2022

ANNUAL STANDARDS AND SPECIFICATIONS FOR EROSION AND SEDIMENT CONTROL AND STORMWATER MANAGEMENT FOR RESTORATION OF THE ATLANTIC COAST PIPELINE PROJECT IN VIRGINIA

Submitted By:

Atlantic Coast Pipeline, LLC.

707 East Main Street, 19th Floor, Richmond, Virginia 23219

MAY 2022

Annual Standards and Specifications Certification:

I certify under penalty of law that all documents and all attachments related to the submission and updating of Atlantic Coast Pipeline, LLC's (ACP) Annual Standards and Specifications for Erosion and Sediment Control have been prepared under my direction or supervision in a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of a fine and imprisonment for knowing violations.

__ _____ _5/20/22_____

Signed: Jason Ericson, Director Environmental
Dated

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1. ANNUAL STANDARDS AND SPECIFICATIONS ADMINISTRATION

NOTE – ACP, LLC Entity Change Clarification – The Virginia Department of Environmental Quality (VDEQ) previously approved the Annual Standards and Specification for Erosion and Sediment Control and Stormwater Management for Construction and Maintenance of Gas Transmission Facility Projects in Virginia (Annual Standards and Specifications for ESC and SWM) for Dominion Energy Transmission, Inc. (DETI) dated June 2017 with revisions to Appendix G dated October 18, 2018.

The Atlantic Coast Pipeline (ACP) project was cancelled in July 2020 and DETI assets were sold to Berkshire Hathaway Energy, except for the ACP project. Annual Standards and Specification coverage will need to be retained to support restoration activities. As such, the DETI Annual Standards and Specifications have been revised to reference an entity change from DETI to Atlantic Coast Pipeline, LLC (ACP, LLC) and the change in scope from construction, maintenance and operation to restoration activities. Those entity changes apply in all locations except those that are support documents (within the Appendices) that have previously been produced, sealed by licensed professionals, and/or reviewed and approved by VDEQ. Regardless, ACP, LLC is responsible for administration of these Annual Standards and Specifications for ESC and SWM, including prior project commitments, as applicable.

Atlantic Coast Pipeline, LLC(ACP, LLC) is responsible for administering, implementing and complying with the Annual Standards and Specifications for Erosion and Sediment Control (ESC) and Stormwater Management (SWM) for Gas Transmission Facility Development. In accordance with Va. Code §§ 62.1-44.15:54.E and 62.1-44.15:27.F, this document serves as the annual submittal to the Virginia Department of Environmental Quality (DEQ) of standards and specifications developed so that ACP, LLC can continue to operate under Annual Standards and Specifications for ESC and SWM. This document addresses stormwater management and ESC and establishes general specifications for the control of erosion and sedimentation and stormwater runoff management as a result of land-disturbing activities[1] performed during the construction, operation and maintenance of natural gas pipelines. These Annual Standards and Specifications for ESC and SWM shall be consistent with the requirements of the Virginia Erosion and Sediment Control Law and associated regulations and the Virginia Stormwater

[1] For stormwater management compliance, "*Land disturbance" or "land-disturbing activity" means a manmade change to the land surface that potentially changes its runoff characteristics including clearing, grading, or excavation, except that the term shall not include those exemptions specified in § 62.1-44.15:34 of the Code of Virginia*. For Erosion and Sediment Control compliance, ""*Land-disturbing activity" means any man-made change to the land surface that may result in soil erosion from water or wind and the movement of sediments into state waters or onto lands in the Commonwealth, including, but not limited to, clearing, grading, excavating, transporting, and filling of land…*" with exemptions defined per § 62.1-44.15:51, and

Management Act and associated regulations, where applicable. The specifications shall apply to applicable natural gas transmission facility projects pursuant to subdivision 1 of § 62.1-44.15:55 of the Code of Virginia, which allows annual standards and specifications for, "Construction, installation or maintenance of electric transmission, natural gas and telephone utility lines and pipelines, and water and sewer lines." ACP, LLC projects not provided for in subdivision 1, and not otherwise exempted from ESC or SWM requirements, will comply with the requirements of the local or state authority in the locality in which the project is located.

In accordance with federal law, construction stormwater permits issued under a delegated National Pollutant Discharge Elimination System (NPDES) permit like the one in place in Virginia cannot be required unless there is a triggering event (i.e., the release of a hazardous substance in excess of its reportable quantity or a discharge that contributes to a violation of a water quality standard). See 33 U.S.C. § 1342(l)(2); 40 C.F.R. § 122.26(c)(1)(iii); Natural Resources Defense Council v. United States Environmental Protection Agency, 526 F.3d 591 (9th Cir. 2008) (invalidating EPA's unconditional exemption in 40 C.F.R. § 122.26(a)(2) and reinstating the conditional exemption). This exemption is embodied in the Virginia Stormwater Management Program (VSMP) Regulation in 9VAC25-870-380A(2) which states: "*The board may not require a state permit for discharges of stormwater runoff from mining operations or oil and gas exploration, production, processing or treatment operations, or transmission facilities, composed entirely of flows that are from conveyances or systems of conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and that are not contaminated by contact with or that has not come into contact with, any overburden, raw material, intermediate products, finished product, by-product or waste products located on the site of such operations.*"

ACP, LLC intends to follow the provisions outlined in DEQ Guidance Memorandum No. 15-2003 (GM15-2003), when applicable. GM15-2003 provides guidance on stormwater implementation for linear utility projects under the Virginia Stormwater Management Program. The guidance document describes general terms and conditions under which linear utility projects are expected to operate if they are to maintain exemption from Stormwater Management Plan submission and CGP coverage requirements. The review for initial applicability of GM15-2003 to a specific project will be conducted and documented by Dominion using DEQ-certified Plan Reviewers early in the project planning process. ACP, LLC will then contact DEQ for a preliminary review to determine whether GM15-2003 will be applicable to the project, prior to the development of detailed ESC and SWM plans. The preliminary submission and review must include sufficient information (estimated extent of land disturbance, estimated land cover conditions, anticipated sequence of construction, anticipated drainage features and receiving outfalls, etc.) for DEQ to review applicability under the Guidance Memorandum and notify ACP, LLC if a SWM plan will be required. DEQ has indicated that the review and coordination to

determine if a SWM plan waiver will be issued will typically take less than 30 days (typically 7 days for initial review and then subsequent time for revisions, meetings and coordination). DEQ advises that face-to-face project review meetings with the project proponent are often an easy way to secure feedback early in the planning process. If DEQ concurs that the project qualifies under GM15-2003, detailed erosion control plans will be developed (and annotated in accordance with the guidance memorandum), reviewed and approved by Dominion prior to engaging in land disturbance. ACP, LLC may be required by DEQ to produce additional documentation of water quantity or water quality calculations/analysis to demonstrate the applicability of Guidance Memo No. 15-2003. If GM15-2003 is determined to not be applicable, the stormwater-related technical criteria set forth in Appendix B must be implemented, unless an exception is secured. Note that permanent access roads are generally not envisioned to qualify under GM 15-2003 and will require stormwater management or an exception from the DEQ (see Appendix B for more information/discussion).

The gas transmission facilities covered under these Annual Standards and Specifications from ESC and SWM are envisioned to primarily include conventional buried pipeline systems consistent with subdivision 1 of § 62.1-44.15:55 of the Code of Virginia including associated valves, pigging facility launchers and receivers, odorization facilities, measurement and regulation stations, points of delivery, compressor stations, and necessary access. These Annual Standards and Specifications for ESC and SWM must be submitted annually to DEQ for review and approval. ACP, LLC is responsible for ensuring that individual project plans are developed and implemented in compliance with these Annual Standards and Specifications and applicable laws and regulations. As a holder of Annual Standards and Specifications, ACP, LLC ensures compliance with these Annual Standards and Specifications for ESC and SWM for gas pipeline projects through self-administration of these Standards and Specifications, including plan review, inspections, and overall compliance rather than the individual localities in which the projects are located. ACP, LLC may be required to submit relevant project documentation and plans for covered activities to the DEQ. DEQ receives regular notifications of the work done by ACP, LLC, and provides random site inspections and inspections in response to complaints to assure compliance. Enforcement shall be administered by the DEQ and the State Water Control Board where applicable. DEQ and the State Water Control Board has the authority to enforce these specifications, to take enforcement actions, and to charge fees for the costs of review and approval of standards and specifications, project inspections and compliance pursuant to § 62.1-44.15:55(D).2.

These Annual Standards and Specifications for ESC and SWM also assist ACP, LLC in meeting the standards of the Federal Energy Regulatory Commission (FERC) Upland Erosion Revegetation and Maintenance Plan (Plan) and the FERC Wetland and Waterbody Construction and Mitigation Procedures (Procedures) (FERC, 2013). A copy of the Plan and Procedures can be found in Appendix C and D. ACP, LLC and its construction contractors must implement this

plan as appropriate for all construction in Virginia unless a project-specific variance to the Virginia Erosion and Sediment Control Laws and regulation and/or exception under the Virginia Stormwater Management Act and associated regulations has been reviewed and granted by the DEQ. In instances where the requirements or practices differ between the Virginia Erosion and Sediment Control Handbook and the FERC Plan and Procedures guidance, the more stringent criteria shall be applied. The Annual Standards and Specifications will be compared to FERC's Plan and Procedures to determine the appropriate (i.e., whichever is more stringent) best management practices. Project variance and exception requests will be considered freestanding of this Annual Standards and Specifications submission and will be considered by DEQ on a site-specific basis.

Approved deviation requests (DEQ approved deviations from guidance documents (e.g. VESCH)) and the associated DEQ approval letters will also be appended to these Annual Standards in Appendix H, since these technical modifications to practices may be applied more broadly to many projects.

ACP, LLC anticipates that gas transmission projects will remain exempt from the *General VPDES Permit for Discharges of Stormwater from Construction Activities* (9VAC25-880) (also referred to more generally as the construction general permit) pursuant to federal and state exemptions. Each project will be reviewed for consistency with these exemptions or the appropriate requirements and GM15-2003, and applicable stormwater management provisions (see Appendix B) are incorporated in these Annual Standards and Specifications for ESC and SWM if the DEQ requires a construction general permit (CGP) for a specific project, or determines that GM15-2003 will not apply.

1.1 PROJECT TRACKING AND REPORTING

ACP, LLC is responsible for providing project tracking and e-notification to DEQ of all regulated land-disturbing activities subject to these Annual Standards and Specifications to comply with applicable ESC requirements pursuant to 9VAC25-840-65 and applicable SWM requirements pursuant to 9VAC25-870-170.

The ACP, LLC project team must electronically notify the DEQ of any project that ACP, LLC intends to construct in Virginia to start the project permitting process. The following information is required to be included in the e-notification two weeks prior to initiating the regulated land disturbing activity (LDA):

- Project name or project number
- Project location (including nearest intersection, latitude, and longitude)
- On-site project manager name and contact info

- Responsible Land Disturber (RLD) name and contact info
- Project description
- Acreage of disturbance for project
- Project start and finish date
- Any variances/waivers/exceptions associated with the project

Notification must be made electronically to standardsandspecs@deq.virginia.gov. Other questions should be directed to Larry Gavan (804-698-4040) and Hannah Zegler (804-698-4206).

Under the Construction General Permit (CGP), if applicable, the operator shall post the notice of coverage letter at a publicly accessible location near an active part of the construction project (e.g. where pipeline crosses a public road). The operator shall maintain the posted information until the termination of the general permit. The operator will also make the SWPPP available as follows:

1. Operators with day-to-day operational control over SWPPP implementation shall have a copy of the SWPPP available at a central location on-site for use by those identified as having responsibilities under the SWPPP whenever they are on the construction site.

2. The operator shall make the SWPPP and all amendments, modifications, and updates available upon request to the department, the VSMP authority, the EPA, the VESCP authority, local government officials, or the operator of a municipal separate storm sewer system receiving discharges from the construction activity. If an on-site location is unavailable to store the SWPPP when no personnel are present, notice of the SWPPP's location must be posted near the main entrance of the construction site.

The operator shall make the SWPPP available for public review in an electronic format or in hard copy. Information for public access to the SWPPP shall be posted and maintained in accordance with Part II C. If not provided electronically, public access to the SWPPP may be arranged upon request at a time and at a publicly accessible location convenient to the operator or his designee but shall be no less than once per month and shall be during normal business hours. Information not required to be contained within the SWPPP by this general permit is not required to be released.

1.2 EROSION AND SEDIMENT CONTROL - Quarterly Reports

ACP, LLC will report, on a quarterly basis, a listing of each regulated land-disturbing activity for which an ESC plan (and a SWM plan if applicable) has been approved under these Annual Standards and Specifications for ESC and SWM, and the construction status (construction

ongoing, not started, completed during quarter), to DEQ quarterly. The report must include the following:

- Project name or project number
- Project location (including nearest intersection, latitude, and longitude)
- On-site project manager name and contact info (if applicable)
- Responsible Land Disturber (RLD) name and contact info
- Project description
- Acreage of disturbance for project
- Anticipated project start and finish date
- Any approved variances/exceptions associated with the project

1.3 STORMWATER MANAGEMENT – Annual Reports

Stormwater Management Plans will be required for ACP, LLC projects when projects are unable to satisfy the terms and conditions contained in DEQ Guidance Memo No. 15-2003, or are determined not to be exempt from associated requirements of the *General VPDES Permit for Discharges of Stormwater from Construction Activities* (9VAC25-880) (referred to more generally as the construction general permit or CGP). When applicable, ACP, LLC will assure that SWM plans and associated Stormwater Pollutant Prevention Plans (SWPPPs) and CGP registrations statements are prepared, reviewed, and approved prior to initiating regulated land disturbing activities. The technical criteria for SWM are addressed in Appendix B of these Annual Standards and Specifications for ESC and SWM.

On a fiscal year basis (July 1 to June 30), ACP, LLC will report to the department by October 1 of each year in a format provided by DEQ. The information to be provided shall include the following:

1. Information on each permanent stormwater management facility completed during the fiscal year to include type of stormwater management facility, geographic coordinates, acres treated, and the surface waters or karst features into which the stormwater management facility will discharge;

2. Number and type of enforcement actions during the fiscal year; and

3. Number of exceptions granted during the fiscal year.

1.4 RECORDKEEPING

ACP, LLC must keep records in accordance with the following:

- All individual project records, including approved plans, inspection records, documented field changes, and CGP registration statements (if applicable) must be maintained for a period of three years after completion of the project or state permit termination. This period of retention shall be extended automatically during the course of any unresolved litigation regarding the regulated activity or regarding control standards applicable to ACP, LLC, or as requested by the State Water Control Board.
- A construction record drawing for all permanent, structural stormwater management facilities ("as-built") with seal and signature of a Virginia-licensed Professional Engineer must be maintained by ACP, LLC in perpetuity, or until the stormwater facility is removed.
- Stormwater management facility inspection records must be documented and retained for at least five years from the date of inspection.

1.5 PLAN DESIGN, REVIEW, AND APPROVAL

This section outlines requirements for Erosion and Sediment Control and Stormwater Management, along with applicable plan contents for review and approval by DEQ certified personnel (as described in Section 2 of this document) prior to initiating regulated land disturbing activities.

1.5.1 ESC REQUIREMENTS

ACP, LLC follows the policies and procedures described in the Virginia Erosion and Sediment Control Handbook (VESCH). The use of the VESCH, along with accompanying technical documents and guidance, is strongly preferred. ACP, LLC utilizes a comprehensive design, review and approval program that includes review for consistency with both the general specifications for Minimum Standards and Specifications (STDS & SPEC) and the FERC Plan and Procedures. The FERC Plan and Procedures (Appendices C and D) are hereby incorporated by reference and must be utilized on all FERC-regulated ACP, LLC projects. In the event of differences between the FERC Plan and Procedures and the VESCH criteria, the more stringent criteria shall apply. The Annual Standards and Specifications will be compared to FERC's Plan and Procedures to determine the appropriate (i.e., whichever is more stringent) best management practices. The general specifications for ESC apply to land-disturbing activities and are included in these Annual Standards and Specifications by reference, as follows:

- Virginia Erosion and Sediment Control Law (§62.1-44 et seq. as amended);
- Virginia Erosion and Sediment Control Regulations (9VAC25-840 et seq. as amended);
- Virginia Erosion and Sediment Control and Stormwater Management Certification Regulations (9VAC25-850 et seq. as amended);
- Virginia Erosion and Sediment Control Handbook, 1992, as amended, and related technical documents and guidance specifications;
- Technical Bulletins and Memos, as amended, on the DEQ website.

ESC plans and documents must be submitted to the designated Plan Reviewer (defined in Section 2.2) for review and approval. Plans must be reviewed and approved by DEQ certified personnel (*as described in Section 2, Personnel Roles and Responsibilities*) to ensure compliance with these Annual Standards and Specifications for ESC and SWM and reviewed by ACP, LLC for consistency with the FERC Plan and Procedures guidance. Any non-VESCH control measures incorporated into plans must include all applicable practical information including definition, purpose, conditions where practice applies, planning considerations, design criteria, construction specifications, design tables and plates and maintenance/inspection requirements. Should non-VESCH control measures fail to effectively control soil erosion, sediment deposition, and non-agricultural runoff, then VESCH control measures shall be utilized. All

documents submitted for review must include the appropriate information, as described below (and shown in the flow chart below) in addition to the ESC Plan Checklist (Appendix A).

1.5.2 ESC PLAN CONTENTS

As applicable, ESC drawings must include the following:

a) Minimum standards 1 through 19 as applicable;
b) General Erosion and Sediment Control Notes ES-1 through ES-9 (Appendix E);
c) Total area of disturbance. If the project is phased, the total area of disturbance for each phase must be noted;
d) Pre-development and post-development land cover conditions
e) Construction sequence of operations with staged implementation of ESC measures for each phase;
f) Existing features that will be demolished or removed that may require ESC measures;
g) Erosion and Sediment Control Critical Areas identification and discussion;
h) Location of various support activities including, but not limited to, areas where wash water may occur; storage area for chemicals, fuels and fertilizers; concrete wash out areas; vehicle fueling and maintenance areas; sanitary waste facilities and construction waste storage; and
i) Information suitable for drainage and ESC review (may include drainage areas, flow paths, points of analysis, outfalls, or other drainage patterns) should be submitted (either on the plans or in supporting documentation).
j) When applicable, the location of the on-site rain gauge must be included.

The Erosion and Sediment Control Plan Checklist is included in Appendix A.

1.5.3 SWM REQUIREMENTS

Portions of these Annual Standards and Specifications related to Stormwater Management shall apply to regulated land-disturbing activities which are not exempted under GM 15-2003 from SWM plan submission and/or projects which are required to obtain CGP coverage. The following requirements shall apply, when applicable, and are hereby incorporated by reference:

- Virginia Stormwater Management Act (§62.1-44 et seq. as amended);
- Virginia Stormwater Management Permit Regulations (9VAC25-870 et seq. as amended);
- Virginia Stormwater Management Handbook, 1999, as amended; and
- Technical Bulletins and Memos, as amended, on the DEQ website.
- DEQ Guidance Memorandum No. 15-2003 (GM 15-2003)
- Construction General Permit Regulation 9VAC25-880 et seq.
- Standards and Specifications for stormwater practices as published on the Virginia Stormwater BMP Clearinghouse (http://www.vwrrc.vt.edu/swc/index.html).

Off-site credit use should be coordinated with the DEQ Central Office Nutrient Credit Coordinator (Derick Winn, Office of Stormwater Permits: 804-698-4114).

