STONE ENVIRONMENTAL
100% EMPLOYEE-OWNED

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

September 30, 2021

MEMO

To: Christy Witters and Emily Schelley
Vermont DEC Stormwater Program

From: Amy Macrellis & Warren Rich, Stone Environmental
Jenn Callahan, Vermont Agency of Transportation

Stone Project No. 18-008-D
Subject: Lake Champlain Basin Phosphorus Control Plan, Vermont Agency of Transportation – Progress Report

---

On behalf of VTrans and in accordance with *NPDES General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4)* Section 9.2.D, Stone is pleased to submit this Progress Report summarizing actions taken to implement all Phosphorus Control Plan (PCP) components. This submittal includes final summaries of impervious and pervious acres managed, and BMPs implemented, through December 31, 2020 and provides updates to estimated extent of completion for remaining items and schedule as of June 30, 2021.

1. Extent of BMP implementation

Documentation of historic and current operations, and projection of current operations through the term of the first VTrans Phosphorus Control Implementation Plan (PCIP) (submitted October 1, 2020) was updated in the implementation model to account for capital projects and maintenance activities completed through December 31, 2020. Figure 1 below is an updated version of Figure 8 from the PCIP. This figure compares the progress documented in the October 1, 2020 PCIP to final documentation of road drainage improvements, capital projects, maintenance-level improvements, non-structural control application, and other creditable activity through December 31, 2020. In the PCIP submittal, 2020 maintenance operations and constructed projects were documented as achieving P load reductions of 23.3 kg/yr. Following full documentation and crediting of 2020 activities, P load reductions of 61.4 kg/yr were achieved -an increase of 38.1 kg/yr. Table 1, drawn from the implementation model, illustrates adjustments to P load reduction by Lake segment and BMP type. Completed road drainage repairs through the end of 2020 were sometimes slightly below the 2015-2019 average, which was estimated in the model for 2020 at PCIP submittal. Location accuracy of maintenance-level localized erosion repairs was greatly improved in 2020.

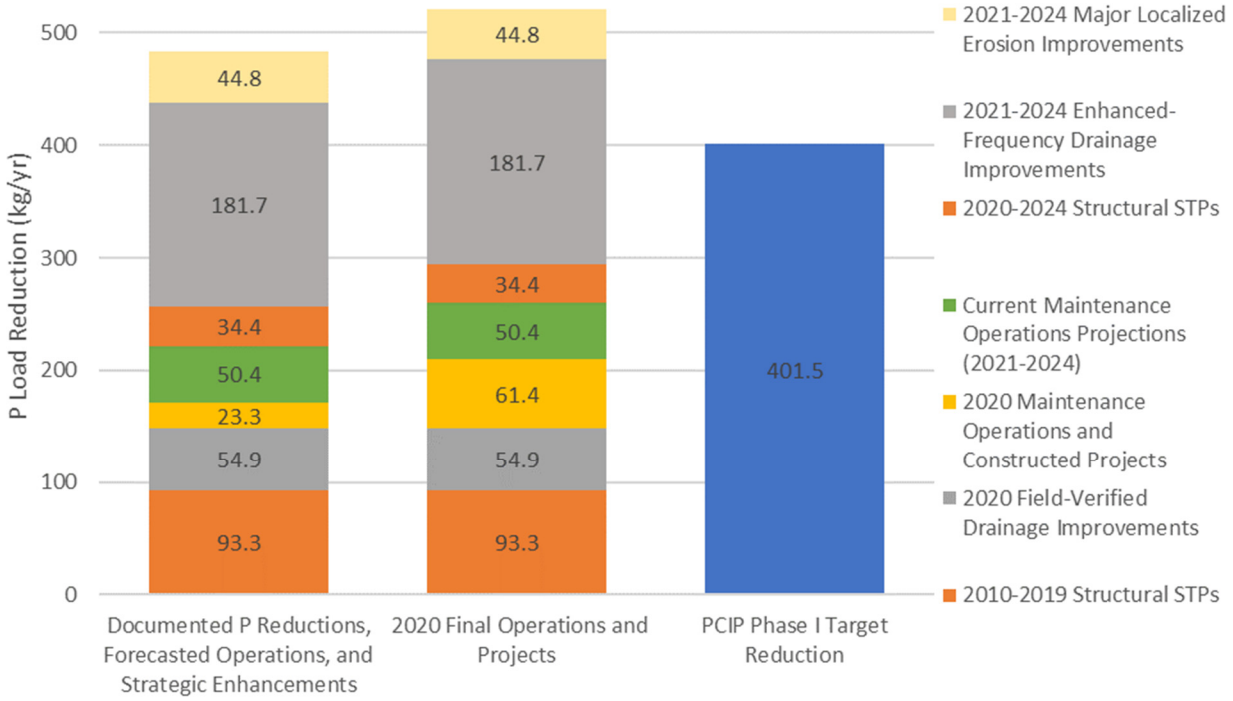


Figure 1. Summary of Phase 1 anticipated progress toward target P load reduction, comparing progress projected in the PCIP to that achieved through 2020

Table 1. Final P load reductions for BMPs implemented in 2020 (kg/yr) compared to Phase 1 PCIP submittal

	P load reduction (kg/yr)		
Lake Segment	Completed Road Drainage Repair	Road Drainage Repair, Major Project	Completed Localized Erosion Repair
1-South Lake B	-0.82	0.00	2.17
2-South Lake A	-0.20	0.00	0.00
3-Port Henry	0.37	0.00	0.00
4-Otter Creek	3.83	1.24	4.92
5-Main Lake	13.05	0.55	1.73
6-Shelburne Bay	0.32	0.062	-0.10
8-Malletts Bay	4.20	4.72	1.36
9-Northeast Arm	0.00	0.00	0.00
10-St. Albans Bay	-0.26	0.00	0.11
11-Missisquoi Bay	0.86	0.37	10.93
12-Grand Isle	-0.040	0.00	0.00
TOTAL	21.30	6.94	21.12

Table 2, at the end of this memo, provides an update to the implementation model as submitted with the PCIP and includes VTrans' present understanding of improvements credited through December 31, 2020. The interactive charts of impervious acres managed and P load reductions achieved[1] over the term of the PCP that accompanied the October 1, 2020 PCIP were updated to include improvements through 2020.

Below, we briefly summarize activities undertaken and progress documented since Phase 1 Phosphorus Control Implementation Plan (PICP) submittal, organized by the suite of necessary BMPs set forth in that plan.

1.1 Tracking and Accounting

VTrans continued development of a tracking and accounting system, working to integrate with and build from its Vermont Asset Management Information System (VAMIS). Refinements to the TS4 ditch inventory were developed and iteratively field-tested in the summer of 2021, including dividing the swale assets to correspond to linear road segments and to cross culverts represented in the Small Culverts Inventory (SCI). The existing PCP road segment dataset is also under refinement, primarily to standardize road segment lengths while preserving key attributes, such as hydrologic connectivity and road slope.

1.2 Structural Correction of Road Drainage Deficiencies

As specified in the Phase 1 PCIP submittal, a 'draft' set of roadway drainage standards was developed that describes minimum performance expectations applicable to "hydrologically-connected" VTrans roads in the Lake Champlain Basin portion of VTrans' Transportation Separate Storm Sewer System (TS4)-permitted area. Road segments where associated culverts, swales, and/or closed drainage systems do not meet the standards outlined in this document may be improved in order to meet the standards, restore function, and improve water quality – and thus may be credited towards achievement of VTrans' target phosphorus load reductions under the Vermont Lake Champlain Phosphorus TMDLs. The *VTrans Phosphorus Control Highway Drainage Management Standards (August 3, 2021)* are attached to this progress report.

These standards, and the menu of standard BMPs and maintenance activities that may be undertaken to bring road segments and related assets 'up to standards', are living documents and will be updated periodically as conditions warrant. One improvement already in progress is to integrate the VTrans Short Structures asset inventory into the existing drainage standards and phosphorus crediting framework. The SCI includes only culverts that are six feet in diameter or smaller. Larger culverts, including many concrete box culverts now being installed by VTrans to replace undersized structures, are not tracked in the SCI.

[1] For interactive charts of impervious acres and P load reductions potentially achieved by management strategy, visit https://bitl.y/3kUTCJz

Correction of road drainage deficiencies, as documented in MATS and in programmed capital projects during calendar 2020 that were not captured in the Phase 1 PCIP submittal were summarized and credited in the implementation model (Table 1, Table 2, and Figure 1).

1.3 Structural Correction of Road Erosion Issues

Specific crediting mechanisms for stabilization and treatment of areas of localized erosion caused by roadway runoff remain in development. VTrans, with DEC, participated in the research project *Quantifying Nutrient Pollution Reductions Achieved by Erosion Remediation Projects on Vermont's Roads*, which was completed in June 2021. While the study was valuable, the findings did not include an actionable phosphorus crediting strategy. VTrans anticipates further dialogue with ANR in the fall of 2021 and stands ready to assist as warranted.

Correction of minor areas of localized erosion as documented in MATS and in programmed capital projects during calendar 2020 that were not captured in the October 1, 2020 PCIP submittal were summarized and credited in the implementation model (Table 1, Table 2, and Figure 1).

1.4 Non-Structural Controls

Lane miles swept and drop inlets (DIs) cleaned in calendar 2020 were summarized and credited in the implementation model (Table 2). No Vactor contracts were executed in 2020, and lane miles swept were also reduced due to COVID-related staffing limitations.

1.5 Structural Stormwater Treatment Practices

Information about existing and planned structural stormwater treatment practices (STPs) throughout the TS4 is updated in the TS4's BMP Tracking Table and in the implementation model as practices move through design or are constructed. No updates were made to the tracking system for completed structural STPs after the Phase 1 PCIP submittal but are anticipated following the close of the 2021 construction season.

1.6 Natural Resource Restoration Projects

Natural resource restoration projects, and particularly floodplain restoration projects, may be credited as stormwater treatment practices in the context of the VTrans PCP if the floodplain area to be restored is also connected to a TS4 roadway or other VTrans-controlled contributing drainage. Since the PICP submittal. VTrans has continued to complete preliminary evaluations of specific floodplain restoration projects for P reduction credit. The potential for floodplain restoration, bank stabilization, and other relevant practices were evaluated in the Potash Brook watershed near the I-89/I-189 interchange, which may be advanced in 2022 pending completion of cost estimation and benefit-cost analysis.

More exhaustive evaluation of how to execute and credit floodplain reconnection will be possible through application of results from Vermont's Functioning Floodplains Initiative (FFI). Phase I outputs, including a

web-based application, are anticipated in the spring of 2022. The initiative is developing and applying methodologies for evaluating river reach and watershed-scale restoration of stream, riparian, wetland, and floodplain function. Phosphorus crediting strategies are in development between the FFI technical team and Vermont ANR in the summer and fall of 2021.

2. Estimate of extent of completion for remaining items

The draft implementation schedule as presented in the October 1, 2020 PCIP remains generally accurate. Both the schedule and the implementation model are planning-level documents only and will be subject to continued adjustment as the implementation plan is executed.

The implementation model (Table 2) serves as a revised draft implementation schedule that includes estimates of the area (acreage) to be treated and the extent and type of treatment strategies that will be applied to meet the P load reduction required from the first PCIP and ultimately from the entire VTrans PCP. The base assumptions used to populate the model remain unchanged from the Generalized PCP submittal. Updates to those assumptions, particularly assumptions related to implementation costs, will continue as plan execution proceeds.

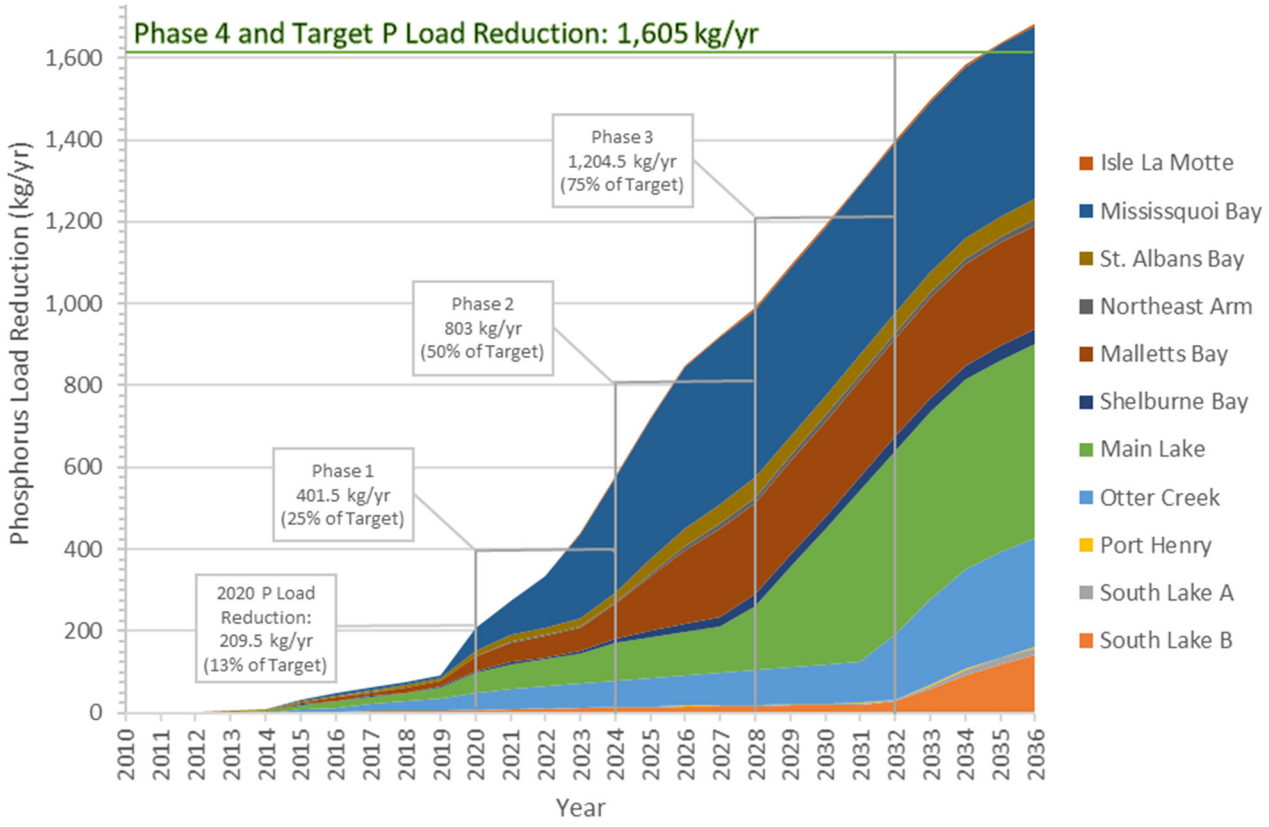


Figure 2. Cumulative annual P load reduction (kg/yr) achieved and projected by Lake segment as of December 31, 2020

Figure 2 provides a visual summary of the implementation model's tracking of P load reductions achieved through calendar 2020 (Table 2), and P load reductions planned and projected through achievement of TMDL target P load reductions before June 17, 2036. Though much work remains, at the end of 2020 VTrans achieved 209.5 kg/yr (52%) of the targeted Phase 1 reduction. The P load reduction achieved through 2020 constitutes 13% of VTrans' overall target P load reduction (Figure 2 and Table 2). The implementation model presently indicates that VTrans should achieve its Phase 1, Phase 2, and Phase 3 target P load reductions roughly a year ahead of the end of those phases and be in compliance with the TMDL target P load reduction in 2035.

