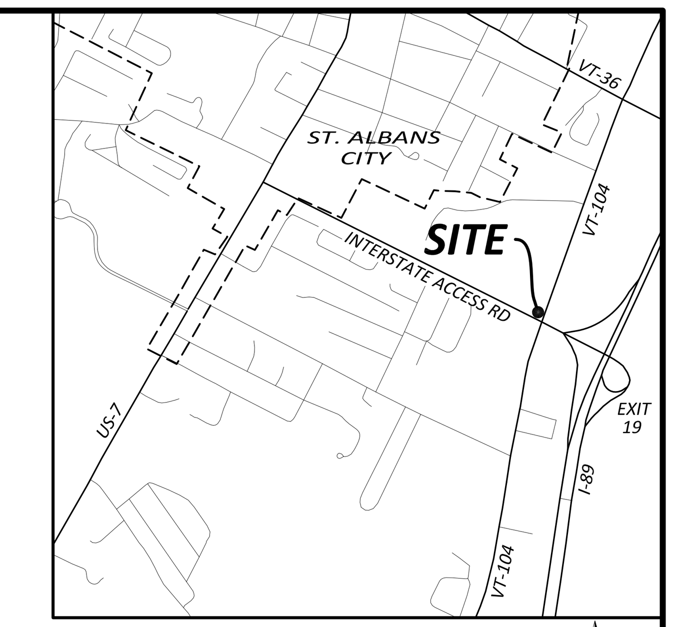
DATE:	3-25-15	CHECKED BY:	AT	SHEET:	1 OF 1