1.5.4 SWM PLAN CONTENTS

ESC and SWM/SWPPP plans and documents must be submitted to the designated Plan Reviewer (certified in accordance with Section 2 of this document) for review and approval. Plans must be reviewed to ensure compliance with these Annual Standards and Specifications for ESC and SWM.

If applicable, the stormwater management plan shall be implemented as approved or modified by ACP, LLC and shall be developed in accordance with the following:

1. A stormwater management plan for a land-disturbing activity shall apply the stormwater management technical criteria set forth in this part to the entire land-disturbing activity. Individual lots in new residential, commercial, or industrial developments shall not be considered separate land-disturbing activities.

2. A stormwater management plan shall consider all sources of surface runoff and all sources of subsurface and groundwater flows converted to surface runoff.

A complete stormwater management plan shall include the following elements:

1. Information on the type of and location of stormwater discharges, information on the features to which stormwater is being discharged including surface waters or karst features if present, and predevelopment and postdevelopment drainage areas;

2. Contact information including the name, address, telephone number, and email address of the owner and the tax reference number and parcel number of the property or properties affected;

3. A narrative that includes a description of current site conditions and final site conditions or if allowed by the VSMP authority, the information provided and documented during the review process that addresses the current and final site conditions;

4. A general description of the proposed stormwater management facilities and the mechanism through which the facilities will be operated and maintained after construction is complete;

5. Information on the proposed stormwater management facilities, including (i) the type of facilities; (ii) location, including geographic coordinates; (iii) acres treated; and (iv) the surface waters or karst features into which the facility will discharge;

6. Hydrologic and hydraulic computations, including runoff characteristics;

7. Documentation and calculations verifying compliance with the water quality and quantity requirements of these regulations;

8. A map or maps of the site that depicts the topography of the site and includes:

a. All contributing drainage areas;

b. Existing streams, ponds, culverts, ditches, wetlands, other water bodies, and floodplains;

c. Soil types, geologic formations if karst features are present in the area, forest cover, and other vegetative areas;

d. Current land use including existing structures, roads, and locations of known utilities and easements;

e. Sufficient information on adjoining parcels to assess the impacts of stormwater from the site on these parcels;

f. The limits of clearing and grading, and the proposed drainage patterns on the site;

g. Proposed buildings, roads, parking areas, utilities, and stormwater management facilities; and

h. Proposed land use with tabulation of the percentage of surface area to be adapted to various uses, including but not limited to planned locations of utilities, roads, and easements;

9. If an operator intends to meet the requirements established in 9VAC25-870-63 or 9VAC25-870-66 through the use of off-site compliance options, where applicable, then a letter of availability from the off-site provider must be included; and

10. If payment of a fee is required with the stormwater management plan submission by the VSMP authority, the fee and the required fee form in accordance with Part XIII (9VAC25-870-700 et seq.) must have been submitted.

Elements of the stormwater management plans that include activities regulated under Chapter 4 (§ 54.1-400 et seq.) of Title 54.1 of the Code of Virginia shall be appropriately sealed and signed by a professional registered in the Commonwealth of Virginia pursuant to Article 1 (§ 54.1-400 et seq.) of Chapter 4 of Title 54.1 of the Code of Virginia.

A construction record drawing for permanent stormwater management facilities shall be submitted to the VSMP authority in accordance with 9VAC25-870-108 and 9VAC25-870-112.

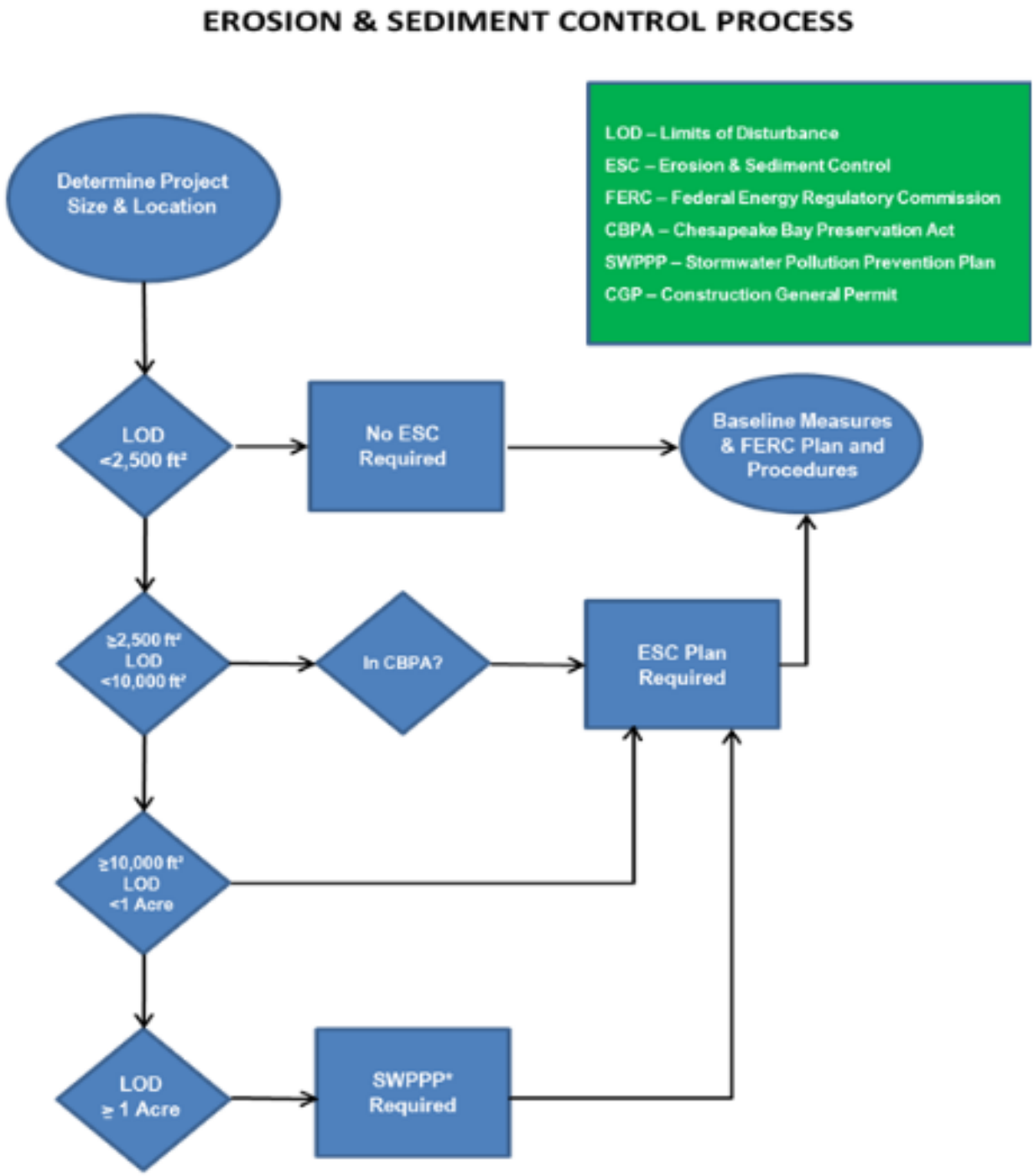
The construction record drawing shall be appropriately sealed and signed by a professional registered in the Commonwealth of Virginia, certifying that the stormwater management facilities have been constructed in accordance with the approved plan.

ACP, LLC Plan Review personnel (see Section 2.0) will verify whether a SWM plan is required for submission (as outlined above) and will document that the required elements above are included, when applicable. In addition to the above elements, the following documentation will be reviewed and approved prior to initiating the land disturbing activity:

- If applicable, the Stormwater Pollution Prevention Plan (SWPPP), inclusive of registration statement, Pollution Prevention Plan, Erosion and Sediment Control Plan, and Stormwater Management Plan and Calculations;
- If a SWPPP and/or CGP is required for a project, applicable TMDL information and general information shall be included, in addition to the required registration statement.
- Post-construction maintenance requirements of permanent BMPs, if applicable (See Appendix B);
- Manufacturer's recommended maintenance and inspection of manufactured permanent BMPs (per the BMP Clearinghouse);
- Post-construction inspection requirements for permanent BMPs;
- A map or digital file, including the appropriate base data, delineating the area treated by the BMP;
- A map or digital file, including the appropriate base data, depicting the applicable area used to determine percent impervious cover; and
- SWM Plan Checklist (Appendix B).

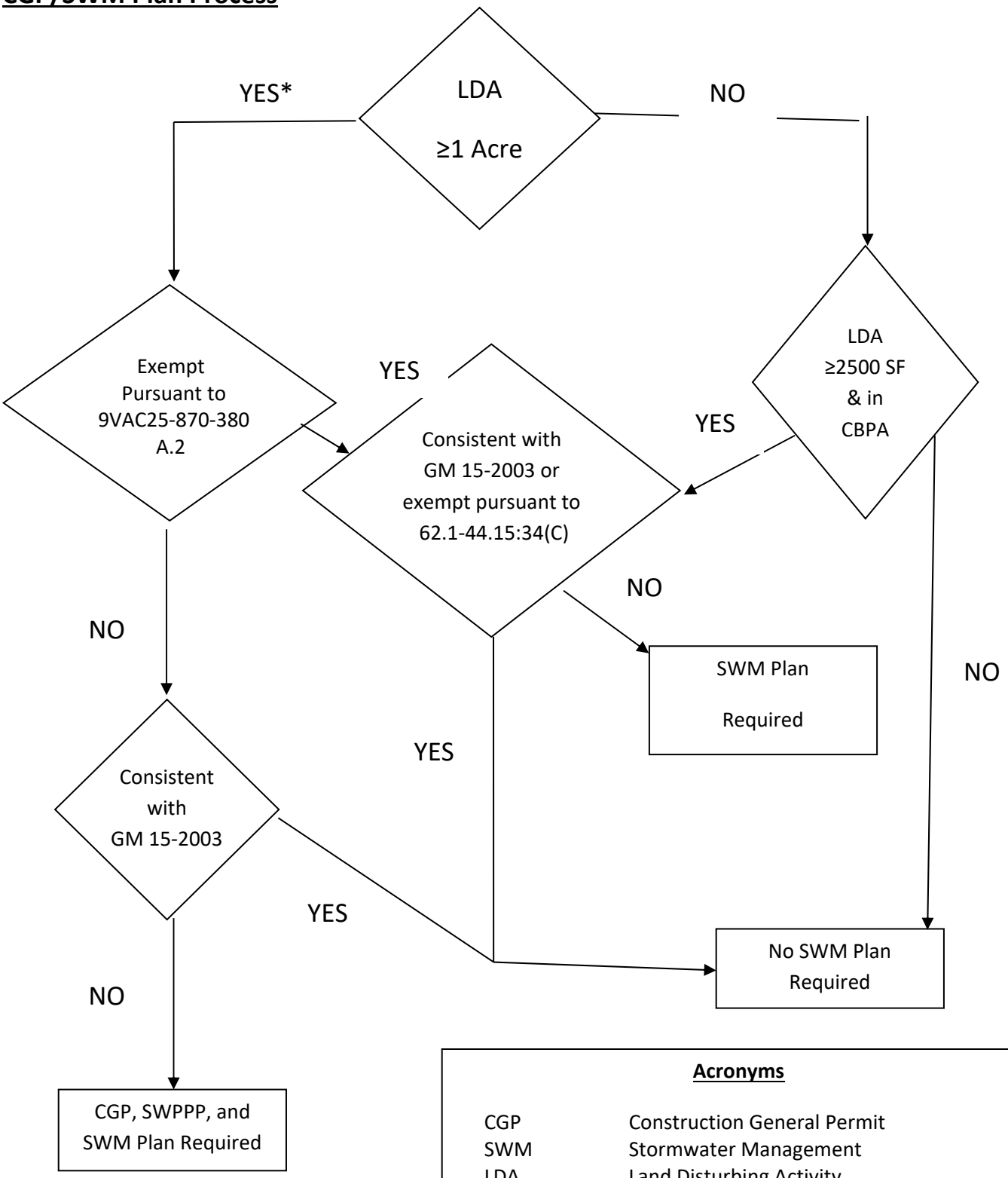
1.5.5 REVISIONS

All revisions to the approved Erosion and Sediment Control Plan or the approved Stormwater Management Plan for the project require review and approval by DEQ certified Plan Reviewer for ESC (and SWM, when applicable). Changes shall be documented and dated on the plans.



* See Figure 2 – next page

CGP/SWM Plan Process



Acronyms

CGP	Construction General Permit
SWM	Stormwater Management
LDA	Land Disturbing Activity
SF	Square Feet
CBPA	Chesapeake Bay Preservation Area
GM 15-2003	Guidance Memo No. 15-2003
SWPPP	Stormwater Pollution Prevention Plan

*SWPPP required for all projects disturbing ≥ 1 acre.

2. PERSONNEL ROLES AND RESPONSIBILITIES

ACP, LLC will be the plan approval authority and administrator for the ACP, LLC Annual Standards and Specifications for ESC and SWM. A description of the expected administrative roles and associated required certifications[2] is provided below. Note that roles may be combined for staff resource purposes as long as the person responsible for each task is fully qualified for all assigned roles. The ESC plans and SWM plans/SWPPP (where applicable) must be included in all pipeline construction specifications and ACP, LLC must assure that the contractor is aware of their responsibility prior to starting any construction activities by covering this specification during pre-construction training and meetings. ACP, LLC must provide quality assurance for the ESC and SWM plans as well as guidance, as needed, for implementation of ESC and SWM measures on all projects. ACP, LLC may enter into agreements or contracts with contractors to assist with carrying out the certification requirements set forth in the ESC and SWM Law and Regulations.

2.1 PROGRAM ADMINISTRATOR

The Program Administrator will be responsible for the management and coordination of these Annual Standards and Specifications for ESC and SWM. The Program Administrator must be certified as an ESC (and SWM when applicable) Combined Administrator by DEQ or provisionally certified.

The Program Administrator shall be an employee of the AS&S holder. The AS&S holder may enter into agreements or contracts with soil and water conservation districts, adjacent localities, or other public or private entities to assist with carrying out the provisions of this article, including the review and determination of adequacy of erosion and sediment control plans submitted for land-disturbing activities on a unit or units of land as well as for monitoring, reports, inspections, and enforcement where authorized in this article, of such land-disturbing activities.

2.2 PLAN REVIEWER

The Plan Reviewer will be responsible for the review of ESC and SWM portions of project plans for compliance with these Annual Standards and Specifications and applicable laws and regulations. The Plan Reviewer must be certified as an ESC (and SWM when applicable) Plan Reviewer by DEQ or provisionally certified. This role may be conducted by a third party firm preparing the plans as directed by ACP, LLC.

[2] Detailed directions for obtaining certifications can be found via the DEQ website at: http://www.deq.virginia.gov/ConnectWithDEQ/TrainingCertification.aspx

2.3 CONSTRUCTION SITE SUPERVISOR

The Construction Site Supervisor will have direct oversight of all personnel that prepare, construct, maintain and rehabilitate a given project. The Supervisor also has control over site-specific construction plans, including the ability to make modifications to those plans. This person must ensure compliance with ESC, SWPPP, and Virginia Stormwater Management Program (VSMP) requirements as well as compliance with these Annual Standards and Specifications. The Construction Site Supervisor is authorized to direct workers at a site to carry out activities in accordance with these and other permit conditions. The Construction Site Supervisor must be certified as a Responsible Land Disturber (RLD) by DEQ.

2.4 ENVIRONMENTAL INSPECTOR

The Environmental Inspector (EI) will serve as the primary point of contact for on-site environmental compliance. The EI will provide expert technical support on a wide range of environmental issues and is responsible for:

- ESC Plan, FERC Plan and Procedures and environmental conditions of FERC's Orders compliance;
- Verifying that the limits of disturbance (LOD) and locations of access roads are visibly marked before clearing and maintained throughout construction;
- Proper maintenance of environmental records on site;
- Advising the Environmental Construction Coordinator (ECC) on site-specific environmental concerns;
- Educating company inspectors and personnel on site-specific environmental concerns and requirements; and
- Reporting any non-compliance and problem areas.

An EI is required on projects involving oversight by the FERC, and ACP, LLC may assign them on other projects as well. The EI must be certified as an ESC (and SWM, when applicable) Inspector by DEQ or provisionally certified. This role may be conducted by a certified, third party firm as directed by ACP, LLC. At least one EI is required for each construction spread during construction and restoration. ACP, LLC must ensure that the number and experience of EI's assigned to each construction spread will be appropriate for the length of the construction spread and the number/significance of resources affected.

2.5 ENVIRONMENTAL CONSTRUCTION COORDINATOR

The Environmental Construction Coordinator (ECC) will serve as part of the environmental team relative to environmental compliance within ACP, LLC. The ECC has the responsibility of ensuring full compliance with applicable laws, environmental rules, regulations, permits, and

company policies that pertain to their projects. The ECC's roles and responsibilities may include:

- Ensure compliance with applicable federal, state, and local environmental regulations, permits, company standards, and procedures, and facility procedures at assigned projects;
- Promote environmental stewardship;
- Coordinate with EI's and contractors to ensure site environmental compliance;
- Serve as primary site coordinator with Dominion Environmental Services (DES), internal departments, and external agencies regarding environmental issues;
- Serve as contact with community or local public to resolve environmental emergencies, complaints, or problems;
- Maintain environmental permits, plans, and various compliance records; and
- Assist with environmental emergency response activities.

2.6 EROSION AND SEDIMENT CONTROL AND STORMWATER INSPECTOR

The Erosion and Sediment Control Inspector will be responsible for the inspection and compliance with ESC and SWM/SWPPP practices, as applicable, as well as those practices outlined in these Annual Standards and Specifications. These responsibilities will typically be shared between the EI and the ESC/SWM Inspector. The Inspector must be certified as an ESC (and SWM when applicable) Inspector by DEQ or provisionally certified. This role may be conducted by a third-party firm preparing the plans as directed by ACP, LLC. ACP, LLC must ensure that inspection staff is suitable for the size and scope of the project.

3. TECHNICAL CRITERIA

3.1 EROSION AND SEDIMENT CONTROL

ACP, LLC must employ erosion and sediment control measures for all land-disturbing activities associated with the restoration of gas transmission facility projects.

The minimum standards set forth in 9 VAC 25-840-40 and the control practices laid out in the Virginia Erosion and Sediment Control Handbook (VESCH) shall be applied to the planning, design, construction, and maintenance of ESC and SWM plans (when applicable).

1. Permanent or temporary soil stabilization shall be applied to denuded areas within seven days after final grade is reached on any portion of the site. Temporary soil stabilization shall be applied within seven days to denuded areas that may not be at final grade but will remain dormant for longer than 14 days. Permanent stabilization shall be applied to areas that are to be left dormant for more than one year.

2. During construction of the project, soil stock piles and borrow areas shall be stabilized or protected with sediment trapping measures. The applicant is responsible for the temporary protection and permanent stabilization of all soil stockpiles on site as well as borrow areas and soil intentionally transported from the project site.

3. A permanent vegetative cover shall be established on denuded areas not otherwise permanently stabilized. Permanent vegetation shall not be considered established until a ground cover is achieved that is uniform, mature enough to survive and will inhibit erosion.

4. Sediment basins and traps, perimeter dikes, sediment barriers and other measures intended to trap sediment shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

5. Stabilization measures shall be applied to earthen structures such as dams, dikes and diversions immediately after installation.

6. Sediment traps and sediment basins shall be designed and constructed based upon the total drainage area to be served by the trap or basin.