3. Assessment of ability to meet remaining schedule items

VTrans is presently on or slightly ahead of schedule and is capable of meeting remaining schedule items. As implementation of the PCPs proceeds, if any changes in ability to meet schedule items arise, VTrans report on schedule adjustments as warranted.

4. Written designer statements

Subpart 9.2.D.4 of the TS4 General Permit requires submittal of *a written statement signed by a designer acceptable to the Secretary that any structural BMP build or implemented within the preceding 6 month period was constructed in compliance with the approved plans.* No structural BMPs requiring written designer statements were completed within the preceding 6 month period.

Table 2. Implementation model summary as of December 31, 2020

Lake Segment: Lake Champlain Basin
Target Reduction: 20.96%

Land Cover Type	PCP Area (acres)	P Base Load (kg/yr)	P Target Reduction (kg/yr)
Developed Impervious	416.78	466.78	97.85
Paved Roads	5,983.87	4,836.67	1,014.55
Unpaved Roads	12.74	28.85	5.96
Developed Pervious	9,483.84	2,330.74	487.56
Total	15,897.23	7,663.04	1,605.91

Progress to Target P Reduction Key:

Less than 25%
26%-50%
51%-75%
76%-99%
100%+

													Gen PCP, 1st Imp Plan				2nd Imp Plan			3rd Imp Plan			4th Imp Plan				Complete	
Metric	**Lake Segment**	**Total Managed**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	South Lake B	**232.0**	0.0	0.0	0.0	0.0	0.0	0.2	2.2	1.9	2.3	0.6	7.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	21.3	48.1	48.1	37.5	37.5
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	South Lake A	**20.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.1	1.1	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	2.4	8.6	3.6	0.3
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Port Henry	**2.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Otter Creek	**425.9**	0.0	2.2	5.1	0.0	0.0	6.9	4.6	7.5	20.7	3.0	31.5	19.1	9.7	10.6	9.7	18.4	9.7	14.2	9.7	9.7	9.7	9.7	71.8	60.9	44.7	23.8	13.2
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Main Lake	**765.3**	3.0	0.7	0.0	5.0	6.2	2.9	6.4	11.4	4.5	13.2	40.2	12.6	10.0	14.5	23.8	14.6	10.0	10.0	62.4	119.5	116.2	114.9	120.6	12.7	10.0	10.0	10.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Shelburne Bay	**97.2**	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.6	10.0	0.1	6.7	11.9	11.9	5.2	13.5	4.7	3.4	9.4	9.4	9.4	0.1	0.1	0.1	0.1
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Malletts Bay	**383.9**	2.0	0.0	0.4	0.0	6.5	4.6	7.4	5.1	10.5	3.5	37.3	14.3	6.4	8.4	40.0	70.5	57.0	41.7	13.1	10.5	6.4	6.4	6.4	6.4	6.4	6.4	6.4
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Northeast Arm	**19.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.2	0.3	1.1	0.3	0.3	6.2	6.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	St. Albans Bay	**104.8**	1.7	3.8	0.0	4.0	0.0	1.2	2.4	0.0	0.5	0.7	9.6	25.9	1.0	1.0	12.9	12.9	13.9	4.0	1.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Mississquoi Bay	**717.3**	0.0	3.8	0.0	0.0	0.0	2.6	3.1	3.3	1.6	1.2	138.4	40.0	78.5	132.1	107.8	82.9	74.7	25.8	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Isle La Motte	**7.9**	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.1	3.1	3.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	**PCP Area**	**2,777.1**	**6.6**	**10.4**	**5.4**	**9.0**	**12.7**	**18.9**	**26.7**	**29.4**	**40.2**	**23.7**	**267.6**	**124.9**	**109.5**	**176.2**	**212.1**	**223.0**	**179.3**	**112.1**	**96.8**	**149.6**	**148.1**	**146.8**	**234.6**	**135.3**	**121.6**	**85.2**	**71.3**
TOTAL ACRES MANAGED (STRUCTURAL)	South Lake B	**387.1**	0.0	0.0	0.0	0.0	0.0	0.2	2.2	1.9	2.3	0.6	7.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	21.3	97.5	97.5	65.7	65.7
TOTAL ACRES MANAGED (STRUCTURAL)	South Lake A	**24.5**	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.1	1.1	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	4.5	10.7	3.6	0.3
TOTAL ACRES MANAGED (STRUCTURAL)	Port Henry	**2.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	Otter Creek	**833.4**	0.0	5.3	8.5	0.0	0.0	6.9	4.6	7.5	107.0	3.2	31.5	38.3	9.7	10.6	9.7	217.1	9.7	19.2	9.7	9.7	9.7	9.7	117.2	94.1	57.7	23.8	13.2
TOTAL ACRES MANAGED (STRUCTURAL)	Main Lake	**1,100.1**	2.9	1.1	0.0	59.0	10.6	3.1	6.4	11.4	5.0	58.8	54.6	13.5	10.0	17.0	49.2	16.1	10.0	10.0	85.4	165.4	162.1	156.5	140.6	21.3	10.0	10.0	10.0
TOTAL ACRES MANAGED (STRUCTURAL)	Shelburne Bay	**226.1**	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.6	20.8	0.1	16.5	21.6	21.6	5.2	20.4	7.9	7.4	34.3	34.3	34.3	0.1	0.1	0.1	0.1
TOTAL ACRES MANAGED (STRUCTURAL)	Malletts Bay	**452.1**	2.5	0.0	1.1	0.0	11.1	5.6	7.4	9.0	23.6	3.5	37.3	25.2	6.4	11.7	40.0	70.5	57.0	46.4	13.1	35.8	6.4	6.4	6.4	6.4	6.4	6.4	6.4
TOTAL ACRES MANAGED (STRUCTURAL)	Northeast Arm	**20.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.4	0.3	1.1	0.3	0.3	6.2	6.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
TOTAL ACRES MANAGED (STRUCTURAL)	St. Albans Bay	**483.5**	1.7	61.2	0.0	13.0	0.0	1.2	2.4	0.0	0.5	0.7	9.6	328.6	1.0	1.0	12.9	12.9	16.5	9.5	2.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TOTAL ACRES MANAGED (STRUCTURAL)	Mississquoi Bay	**1,041.4**	0.0	61.3	0.0	0.0	0.0	2.6	3.1	3.3	1.6	1.2	138.4	40.0	78.5	182.0	157.7	147.0	138.8	64.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
TOTAL ACRES MANAGED (STRUCTURAL)	Isle La Motte	**7.9**	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.1	3.1	3.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL ACRES MANAGED (STRUCTURAL)	**PCP Area**	**4,578.7**	**7.1**	**128.9**	**9.6**	**72.0**	**21.7**	**20.1**	**26.7**	**33.3**	**140.1**	**69.5**	**282.2**	**469.4**	**109.5**	**241.8**	**297.1**	**497.1**	**246.1**	**172.7**	**124.3**	**224.7**	**219.0**	**213.3**	**324.9**	**228.6**	**186.1**	**113.4**	**99.5**
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	South Lake B	**153.7**	0.0	0.0	0.0	0.0	0.0	147.4	99.4	295.8	155.3	95.5	48.3	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	South Lake A	**42.7**	0.0	0.0	0.0	0.0	0.0	57.5	18.7	59.7	61.9	22.2	8.2	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Port Henry	**12.0**	0.0	0.0	0.0	0.0	0.0	15.0	0.3	13.8	15.4	15.0	14.5	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Otter Creek	**790.8**	0.0	0.0	0.0	0.0	0.0	839.2	654.9	880.0	608.1	961.9	590.3	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Main Lake	**510.3**	0.0	0.0	0.0	0.0	0.0	434.7	715.3	442.4	508.1	471.8	52.1	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Shelburne Bay	**95.0**	0.0	0.0	0.0	0.0	0.0	81.0	33.9	101.4	90.9	186.7	36.6	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Malletts Bay	**437.9**	0.0	0.0	0.0	0.0	0.0	324.9	463.9	485.2	526.4	409.5	111.0	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Northeast Arm	**87.4**	0.0	0.0	0.0	0.0	0.0	116.3	140.9	61.6	12.4	125.7	0.0	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	St. Albans Bay	**63.5**	0.0	0.0	0.0	0.0	0.0	24.2	53.2	76.6	112.4	56.3	15.8	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Mississquoi Bay	**217.0**	0.0	0.0	0.0	0.0	0.0	20.3	181.4	427.7	341.9	132.5	97.2	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Isle La Motte	**25.7**	0.0	0.0	0.0	0.0	0.0	31.4	38.1	19.1	15.2	35.4	0.0	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	**PCP Area**	**2,436.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2091.8**	**2400.0**	**2863.3**	**2448.0**	**2512.5**	**974.1**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**
CUMULATIVE TOTAL P REDUCTION	South Lake B	142.4	0.0	0.0	0.0	0.0	0.0	0.7	2.0	4.4	5.0	5.2	7.3	8.4	9.6	10.8	12.0	13.2	14.4	15.6	16.8	18.0	19.2	20.4	28.7	60.4	92.2	117.3	142.4
CUMULATIVE TOTAL P REDUCTION	South Lake A	17.1	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.7	0.8	1.3	1.2	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	6.2	13.6	16.9	17.1
CUMULATIVE TOTAL P REDUCTION	Port Henry	1.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.2	1.9	1.9	1.9	1.9
CUMULATIVE TOTAL P REDUCTION	Otter Creek	264.5	0.0	0.0	0.4	0.4	0.4	9.6	10.3	16.6	22.6	28.3	39.7	47.9	53.2	59.3	64.6	70.3	75.6	80.9	86.2	91.5	96.8	102.1	156.7	208.0	242.6	257.2	264.5
CUMULATIVE TOTAL P REDUCTION	Main Lake	475.1	1.3	1.4	1.4	1.9	4.4	9.8	16.4	18.4	21.1	28.6	51.4	61.8	67.4	74.2	92.0	99.2	104.8	110.4	155.5	243.0	329.6	416.2	449.7	458.3	463.9	469.5	475.1
CUMULATIVE TOTAL P REDUCTION	Shelburne Bay	35.0	0.0	0.0	0.0	0.0	0.0	0.7	0.6	0.7	0.8	1.7	0.8	3.8	3.9	5.8	11.0	16.2	19.6	25.7	29.6	30.3	31.8	33.2	34.6	34.7	34.8	34.9	35.0
CUMULATIVE TOTAL P REDUCTION	Malletts Bay	254.7	0.4	0.4	0.4	0.4	0.5	4.5	8.8	9.5	12.4	14.1	37.7	48.7	52.5	57.2	84.0	132.2	178.1	213.5	222.9	228.1	231.9	235.7	239.5	243.3	247.1	250.9	254.7
CUMULATIVE TOTAL P REDUCTION	Northeast Arm	14.8	0.0	0.0	0.0	0.0	0.0	0.5	0.7	0.3	0.0	0.9	1.2	2.3	3.0	3.2	3.3	8.2	13.1	13.3	13.5	13.6	13.8	14.0	14.2	14.3	14.5	14.7	14.8
CUMULATIVE TOTAL P REDUCTION	St. Albans Bay	50.6	0.0	0.5	0.5	2.3	2.3	2.9	4.1	4.2	5.2	4.9	10.4	16.6	17.1	17.6	26.2	34.8	42.2	45.5	46.6	47.1	47.6	48.1	48.6	49.1	49.6	50.1	50.6
CUMULATIVE TOTAL P REDUCTION	Mississquoi Bay	420.5	0.0	0.5	0.5	0.5	0.5	2.0	5.1	7.3	8.2	8.1	59.3	81.3	126.2	207.9	280.0	340.5	393.3	408.8	410.1	411.4	412.7	414.0	415.3	416.6	417.9	419.2	420.5
CUMULATIVE TOTAL P REDUCTION	Isle La Motte	5.7	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.5	0.3	0.2	0.4	0.4	0.4	3.2	5.5	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
CUMULATIVE TOTAL P LOAD REDUCTION	**PCP Area**	1,682.3	**1.6**	**2.8**	**3.3**	**5.5**	**8.1**	**31.2**	**48.6**	**62.2**	**76.8**	**93.5**	**209.6**	**273.2**	**335.5**	**438.7**	**578.9**	**723.0**	**849.7**	**922.6**	**990.3**	**1092.5**	**1193.0**	**1293.5**	**1397.9**	**1498.5**	**1583.7**	**1638.2**	**1682.3**

VTRANS PHOSPHORUS CONTROL HIGHWAY DRAINAGE MANAGEMENT STANDARDS (August 3, 2021)

1.0 Applicability

A. The standards listed below constitute minimum performance expectations applicable to "hydrologically-connected" VTrans roads in the Lake Champlain Basin portion of VTrans' Transportation Separate Storm Sewer System (TS4)-permitted area. Road segments where associated culverts, swales, and/or closed drainage systems do not meet the standards outlined below, as detailed in the VTrans Generalized Phosphorus Control Plan, may be improved in order to meet the standards, restore function, and improve water quality. When road drainage asset conditions are improved to meet these standards, the improvements result in reduced sediment and phosphorus loading to surface waters and to Lake Champlain, and thus may be credited towards achievement of VTrans' target phosphorus load reductions under the Vermont Lake Champlain Phosphorus TMDLs.