SITE LOCATION

NTS

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- EXISTING STORM LINE
- PROPOSED STORM LINE
- DRAINAGE FLOW PATH

NOTES

1. THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.

2. EXISTING TOPOGRAPHY WAS CREATED FROM ROCK RIVER LiDAR (2008).

CONCEPT

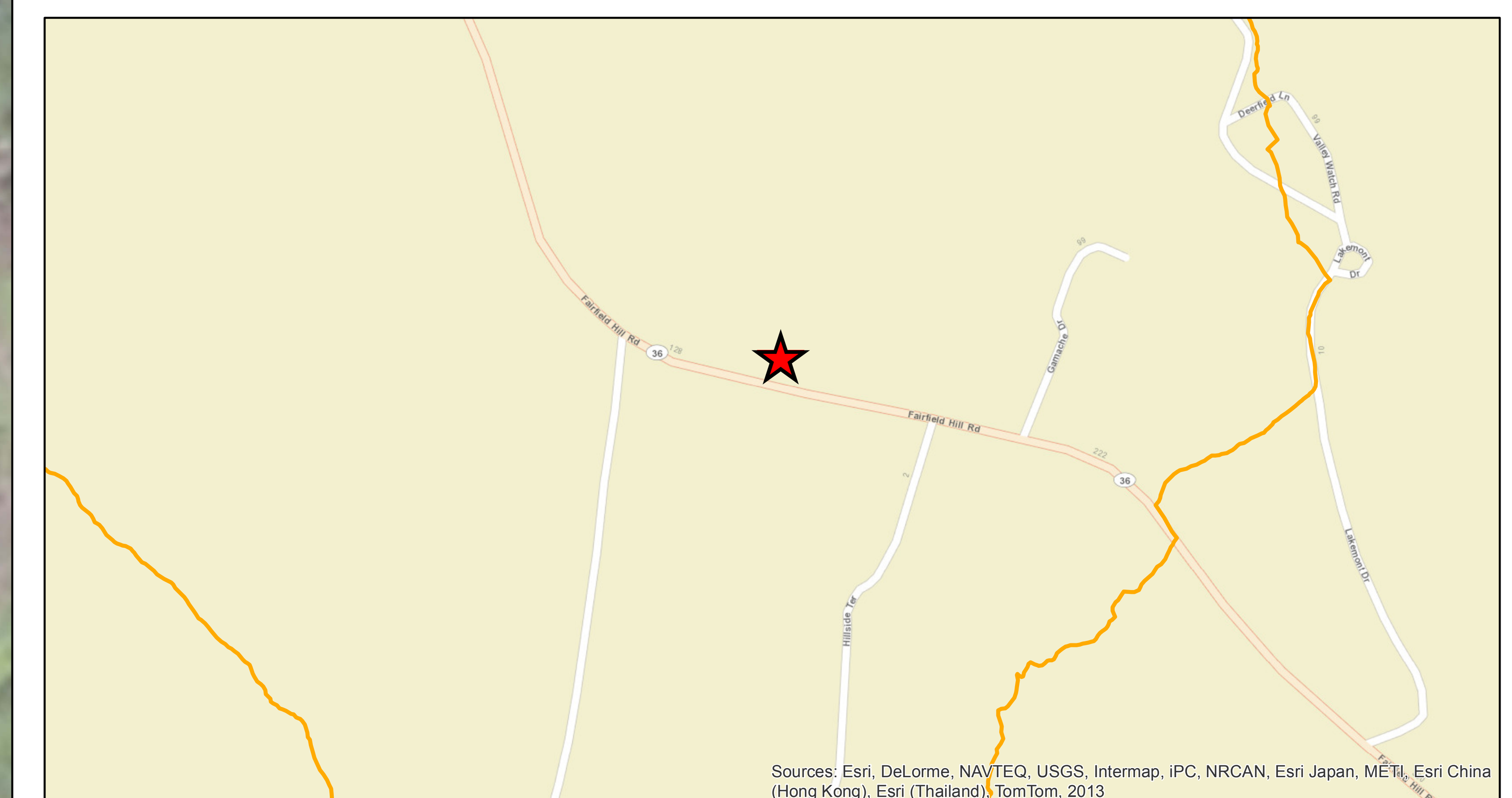
RUGG BROOK FLOW RESTORATION PLAN

ST. ALBANS, VERMONT

INTERSTATE ACCESS EAST STORMWATER IMPROVEMENT PLAN

WATERSHED
CONSULTING ASSOCIATES, LLC
Stormwater Management | Water Quality | Erosion Control
430 Shelburne Road P.O. Box 4413
Burlington, VT 05406
Mobile: 802.922.4871 | Main: 802.497.2367
www.watershedca.com

APPROVED BY: AT		DRAWN BY: SMS/ATS		SCALE: NOTED	
DATE: 4-7-15		CHECKED BY: AT		SHEET: 1 OF 1	



NOTES

Upper Fairfield Basin (TOWN/VTRANS)

BMP Description: Site is located off of Fairfield Hill Rd (VT 36, VTRANS-owned) on a private parcel within the Town, capturing approximately 34 ac of drainage from VT36 and neighboring homes and driveways. A water quality treatment/flow control basin is proposed.