> a. The minimum storage capacity of a sediment trap shall be 134 cubic yards per acre of drainage area and the trap shall only control drainage areas less than three acres.
>
> b. Surface runoff from disturbed areas that is comprised of flow from drainage areas greater than or equal to three acres shall be controlled by a sediment basin. The minimum storage capacity of a sediment basin shall be 134 cubic yards per acre of drainage area. The outfall system shall, at a minimum, maintain the structural integrity of the basin during a 25-year storm of 24-hour duration. Runoff coefficients used in runoff calculations shall correspond to a bare earth condition or those conditions expected to exist while the sediment basin is utilized.

7. Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion. Slopes that are found to be eroding excessively within one year of permanent stabilization shall be provided with additional slope stabilizing measures until the problem is corrected.

8. Concentrated runoff shall not flow down cut or fill slopes unless contained within an adequate temporary or permanent channel, flume or slope drain structure.

9. Whenever water seeps from a slope face, adequate drainage or other protection shall be provided.

10. All storm sewer inlets that are made operable during construction shall be protected so that sediment-laden water cannot enter the conveyance system without first being filtered or otherwise treated to remove sediment.

11. Before newly constructed stormwater conveyance channels or pipes are made operational, adequate outlet protection and any required temporary or permanent channel lining shall be installed in both the conveyance channel and receiving channel.

12. When work in a live watercourse is performed, precautions shall be taken to minimize encroachment, control sediment transport and stabilize the work area to the greatest extent possible during construction. Nonerodible material shall be used for the construction of causeways and cofferdams. Earthen fill may be used for these structures if armored by nonerodible cover materials.

13. When a live watercourse must be crossed by construction vehicles more than twice in any six-month period, a temporary vehicular stream crossing constructed of nonerodible material shall be provided.

14. All applicable federal, state and local requirements pertaining to working in or crossing live watercourses shall be met.

15. The bed and banks of a watercourse shall be stabilized immediately after work in the watercourse is completed.

16. Underground utility lines shall be installed in accordance with the following standards in addition to other applicable criteria:

a. No more than 500 linear feet of trench may be opened at one time.

b. Excavated material shall be placed on the uphill side of trenches.

c. Effluent from dewatering operations shall be filtered or passed through an approved sediment trapping device, or both, and discharged in a manner that does not adversely affect flowing streams or off-site property.

d. Material used for backfilling trenches shall be properly compacted in order to minimize erosion and promote stabilization.

e. Restabilization shall be accomplished in accordance with this chapter.

f. Applicable safety requirements shall be complied with.

17. Where construction vehicle access routes intersect paved or public roads, provisions shall be made to minimize the transport of sediment by vehicular tracking onto the paved surface. Where sediment is transported onto a paved or public road surface, the road surface shall be cleaned thoroughly at the end of each day. Sediment shall be removed from the roads by shoveling or sweeping and transported to a sediment control disposal area. Street washing shall be allowed only after sediment is removed in this manner. This provision shall apply to individual development lots as well as to larger land-disturbing activities.

18. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization or after the temporary measures are no longer needed, unless otherwise authorized by the VESCP authority. Trapped sediment and the disturbed soil areas resulting from the disposition of temporary measures shall be permanently stabilized to prevent further erosion and sedimentation.

19. Properties and waterways downstream from development sites shall be protected from sediment deposition, erosion and damage due to increases in volume, velocity and peak flow rate of stormwater runoff for the stated frequency storm of 24-hour duration in accordance with the following standards and criteria. Stream restoration and relocation projects that incorporate natural channel design concepts are not man-made channels and shall be exempt from any flow rate capacity and velocity requirements for natural or man-made channels:

a. Concentrated stormwater runoff leaving a development site shall be discharged directly into an adequate natural or man-made receiving channel, pipe or storm sewer system. For those sites where runoff is discharged into a pipe or pipe system, downstream stability analyses at the outfall of the pipe or pipe system shall be performed.

b. Adequacy of all channels and pipes shall be verified in the following manner:

(1) The applicant shall demonstrate that the total drainage area to the point of analysis within the channel is one hundred times greater than the contributing drainage area of the project in question; or

(2) (a) Natural channels shall be analyzed by the use of a two-year storm to verify that stormwater will not overtop channel banks nor cause erosion of channel bed or banks.

(b) All previously constructed man-made channels shall be analyzed by the use of a ten-year storm to verify that stormwater will not overtop its banks and by the use of a two-year storm to demonstrate that stormwater will not cause erosion of channel bed or banks; and

(c) Pipes and storm sewer systems shall be analyzed by the use of a ten-year storm to verify that stormwater will be contained within the pipe or system.

c. If existing natural receiving channels or previously constructed man-made channels or pipes are not adequate, the applicant shall:

(1) Improve the channels to a condition where a ten-year storm will not overtop the banks and a two-year storm will not cause erosion to the channel, the bed, or the banks; or

(2) Improve the pipe or pipe system to a condition where the ten-year storm is contained within the appurtenances;

(3) Develop a site design that will not cause the pre-development peak runoff rate from a two-year storm to increase when runoff outfalls into a natural channel or will not cause the pre-development peak runoff rate from a ten-year storm to increase when runoff outfalls into a man-made channel; or

(4) Provide a combination of channel improvement, stormwater detention or other measures which is satisfactory to the VESCP authority to prevent downstream erosion.

d. The applicant shall provide evidence of permission to make the improvements.

e. All hydrologic analyses shall be based on the existing watershed characteristics and the ultimate development condition of the subject project.

f. If the applicant chooses an option that includes stormwater detention, he shall obtain approval from the VESCP of a plan for maintenance of the detention facilities. The plan shall set forth the maintenance requirements of the facility and the person responsible for performing the maintenance.

g. Outfall from a detention facility shall be discharged to a receiving channel, and energy dissipators shall be placed at the outfall of all detention facilities as necessary to provide a stabilized transition from the facility to the receiving channel.

h. All on-site channels must be verified to be adequate.

i. Increased volumes of sheet flows that may cause erosion or sedimentation on adjacent property shall be diverted to a stable outlet, adequate channel, pipe or pipe system, or to a detention facility.

j. In applying these stormwater management criteria, individual lots or parcels in a residential, commercial or industrial development shall not be considered to be separate development projects. Instead, the development, as a whole, shall be considered to be a single development project. Hydrologic parameters that reflect the ultimate development condition shall be used in all engineering calculations.

k. All measures used to protect properties and waterways shall be employed in a manner which minimizes impacts on the physical, chemical and biological integrity of rivers, streams and other waters of the state.

l. Any plan approved prior to July 1, 2014, that provides for stormwater management that addresses any flow rate capacity and velocity requirements for natural or man-made channels shall satisfy the flow rate capacity and velocity requirements for natural or man-made channels if the practices are designed to (i) detain the water quality volume and to release it over 48 hours; (ii) detain and release over a 24-hour period the expected rainfall resulting from the one year, 24-hour storm; and (iii) reduce the allowable peak flow rate resulting from the 1.5, 2, and 10-year, 24-hour storms to a level that is less than or equal to the peak flow rate from the site assuming it was in a good forested condition, achieved through multiplication of the forested peak flow rate by a reduction factor that is equal to the runoff volume from the site when it was in a good forested condition divided by the runoff volume from the site in its proposed condition, and shall be exempt from any flow rate capacity and velocity requirements for natural or man-made channels as defined in any regulations promulgated pursuant to § 62.1-44.15:54 or 62.1-44.15:65 of the Act.

m. For plans approved on and after July 1, 2014, the flow rate capacity and velocity requirements of § 62.1-44.15:52 A of the Act and this subsection shall be satisfied by compliance with water quantity requirements in the Stormwater Management Act (§ 62.1-44.15:24 et seq. of the Code of Virginia) and attendant regulations, unless such land-disturbing activities are in accordance with 9VAC25-870-48 of the Virginia Stormwater Management Program (VSMP) Regulations.

n. Compliance with the water quantity minimum standards set out in 9VAC25-870-66 of the Virginia Stormwater Management Program (VSMP) Regulations shall be deemed to satisfy the requirements of subdivision 19 of this subsection.

3.2 GENERAL DESCRIPTION OF CONSTRUCTION ACTIVITIES

The stages of construction typically include: survey and planning, mowing and clearing, grubbing and grading, trenching, pipe assembly (including stringing, bending, welding, testing, coating, and lowering-in), backfilling, final grading, and restoration. The erosion and sediment control

measures to be installed for each of these stages are described below. If any denuded area will remain idle for more than 14 days, temporary stabilization (temporary seed, mulch, additional sediment barriers as directed by the ECC) must be applied within seven (7) days to that area.

3.2.1 CONSTRUCTION WORK AREAS

Construction work areas, also called the LOD, include all access roads, staging areas, temporary pipe yards and contractor yards, and the construction right-of-way. To the extent possible, previously disturbed areas will be used for construction to minimize new impacts. Landowner agreement and appropriate permits must be obtained prior to the use of any area for construction activities. Erosion and sediment control plans apply to all construction work areas.

The construction right-of-way will include the permanent pipeline right-of-way and temporary right-of-way for the length of the project. Additional workspace may be required in certain areas. The construction right-of-way may be widened (subject to compliance with all applicable survey, plan preparation and approval, and mitigation requirements) in areas such as steep slopes and topsoil conservation areas to ensure safe construction or for storage of excess spoil.

Following construction, all disturbed areas must be restored with an approved vegetative cover directed by the landowner, permits these Annual Standards and Specifications. All temporary work areas must be restored to pre-construction conditions and uses.

ACP, LLC must provide the contractor with a construction line list that describes any special requirements (i.e. timber salvage, topsoil segregation, restoration measures, fencing requirements, etc.) requested by landowners. The contractor must comply with these special requirements.

ACP, LLC must also obtain the necessary right-of-way permits (i.e. federal, state, stream crossing, wetland crossing, road crossing permits, etc.) for the installation of pipeline. Permit requirements may be more stringent than the requirements of this plan and, if so, the more restrictive requirements will be implemented. The contractor must obtain permits that may be required for activities such as burning, blasting, and transportation.

3.2.2 SURVEY AND PLANNING

In most cases the LOD will be selected in advance and included in all surveys, landowner negotiations and permitting. Any work areas selected by the contractor must receive appropriate review and permitting prior to their use. The limits of the approved work areas, boundaries of environmentally sensitive areas, and the location of the facilities must be marked in the field prior to the start of mechanized activities. Changes to the LOD must be denoted/marked up on the ESC plans and recorded in the SWPPP (if applicable). Any changes affecting overall permitted disturbed area or potential affecting compliance with stormwater or ESC criteria must be reviewed and approved in advance in accordance with Section 1.5.5 (Revisions).

Environmentally sensitive areas are those that are more susceptible to serious erosion problems and thus may require enhanced erosion and sediment control measures. Examples of such areas may include steep slopes and sinkholes down-gradient of project activities. Examples of specialized controls that may be used in these areas include specialized pipeline construction methods that combine several construction stages, thereby reducing earth disturbance. Additional details for working in steep slopes can be found below in Section 3.4 Special Procedures.

3.2.3 CLEARING AND MOWING

The initial tree clearing may be performed by either non-mechanized or mechanized means. Non-mechanized methods entail the use of crews accessing the construction work areas on foot and cutting timber with handheld chainsaws. Trees are removed when mechanized equipment is mobilized to the project. Erosion and sedimentation control measures must be installed as a **first step** in any land-disturbing activity after clearing and must be made functional before upslope land disturbance takes place.

Vegetation will be cut at ground level and un-merchantable timber (i.e. brush, stumps, slash, and tree tops) may be disposed of by chipping and distribution along the upland right-of-way or by burning, if allowed. Burning must be avoided if practicable. Merchantable timber will be cut and stacked along the outboard edge of the construction right-of-way in upland areas as directed by the landowner or the Construction Supervisor. If chips are spread along the right-of-way, they must be spread at no more than 1-ton per acre and an additional application of 11 pounds of nitrogen per acre, at least 50% is slow release, must be made to affected areas. If necessary, the desirable trees will be protected by fencing and armoring. If chipping is to serve as "Mulching" for Erosion and Sediment Control purposes, then mulching should be consistent with the application rates from ESC Standard and Specification 3.35.

3.2.4 GRUBBING AND GRADING

This step involves grubbing stumps, removing and segregating topsoil where applicable, and leveling the construction right-of-way to create a safe operating area for equipment and vehicles. Topsoil and subsoil disturbed during grading operations will not be mixed with foreign material (i.e. stumps and slash). The disposal methods described above for clearing debris also apply to stumps. In addition, stumps may not be buried in the right-of-way in upland, non-agricultural, non-residential areas. Grading must be delayed at environmentally sensitive areas that will be treated as separate construction areas (i.e. steep slopes) until the contractor is prepared to complete all other construction activities at that site in the shortest practicable time.

Erosion and sedimentation control measures must be installed as a **first step** in any land-disturbing activity and must be made functional before upslope land disturbance takes place.

3.3 EROSION AND SEDIMENT CONTROL PRACTICES

The following are the more commonly used practices applied to pipeline construction (from Virginia Uniform Coding System for Erosion and Sedimentation Control Practices). The use of the VESCH, along with accompanying technical documents, guidance and practices is strongly preferred. The VESCH and related technical documents and guidance specifications are incorporated by reference into these Annual Standards and Specifications. Details for those practices marked with an * are included in Appendix A. For full details, refer to the 1992 VESCH. Non-VESCH measures are included herein but may be further reviewed and approved by DEQ on a project-specific basis.

Practice	Title	Key
3.01*	Safety Fence	SAF
3.02*	Temporary Stone Construction Entrance	CE
3.03	Construction Road Stabilization (Temp)	CRS
3.04*	Straw Bale Barrier	STB
3.05*	Silt Fence	SF
3.07*	Storm Drain Inlet Protection	IP
3.08*	Culvert Inlet Protection	CIP
3.09*	Temporary Diversion Dike	DD
3.10*	Temporary Fill Diversion	FD
3.11*	Temporary ROW Diversion/Water Bars	RWD
3.12*	Diversion	DV
3.13	Temporary Sediment Trap	ST
3.14	Temporary Sediment Basin	SB
3.15	Temporary Slope Drain	TSD
3.17	Stormwater Conveyance Channel	SCC
3.18*	Outlet Protection	OP
3.19*	Riprap	RR
3.20*	Rock Check Dams	CD
3.21	Level Spreader	LS

3.22	Vegetative Streambank Stabilization	VSS
3.23	Structural Streambank Stabilization	SSS
3.24*	Temporary Vehicular Stream Crossing	SC
3.25*	Utility Stream Crossing	USC
3.26*	Dewatering Structure	DS
3.29	Surface Roughening	SR
3.30	Topsoiling	TO
3.31	Temporary Seeding	TS
3.32	Permanent Seeding	PS
3.34	Bermudagrass & Zoysiagrass Est.	BE/ZE
3.35	Mulching	MU
3.36*	Soil Stabilization Blankets & Matting	B/M
3.37	Trees, Shrubs, Vines & Ground Cover	VEG
3.38	Tree Preservation & Protection	TP
3.39	Dust Control	DC

The following practices are identified as baseline measures for minimizing erosion and enhancing revegetation in accordance with the FERC Plan, found in Appendix C. They are listed by Plan section reference.

IV.B	Topsoil Segregation	TSS
IV.F.1	Temporary Slope Breakers	TSB
IV.F.2	Temporary Trench Plugs	TTP
V.C	Soil Compaction	SCO
VI.	Off-Road Vehicle Control	ORV

In instances where the requirements or practices differ between the VESCH and the FERC Plan and Procedures guidance, the more stringent criteria shall be applied. *(e.g. FERC TSB spacing criterion are not as stringent as VESCH RWD spacing criterion, so the VESCH criterion would be applied.)* The following practices and measures are identified as baseline measures for minimizing erosion and sediment control and are not found in the VESCH or the Plans and Procedures. These include:

Timber Mat Stabilization TM

ACP, LLC utilizes construction timber mats to provide access through areas such as wetlands and waterbodies, some agricultural fields, steep slopes, and other areas as determined by the Construction Supervisor. This practice reduces soil compaction and provides a stable travel lane for contractors along the project right-of-way, thus minimizing land disturbance. This practice may be incorporated in addition to the VESCH-related practices and requirements.

The use of construction timber may generally not constitute soil disturbance or a change in hydrology. Therefore, the installation of timber mat access roads and work pads is not considered a regulated land-disturbing activity and these areas are generally not included in land disturbance area calculations.

Geotextile Bag/Dewatering Bag GB

ACP, LLC utilizes geotextile bags for dewatering and velocity reduction on a majority of pipeline construction projects in lieu of straw bale dewatering practices illustrated in DS (Std. 3.26 Dewatering Structure). The purpose, definition, conditions of application and planning considerations are identical. Design criteria and specifications vary by dewatering bag manufacturer. A variety of geotextile dewatering bag products are available on the market. When incorporated into a plan, all manufacturers' guidance on the use, design, sizing, maintenance and application of the geotextile dewatering bag shall be followed.

3.4 SPECIAL PROCEDURES

The following procedures and practices are commonly utilized on pipeline construction sites and may have standards established by more than one regulation.

3.4.1 WETLAND AND WATERBODY CROSSINGS (PROCEDURES V & VI)

Sections V and VI of the FERC Procedures outline methods for crossing wetlands and waterbodies. See Appendix D for additional details regarding equipment bridges and crossing methodologies including: dry-ditch, flume, and horizontal direction drill.

3.4.2 TIME WINDOWS FOR CONSTRUCTION (PROCEDURES V.B.1)

Unless expressly permitted or further restricted by the appropriate federal or state agency in writing on a site-specific basis, crossings must be constructed during the following time windows:

- Coldwater Fisheries - June 1 through September 30;
- Coolwater and Warmwater Fisheries - June 1 through November 30;

- Natural Trout Streams - restrictions set forth by the Virginia Department of Game and Inland Fisheries (VDGIF), October 1st through March 31st for Brown Trout (*Salmo trutta*) and Brook Trout (*Salvelinus fontinalis*), March 15th through May15th for Rainbow Trout (*Oncorhynchus mykiss*) and March 15th through June 30th for the Roanoke Logperch (*Percina rex*); and
- Stockable Trout Streams - there are no time of year restrictions for stockable trout streams; however, as required by the VDGIF, ACP, LLC must consult with the VDGIF regional offices before constructing in stockable trout streams.
- Time-of-Year Restrictions (TOYR) – TOYR may be applied to certain construction activities for protection of certain species (e.g. listed freshwater mussels, bat hibernaculum, etc.) as required by UFWS and/or wetland permitting agencies. Applicable TOYR will be described in permit documentation and enforced by the ECC.

3.4.3 POTENTIAL EROSION PROBLEM AREAS/CRITICAL AREAS

Critical Areas, or potential erosion problem areas, **as described in VESCH** will be protected by project specific BMPs. A list of potential critical areas is included in **Appendix J**. Special attention will be given to those slopes that are near surface waters. The discharge of soils from failed slopes into surface waters is a serious occurrence and may result in environmental non-compliance. Critical Areas must be identified in the Erosion and Sediment Control narrative and appropriate management measures must be provided. Critical areas are defined as areas on the site which have potentially serious erosion problems (steep slopes, channels, wet weather/underground springs, etc.).

Potential erosion problem areas or critical areas (see slope length and gradient erodibility criteria in VESCH), including but not limited to areas with 30º slopes (58%) or greater, will be protected by belted silt retention fence and permanent slope breakers. Slope breakers (aka right-of-way diversions) will be placed in the appropriate spacing listed in VESCH Std. and Spec. 3.11 (RWD) in areas with greater than 14º slopes (25% slopes). Spacing shall be 50 ft. when slopes are 25-40%, and 25 ft. when in excess of 40%. In addition to the criteria for RWD on slopes steeper than 25%, RWD should be installed at the designer's discretion and consistent with the VESCH 3.11 RWD specification.