2.0 Feasibility

A. VTrans may implement these standards to the extent feasible as one component of the overall Phosphorus Control Plan implementation strategy. In determining feasibility, VTrans may consider that the implementation of a standard or BMP listed in this document shall not require:

i. acquisition of additional state or federal permits or noncompliance with such permits;
ii. noncompliance with any other state or federal law;
iii. acquisition or condemnation of real property;
iv. impacts to significant environmental and historic resources, including historic stone walls, historic structures, historic landscapes, or vegetation within 250 feet of a lakeshore;
v. impacts to utilities; or
vi. excessive ledge removal.

B. VTrans may document in an Implementation Table, or other data management and tracking system, each instance where feasibility constraints affect implementation of the standards.

3.0 Standards for Construction and Soil Disturbing Activities

A. Following soil disturbance on a hydrologically-connected road segment, all bare or unvegetated areas shall be revegetated with seed and mulch, hydroseeded, or stone lined within 48 hours of reaching final grade. Activities shall follow the current version of the VTrans Erosion Prevention and Sediment Control (EPSC) Protocol,[1] as specified in the VTrans SWMP[2].

[1] https://vtrans.vermont.gov/working/enviro/erosion-prevent
[2] https://anrweb.vt.gov/PubDocs/DEC/Stormwater/PublicNotice/7892-9007/VTrans Final SWMP - December 5 2017.pdf

4.0 Standards for Travel Lanes, Shoulders, and Guardrails

A. Roadway Crown, Cross-slope, and Superelevation

i. Roads shall be designed and constructed with appropriate crown, cross-slope, and superelevation during new construction, redevelopment, or repaving where repaving involves removal of the existing paving. Recommended cross slope is average 2%[3][4].

B. Roadway Shoulders

i. Roadway runoff shall flow in a distributed manner to a vegetated or forested area.

ii. There shall be no shoulder berms, except where installed to prevent slope failure or direct runoff away from steep slopes. Shoulder berms may be removed to allow precipitation to shed from the travel lane to a vegetated or forested area or into a road drainage system.

iii. There shall be no evidence of a "secondary ditch", or other erosion of the road shoulder. Where shoulder erosion is identified, it may be corrected to meet standards by implementing repairs including but not limited to those illustrated in the following standard details and related resources:

a. LE-5: Riprap Slope Protection
b. LE-6: Armored Shoulder Protection
c. District Maintenance and Fleet Division Work Activity Guidelines[5]:
    a. 4570, Protecting Banks and Slopes (ton)
    b. 4180, Maintaining Gravel Surfaces (lane miles)
    c. 4360, Ditching (lin. foot)

C. Guardrails

i. Where guardrails without curb board are present, the standards for Roadway Shoulders shall apply (Section 4.B).

ii. Where guardrails with curbing, curb board, and/or drop inlets are present, the standards for Roadway Shoulders (Section 4.B), Culverts (Section 6.0), and Outlets and Turnouts (Section 7.0) shall apply as appropriate.

iii. Guardrails shall be evaluated during the development process for VTrans construction projects, and curb removed if feasible per the following references:
a. Vermont Stormwater Management Manual Figure 6-1, Curb Removal (Detail)[6]
b. District Maintenance and Fleet Division Work Activity Guidelines for Activity 4480, Eliminating Guardrail (lin. foot)

---

[3] https://vtrans.vermont.gov/sites/aot/files/highway/documents/publications/VTrans Roadway Design Manual.zip
[4] https://vtrans.vermont.gov/sites/aot/files/highway/documents/publications/VermontStateDesignStandards.pdf
[5] MATS Complete Activity Book / Work Activity Guidelines document, updated September 2019; available via internal VTrans network or by request.
[6] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017_VSMM_Rule_and_Design_Guidance_04172017.pdf

iv. If curb board is removed, the adjacent shoulder and slope must have adequate stabilization measures to handle the flows. In some cases, larger stone may be needed. Following curb board removal, the roadway draining to the guardrail and the downslope right-of-way area may be tracked and managed as a disconnection structural stormwater treatment practice.

5.0 Standards for Ditches

A. If it is not possible for runoff to flow from the roadway in a distributed manner, runoff may enter a drainage ditch.

B. Ditches adjacent to hydrologically connected road segments shall be constructed and maintained consistent with the standards and guidance provided in the VTrans Hydraulics Manual[7] and the VTrans Highway System Ditching Best Management Practices (BMPs)[8].

C. Ditches identified in the TS4 Swales Inventory[9] as being in "Critical" or "Poor" condition, or otherwise exhibiting bare soil, erosion, sediment accumulation, or substantial deficiencies in geometry (trapezoidal or parabolic cross section with mild side slopes of two feet horizontal per one foot vertical or flatter, 2-foot minimum ditch bottom width, and 2 foot ditch depth) do not meet standards.

D. Best management practices that may be utilized to improve ditches to meet standards include but are not limited to those listed in Table 1.

E. . The listed BMPs may be supplemented with or replaced with armored shoulders, step pool conveyances, or sub-surface drainage practices as warranted. The following standard details and related references may also be utilized:

i. DD-3: Plunge Pool
ii. DD-4: Outlet Protection (No Defined Channel)
iii. DD-7: Rock Step and Riffle
iv. LE-1: Seed and Mulch Guidelines
v. LE-2: Stone Check Dam
vi. LE-3: Stone-Lined Ditch
vii. LE-4: Grass-Lined Ditch
viii. LE-7: Clearing Debris/Clogging
ix. District Maintenance and Fleet Division Work Activity Guidelines[10]:
    a. 4360, Ditching (lin. ft.)

[7] https://vtrans.vermont.gov/sites/aot/files/highway/documents/structures/VTrans Hydraulics Manual.pdf
[8] https://vtrans.vermont.gov/sites/aot/files/DitchingBMP_FINAL_SIGNED_1_12_21.pdf
[9] https://www.arcgis.com/home/webmap/viewer.html?url=https%3A%2F%2Fmaps.vtrans.vermont.gov%2Farcgis%2Frest%2Fservices%2FHWY%2FMOB_EPWQ_TS4_Inventory%2FFeatureServer&source=sd
[10] MATS Complete Activity Book / Work Activity Guidelines document, updated September 2019; available via internal VTrans network or by request.

Table 1. Summary of Ditch and Outlet Protection Treatments

Ditch or Outlet Slope	Acceptable Treatments						
	Seed & Mulch*	Hydro-seeding*	Rolled Erosion Control Product Type I (Natural) Matting & Seed	Rolled Erosion Control Product Type II (Permanent)	Stone Check Dam	Type I Stone	Type II Stone
0 - 2.5%	X	X	X				
2.5 - 5%	X	X	X	X			
5 - 10%	X	X	X	X	X	X	
> 10%		X	X	X	X		X
* Treatment not recommended for application in areas of concentrated flow							

6.0 Standards for Culverts (Ultra Short and some Short Structures)

A. If it is not possible for runoff to flow from the roadway in a distributed manner, runoff may enter and flow through a culvert.

B. VTrans cross culverts or lateral culverts adjacent to hydrologically connected road segments shall be constructed and maintained consistent with the standards and guidance provided in the VTrans Hydraulics Manual or other applicable design guidance.

C. VTrans culverts identified in the AMB Small Culverts Inventory (Ultra-Short Structures) as exhibiting one or more of the following asset conditions, or otherwise exhibiting bare soil, erosion, sediment accumulation, or other substantial deficiencies that may impact water quality, do not meet standards:

i. Culvert condition = critical or poor
ii. Culvert erosion = severe or moderate
iii. Culvert sediment = plugged or heavy
iv. Culvert sink hole = severe or major
v. Road settling = grade

D. Best management practices that may be utilized to improve VTrans culverts to meet standards include but are not limited to:

i. Culvert end treatment or headwall, if erosion is due to absence of these structures and the treatment can be installed while maintaining the safety of the traveling public (standard detail DD-1 Dry Laid Field Stone Header)

ii. Stabilize outlet such that there will be no scour erosion (standard details DD-3 Plunge Pool, DD-4 Outlet Protection, DD-7 Rock Step and Riffle) . Stone aprons or plunge pools required for new construction on slopes 5% or greater per the VTrans Hydraulics Manual[11]

iii. Upgrade to 18" culvert (minimum) if erosion is due to inadequate size or absence of structure (standard details DD-2 Culvert Replacement, DD-5 Upsize Culvert, DD-6 Partial Culvert Replacement)

[11] https://vtrans.vermont.gov/sites/aot/files/highway/documents/structures/VTrans Hydraulics Manual.pdf

iv. District Maintenance and Fleet Division Work Activity Guidelines[12]:

a. 4610, Maintaining Culverts (culvert)
b. 4620, Installing Culverts (lin. foot)
c. 4640, Stormwater/Drainage Work (each)
d. 5130, Repairing Structures (each)
e. 5150, Repairing Culvert Headwalls (each)
f. 5170, Small Structures Culvert Liners (lin. foot)
g. 5171, Small Structures Culvert Invert (lin. foot)
h. 5172, Small Structures Replacement (lin. foot)
i. 4640, Maintaining Drainage Structures (each)

v. Where feasible, culverts shall be installed, repaired, or replaced with minimal slope (1%) to reduce outlet velocity and outlet erosion.

E. In some instances, intermittent streams enter the VTrans road drainage network. In these cases, culvert sizing may be based on the VTrans Hydraulics Manual[11]. VTrans culverts conveying perennial waters are not subject to the DEC Stream Alteration General Permit, and instead are subject to Title 19 consultation[13] if alterations are considered.

F. An underdrain (also called a French Drain) sub-surface drainage practice may be substituted for a VTrans lateral culvert.

G. Driveway Culverts within the VTrans ROW

i. All driveway culverts, and their construction and maintenance within the VTrans ROW, are the responsibility of the property owner. Driveway culverts and other aspects of residential and commercial access to the VTrans ROW are permitted through the VTrans State Highway Access and Work Permit[14], and as specified in the VTrans TS4 SWMP .

ii. Access to a state highway shall be constructed and maintained by property owners consistent with minimum VTrans standards for driveway access (Standard B-71a[15] or B-71b[16])

iii. VTrans may consider the following recommended BMPs as permit conditions during review of VSA Title 19 Section 1111 Permit applications for alterations to existing access points:

a. Culvert end treatment recommended for areas with slopes of 5% or greater if erosion is due to absence of these structures.
b. Stabilize outlet such that there will be no scour erosion if erosion is due to absence or inadequacy of outlet stabilization.

[12] MATS Complete Activity Book / Work Activity Guidelines document, updated September 2019; available via internal VTrans network or by request.
[13] https://vtrans.vermont.gov/environmental-manual/permitting/wetlands/stream-alteration
[14] https://vtrans.vermont.gov/planning/permitting
[15] https://outside.vermont.gov/agency/vtrans/external/CADD/WebFiles/Downloads/Standards/English/PDF/stdb71a.pdf
[16] https://outside.vermont.gov/agency/vtrans/external/CADD/WebFiles/Downloads/Standards/English/PDF/stdb71b.pdf

c. Upgrade to minimum 15" culvert, if erosion is due to inadequate size or absence of structure.

iv. VTrans may review issued VSA Title 19 Section 1111 Permits during VTrans project development[17]. If a driveway culvert in the VTrans ROW has not been issued an 1111 Permit, the property owner may be required to obtain the appropriate permit for access and to make improvements consistent with permit conditions. Otherwise, the access may be considered abandoned and be eliminated during the project's construction phase.

7.0 Standards for Outlets and Turnouts

A. Roadway drainage shall be disconnected from or turned out to avoid direct outlet to waterbodies and defined channels where feasible. Hydrologically-connected drop inlet and closed drainage system outlets, culvert and ditch outlets, turnouts, and conveyance areas shall be constructed and maintained consistent with the standards and guidance provided in the VTrans Hydraulics Manual[18] or other applicable design guidance.

B. Adequate outlet protection must be provided at the outlet or turnout, consistent with slope ranges provided in Table 1. Outlet and turnout slopes shall be measured on the bank where the practice is located.

C. Closed drainage or culvert outlets, ditch outlets, or turnouts exhibiting bare soil, erosion, or sediment accumulation do not meet standards. Best management practices that may be utilized to meet standards include but are not limited to those listed for ditches in Table 1. The listed BMPs may be supplemented with or replaced with level spreaders, plunge pools (standard detail DD-3), step pool conveyances (standard detail DD-7) or other BMPs as warranted.