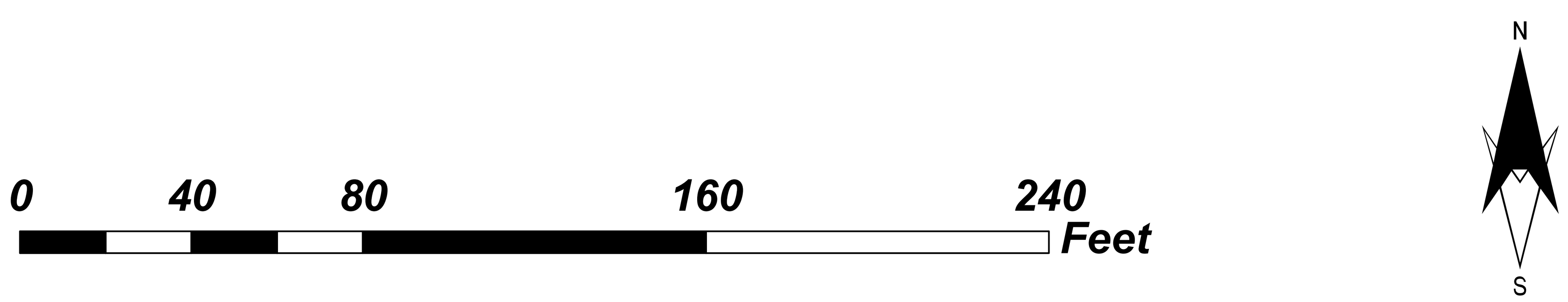
Implementation Cost: $163,761.00

Ownership/Regulatory Considerations: Private land would need to be acquired in order to implement the BMP. The land as of November 2013 is advertised for sale. The benefit of the proposed facility location is the ability to control flow at the top of the watershed, before stormwater flows enter the main stream channel and gains velocity and erosive strength.

LEGEND

- D PROPOSED OUTLET
- PROPOSED CULVERT
- EXISTING 2' CONTOUR
- FINISH GRADE 2' CONTOUR
- PROPERTY LINE

WATERSHED CONSULTING ASSOCIATES, LLC



STEVENS BROOK FLOW RESTORATION STUDY ST. ALBANS, VERMONT		
UPPER FAIRFIELD ROAD RETROFIT		
DATE:12-02-13	DRAWN BY:AT	SCALE:NOTED