Care will be taken to avoid areas of steep slopes as much as practical; however, areas which could not be avoided will be addressed with waterbars and Rolled Erosion Control Product (RECP). RECPs must be consistent with VESCH Std. and Spec. 3.36 for Soil Stabilization Blankets and Matting. In the event that subsurface flow is encountered, an Under Drain will be utilized, as necessary, to divert water outside of the LOD. If encountered, seeps can be mitigated by using seep collectors placed down-slope of areas showing seepage. Armored fill placed at the

toe of the slope may be used in areas of steep slopes in addition to a perforated drain pipe to divert subsurface water away from the cut slope. If a slip occurs Dominion will install super silt fence, gabion baskets, jersey barriers or other portable containment devices to keep the slip from impacting areas outside the LOD or waters of the state. Steep slopes will be avoided to the maximum extent practicable and are limited. Those areas will be restored with erosion control blanket and Dominion will implement the slip prevention items mentioned above as needed. Please also see ACP, LLC's *Slope Stability Policy and Procedure for Pipeline Design, Construction and Right of Way Maintenance* (Appendix I) for additional details regarding Dominion's internal policy regarding slips.

3.4.4 ADDITIONAL CRITERION – ACP/OTHER LARGE PROJECTS

The Department of Environmental Quality, in some instances, exercises discretionary authority on certain large projects to apply more stringent additional criteria than those normally applied under these Standards and Specifications. The Atlantic Coast Pipeline (ACP) project is an example of one of these large projects. While ACP has been cancelled, there remain closeout, restoration, or potentially other activities for the project that may require application of these Annual Standards and Specifications by ACP, LLC. As such, it is the intention of ACP, LLC to maintain the entirety of the Annual Standards and Specifications, inclusive of all appendices in the event of need as the course of these activities may be resolved over time. The special conditions for the ACP project are contained in Appendix G and will be adhered to, in addition to the minimum criteria outlined in this document. Project managers at ACP, LLC should be advised that projects with significant disturbed acreage (e.g. > 50 acres) are likely to face additional scrutiny by DEQ and certain additional criterion may apply. Early coordination with DEQ for large projects is recommended.

3.4.5 SWPPP APPLICABILITY

Per the request of DEQ, ACP, LLC commits to develop and implement Stormwater Pollution Prevention Plans (SWPPPs) for all projects that equal or exceed 1 acre of disturbance, even if exemptions from a permit are granted (via oil and gas exemption and/or GM 15-2003). The ESC and SWM Plan requirements are addressed separately in this document. In addition to those requirements, ACP, LLC will include the relevant general information and the SWPPP. The components ACP, LLC to be included in the SWPPP include the following:

SWPPP Contents

1. General Information (as described in section B 1 of Part II of the CGP): Subsections (d) & (e) only
2. Erosion and Sediment Control Plan (addressed separately herein)
3. SWM Plan (addressed separately herein, if no SWM Plan waiver secured)
4. Pollution Prevention Plan (as described in Section B.4 of Part II of the CGP)

5. SWPPP Requirements for Impaired Waters, etc. (as described in Section B.5 of Part II of the CGP)
6. SWPPP Requirements to polychlorinated biphenyl (PCB) impaired waters (as described in Section B.6 of Part II of the CGP).
7. SWPPP requirements for discharges to exceptional waters identified in 9VAC25-260-30 A.3 c (as described in Section B.7 of Part II of the CGP).
8. Qualified Personnel (as described in Section B.8 of Part II of the CGP).
9. Individuals or positions with delegated authority to sign inspection reports or modify the SWPPP (as described in B.9 of Part II of the CGP).
10. SWPPP signature (as described in B.10 of Part II of the CGP).
11. Certification: "I certify under penalty of the law that I have read and understand this document and that this document and all attachments were prepared in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations."

SWPPP Provisions to be Implemented by ACP, LLC:

1. Provisions for SWPPP Amendments, Modifications, and Updates (as described in Section B of Part II of the CGP, excluding references to federal officials and Part III.K)
2. SWPPP Implementation (as described in Section E of Part II of the CGP, excluding references to general permit coverage)
3. SWPPP Inspections (as described in Section F of Part II of the CGP, excluding references to the general permit and certifications pursuant to Part III.K)
4. Corrective Actions (as described in Section G of Part II of the CGP)

3.5 MAINTENANCE

Rights-of-way are generally maintained by mowing not more frequently than once every three years by the pipeline patrol and when necessary for inspection purposes. In no case will routine vegetation mowing or clearing occur during the migratory bird nesting season between April 15 and August 1 of any year unless specifically approved in writing by the responsible land management agency or the U.S Fish and Wildlife Service.

Maintenance of permanent rights-of-way in wetlands will be performed on an "as-needed" basis and will consist of limited cutting of growth as required to permit operation and maintenance pursuant to Dominion requirements. Native herbaceous and woody shrub species must be allowed to reestablish in wetland right-of-way. Herbicides or pesticides will not be used in or within 100 feet of a wetland, except as allowed by the appropriate federal or state agency.

In all cases, rights-of-way will be left in a natural vegetated state and may not be mowed or bush hogged more than four times per year in accordance with the management guidelines for *Open Space* in Table 1 of the *Virginia Runoff Reduction Method Instructions and Documentation.* Section 7c FERC projects will follow the FERC Plan and Procedures guidance criteria for the restoration of disturbed lands to a hydrologically functional state.

3.6 EMERGENCY PROVISIONS

In the event of an emergency, ACP, LLC reserves the right to conduct land-disturbing activities in response to a public emergency, including grid reliability issues, to avoid imminent endangerment to human health or the environment in accordance with exemptions cited in Virginia Code §62.1-44.15:34. In such situations, the DEQ shall be advised of the disturbance within seven days of commencing the land-disturbing activity, and compliance with the administrative requirements of these Annual Standards and Specification is required within 30 days of commencing the land-disturbing activity.

3.7 INSPECTIONS

ACP, LLC or its designated representative will continue to be responsible for routine inspections for compliance with the erosion and sediment control and stormwater management (where applicable) regulations and any FERC Certificate. Certified personnel as outlined in Section 2 must conduct all inspections.

For all projects, ACP, LLC or its designated representative will be responsible for periodic inspections in compliance with 9 VAC 25-840-60(B).1. Specifically, ACP, LLC or its designated representative will provide for an inspection during or immediately following initial installation of erosion and sediment controls, at least once in every two-week period, within 48 hours following any runoff producing storm event, and at the completion of the project, or in accordance with an alternate inspection approved by the State Water Control Board.

For FERC-regulated projects, ACP, LLC or its designated representative will be responsible for periodic inspections in compliance with FERC Plan II.B.13. Specifically, FERC Plan related inspections must be conducted;

- on a daily basis in areas of active construction or equipment operation;
- on a weekly basis in areas with no construction or equipment operation; and
- within 24 hours of each 0.5 inch of rainfall.

Pipeline projects must avoid discharges of concentrated runoff to surface waters unless permitted discharges (such as dewatering) have been appropriately filtered, treated or settled prior to being discharged in a dispersed manner.

In instances where a project is subject to Stormwater Management requirements, inspections must be conducted in accordance with the inspection frequencies outlined in Appendix B (Section 5). For all projects with Stormwater Management inspection requirements, ACP, LLC or its designated representative will inspect land-disturbing activity in accordance with 9VAC25-870-114(A) and § 62.1-44.15:37. A. Land-disturbing activity will be inspected for:

1. Compliance with the approved erosion and sediment control plan;
2. Compliance with the approved stormwater management plan;
3. Development, updating, and implementation of a pollution prevention plan; and
4. Development and implementation of any additional control measures necessary to address a TMDL.

3.8 ENFORCEMENT

While ACP, LLC continues to hold its employees, consultants and contractors to strict environmental compliance standards, regulatory enforcement will be administered by DEQ. ACP, LLC may be required to submit relevant project documentation and plans for covered activities to the DEQ to ensure consistency with these Annual Standards and Specifications and applicable permit requirements. The State Water Control Board has the authority to enforce approved specifications and charge fees equal to the lower of (i) $1000 or (ii) an amount sufficient to cover the costs associated with standard and specification review and approval, project inspections and compliance. The Virginia DEQ will serve as the VESCP and VSMP authority and will perform random site inspections or inspections in response to a complaint to assure compliance with the associated laws/regulations and these Annual Standards and Specifications. Construction contracting firms retained by ACP, LLC must be required to comply with all contractual obligations, and ACP, LLC must enforce their compliance to the extent legally available, as necessary.

APPENDIX A

ESC Plan Checklist

Erosion and Sediment Control Practice Details

The following construction details are taken from the Virginia Erosion and Sediment Control Handbook (VESCH), Third Edition, 1992, as amended. Specific details and guidelines are covered more completely in Chapter 3 of the VESCH.

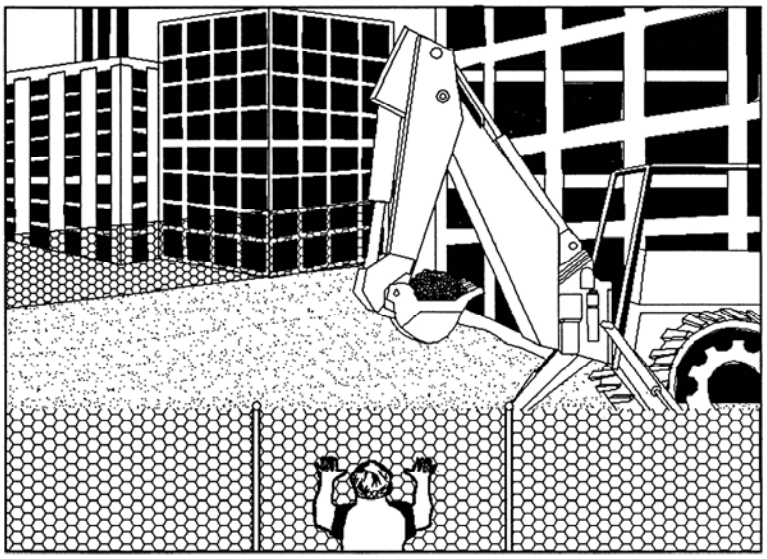
The Contractor must go to the VESCH to reference practices that are covered in the specification but not listed below.

Practice	Title	Key
3.01	Safety Fence	SAF
3.02	Temporary Stone Construction Entrance	CE
3.04	Straw Bale Barrier	STB
3.05	Silt Fence	SF
3.07	Storm Drain Inlet Protection	IP
3.08	Culvert Inlet Protection	CIP
3.09	Temporary Diversion Dike	DD
3.10	Temporary Fill Diversion	FD
3.11	Temporary Right-Of-Way Diversion	RWD
3.12	Diversion	DV
3.18	Outlet Protection	OP
3.19	RipRap	RR
3.20	Rock Check Dams	CD
3.24	Temporary Vehicular Stream Crossing	SC
3.25	Utility Stream Crossing	USC
3.26	Dewatering Structure	DS
3.36	Soil Stabilization Blankets & Matting	B/M

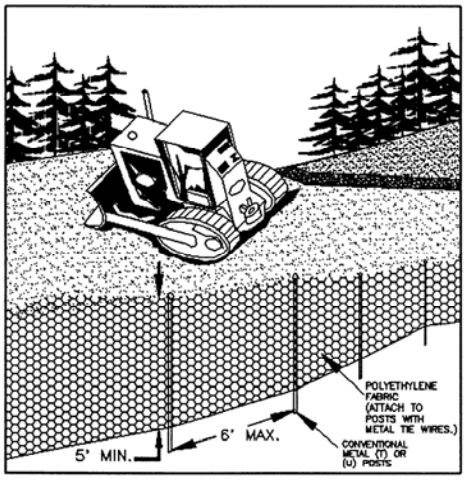
The following items are specific to the practices within this document and are not found in the VESCH manual. Details for these items are located at the end of this appendix following the items listed above.

Timber Mat Stabilization	TM
Geotextile Bag/Dewatering Bag	GB
Bleeder Drain and Outlet	BD
Trench Plug Drain	TP

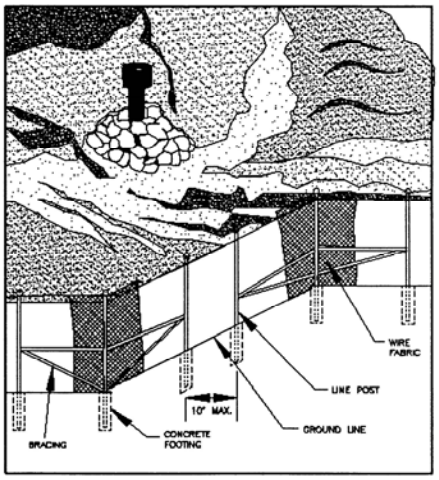
SAFETY FENCE



PERSPECTIVE VIEW



PERSPECTIVE VIEW
PLASTIC FENCE

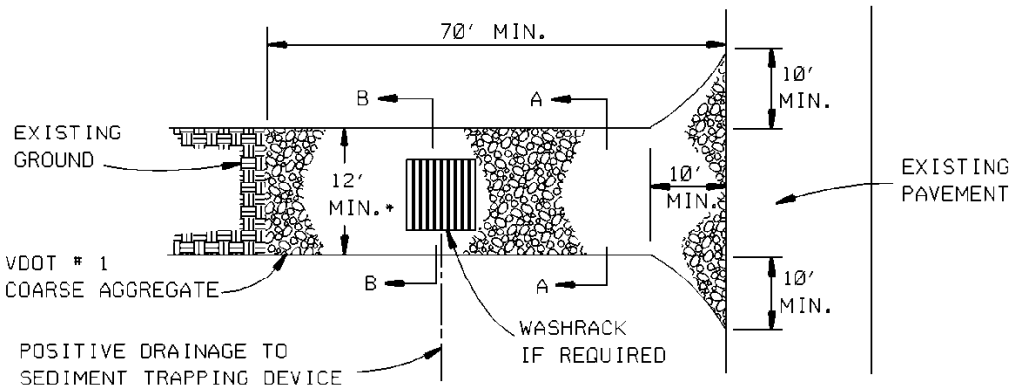


PERSPECTIVE VIEW
METAL FENCE

Source: Adapted from Conwed Plastics and VDOT Road and Bridge Standards

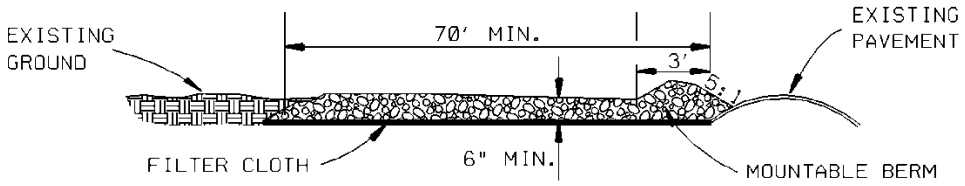
Plate 3.01-1

STONE CONSTRUCTION ENTRANCE - 3.02

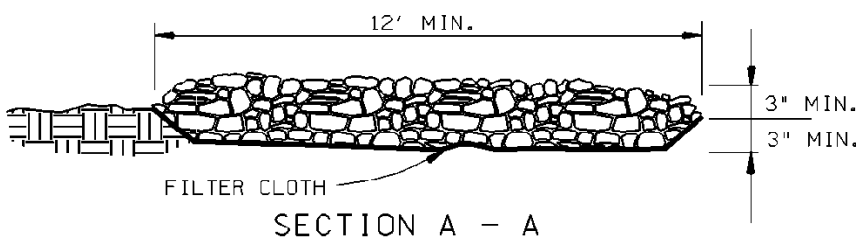


* MUST EXTEND FULL WIDTH OF INGRESS AND EGRESS OPERATION

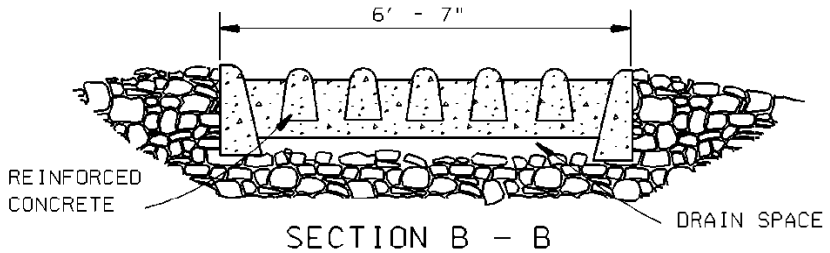
PLAN VIEW



ELEVATION



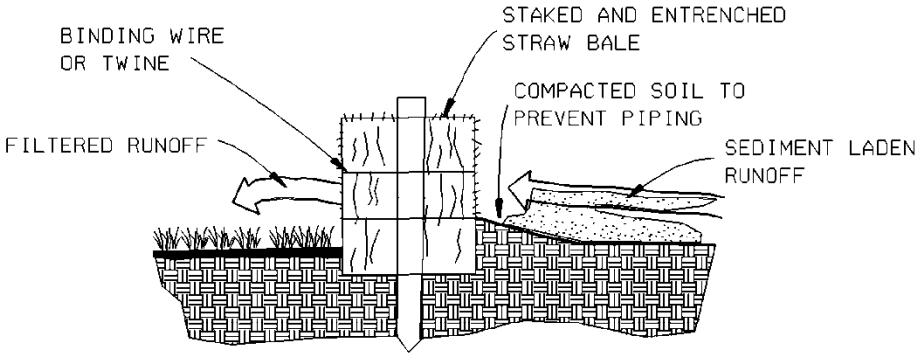
SECTION A - A



SECTION B - B

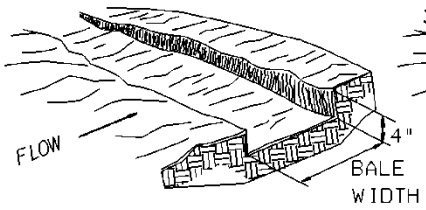
vee302.dgn

STRAW BALE BARRIER - 3.04

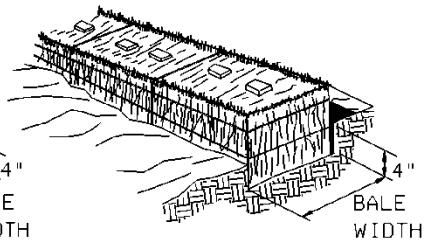


PROPERLY INSTALLED STRAW BALE CROSS SECTION

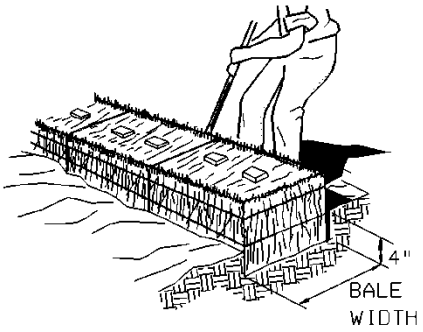
1. EXCAVATE THE TRENCH



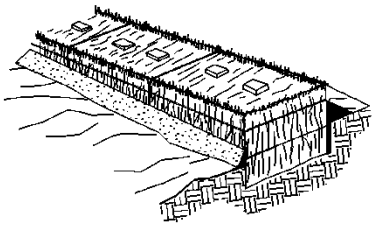
2. PLACE AND STAKE STRAW BALES



3. WEDGE LOOSE STRAW BETWEEN BALES



4. BACKFILL AND COMPACT THE EXCAVATED SOIL



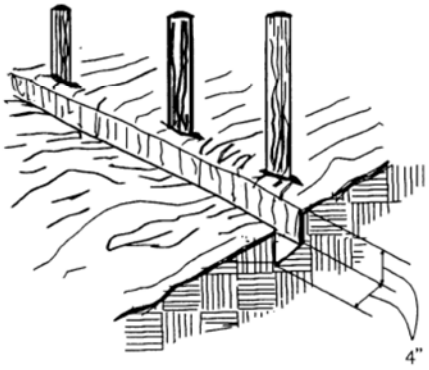
CONSTRUCTION OF STRAW BALE BARRIER

vae304.dgn

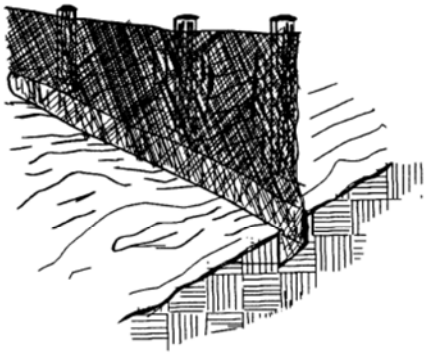
CONSTRUCTION OF A SILT FENCE (WITHOUT WIRE SUPPORT)

1. SET THE STAKES.

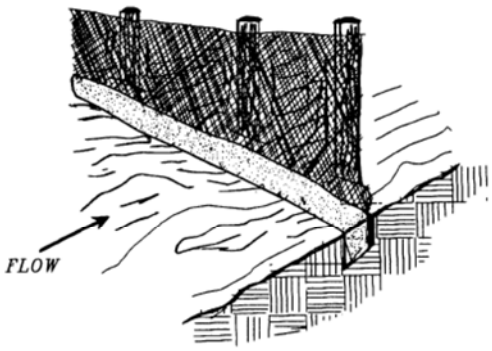
2. EXCAVATE A 4"X 4" TRENCH UPSLOPE ALONG THE LINE OF STAKES.