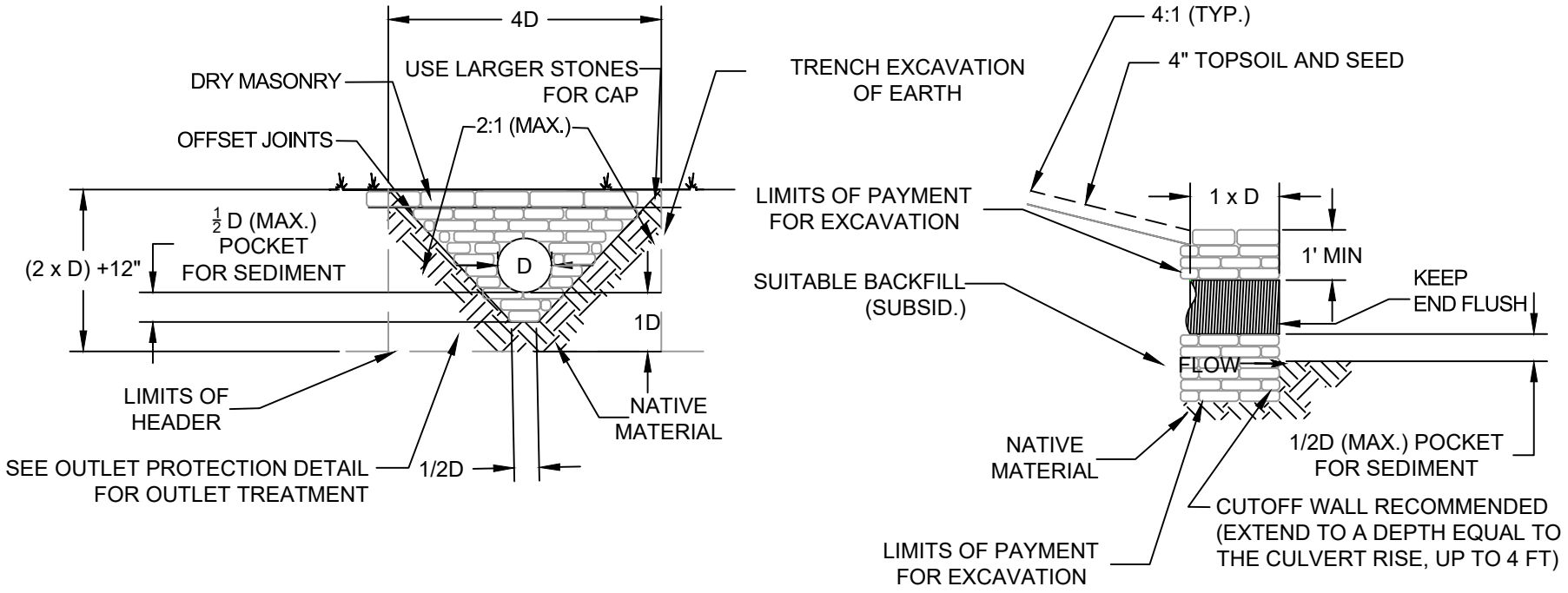
[17] https://vtrans.vermont.gov/sites/aot/files/highway/documents/publications/PDManual.pdf
[18] https://vtrans.vermont.gov/sites/aot/files/highway/documents/structures/VTrans Hydraulics Manual.pdf

NOTES:

1. DRY LAID FIELD STONE HEADERS ARE RECOMMENDED. SEE VTRANS STANDARD DETAILS D-33 AND D-34 FOR REINFORCED CONCRETE HEADWALL OPTIONS.

2. PRIOR TO INSTALLATION OF A HEADER TO A CULVERT END, DESIGNER SHALL REVIEW THE VTRANS HYDRAULICS MANUAL SECTION 6.4.3.5 TO DETERMINE PROPER PIPE END TREATMENT.

3. EXISTING NATIVE MATERIAL SHALL BE USED AS BACKFILL UNLESS UNSUITABLE MATERIAL IS DISCOVERED DURING EXCAVATION AND PLACEMENT OF HEADER. UNSUITABLE MATERIAL SHALL BE REMOVED AND REPLACED WITH APPROVED MATERIAL PER VTRANS STANDARD SPECIFICATIONS.



DRY LAID FIELD STONE HEADER DETAIL

Not To Scale

FIGURE NO. 1

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

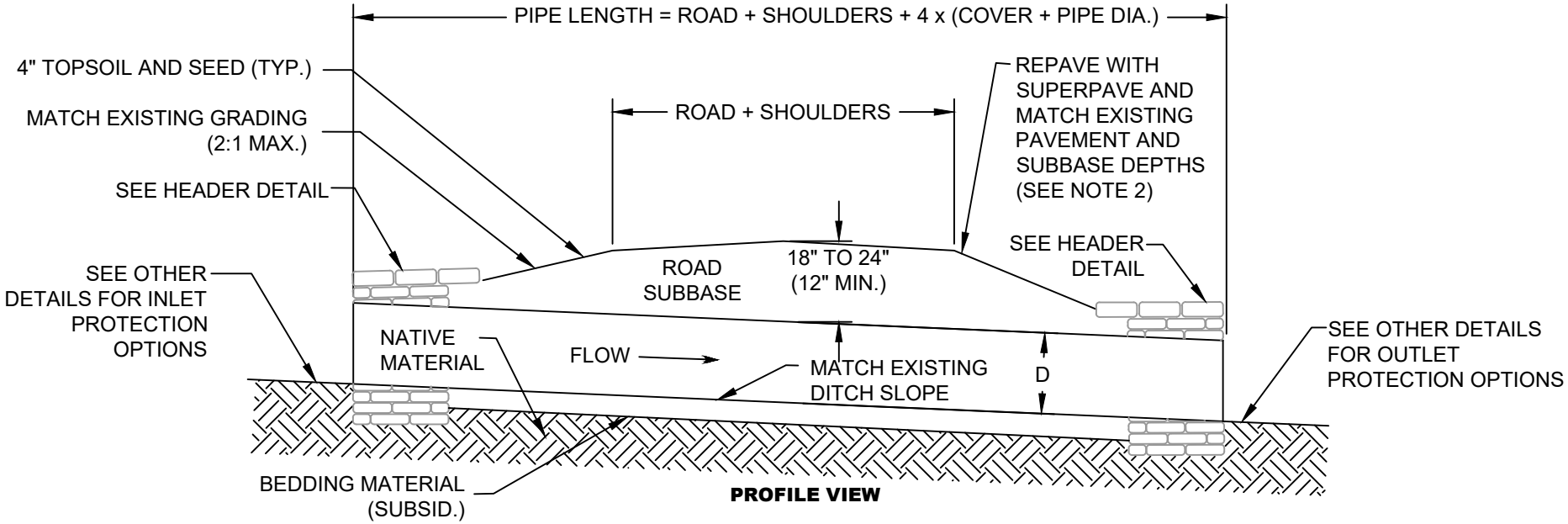
DRAINAGE DEFICIENCIES
DRY LAID FIELD STONE HEADER
PCP IMPLEMENTATION PLAN

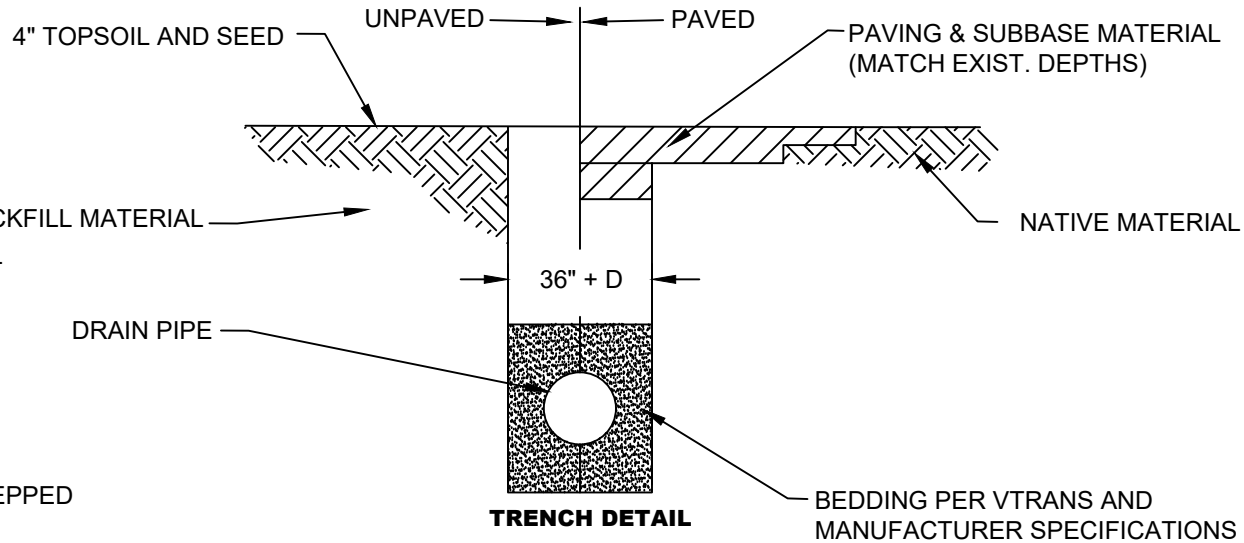
VERMONT

DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	MMI
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

File: V:\HSG\125502 - Stone, VTrans PCP Implementation\2-CADD





NOTES:

1. EXISTING NATIVE MATERIAL SHALL BE USED AS BACKFILL UNLESS UNSUITABLE MATERIAL IS DISCOVERED DURING EXCAVATION AND PLACEMENT OF HEADER. UNSUITABLE MATERIAL SHALL BE REMOVED AND REPLACED WITH APPROVED MATERIAL PER VTRANS STANDARD SPECIFICATIONS.

2. SUPERPAVE SHALL BE UTILIZED MATCHING EXISTING PAVEMENT DEPTHS. PAVEMENT COURSES SHALL BE STEPPED TO AVOID A SINGLE PAVEMENT JOINT AND EMULSIFIED ASPHALT SHALL BE USED PER VTRANS STANDARD SPECIFICATIONS.

CULVERT REPLACEMENT DETAIL

Not To Scale

FIGURE NO. 2

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

DRAINAGE DEFICIENCIES
CULVERT REPLACEMENT DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	MMI
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

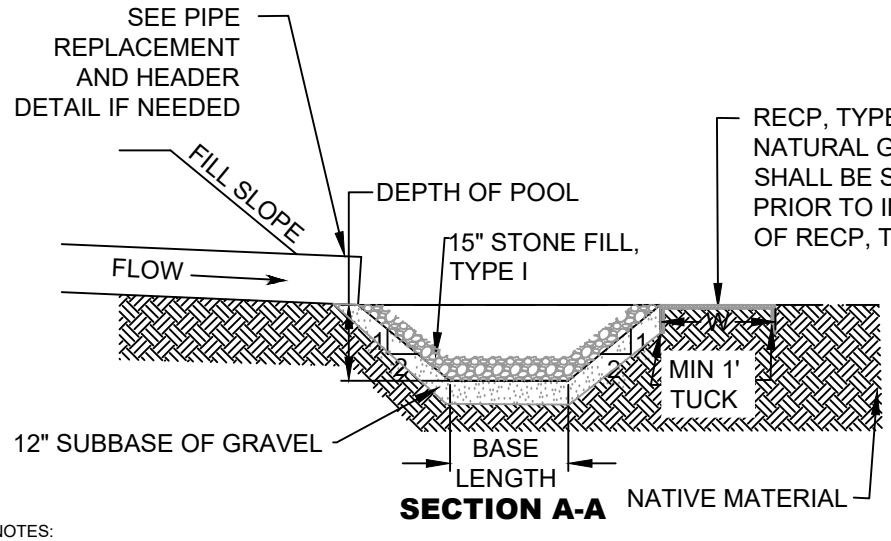
TABLE 1

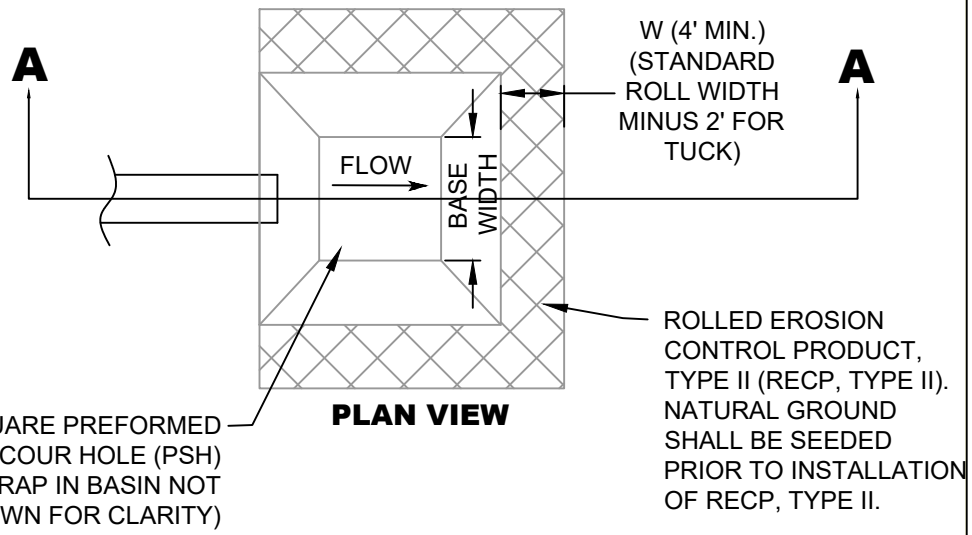
PIPE SIZE/FLOW	BASE WIDTH (W) (FT)	BASE LENGTH (L) (FT)	DEPTH OF POOL (FT)	L:W RATIO
PIPE <= 18" DIA AND FLOWS <= 9 CFS	3 x D	3 x D	1' MIN/3' MAX	1:1
PIPE > 18" DIA AND FLOWS > 9 CFS	SEE TABLE 2	SEE TABLE 2	3' MIN/5' MAX	2:1 MIN/6:1 MAX

TABLE 2

PIPE SIZE/FLOW	IMPERVIOUS AREA (SF)	CALCULATED VOLUME (CF)	BASE WIDTH (W) (FT)	BASE LENGTH (L) (FT)	DEPTH OF POOL (FT)	ACTUAL VOLUME (CF)
PIPE > 18" DIA AND FLOWS > 9 CFS	LESS THAN 60,000	500	4	8	3	512
	BETWEEN 60,000 AND 110,000	917	4	8	4	939
	BETWEEN 110,000 AND 180,000	1500	4	8	5	1547

IMPERVIOUS AREA DRAINING TO PRACTICE.
SIZE IS BASED ON VOLUME ASSOCIATED WITH 0.1 IN OF RUNOFF FOR THE IMPERVIOUS AREA WITHIN THE CONTRIBUTING DRAINAGE AREA





NOTES:

1. EXISTING NATIVE MATERIAL SHALL BE USED AS BACKFILL UNLESS UNSUITABLE MATERIAL IS DISCOVERED DURING EXCAVATION AND PLACEMENT OF PLUNGE POOL. UNSUITABLE MATERIAL SHALL BE REMOVED AND REPLACED WITH APPROVED MATERIAL PER VTRANS STANDARD SPECIFICATIONS.
2. PLUNGE POOLS SHALL BE LIMITED TO AREAS WITH <10% SLOPE.
3. THE GRAVEL LAYER SHALL BE REPLACED WITH FILTER FABRIC IN CLAY AND SILT SOILS.
4. PLUNGE POOLS SHALL BE INSTALLED WHERE EXISTING STORMWATER HAS ERODED A HOLE IN THE NATIVE MATERIAL AT THE PIPE OUTLET. PLUNGE POOLS CAN NOT BE INSTALLED ON SLOPES.
5. PLUNGE POOLS SHALL BE CONSTRUCTED IN UNDISTURBED SOILS INSTEAD OF IN FILL MATERIAL.
6. PLUNGE POOLS SHALL BE CONSTRUCTED OUTSIDE OF CLEAR RECOVERY ZONES AND ENVIRONMENTALLY SENSITIVE AREAS AND SHALL BE DESIGNED PER THE VERMONT STORMWATER TREATMENT STANDARDS.