Layout Plan Basin 105B

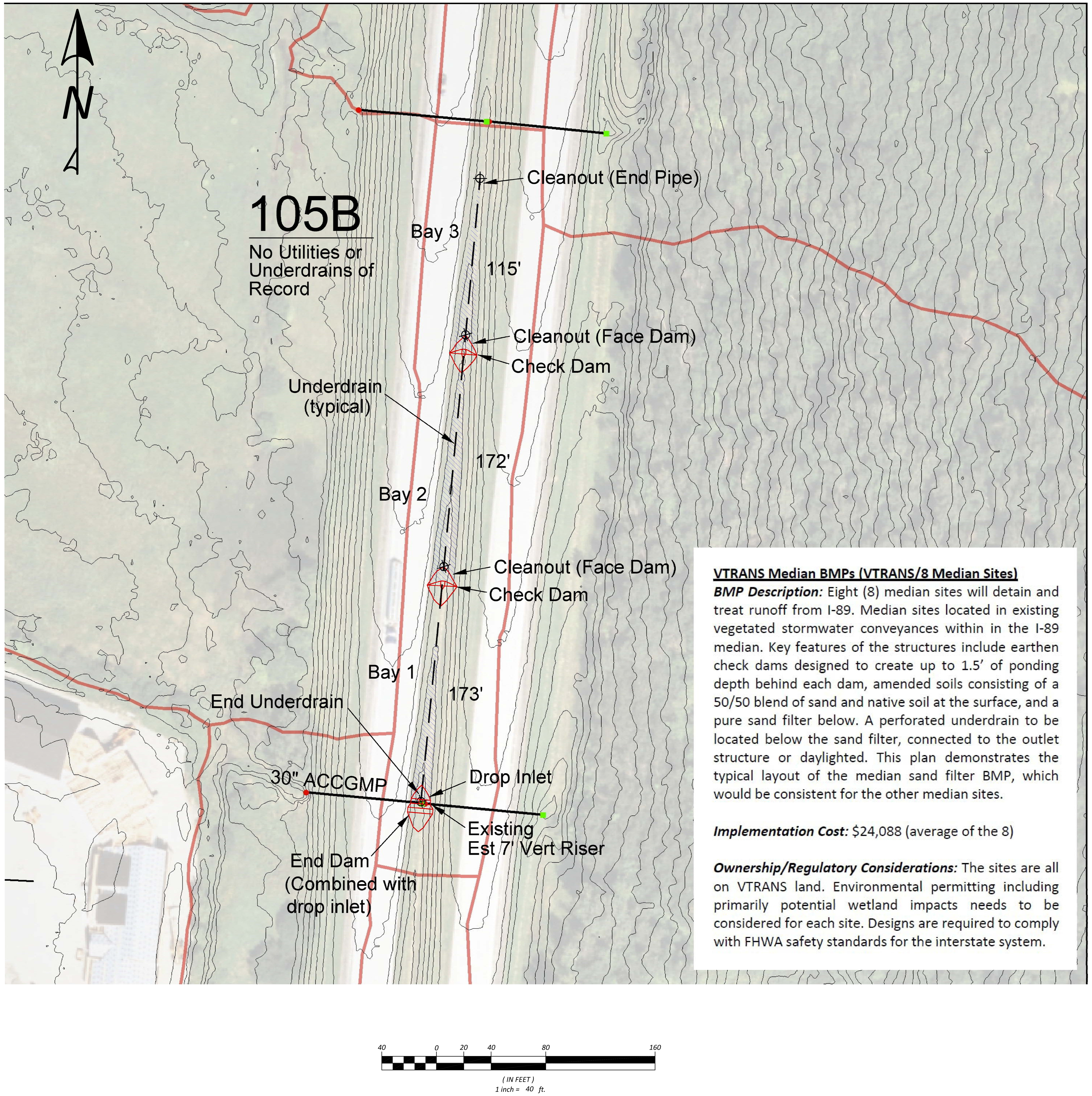
Drainage = 0.99 Ac

Imperv. = 0.48 Ac

Underdrain Orifice = 1.0"

Vol @ 1.5' = 3618 cf

Inundation shown at 1.5'



VTRANS Median BMPs (VTRANS/8 Median Sites)

BMP Description: Eight (8) median sites will detain and treat runoff from I-89. Median sites located in existing vegetated stormwater conveyances within in the I-89 median. Key features of the structures include earthen check dams designed to create up to 1.5' of ponding depth behind each dam, amended soils consisting of a 50/50 blend of sand and native soil at the surface, and a pure sand filter below. A perforated underdrain to be located below the sand filter, connected to the outlet structure or daylighted. This plan demonstrates the typical layout of the median sand filter BMP, which would be consistent for the other median sites.

Implementation Cost: $24,088 (average of the 8)

Ownership/Regulatory Considerations: The sites are all on VTRANS land. Environmental permitting including primarily potential wetland impacts needs to be considered for each site. Designs are required to comply with FHWA safety standards for the interstate system.

Structure (See Detail)

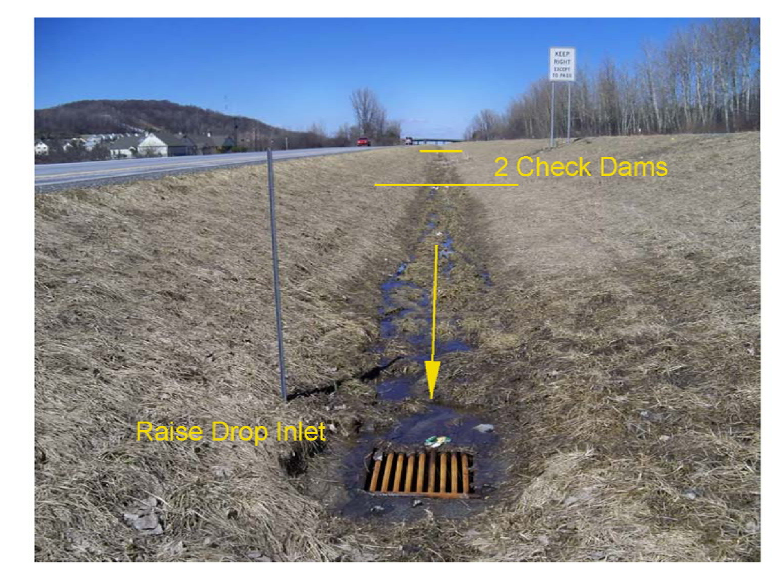
Design Storm Pool

Pre-Construction Stake (See Detail)

Underdrain

Note: Verify depth of drop inlet riser; adjust depth of underdrain as necessary.