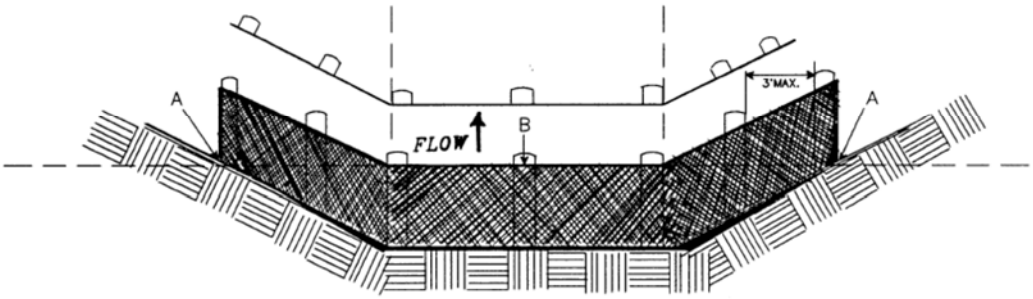
3. STAPLE FILTER MATERIAL TO STAKES AND EXTEND IT INTO THE TRENCH.



4. BACKFILL AND COMPACT THE EXCAVATED SOIL.



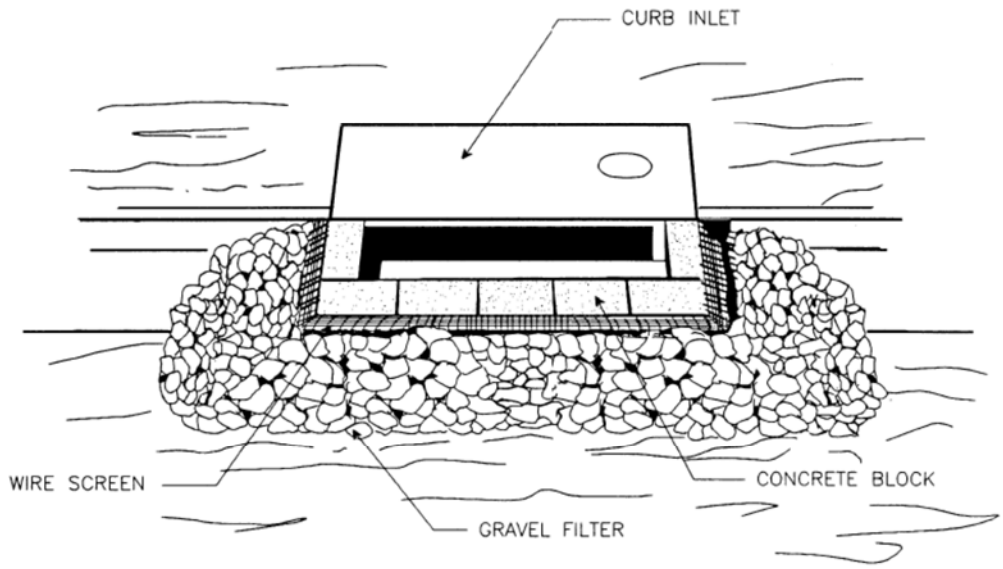
SHEET FLOW INSTALLATION
(PERSPECTIVE VIEW)

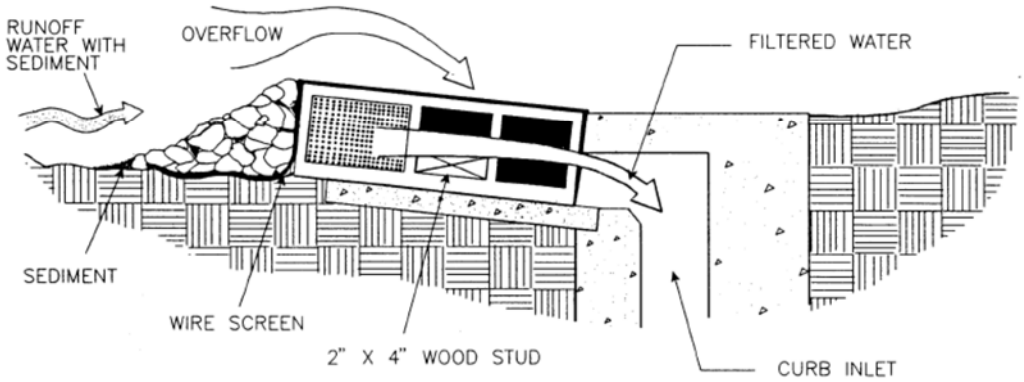


POINTS A SHOULD BE HIGHER THAN POINT B.

DRAINAGEWAY INSTALLATION
(FRONT ELEVATION)

BLOCK & GRAVEL CURB INLET SEDIMENT FILTER



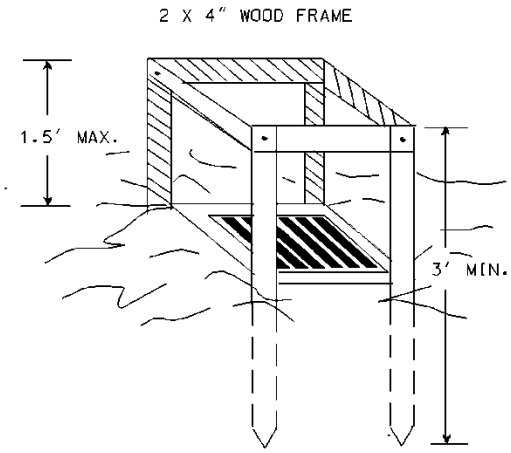


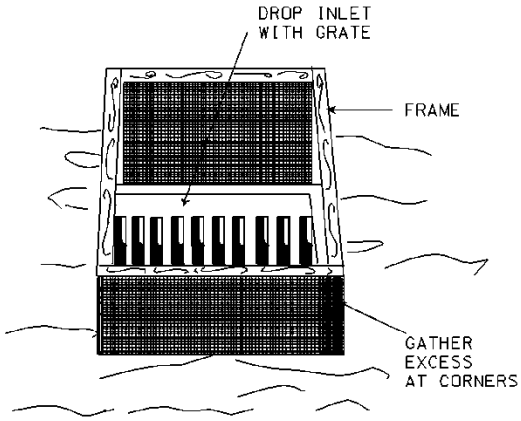
SPECIAL APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE AT CURB INLETS WHERE AN OVERFLOW CAPABILITY IS NECESSARY TO PREVENT EXCESSIVE PONDING IN FRONT OF THE STRUCTURE.

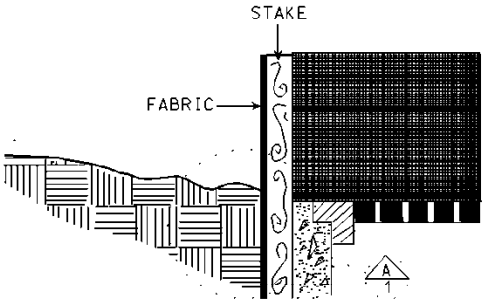
* GRAVEL SHALL BE VDOT #3, #357 OR #5 COARSE AGGREGATE

SILT FENCE DROP INLET PROTECTION - 3.07-1

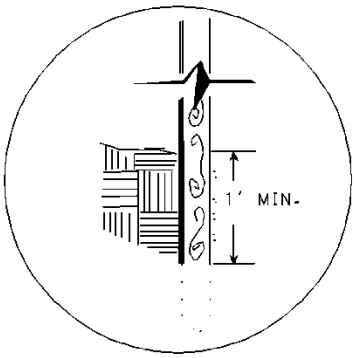




PERSPECTIVE VIEWS



ELEVATION OF STAKE AND FABRIC ORIENTATION

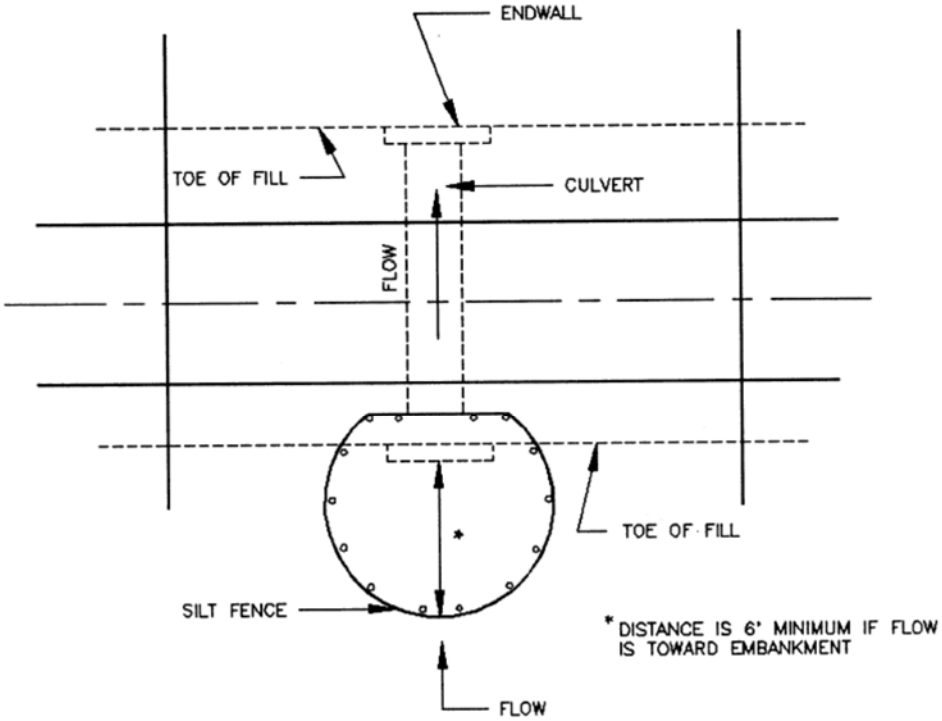


DETAIL A

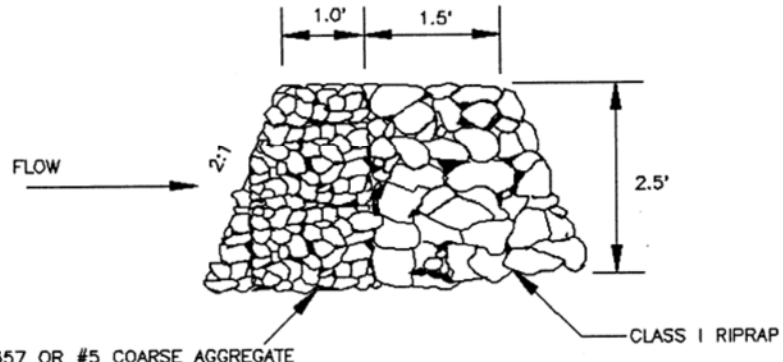
SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE THE INLET DRAINS A RELATIVELY FLAT AREA (SLOPE NO GREATER THAN 5%) WHERE THE INLET SHEET OR OVERLAND FLOWS (NOT EXCEEDING 1 C.F.S.) ARE TYPICAL. THE METHOD SHALL NOT APPLY TO INLETS RECEIVING CONCENTRATED FLOWS, SUCH AS IN STREET OR HIGHWAY MEDIANS.