PLUNGE POOL DETAIL

Not To Scale

FIGURE NO. 3

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

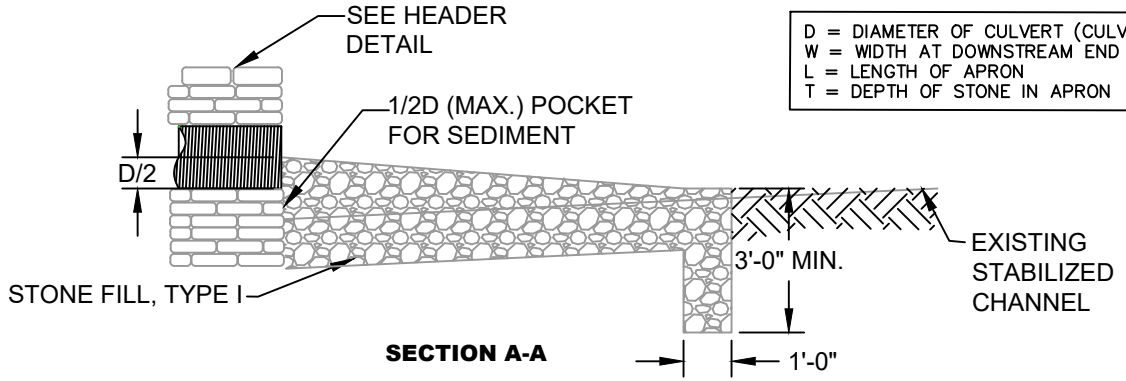
VERMONT AGENCY OF TRANSPORTATION

DRAINAGE DEFICIENCIES
PLUNGE POOL DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

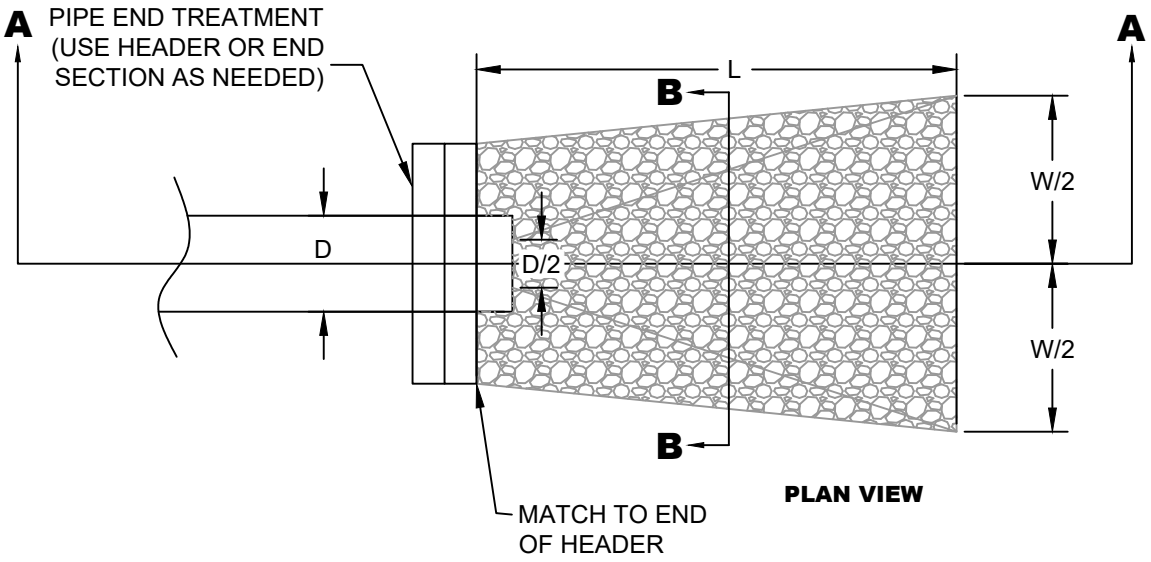
DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	MMI
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C



SECTION A-A

D = DIAMETER OF CULVERT (CULVERT RISE)
W = WIDTH AT DOWNSTREAM END OF APRON
L = LENGTH OF APRON
T = DEPTH OF STONE IN APRON



PLAN VIEW

TABLE 1: STONE FILL TYPE REQUIRED AT CULVERT OUTLETS

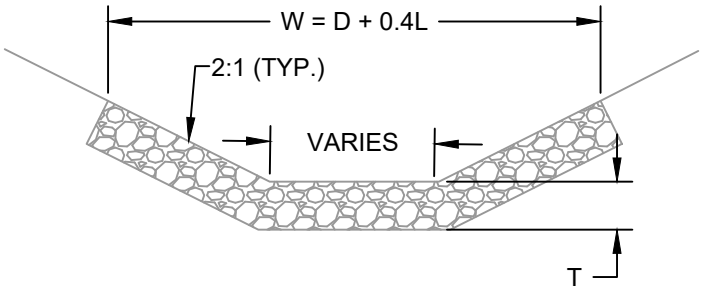
CULVERT RISE (FT)	DESIGN DISCHARGE (CFS)			
	10	20	30	40
2	I	II	II	IV
3	I	I	II	II
4	I	I	I	I

SEE VTRANS HYDRAULICS MANUAL FOR ADDITIONAL PIPE SIZE AND DISCHARGE OPTIONS (TABLE 6-4)

TABLE 2: STONE APRON DIMENSIONS AT CULVERT OUTLETS WITH COMMERCIAL END SECTIONS

STONE FILL TYPE	D_{50}	APRON LENGTH	APRON DEPTH
	(IN)	(L) (FT)	(T) (FT)
TYPE I	4	4 x D	1.2
TYPE II	12	5.5 x D	2.3
TYPE III	16	6.5 x D	2.8
TYPE IV	20	7 x D	3.3

NOTE: FOR CULVERTS WITHOUT COMMERCIAL END SECTIONS, ADD AN ADDITIONAL 3 FT ONTO THE APRON LENGTH
REFERENCE: VTRANS HYDRAULICS MANUAL



SECTION B-B

OUTLET PROTECTION DETAIL (NO DEFINED CHANNEL)

Not To Scale

NOTES:

1. MINIMUM LENGTH (L) SHALL BE A DISTANCE EQUAL TO THE CULVERT RISE UPSTREAM OR DOWNSTREAM.
2. ENERGY DISSIPATOERS SHALL BE UTILIZED IF EXISTING OUTLET HAS EROSION OF AN EXISTING STONE OUTLET PROTECTION AREA. SEE VTRANS STANDARD DETAIL D-16 FOR ADDITIONAL INFORMATION ON ENERGY DISSIPATERS FOR CULVERTS.
3. IF FLOW THROUGH CULVERT IS CAUSING EROSION TO AN EXISTING ENERGY DISSIPATER AS DESIGNED BY VTRANS STANDARD DETAIL D-16, REVISED OUTLET PROTECTION AND ENERGY DISSIPATERS SHALL BE DESIGNED IN ACCORDANCE WITH THE DESIGN GUIDELINES PUBLISHED IN FHWA'S HEC-14, *"HYDRAULIC DESIGN OF ENERGY DISSIPATERS FOR CULVERTS AND CHANNELS."*

FIGURE NO. 4

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

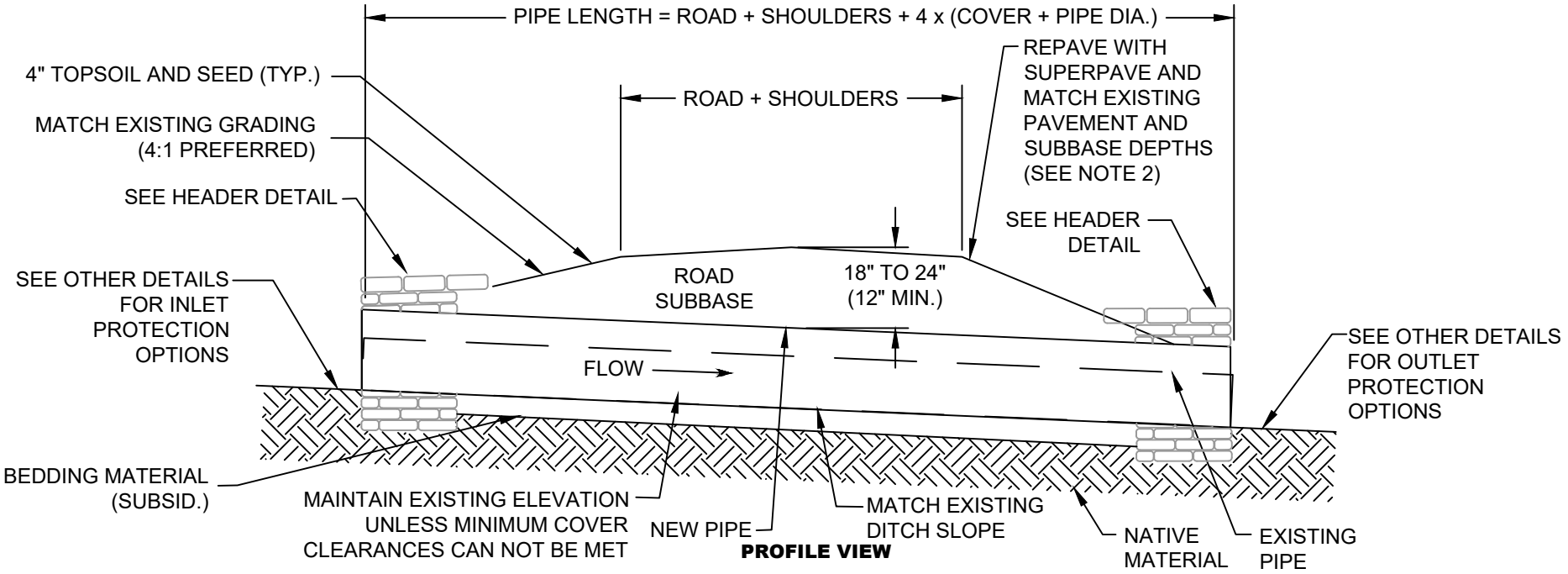
DRAINAGE DEFICIENCIES
OUTLET PROTECTION DETAIL
PCP IMLEMENTATION PLAN

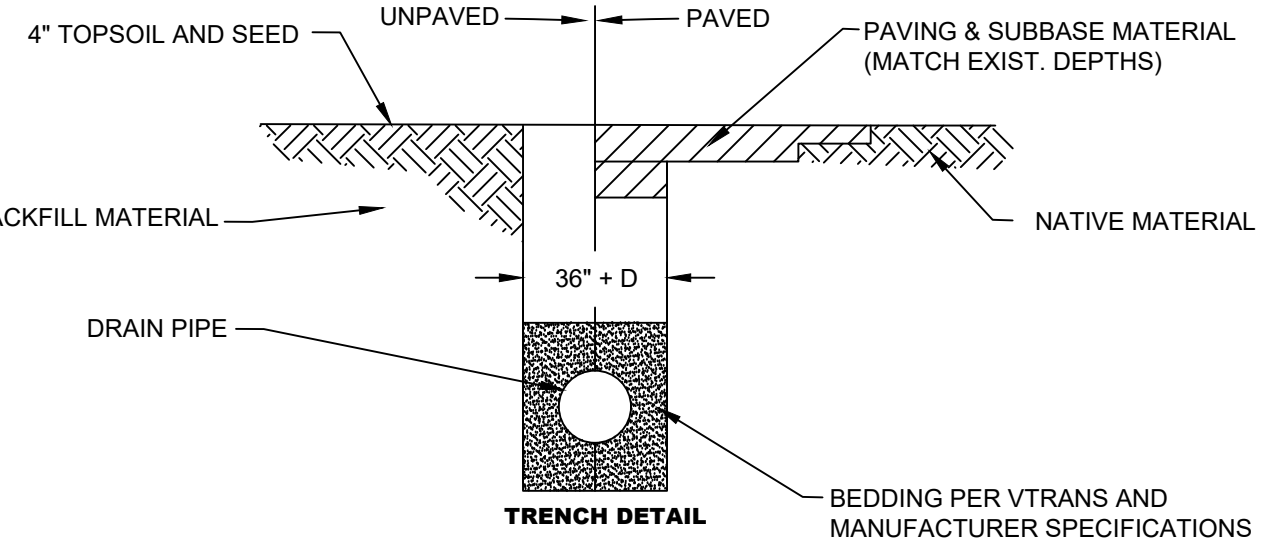
VERMONT

DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	MMI
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

File: V:\HSG\125502 - Stone, VTrans PCP Implementation\2-CADD





NOTES:

1. EXISTING NATIVE MATERIAL SHALL BE USED AS BACKFILL UNLESS UNSUITABLE MATERIAL IS DISCOVERED DURING EXCAVATION AND PLACEMENT OF PIPE. UNSUITABLE MATERIAL SHALL BE REMOVED AND REPLACED WITH APPROVED MATERIAL PER VTRANS STANDARD SPECIFICATIONS.