Looking South 105B



Looking North 105B

Existing Drop Inlet 105B

CONCEPT

STEVENS BROOK FLOW RESTORATION PLAN

ST. ALBANS, VERMONT

MEDIAN SITE 105B BASIN

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SCALE:	*NOTED*
SHEET:	*1 OF 1*

LAKESIDE ENVIRONMENTAL GROUP

P.O. Box 4081
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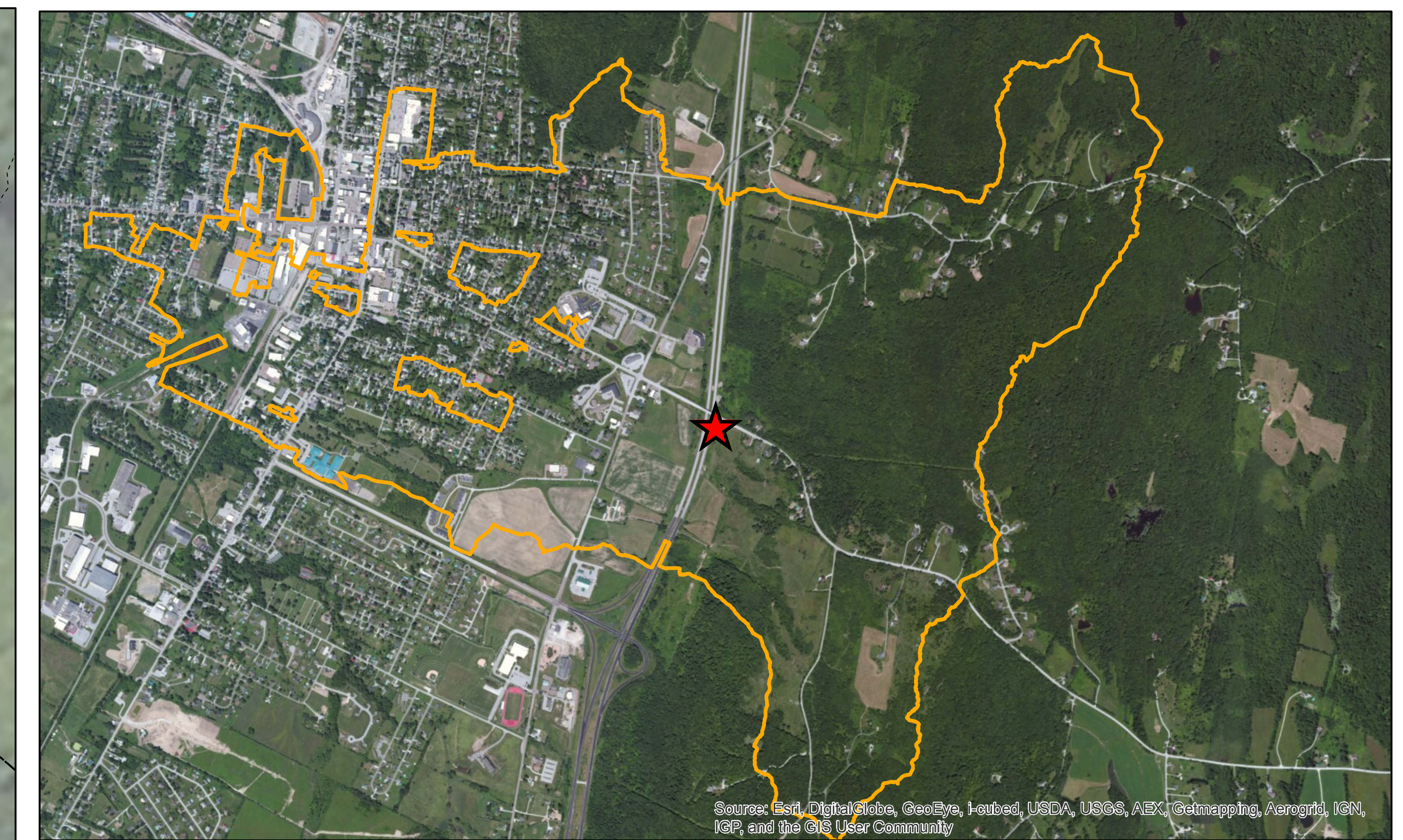
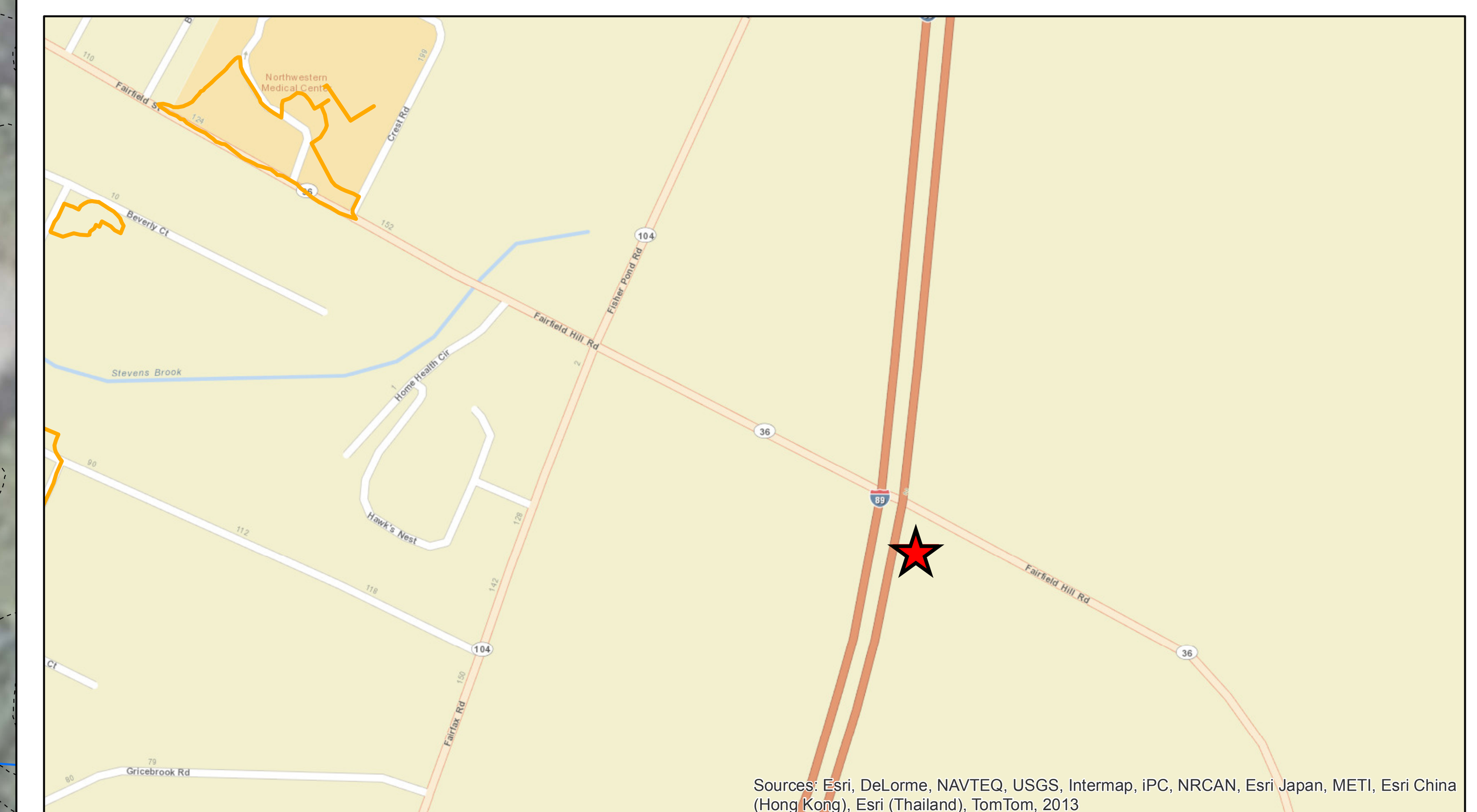