SILT FENCE CULVERT INLET PROTECTION

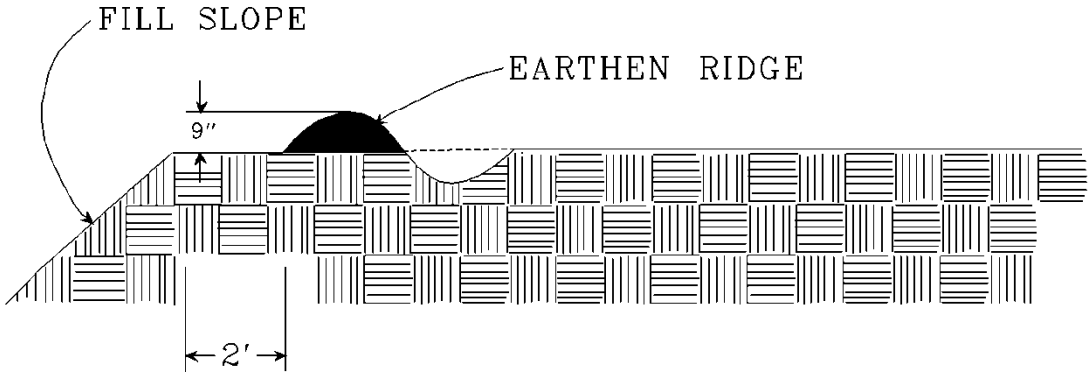


OPTIONAL STONE COMBINATION**

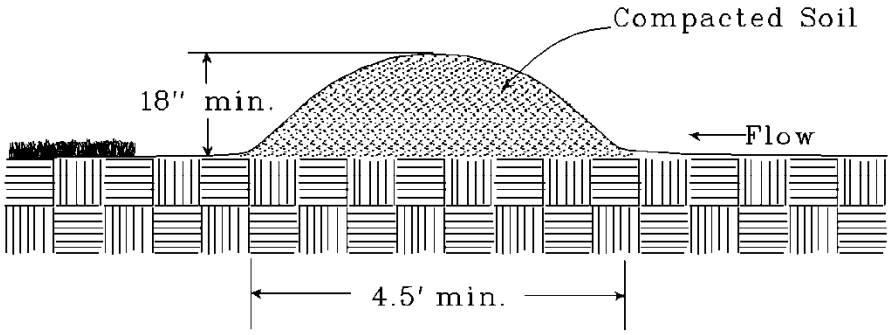


** VDOT #3, #357 OR #5 COARSE AGGREGATE TO REPLACE SILT FENCE IN " HORSESHOE " WHEN HIGH VELOCITY OF FLOW IS EXPECTED

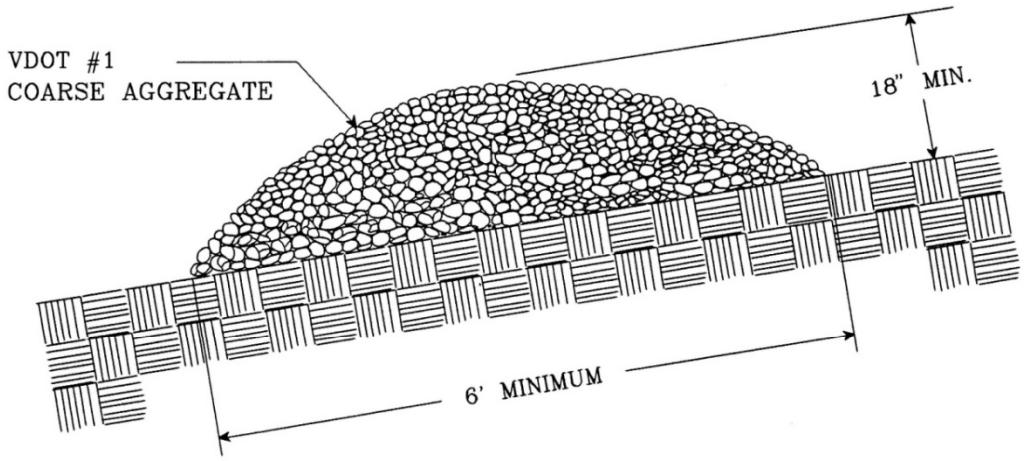
TEMPORARY FILL DIVERSION - 3.10



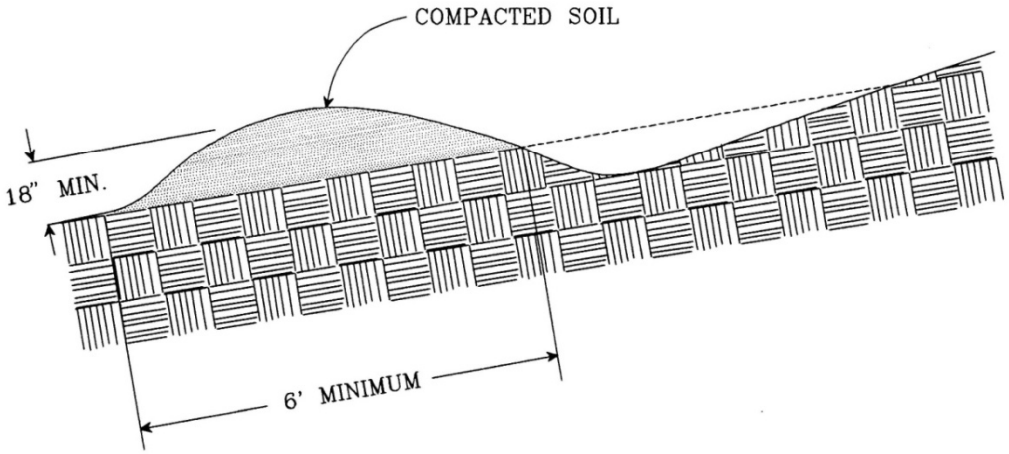
TEMPORARY DIVERSION DIKE - 3.09



TEMPORARY RIGHT-OF-WAY DIVERSIONS

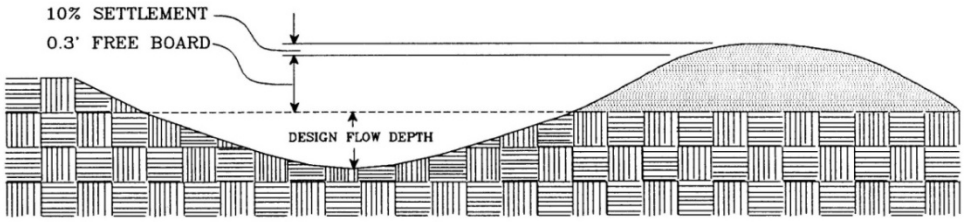


TYPICAL GRAVEL STRUCTURE

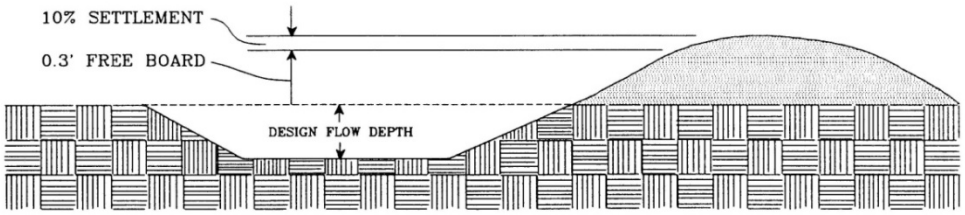


TYPICAL EARTHEN STRUCTURE

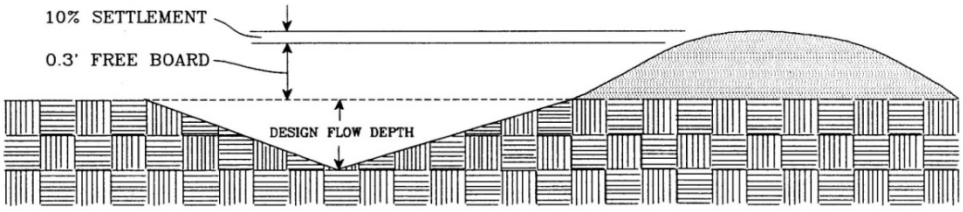
DIVERSIONS



TYPICAL PARABOLIC DIVERSION

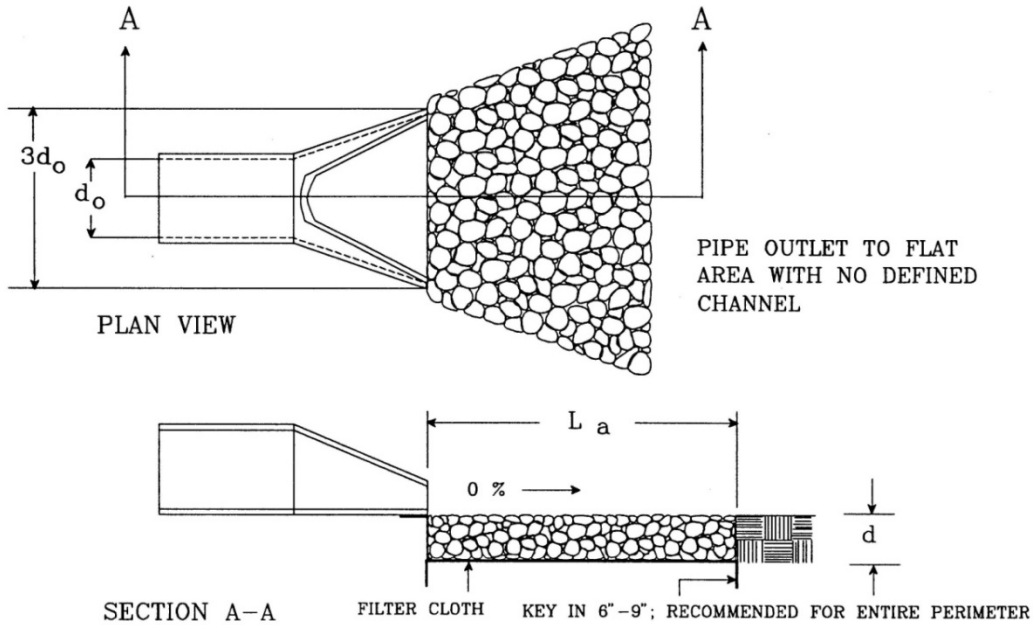


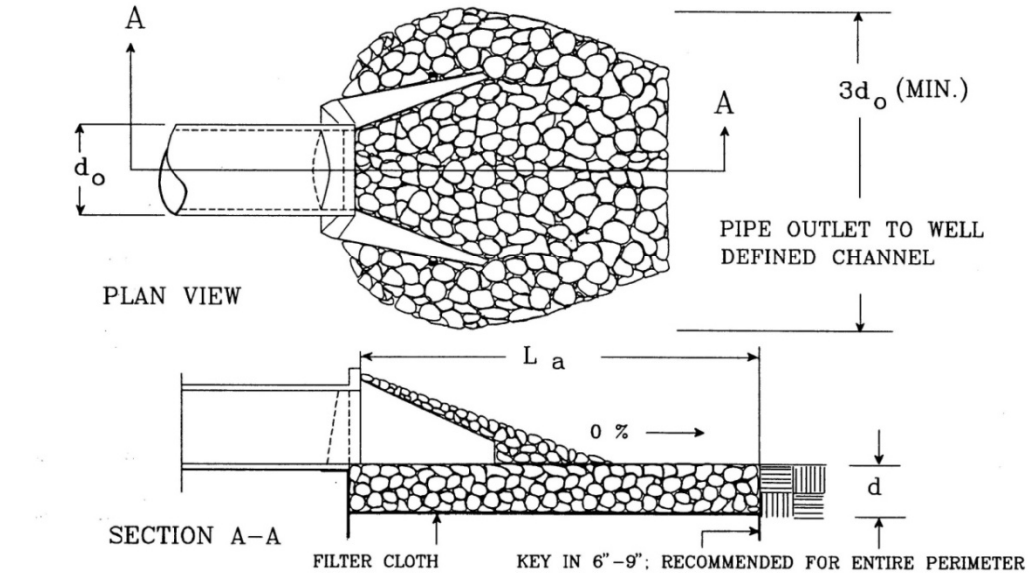
TYPICAL TRAPEZOIDAL DIVERSION



TYPICAL VEE-SHAPED DIVERSION

PIPE OUTLET CONDITIONS



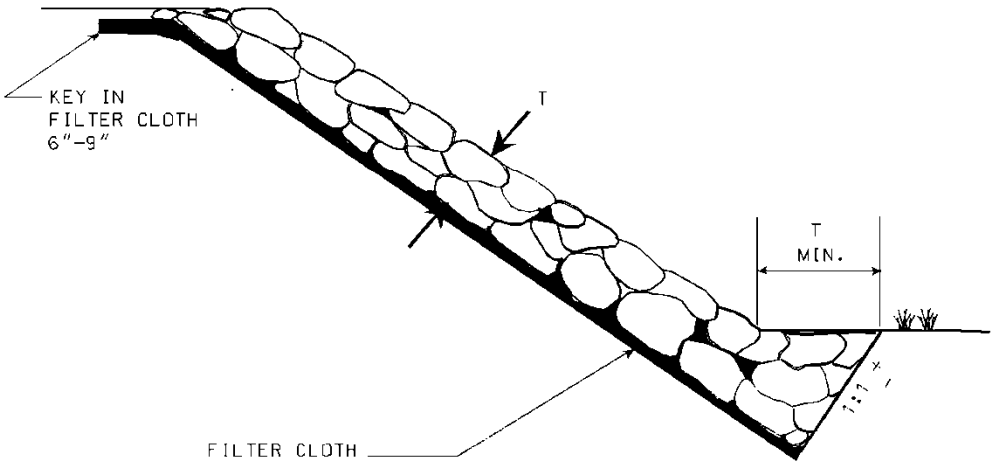


NOTES:
1. APRON LINING MAY BE RIPRAP, GROUTED RIPRAP, GABION BASKET, OR CONCRETE.
2. La IS THE LENGTH OF THE RIPRAP APRON AS CALCULATED USING PLATES 3.18–3 AND 3.18–4.
3. d = 1.5 TIMES THE MAXIMUM STONE DIAMETER, BUT NOT LESS THAN 6 INCHES.

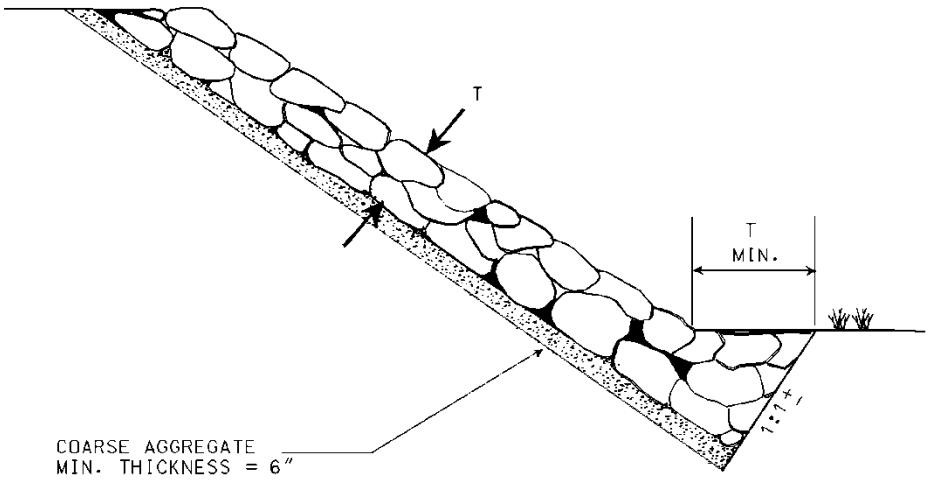
TOE REQUIREMENTS FOR BANK STABILIZATION - 3.19

FILTER CLOTH UNDERLINER

(PREFERRED)

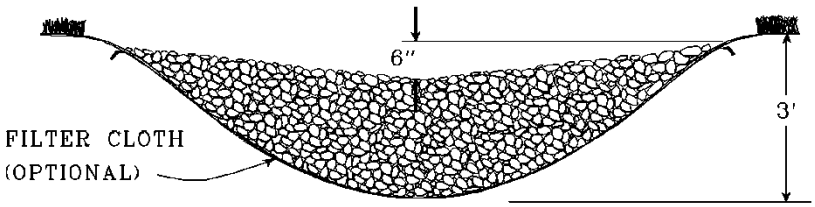


GRANULAR FILTER

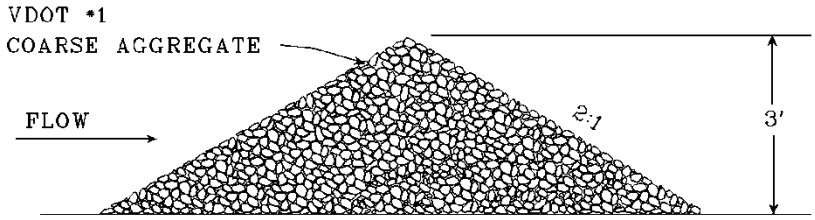


ROCK CHECK DAM - 3.20

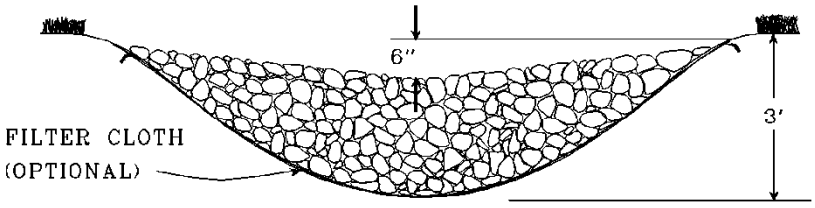
2 ACRES OR LESS OF DRAINAGE AREA:



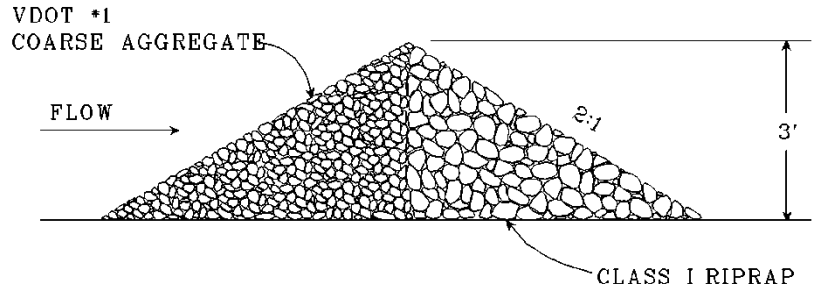
(DOWNSTREAM VIEW)



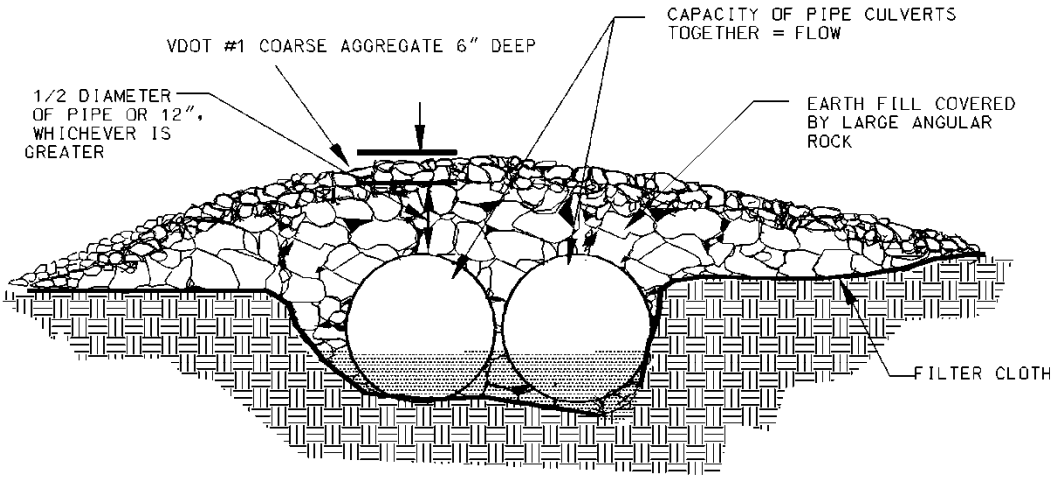
2-10 ACRES OF DRAINAGE AREA:



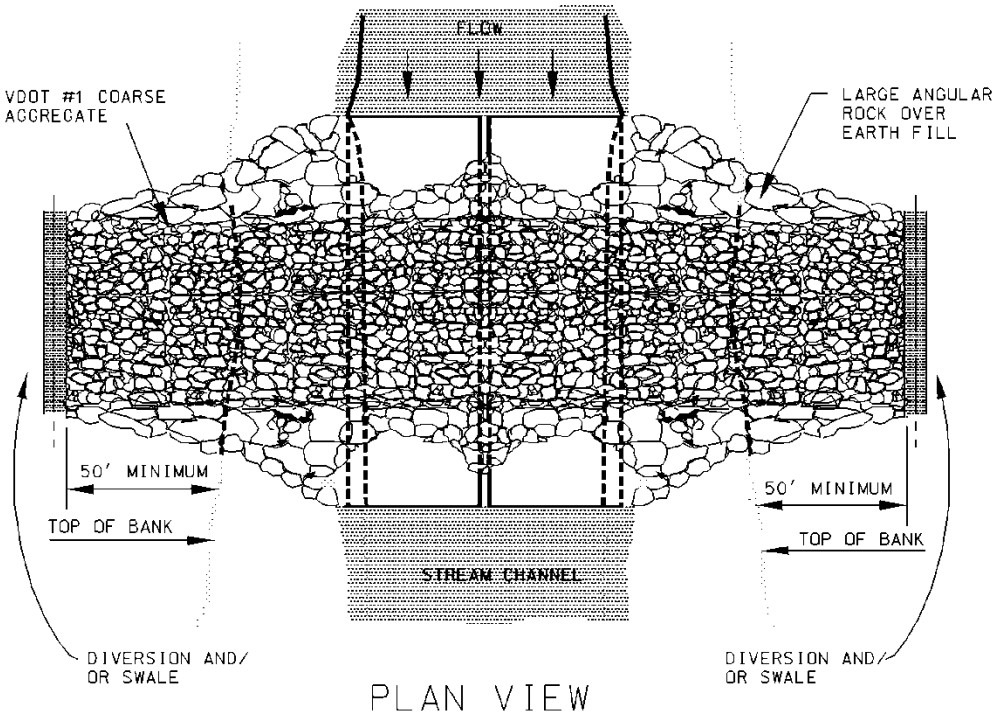
(DOWNSTREAM VIEW)



TEMPORARY CULVERT CROSSING - 3.24

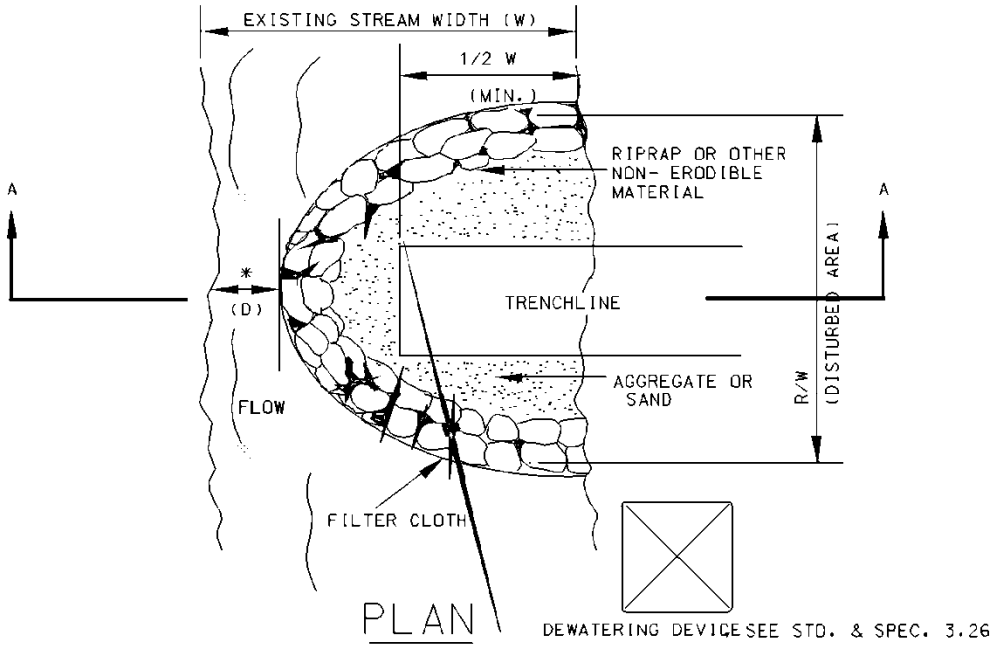


ELEVATION

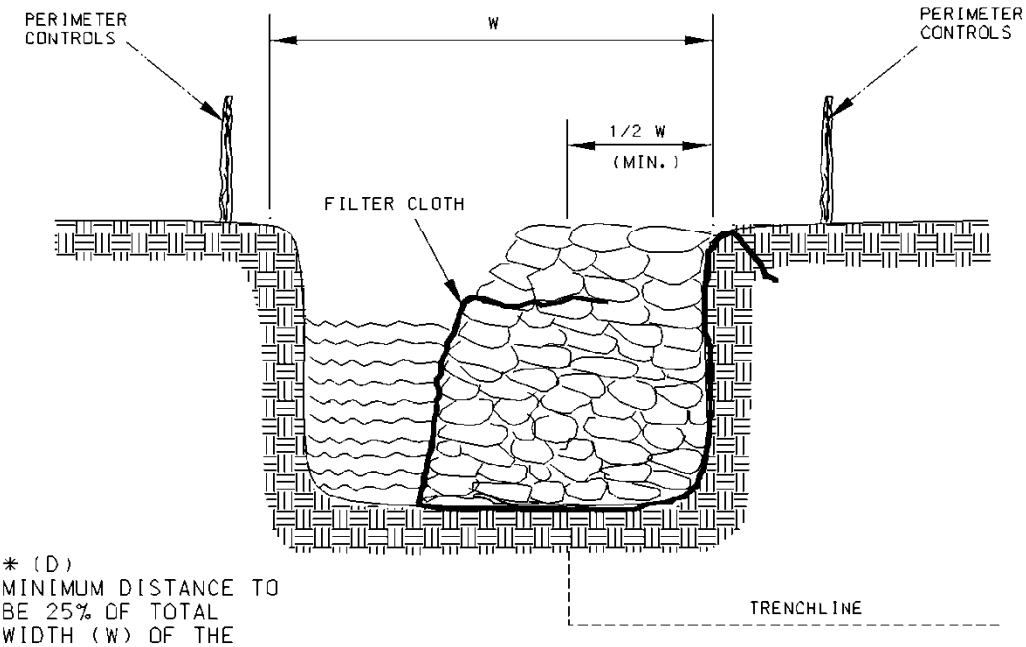


PLAN VIEW

COFFERDAM CROSSING - 3.25



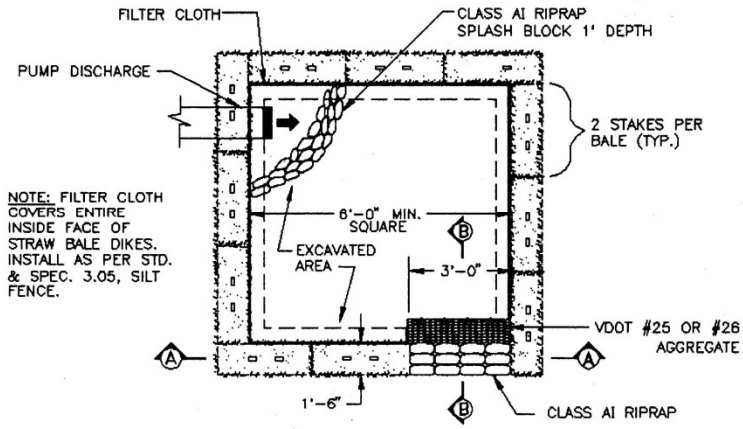
PLAN



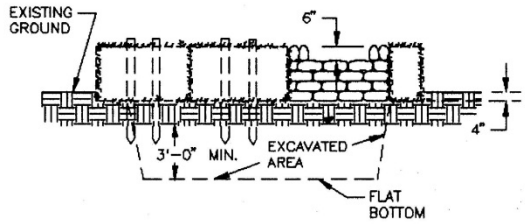
* (D)
MINIMUM DISTANCE TO
BE 25% OF TOTAL
WIDTH (W) OF THE
STREAM.