2. SUPERPAVE SHALL BE UTILIZED MATCHING EXISTING PAVEMENT DEPTHS. PAVEMENT COURSES SHALL BE STEPPED TO AVOID A SINGLE PAVEMENT JOINT AND EMULSIFIED ASPHALT SHALL BE USED PER VTRANS SPECIFICATIONS.

UPSIZE CULVERT DETAIL

Not To Scale

FIGURE NO. 5

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

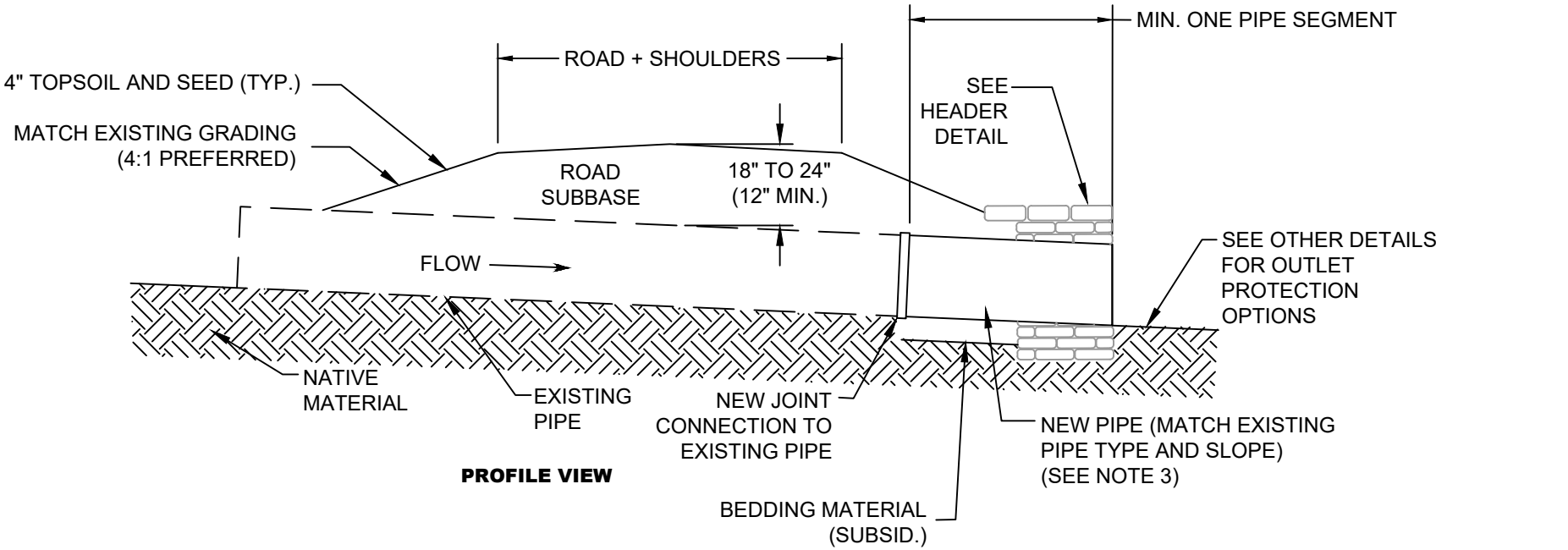
VERMONT AGENCY OF TRANSPORTATION

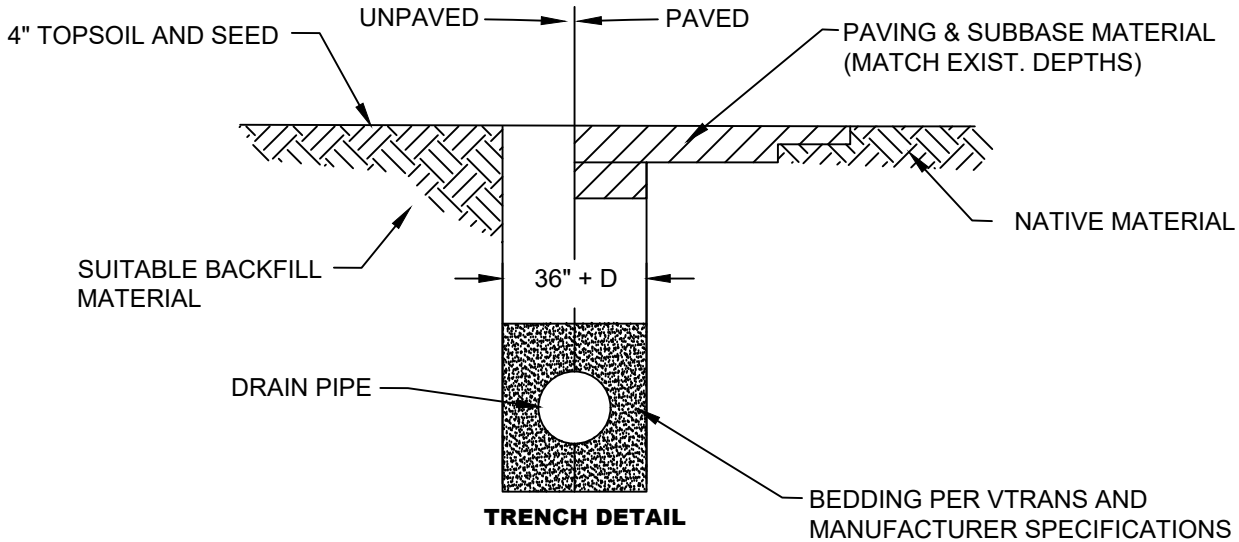
DRAINAGE DEFICIENCIES
UPSIZE CULVERT DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	MMI
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C





NOTES:

1. EXISTING NATIVE MATERIAL SHALL BE USED AS BACKFILL UNLESS UNSUITABLE MATERIAL IS DISCOVERED DURING EXCAVATION AND PLACEMENT OF PIPE. UNSUITABLE MATERIAL SHALL BE REMOVED AND REPLACED WITH APPROVED MATERIAL PER VTRANS STANDARD SPECIFICATIONS.
2. SUPERPAVE SHALL BE UTILIZED MATCHING EXISTING PAVEMENT DEPTHS. PAVEMENT COURSES SHALL BE STEPPED TO AVOID A SINGLE PAVEMENT JOINT AND EMULSIFIED ASPHALT SHALL BE USED PER VTRANS SPECIFICATIONS.
3. PARTIAL CULVERT REPLACEMENTS SHALL ONLY BE USED FOR PLASTIC OR RC PIPES. CORRUGATED METAL PIPES SHOULD BE FULLY REPLACED.

PARTIAL CULVERT REPLACEMENT DETAIL

Not To Scale

FIGURE NO. 9

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

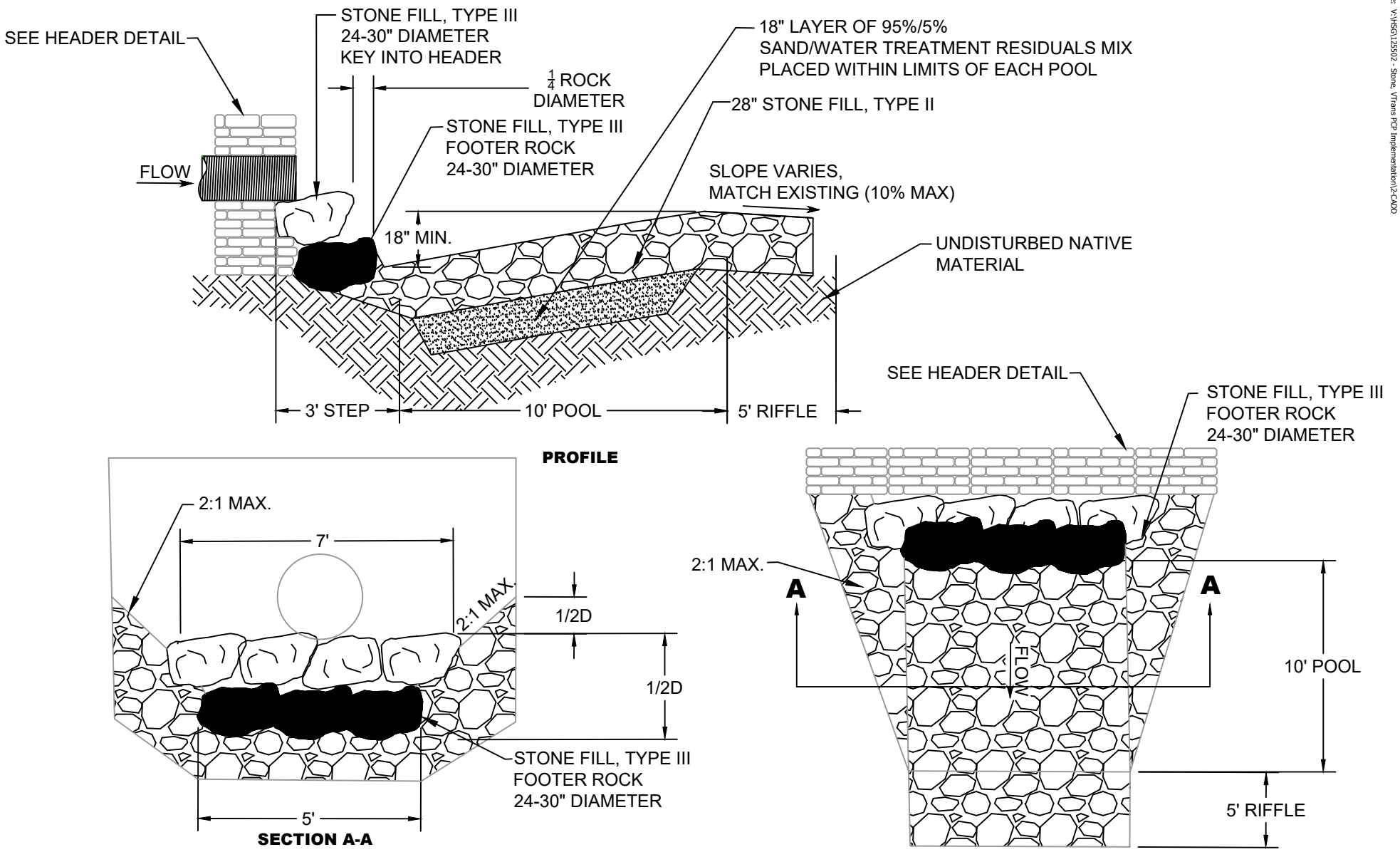
VERMONT
AGENCY OF TRANSPORTATION

DRAINAGE DEFICIENCIES
PARTIAL REPLACEMENT DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	MMI
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C



ROCK STEP AND RIFFLE DETAIL

Not To Scale

NOTES:

1. DETAIL CAN BE USED IN SUCCESSION AS NEEDED.

FIGURE NO. 7

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT
AGENCY OF TRANSPORTATION

DRAINAGE DEFICIENCIES
ROCK STEP AND RIFFLE DETAILS
PCP IMPLEMENTATION PLAN

VERMONT

DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	MMI
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

DITCH GUIDELINES

LONGITUDINAL SLOPE (S) RANGE	APPROPRIATE DITCH TREATMENTS
0% < S < 5%	GRASS-LINED DITCH
5% ≤ S < 8%	GRASS-LINED DITCH WITH STONE CHECK DAMS
	GRASS-LINED DITCH WITH DISCONNECTION PRACTICES
	STONE-LINED DITCH
8% ≤ S < 10%	STONE-LINED DITCH (6" TO 8" MINUS STONE)
10% ≤ S	STONE-LINED DITCH (12" MINUS STONE)

NOTES:

1. GRASS-LINED DITCHES SHALL BE INSTALLED WHENEVER POSSIBLE AND WHENEVER GRASS CAN BE ESTABLISHED NO MATTER THE SLOPE.
2. IF GRASS CANNOT BE ESTABLISHED ON SLOPES LESS THAN 5%, STONE-LINED DITCHES SHALL BE INSTALLED.
3. FOR ADDITIONAL SEEDING INFORMATION SEE VTRANS EPSC TURF ESTABLISHMENT DETAIL.

CULVERT GUIDELINES

NOTES:

1. REPLACE CULVERTS WITH THE SAME SIZE PIPE IF IT IS HANDLING THE FLOW ADEQUATELY.
2. INCREASE CULVERT SIZE AS DEVELOPMENT ALONG A ROAD INCREASES OR IF THE CULVERT IS MORE THAN HALF FULL DURING HIGH FLOWS.

SEED MIXTURES

MIXTURES	`RATE PER ACRE (LBS)	RATE PER 1,000 SF (LBS)
A. BIRDSFOOT TREFOIL OR LADINO CLOVER*	8	0.20
TALL FESCUE OR SMOOTH BROMEGRASS	20	0.45
REDTOP**	2	0.05
	30	0.70
OR		
B. KENTUCKY BLUEGRASS***	25	0.60
CREEPING RED FESCUE	20	0.50
PERENNIAL RYEGRASS	10	0.20
	55	1.30

REFERENCE: THE VERMONT STANDARDS AND SPECIFICATIONS FOR EROSION PREVENTION & SEDIMENT CONTROL 2019.