NOTES

Fairfield Rd. Basin (VTRANS)

BMP Description: Water quality/flow detention retrofit proposed within the I-89 ROW, designed to capture runoff from a 28 ac area. The structure to be designed according to FHWA guidelines for safety. A new culvert under Fairfield Rd. would be required to route flow from north side of VT 36 into the facility.

Implementation Cost: $108,531.80

Ownership/Regulatory Considerations: The proposed BMP would treat runoff from VTRANS and Town impervious cover, and therefore a cost-share is recommended.

LEGEND

- D PROPOSED OUTLET
- PROPOSED CULVERT
- EXISTING 2' CONTOUR
- FINISH GRADE 2' CONTOUR
- PROPERTY LINE

WATERSHED
CONSULTING ASSOCIATES, LLC

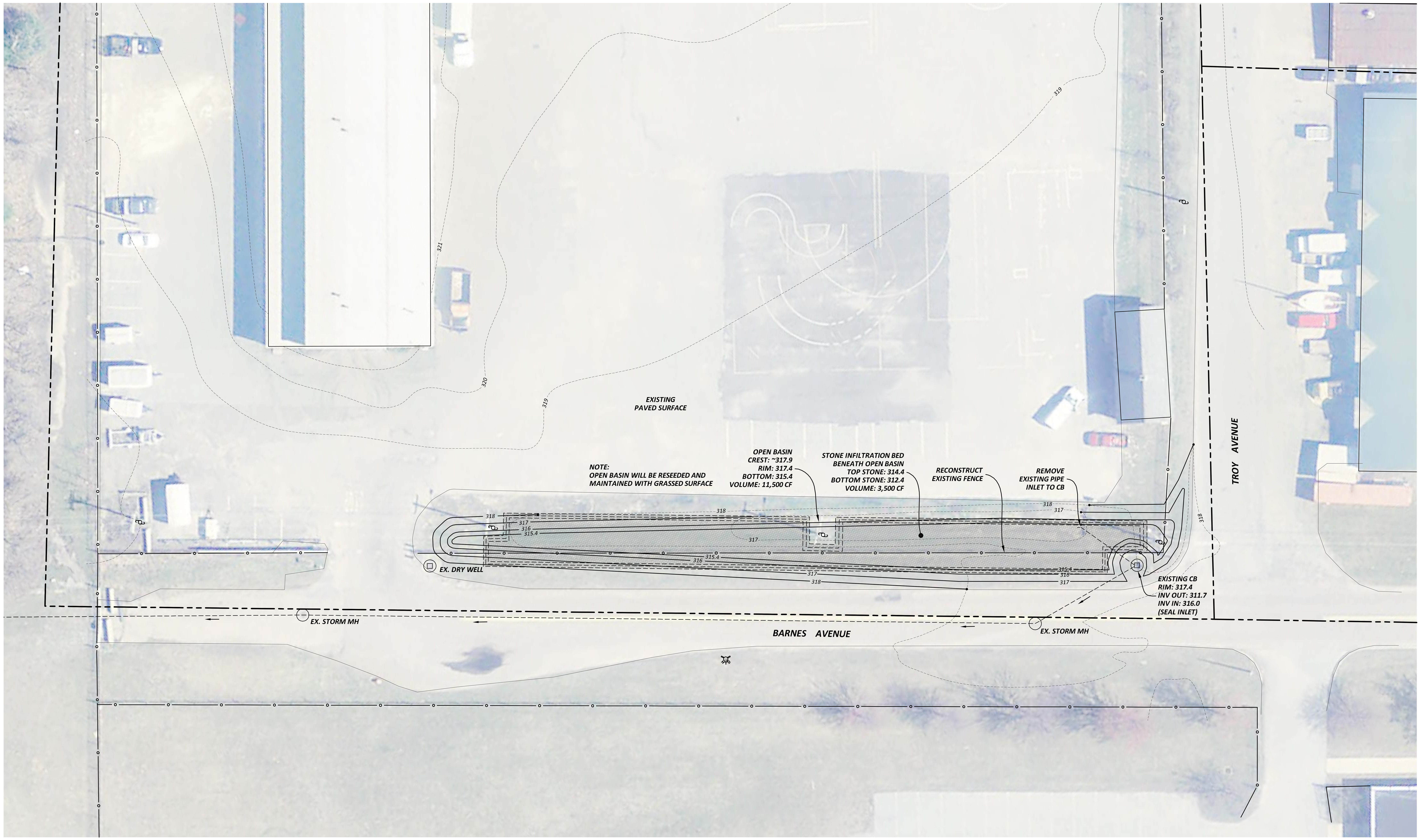
0 40 80 160 240
Feet