SECTION A-A

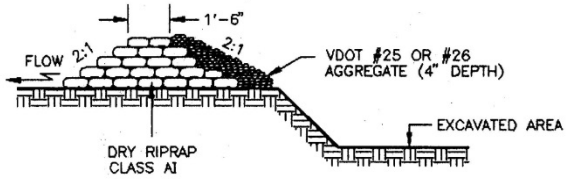
STRAW BALE/SILT FENCE PIT



PLAN VIEW



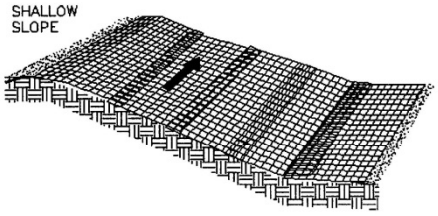
CROSS-SECTION A-A



CROSS-SECTION B-B

TYPICAL ORIENTATION OF TREATMENT – 1 (SOIL STABILIZATION BLANKET)

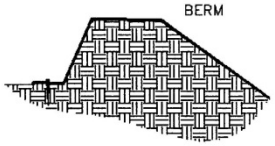
SHALLOW SLOPE



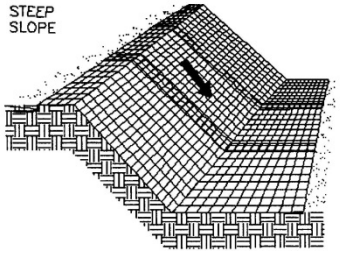
ON SHALLOW SLOPES, STRIPS OF NETTING PROTECTIVE COVERINGS MAY BE APPLIED ACROSS THE SLOPE.

WHERE THERE IS A BERM AT THE TOP OF THE SLOPE, BRING THE MATERIAL OVER THE BERM AND ANCHOR IT BEHIND THE BERM.

BERM

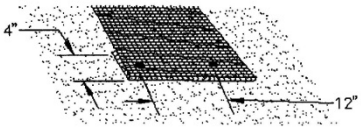


STEEP SLOPE

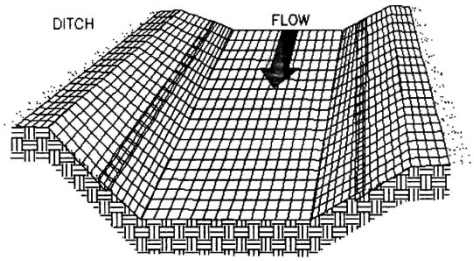


ON STEEP SLOPES, APPLY PROTECTIVE COVERING PARALLEL TO THE DIRECTION OF FLOW AND ANCHOR SECURELY.

BRING MATERIAL DOWN TO A LEVEL AREA BEFORE TERMINATING THE INSTALLATION. TURN THE END UNDER 4" AND STAPLE AT 12" INTERVALS.

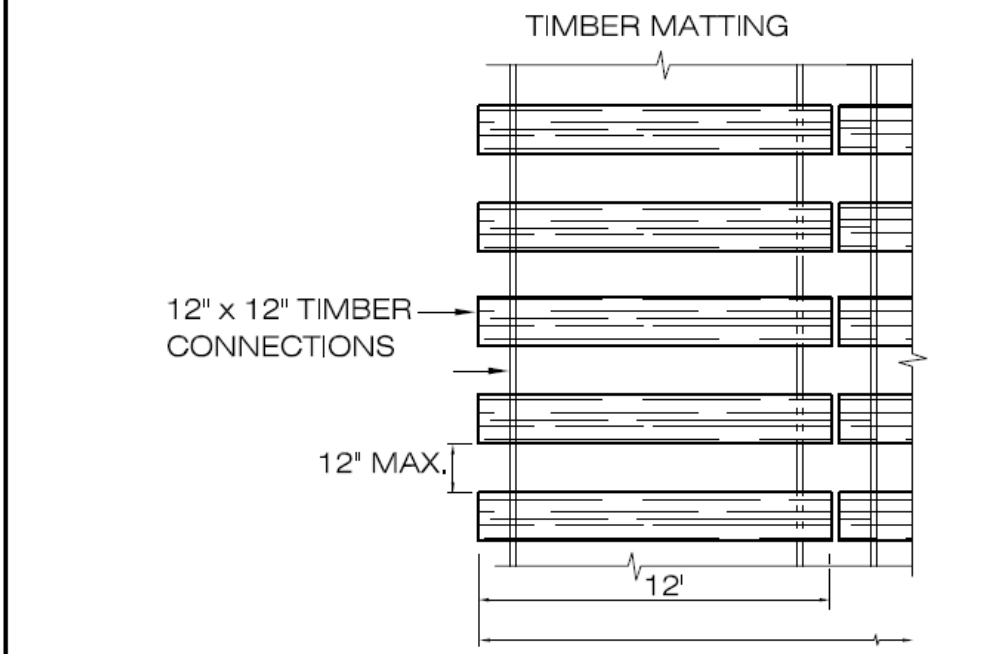


DITCH



IN DITCHES, APPLY PROTECTIVE COVERING PARALLEL TO THE DIRECTION OF FLOW. USE CHECK SLOTS AS REQUIRED. AVOID JOINING MATERIAL IN THE CENTER OF THE DITCH IF AT ALL POSSIBLE.

TIMBER MAT STABILIZATION



EXTEND ACROSS ENTIRE CONSTRUCTION ROUTE AND APPLICABLE LIMITS OF THE CONSTRUCTION ENTRANCE LIMITS (PER PLAN)

DETAIL : CONSTRUCTION ROAD STABILIZATION - TIMBER MATS

NTS

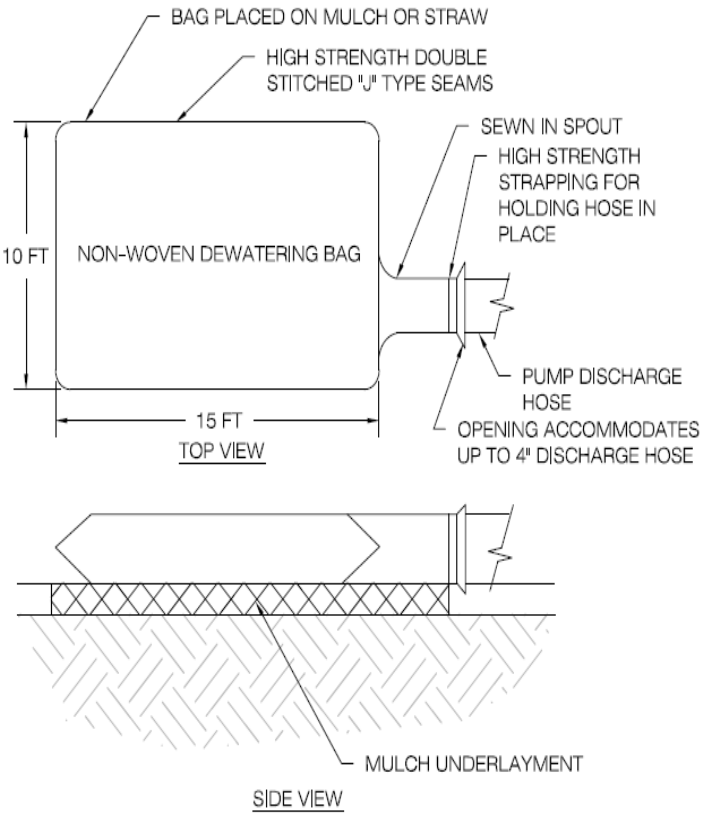
GEOTEXTILE/DEWATERING BAG

THE DEWATERING BAG SHALL BE MADE OF NON-WOVEN GEOTEXTILE WITH A MIN. SURFACE AREA OF 225 SQUARE FEET PER SIDE. ALL STRUCTURAL SEEMS SHALL BE SEWN WITH A DOUBLE STITCH USING A DOUBLE NEEDLE MACHINE WITH HIGH STRENGTH THREAD. THE SEAM STRENGTH SHALL WITHSTAND 100 LB/IN USING ASTM D-4884 TEST METHOD, THE DEWATERING BAG SHALL HAVE A NOZZLE LARGE ENOUGH TO ACCOMMODATE A FOUR INCH DISCHARGE HOSE, THE NOZZLE SHALL BE SEALED TIGHTLY AROUND THE DISCHARGE HOSE WITH A STRAP OR SIMILAR DEVICE TO PREVENT UNTREATED WATER FROM ESCAPING, THE GEOTEXTILE FABRIC SHALL BE A NON-WOVEN FABRIC WITH THE FOLLOWING PROPERTIES;

GEOTEXTILE FABRIC FOR DEWATERING BAG			
PROPERTIES	TEST METHOD	UNITS	DEWATERING BAG 12 OZ
WEIGHT	ASTM D-3776	OZ/YD	12
GRAB TENSILE	ASTM D-4632	LBS.	300
PUNCTURE	ASTM D-4833	LBS.	175
FLOWRATE	ASTM D-4491	GAL/MIN/FT2	70
PERMITIVITY	ASTM D-4491	1,3 SEC-1	1
MULLEN BURST	ASTM D-3786	LBS.IN2	580
UV RESISTANT	ASTM D-4355	%	70
AOS % RETAINED	ASTM D-4751	0.40-0.80 MM	100

NOTE:
ALL PROPERTIES ARE MINIMUM AVERAGE ROLL VALUE EXCEPT THE WEIGHT OF THE FABRIC WHICH IS GIVEN FOR INFORMATION ONLY.

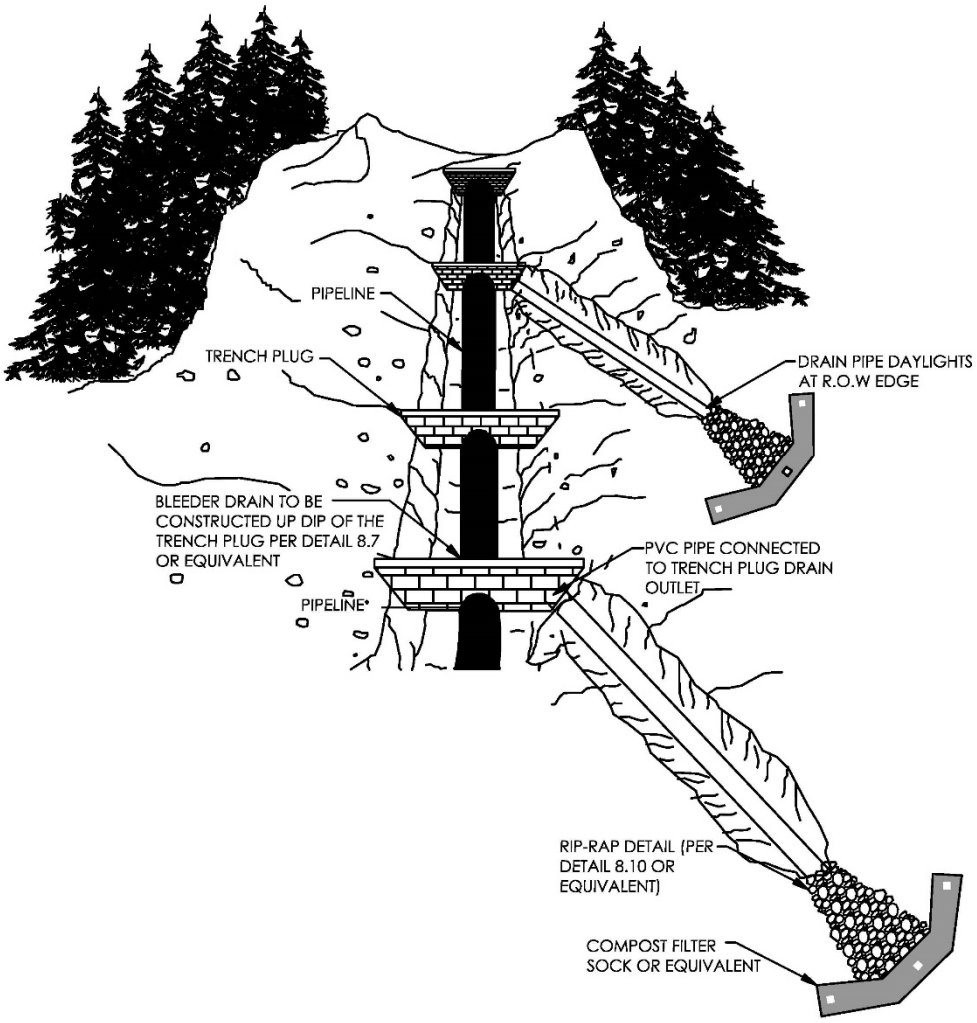
CONSTRUCTION:
THE DEWATERING BAG SHALL BE INSTALLED OVER A 3 INCH GRAVEL BASE TO PROMOTE INFILTRATION AND DEWATERING OF THE BAG.



DETAIL: GEOTEXTILE BAG (DEWATERING BAG)

NTS

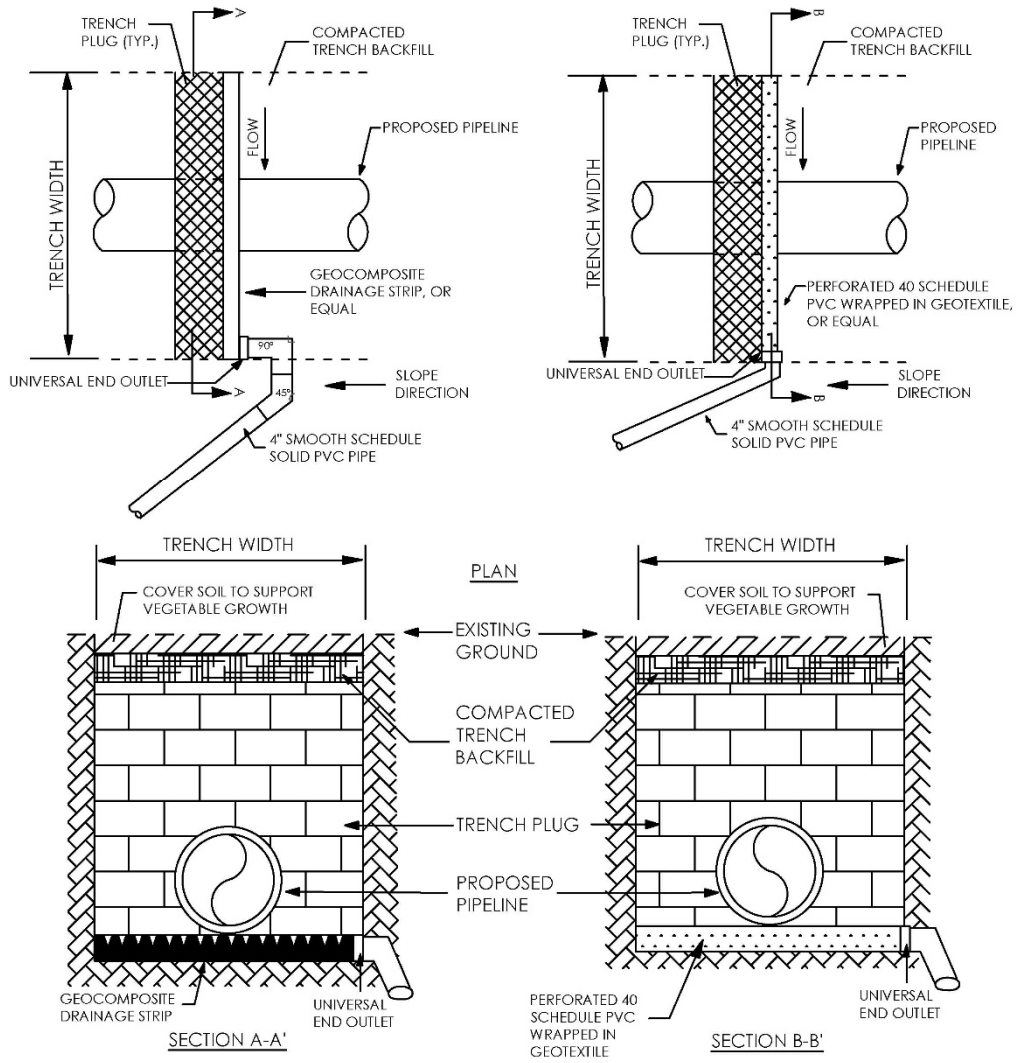
Where trenching activities are proposed in high slip potential soils and in areas where existing ground slopes are greater than 3:1, bleeder drains shall be installed to passively drain water from the trench area. The following illustration shows a drain placed at every second trench plug.



NOT TO SCALE

SLIP PREVENTION: BLEEDER DRAIN AND OUTLET DETAIL

Two (2) types of trench plug drains are illustrated below. Geocomposite Drainage Strips or Perforated Schedule 40 PVC placed behind the trench plug and below the pipeline are effective ways to passively drain water. Both methods show Schedule 40 PVC discharge pipe at a minimum of a 2% grade.



SLIP PREVENTION: TRENCH PLUG DRAIN DETAILS

APPENDIX B

Stormwater Management

SWM Plan Checklist

1. STORMWATER MANAGEMENT

The intent of the Virginia Stormwater Management Program (VSMP) regulations is to improve water quality through runoff reduction and other stormwater control practices and establish water quantity requirements. The baseline level for the stormwater technical criteria is a forested/open space condition.