* INOCULATE WITH APPROPRIATE INOCULUM IMMEDIATELY PRIOR TO SEEDING. LADINO OR COMMON WHITE CLOVER MAY BE SUBSTITUTED FOR BIRDSFOOT TREFOIL AND SEEDED AT THE SAME RATE.

** PERENNIAL RYGRASS MAY BE SUBSTITUTED FOR THE REDTOP BUT INCREASE SEEDING RATE TO 5 LBS/ACRE (0.1 LB/1,000 SF).

*** USE THIS MIXTURE IN AREAS WHICH ARE MOWED FREQUENTLY. COMMON WHITE CLOVER MAY BE ADDED IF DESIRED AND SEEDED AT 8 LBS/ACRE (O.2 LB/1,000 SF).

GUIDELINES, SEED AND MULCH DETAIL

Not To Scale

FIGURE NO. 1

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

LOCALIZED EROSION GUIDELINES, SEED AND MULCH
PCP IMPLEMENTATION PLAN

VERMONT

DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	JFMS
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

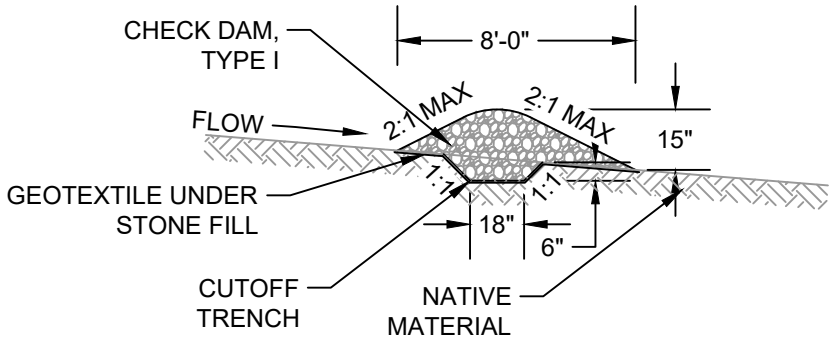
File: FILE LOCATION

NOTES:

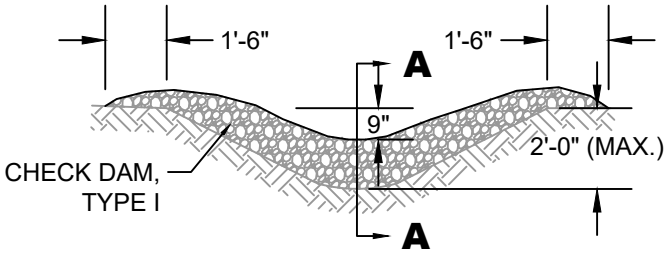
1. STONE WILL BE PLACED ON A FILTER FABRIC FOUNDATION.
2. SET SPACING OF CHECK DAMS TO ASSUME THAT THE ELEVATIONS OF THE CREST OF THE DOWNSTREAM DAM IS AT THE SAME ELEVATION OF THE TOE OF THE UPSTREAM DAM.
3. CHECK DAMS SHALL NOT BE INSTALLED IN LIVE STREAMS OR CHANNELS.
4. EXTEND THE STONE A MINIMUM OF 1.5 FEET BEYOND THE DITCH BANKS TO PREVENT CUTTING AROUND THE DAM.
5. ENSURE THAT CHANNEL APPURTENANCES SUCH AS CULVERT ENTRANCES BELOW CHECK DAMS ARE NOT SUBJECT TO DAMAGE OR BLOCKAGE FROM DISPLACED STONE.
6. MAXIMUM DRAINAGE AREA IS 2 ACRES.

MAINTENANCE:

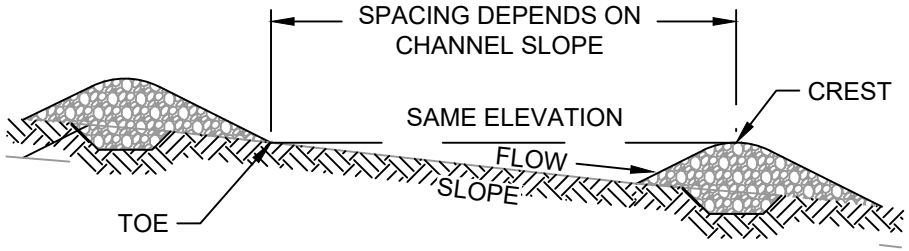
1. REMOVE SEDIMENT ACCUMULATED BEHIND THE DAM AS NEEDED TO ALLOW CHANNEL TO DRAIN THROUGH THE STONE CHECK DAM AND PREVENT LARGE FLOWS FROM CARRYING SEDIMENT OVER THE DAM. IF SIGNIFICANT EROSION OCCURS BETWEEN CHECK DAMS, A LINER OF STONE SHOULD BE INSTALLED.



SECTION A-A



CROSS SECTION



SPACING BETWEEN CHECK DAMS

SAMPLE SPACING FOR 2' HIGH CHECK DAMS	
SLOPE	SPACING
1%	200
2%	100
5%	40
8%	25
10%	20

STONE CHECK DAM DETAIL

Not To Scale

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

LOCALIZED EROSION
STONE CHECK DAM DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

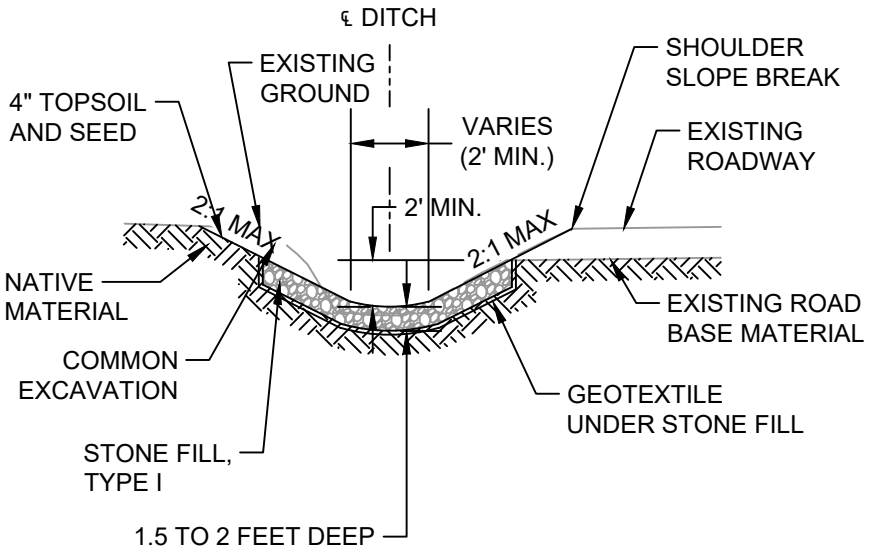
DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	JFMS
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

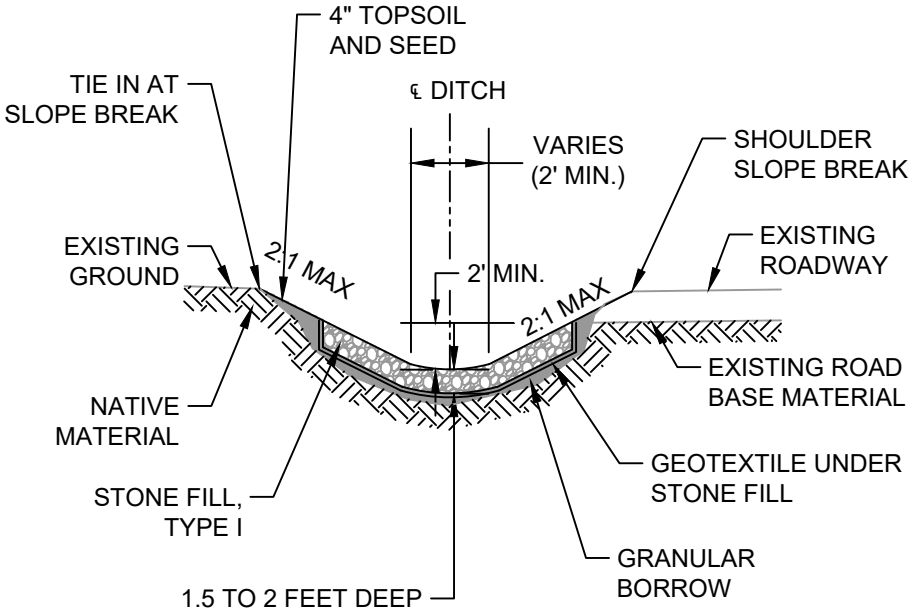
File: FILE LOCATION

NOTES:

1. SEE SEED AND MULCH DETAIL FOR SEEDING MIXTURE.
2. THE MAXIMUM CAPACITY OF THE WATERWAY FLOWING AT DESIGN DEPTH SHALL NOT EXCEED 100 CUBIC FEET PER SECOND.
3. THE MINIMUM CAPACITY SHALL BE ADEQUATE TO CARRY THE PEAK RATE OF RUNOFF FROM A 10-YEAR, 24-HOUR STORM.
4. SEE THE VERMONT STANDARDS AND SPECIFICATIONS FOR EROSION PREVENTION & SEDIMENT CONTROL FOR ADDITIONAL INFORMATION.



TYPICAL CUT SECTION



TYPICAL FILL SECTION

STONE-LINED DITCH DETAIL

Not To Scale

FIGURE NO. 3

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

LOCALIZED EROSION
STONE-LINED DITCH DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

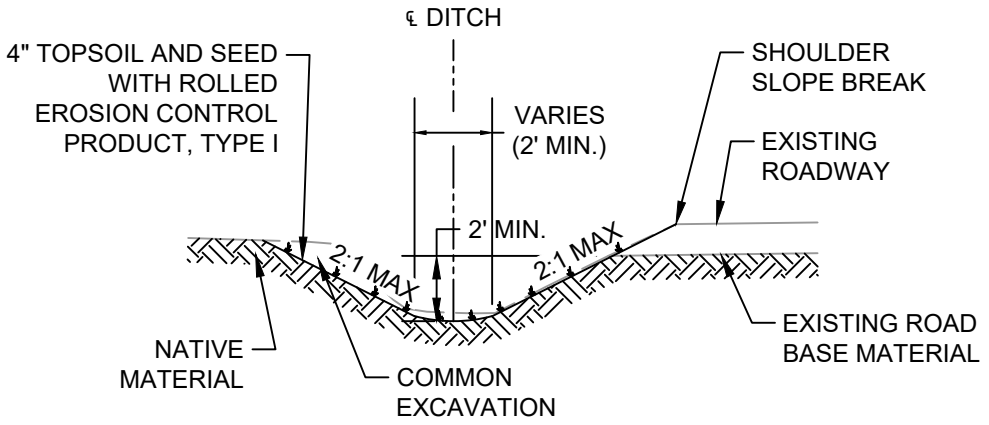
DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	JFMS
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

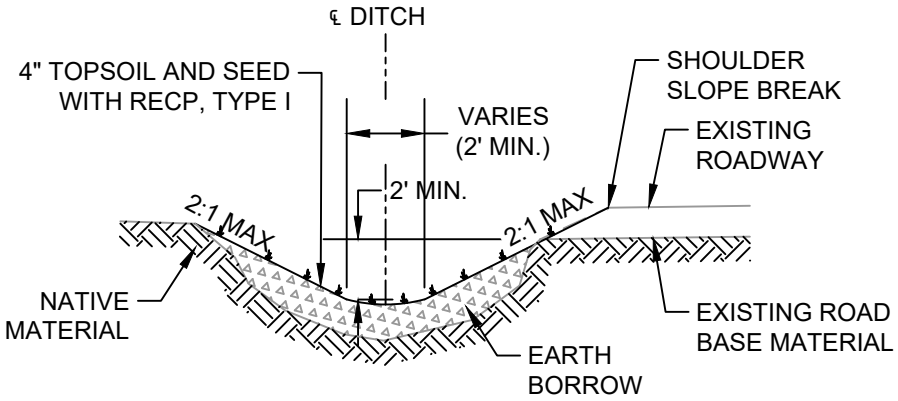
File: FILE LOCATION

NOTES:

1. THE WATERWAY SHALL BE EXCAVATED OR SHAPED TO LINE, GRADE, AND CROSS SECTION AS REQUIRED TO MEET THE CRITERIA SPECIFIED HEREIN, AND BE FREE OF BANK PROJECTIONS OR OTHER IRREGULARITIES WHICH WILL IMPEDE NORMAL FLOW.
2. FILLS SHALL BE COMPACTED AS NEEDED TO PREVENT UNEQUAL SETTLEMENT THAT WOULD CAUSE DAMAGE IN THE COMPLETE WATERWAY.
3. ALL EARTH REMOVED AND NOT NEEDED IN CONSTRUCTION SHALL BE SPREAD OR DISPOSED OF SO THAT IT WILL NOT INTERFERE WITH THE FUNCTIONING OF THE WATERWAY.
4. STABILIZATION SHALL BE DONE ACCORDING TO THE APPROPRIATE STANDARD AND SPECIFICATIONS FOR VEGETATIVE PRACTICES.
   - 4.1. FOR DESIGN VELOCITIES OF LESS THAN 3.5 FT. PER. SEC., SEEDING AND MULCHING MAY BE USED FOR THE ESTABLISHMENT OF THE VEGETATION. IT IS RECOMMENDED THAT, WHEN CONDITIONS PERMIT, TEMPORARY WATERWAYS OR OTHER MEANS SHOULD BE USED TO PREVENT WATER FROM ENTERING THE WATERWAY DURING THE ESTABLISHMENT OF THE VEGETATION.
   - 4.2. FOR DESIGN VELOCITIES OF MORE THAN 3.5 FT. PER. SEC., THE WATERWAY SHALL BE STABILIZED WITH SOD, WITH SEEDING PROTECTED BY JUTE OR OTHER MATTING OR WITH SEEDING AND MULCHING INCLUDING TEMPORARY DIVERSION OF THE WATER UNTIL THE VEGETATION IS ESTABLISHED.
5. SEE SEED AND MULCH DETAIL FOR ADDITIONAL INFORMATION.