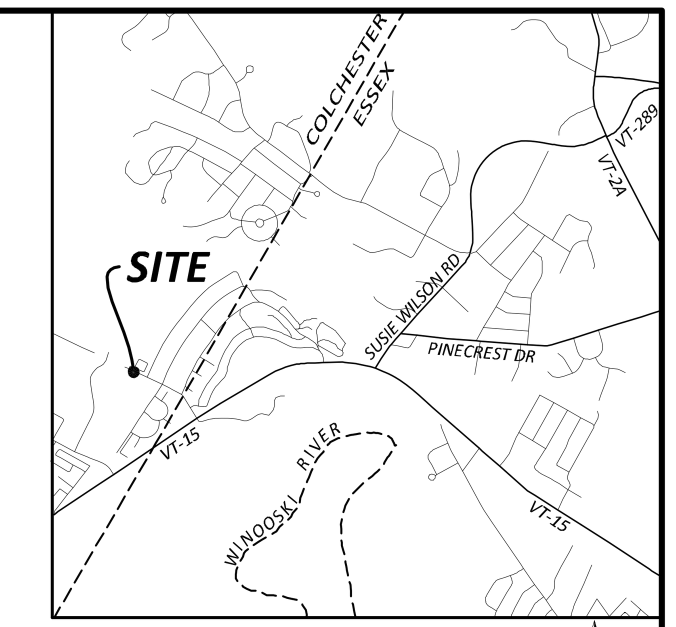
N
S

STEVENS BROOK FLOW RESTORATION STUDY
ST. ALBANS, VERMONT

LOWER FAIRFIELD ROAD RETROFIT

DATE:12-02-13	DRAWN BY:AT	SCALE:NOTED





SITE LOCATION
NTS

LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- EXISTING STORM LINE
- CHAIN LINK FENCE
- HYDRANT
- UTILITY POLE

20 0 10 20 40 80

(IN FEET)
1 inch = 20 ft.

NOTES

1. THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.

2. EXISTING TOPOGRAPHY WAS CREATED FROM CHITTENDEN COUNTY LiDAR (2004).

CONCEPT

SUNDERLAND BROOK FLOW RESTORATION PLAN

ESSEX/COLCHESTER, VERMONT

TRACY ROAD OUFALL STORMWATER IMPROVEMENT PLAN

WATERSHED CONSULTING ASSOCIATES, LLC
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DATE:	2-20-15	CHECKED BY:	AT	SHEET:	1 OF 1