TYPICAL CUT SECTION



TYPICAL FILL SECTION

GRASS-LINED DITCH DETAIL

Not To Scale

FIGURE NO. 4

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

LOCALIZED EROSION
GRASS-LINED DITCH DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

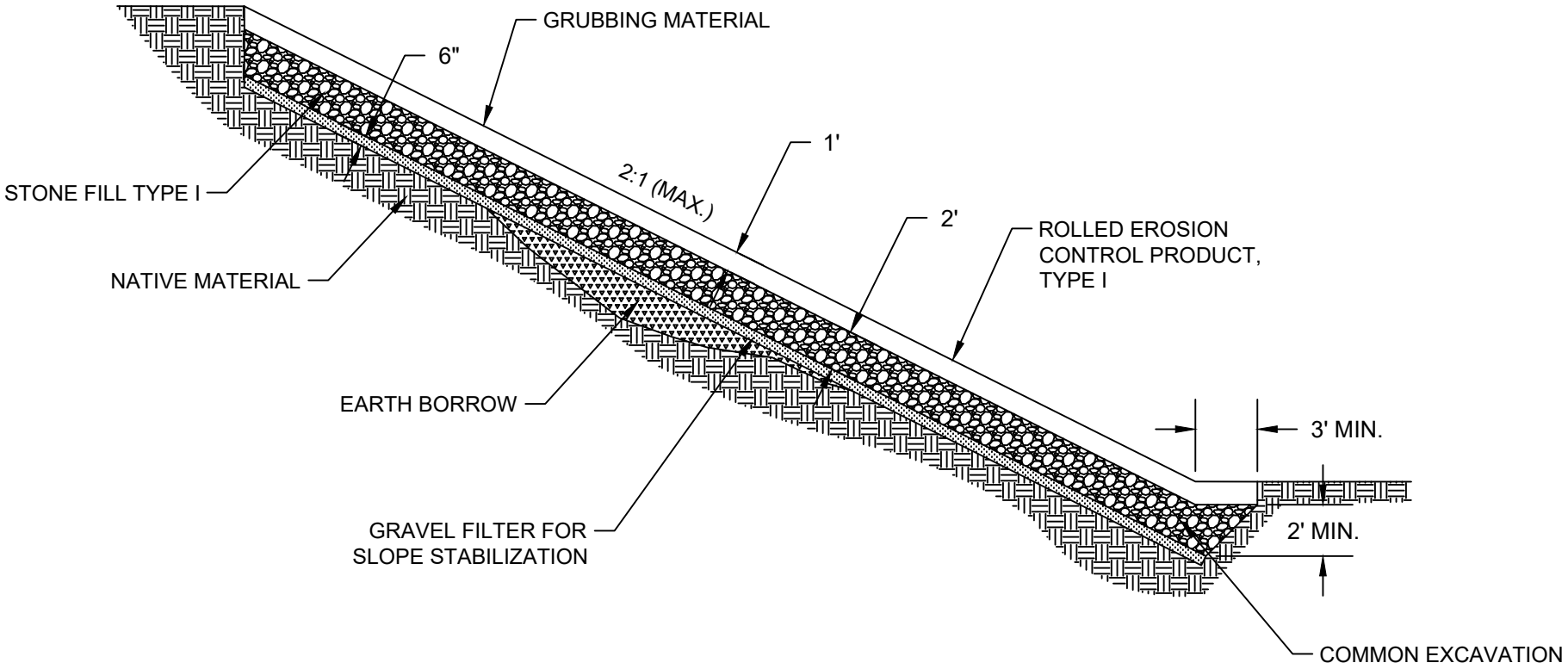
DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	JFMS
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

File: FILE LOCATION

NOTES:

1. THE FINISHED SLOPE SHOULD BE FREE OF POCKETS OF SMALL STONE OR CLUSTERS OF LARGER STONES.
2. HAND PLACING MAY BE NECESSARY TO ACHIEVE PROPER DISTRIBUTION OF STONE SIZES TO PRODUCE A RELATIVELY SMOOTH, UNIFORM SURFACE.



RIPRAP SLOPE PROTECTION DETAIL

Not To Scale

FIGURE NO. 5

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

LOCALIZED EROSION
SLOPE PROTECTION DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

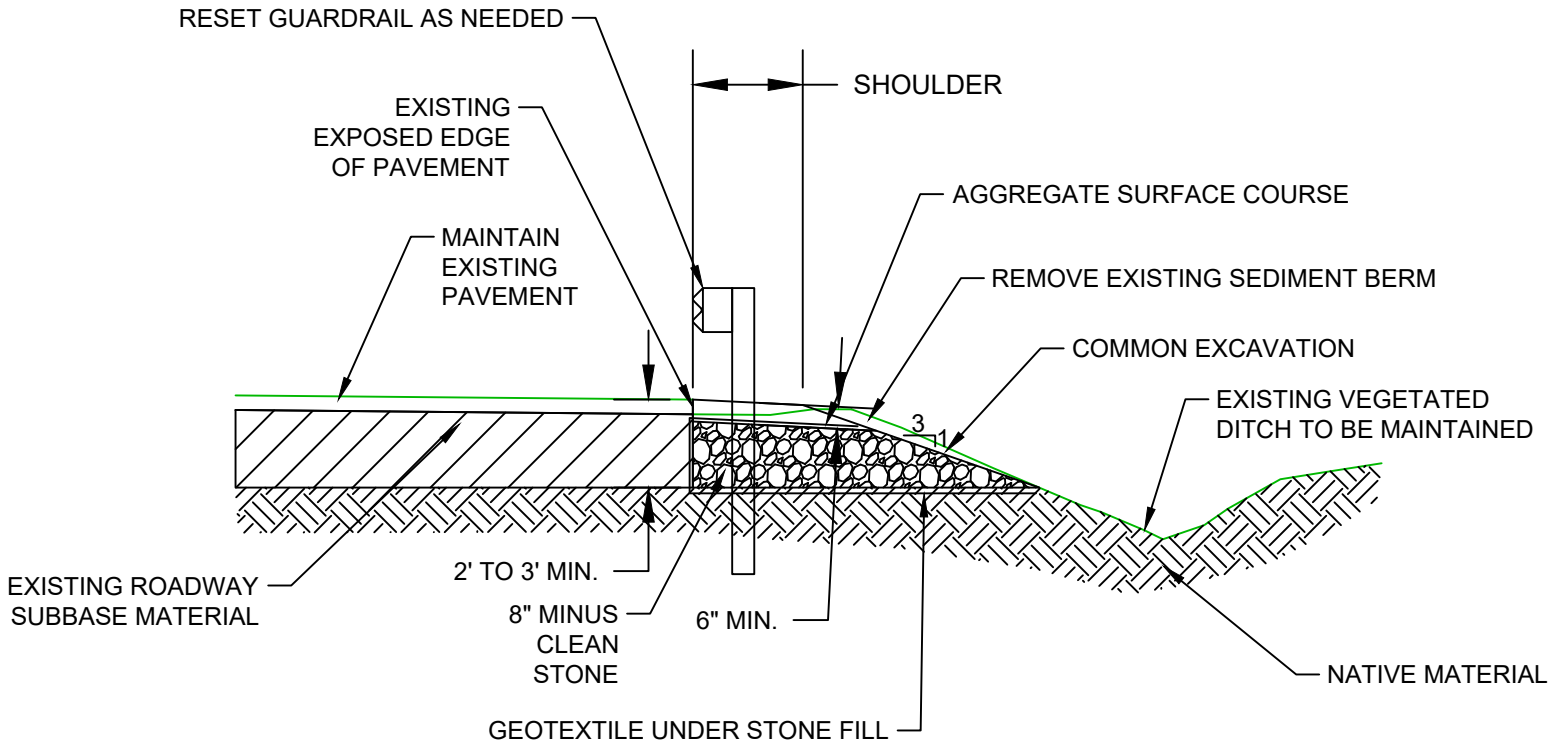
DRAWING CREDITS

Drawn On:	9/3/2020
Drawn By:	AGB
Checked On:	9/3/2020
Checked By:	KDW
Project No.:	18-008-C

File: FILE LOCATION

NOTES:

1. FOR GRAVEL ROADS, SHOULDER GRADES SHOULD BE 6-8% TO ENSURE QUICK RUNOFF AND VISUAL BREAK BETWEEN TRAVEL LAND AND SHOULDER.
2. THE SHOULDER NEEDS TO BE ADEQUATELY COMPACTED TO SUPPORT COMMERCIAL AND AGRICULTURAL VEHICLES.



ARMORED SHOULDER PROTECTION DETAIL

Not To Scale

FIGURE NO. 9

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

LOCALIZED EROSION
SHOULDER PROTECTION DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

DRAWING CREDITS

Drawn On:	9/24/2020
Drawn By:	AGB
Checked On:	9/24/2020
Checked By:	JFMS
Project No.:	18-008-C

File: FILE LOCATION

NOTES:

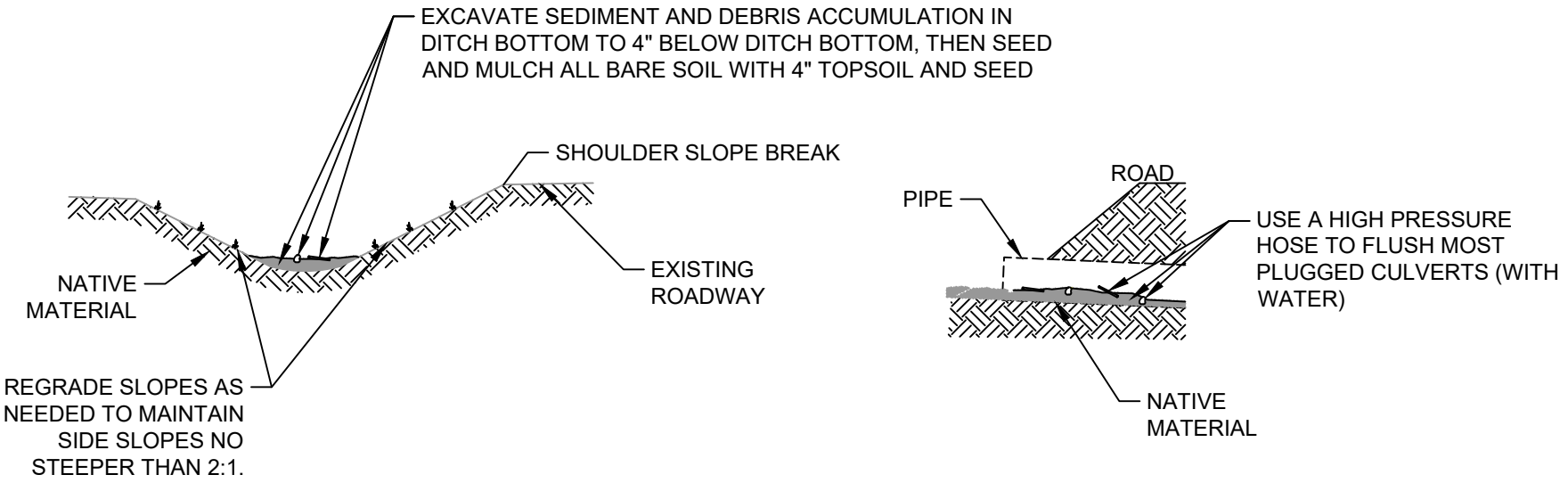
1. ALL TREES, BRUSH, STUMPS, OBSTRUCTIONS, AND OTHER OBJECTIONABLE MATERIAL SHALL BE REMOVED AND DISPOSED OF SO AS NOT TO INTERFERE WITH THE PROPER FUNCTIONING OF THE WATERWAY.
2. SEE SEED AND MULCH DETAIL FOR ADDITIONAL INFORMATION.

CULVERT CLEANING & MAINTENANCE:

1. INSPECT CULVERTS AS OFTEN AS POSSIBLE, BUT AT LEAST IN THE SPRING, FALL AND AFTER MAJOR STORMS.
2. CULVERTS SHOULD BE FLUSHED FROM THE OUTLET END.
3. THE OUTLET DITCH SHOULD BE CLEANED AFTER CULVERT FLUSHING.

DITCH CLEANING & MAINTENANCE:

1. CLEAN DITCHES WHEN THEY BECOME CLOGGED WITH SEDIMENTS OR DEBRIS TO PREVENT OVERFLOWS AND WASHOUTS.
2. CHECK DITCHES AFTER MAJOR STORM EVENTS AS THEY MAY HAVE OBSTRUCTIONS, EROSION, OR COLLAPSED BANKS.
3. REGRADE DITCHES ONLY WHEN ABSOLUTELY NECESSARY AND LINE WITH VEGETATION AS SOON AS POSSIBLE.
4. PREVENTING EROSION FROM UPHILL OR ON BACKSLOPES CAN LENGTHEN THE TIME NEEDED BETWEEN DITCH CLEANINGS.



CLEARING DEBRIS/CLOGGING DETAIL

Not To Scale

FIGURE NO. 7

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

Hoyle, Tanner & Associates, Inc.
125 College Street, 4th Floor
Burlington, Vermont 05401
802-860-1331
802-860-6499 fax
www.hoyletanner.com

VERMONT AGENCY OF TRANSPORTATION

LOCALIZED EROSION
DEBRIS/CLOGGING DETAIL
PCP IMPLEMENTATION PLAN

VERMONT

DRAWING CREDITS

Drawn On:	8/19/2020
Drawn By:	JFMS
Checked On:	8/19/2020
Checked By:	AGB
Project No.:	18-008-C

File: FILE LOCATION