Under 9 VAC 25-870, regulated land-disturbing activities are required to meet the stormwater technical criteria for water quality and water quantity metrics as outlined in Part IIB. The water quality and quantity criterion are largely directed at avoiding, minimizing and mitigating impacts due to changes in hydrology and stormwater pollutant loads associated with changes in land cover. Each project will be reviewed to evaluate consistency with DEQ Guidance Memorandum No. 15-2003. The guidance memorandum stipulates a number of conditions which must be satisfied for linear utility projects if a Stormwater Management Plan will not be required. Specifically, the following conditions must be satisfied:

- The project does not significantly alter the predevelopment runoff characteristics of the land surface after the completion of construction and final stabilization.
- The project is managed so that less than one (1) acre of land disturbance occurs on a daily basis.
- The disturbed land where work has been completed is adequately stabilized on a daily basis.
- The environment is protected from erosion and sedimentation damage associated with the land-disturbing activity.
- The owner and/or construction activity operator designs, installs, implements and maintains pollution prevention measures to:
    - *Minimize the discharge of pollutants from equipment and vehicle washing, wheel wash water, and other wash waters;*
    - *Minimize the exposure of building materials, building products, construction wastes, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on-site to precipitation and to stormwater;*
    - *Minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures;*
    - *Prohibit the discharge of wastewater from the washout of concrete;*
    - *Prohibit the discharge of wastewater from the washout and cleanout of stucco, paint, form release oils, curing compounds, and other construction materials; and*

- *Prohibit the discharge of fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance.*

- ACP, LLC must provide reasonable assurance to DEQ that all of the above conditions will be satisfied. **This may be accomplished by incorporating these conditions into an Erosion and Sediment Control Plan developed for the project.**

Rights-of-way must be maintained in a Forest/Open Space condition consistent with the Virginia Runoff Reduction Method Instructions & Documentation, which stipulate that rights-of-way considered as Forest/Open space must be restored to a hydrologically functional state and "be left in a natural vegetated state (can include areas that will be bush hogged no more than four times per year)," in accordance with Table 1 of the Virginia Runoff Reduction Method (VRRM) Instructions and Documentation. The forestry and vegetative management practices employed by ACP, LLC within the right-of-way comply with the VRRM recommendations for open space. Where the right-of-way consists of forest or open space conditions prior to the construction activity, and will remain in a forested or open space condition under post-developed conditions (e.g. undisturbed or restored to a hydrologically functional state and all surfaces will remain as permeable surfaces which are mowed no more than once every three years, in accordance with FERC Plan Guidelines or maintained in accordance with Table 1 referenced above), runoff curve numbers are identical under the Virginia Runoff Reduction Method. ACP, LLC may be required to provide documentation to DEQ of water quantity analysis, and may be required to document consistency with and applicability of DEQ Guidance Memorandum No. 15-2003.

ACP, LLC will submit project information to DEQ for preliminary review of whether a SWM plan is required (see Section 1.0 of Main Document). Department of Environmental Quality (DEQ) Guidance Memo No. 15-2003 (Appendix F) addresses this for linear development projects in stating, "…the construction of aboveground or underground utilities may not result in changes to the predevelopment runoff characteristics of the land surface after the completion of construction and final stabilization." The guidance memorandum goes on further to state that, "If the project will not result in significant changes to the predevelopment runoff characteristics after the completion of construction and final stabilization…," the requirement for a CGP permit may be waived (this would be separate from the more general exemptions for oil and gas transmission described in Section 1 of the main document). DEQ will review preliminary project information to advise ACP, LLC whether a SWM plan is required.

For projects requesting waiver of Stormwater Plan, DEQ requires information to be submitted that reasonably demonstrates that the project will not significantly change the predevelopment runoff characteristics of the land surface after the completion of construction and final stabilization. Information submitted to DEQ may include:

- Pre- and post-construction drainage areas and land cover conditions.

- Limits of disturbance
- Methodology for the restoration of land cover conditions to predevelopment conditions.
- ESC Plan excluding 9VAC25-840-40.19.m. & n. (The full Erosion and Sediment Control Plan would be available later in the process, after the preliminary review discussed above and in Section 1 of the main document).

If DEQ determines that the project meets the criteria for granting a waiver, then DEQ will waive the requirement for the preparation and implementation of a stormwater management plan. This waiver allows the recipient to exclude the following regulatory sections:

- SWM Quality – 9VAC25-870-63 and -65
- SWM Quantity – 9VAC25-870-66
- ESC MS-19 – 9VAC25-840-40.19.m. & n.

Information shall be submitted to DEQ Central Office for review with a transmittal letter specifically requesting a SWM Plan waiver. DEQ, as the VSMP Authority, will evaluate each project on an individual basis.

If DEQ waives the requirement for a SWM plan, ACP, LLC will utilize the DEQ linear projects guidance and will incorporate the conditions stipulated in GM 15-2003 into the Erosion and Sediment Control plan for the project (See *Additional Note*s in Appendix E).

Each project must be reviewed by a certified SWM Plan Reviewer (qualifications described in Section 2 of the main document) to verify exemption. In certain instances, a project may have an element which does result in significant change to predevelopment runoff characteristics after the land-disturbing activity is completed. In those instances, (generally where the addition of impervious surfaces or conversion of forest to managed turf in combination are expected to cause significant changes in predevelopment runoff characteristics), a SWM plan must be prepared, reviewed, approved, and implemented in accordance with 9VAC25-870 and 9VAC25-880 (if applicable).

ACP, LLC access roads will be grouped into four categories based on the extent of improvements required to prepare the road for use to support the project. Depending on the improvements, the impact on stormwater runoff characteristics will range from no expected impact to a material impact. Specifically, the four categories are defined below; all access roads, or access road segments, will be assigned a category that is depicted on the corresponding alignment sheet and access road plans.

1. Existing road with no improvements proposed – includes those existing roads that are in a condition such that no improvements are needed to prepare the road for use to support the project (e.g., asphalt surfaced roads).

2. Existing road with minor improvements proposed – includes those existing roads that contain either a compacted earth or gravel surface and the current road configuration (i.e., width, grade, etc.) is adequate to support the project. Roads in this category may receive supplemental gravel to improve the surface condition; however, the footprint of the road would not be expanded (i.e., no additional impervious surface).
3. Existing road with major improvements proposed – includes those existing roads that will receive an expanded footprint (i.e., the impervious surface post-construction may exceed that existing preconstruction) in order to prepare the road for use to support the project.
4. New road – includes roads not located within the limits of an existing road.

Access roads in categories 2, 3 and 4 will involve varying degrees of land disturbance, and thus appropriate erosion and sediment controls (e.g., sediment barriers) will be identified and depicted on the plans. No Post-construction stormwater management criteria will apply to categories 1 & 2 because the roads are existing and there is no additional impervious surface. Access roads in categories 3 and 4 may also require drainage improvements (e.g.,road side ditches and ditch relief culverts). The general approach to locating sediment barriers along access roads will be to provide sediment barriers when a resource (e.g., wetland, waterbody) is downgradient of and within 200 feet of an access road.

Access roads in categories 3 and 4 involve improvements that are expected to result in a material change to the existing stormwater runoff characteristics as a result of the addition of impervious surface. These access roads must meet the Stormwater management requirements for quality and quantity.

Access roads in categories 3 and 4 will be identified as to whether they are temporary (meant to serve the project initial construction and then removed and restored after construction is complete) or permanent.

Temporary access roads will be restored/rehabilitated to establish a firm stand of erosion-resistant vegetation and restored to a hydrologically functional state prior to completion of the project. All non-porous stone surfacing will be removed and porous stone ballast will be removed where it impedes infiltration. Any defined ditches or topographic alterations which significantly alter predevelopment runoff characteristics will be graded and topsoiled to match pre-development drainage patterns and avoid concentration of runoff. In accordance with the maintenance guidelines herein, these vegetated areas will be mowed no more than four times per year and will be considered open space. For FERC 7c projects, soils restoration will follow the FERC plan and procedures and will typically include provisions for Soil Restoration, Soil Compaction, Topsoil Segregation, Replacement and Soil Conditioning, and Re-Contouring.

In some instances, permanent access roads may be required for the construction or long-term maintenance and operation of the utility infrastructure. Each instance where a permanent access road is proposed will be reviewed for consistency with stormwater quality and quantity requirements. If ACP, LLC is of the opinion that the increases in runoff relative to pre-development conditions are not significant, ACP, LLC may request an exception from the stormwater management criteria from DEQ. A request for an exception must demonstrate that the request is in accordance with the provisions for exceptions in the VSMP regulations (9VAC25-870-57 & 9VAC25-870-122) and that the activity avoids and minimizes impacts to stormwater runoff. DEQ will scrutinize each exception request, so early coordination is advised.

2. TECHNICAL REQUIREMENTS

2.1 WATER QUALITY

Part IIB of the stormwater regulations states that the total phosphorous load will not exceed 0.41-pound per acre per year (lb./ac/yr.) for new development activities. The Land Cover Guidance for the VRRM defines provides for certain areas (including "Utility rights-of-way that will be left in a natural vegetated state") under certain operational conditions to be considered forested/open space and not as managed turf for the purposes of stormwater quality and quantity compliance. In accordance with the above, ACP, LLC will coordinate with DEQ on the applicability of GM15-2003 and whether a SWM plan is required. If a SWM plan is required (e.g. due to significant changes to predevelopment runoff characteristics, or other requirements which trigger the need for CGP coverage or post-construction SWM), ACP, LLC must develop and implement a SWM plan consistent with the applicable requirements of 9VAC25-870 and 9VAC25-880. The VRRM Spreadsheet is a tool which regulated entities may use to document general water quality planning and consistency with the technical requirements of 9VAC25-870 (et seq).

2.2 WATER QUANTITY

As identified in the VSMP regulations, the technical criteria for water quantity are designed to ensure the protection of State waters from the potential harm of unmanaged stormwater runoff. This is generally achieved through the incorporation of techniques to address localized flooding and the protection of downstream channels. The specific technical criteria to be applied for water quantity analysis and compliance are contained in 9VAC25-870-66.

2.2.3 PRIOR DEVELOPED LANDS

As noted previously, ACP, LLC will provide for an initial evaluation of each project to ascertain whether the project may be exempt from CGP permit coverage and whether there is a significant

change in predevelopment runoff characteristics that might trigger the need for a Stormwater Management Plan and associated controls (pursuant to GM15-2003). ACP, LLC will obtain concurrence from DEQ early in the process if a SWM plan is not required pursuant to GM15-2003. Permanent facilities with significant impervious cover (such as compressor stations) are expected to provide for a stormwater management plan and associated controls if needed, even though these facilities may remain exempt from permit coverage. For portions of pipeline easements which traverse prior developed lands (e.g. under turf-intensive uses such as ballfields, or under existing parking lots or road segments), ACP, LLC does not expect to provide improvements to existing runoff conditions if predevelopment conditions are restored. DEQ has clarified that it is not their expectation that permanent best management practices be installed on restored right-of-way. As discussed earlier, DEQ will review the overall project (at an early stage), including soil restoration conditions, to identify whether SWM plan preparation is waived for these activities.

Where predevelopment land cover conditions are changed significantly triggering requirements for post construction stormwater quality and quantity requirements, post-construction Best Management Practices (BMPs) may be required to comply with water quality and water quantity criteria and MS-19 of the Erosion and Sediment Control Regulations. In such instances, the outfall within the project must comply with Part IIB or Part IIC (where applicable) of the stormwater regulations to assess compliance. This may include the "Energy Balance" method described by item B.3.a of 9VAC25-870-66. In these instances, water quantity criteria for flood control and channel protection must be addressed and managed through the preparation of a SWM plan consistent with 9VAC25-870 and 9VAC25-880.

These Annual Standards and Specifications for ESC and SWM also assist in meeting the standards of the Federal Energy Regulatory Commission (FERC) Upland Erosion Revegetation and Maintenance Plan (Plan) and the FERC Wetland and Waterbody Construction and Mitigation Procedures (Procedures). ACP, LLC and its construction contractors must implement this plan as appropriate for all construction in Virginia unless a variance to the Virginia Erosion and Sediment Control Regulations has been submitted to and granted approval by the DEQ.

3. STORMWATER MANAGEMENT BMPS

Stormwater Management BMPs used for consistency with these specifications should be approved by DEQ and contained in the Virginia Stormwater BMP Clearinghouse. For projects requiring post-construction SWM BMPs, ACP, LLC must report the following annually each year to DEQ:

- Number and types of SWM BMPs installed;
- Geographic coordinates of each BMP;
- Drainage area or watershed size served; and

- Receiving stream or hydrologic unit.

4. STORMWATER MAINTENANCE

Each project plan must be reviewed by certified personnel described in Section 2 (main document) to ascertain whether the specific project is exempt from post-construction stormwater quality and quantity requirement, or whether SWM planning is required (with DEQ concurrence). If post-construction SWM is required, non-structural BMPs allowed by the permit will be the preferred option. A maintenance plan for both the non-structural and any additional structural BMPs must be developed to ensure compliance with requirements for routine inspection or reporting in the Virginia Stormwater BMP Clearinghouse specifications. Maintenance requirements for non-structural BMPs must be identified and incorporated into inspection documentation during routine patrolling of the right-of-way by certified personnel. Any structural BMPs would require a more formal inspection. Each stormwater management facility will be inspected by ACP, LLC, as the owner of the facility, at least once every five years; and all inspections will be documented. Corrective measures must be carried out as soon as practicably feasible when needed. Long-term maintenance of structural SWM facilities must be conducted in accordance with 9VAC25-870-112. To be consistent with the provisions of 9VAC25-870-112, maintenance plans for the stormwater facilities must be submitted to ACP, LLC for formal review and approval prior to initiating the land disturbing activity, made available to DEQ upon request, and must provide for inspections and maintenance and the submission of inspection and maintenance reports to the DEQ. ACP, LLC transmission easements over land under which permanent stormwater management facilities will be placed must further assure the following:

- Be stated to run with the land;
- Provide for all necessary access to the property for purposes of maintenance and regulatory inspections;
- And, be enforceable by all appropriate governmental parties.

5. INSPECTIONS FOR STORMWATER MANAGEMENT

ACP, LLC or its designated representative will continue to be responsible for periodic inspections for compliance with the CGP, if required, erosion and sediment control regulations and any FERC Certificate. Certified personnel, as outlined in Section 2 of the main document, must conduct all inspections.

Inspections for compliance with the SWPPP (and relevant SWM and ESC elements) must occur in accordance with the following:

Inspections must be conducted at the following frequency:

(1) At least once every five business days; or

(2) At least once every 10 business days and no later than 24 hours following a measurable storm event. In the event that a measurable storm event occurs when there are more than 24 hours between business days, the inspection must be conducted on the next business day.

A measurable storm event means a rainfall event producing 0.25 inches of rain or greater over 24 hours. Where areas have been temporarily stabilized or land-disturbing activities will be suspended due to continuous frozen ground conditions and stormwater discharges are unlikely, the inspection frequency described in Part II G 2 a and 2 b may be reduced to once per month. If weather conditions (such as above freezing temperatures or rain or snow events) make discharges likely, the operator must immediately resume the regular inspection frequency.

ACP, LLC's SWPPP inspections will be conducted by Certified Personnel as identified in Section 2 and will serve also as the periodic inspections.

The following SWPPP requirements for discharges to polychlorinated biphenyl (PCB) impaired waters apply to discharges from construction activities that include the demolition of any structure with at least 10,000 square feet of floor space built or renovated before January 1, 1980:

a. The impaired water(s), approved TMDL(s), and pollutant(s) of concern, must be identified in the SWPPP;

b. The approved erosion and sediment control plan must be implemented in accordance with Part II B 2;

c. Waste materials in compliance with the applicable state, federal, and local requirements must be disposed of; and

d. A modified inspection schedule must be implemented in accordance with Part II G 2 a.

For projects discharging to exceptional waters identified in 9VAC25-260-30.A.3.c, or to surface waters identified as impaired in the 2016 § 305(b)/303(d) Water Quality Assessment Integrated Report or for which a Total Maximum Daily Load (TMDL) wasteload allocation has been established and approved prior to the term of this general permit for (i) sediment or a sediment-related parameter (i.e., total suspended solids or turbidity) or (ii) nutrients (i.e., nitrogen or phosphorus), the following additional requirements will apply:

a. The exceptional water(s), impaired water(s), approved TMDL(s), and pollutant(s) of concern, when applicable, must be identified in the SWPPP;

b. Permanent or temporary soil stabilization must be applied to denuded areas within seven days after final grade is reached on any portion of the site;

c. Nutrients must be applied in accordance with manufacturer's recommendations or an approved nutrient management plan and will not be applied during rainfall events; and

d. The applicable SWPPP inspection requirements specified in Part II F 2 must a be amended as follows:

   (1) Inspections must be conducted at a frequency of (i) at least once every four business days or (ii) at least once every five business days and no later than 24 hours following a measurable storm event. In the event that a measurable storm event occurs when there are more than 24 hours between business days, the inspection must be conducted on the next business day; and

PLAN SUBMITTER'S CHECKLIST

FOR STORMWATER MANAGEMENT PLANS

Please fill in all blanks and **please reference the plan sheets/pages where the information may be found,** where appropriate, or write N/A by items that are not applicable.

GENERAL

Plan Submission Date _____
Project Name _____
VSMP Permit Number (if applicable) _____
Site Plan Number _____
Site Address _____
Applicant _____ Phone Number _____
Applicant Legal Address _____
Owner _____ Phone Number _____
Owner E-mail Address _____
Principal Designer _____ Phone Number _____
Principal Designer E-mail Address _____
Total Disturbed Area Figure _____

_____ Professional's seal - The designer's original seal, signature, and date are required on the *cover* sheet of each Narrative and each set of Plan Sheets. A facsimile is acceptable for subsequent Plan Sheets.

_____ Number of plan sets – Attach two sets of SWM Plans.

_____ Exceptions - Exceptions requested are governed by Section 9VAC25-870-57 of the *Virginia Stormwater Management Regulations*. (Exceptions must be requested, reviewed and approved in advance by the Virginia Department of Environmental Quality)

Name _____ Phone Number _____
Address _____

_____ Grandfathering - Attach supporting documentation consistent with the requirements of Section 9VAC25-870-48 of the *Virginia Stormwater Management Regulations*.

_____ Offsite Compliance – Attach letter of availability from the off-site provider as governed by Section 9VAC25-870-55 of the *Virginia Stormwater Management Regulations*.

_____ Consistency with DEQ Guidance Memorandum No. 15-2003 – Attach checklist documenting consistency with GM15-2003, if applicable. Supplemental Checklist found at end of this document.

PROJECT NAME: _____ SUBMITTAL#: _____

PLANS DATED: _____

CHECKLIST PREPARER

I certify that I am a professional in adherence to all minimum standards and requirements pertaining to the practice of that profession in accordance with Chapter 4 (§ 54.1-400 et seq.) of Title 54.1 of the Code of Virginia and attendant regulations. By signing this checklist I am certifying that this document and all attachments are, to the best of my knowledge and belief, true, accurate, and complete.

SIGNATURE _____

PRINTED NAME _____

QUALIFICATIONS _____

DATE _____

PROJECT NAME: _____ SUBMITTAL#: _____

PLANS DATED: _____

SITE PLANS

Please reference the plan sheet numbers where specific information may be found in the blanks below.

_____ Common address and legal description of the site, including the tax reference number(s) and parcel number(s) of the property or properties affected.

_____ A narrative that includes a description of current site conditions and proposed development and final site conditions, including proposed use of environmental site design techniques and practices, stormwater control measures, relevant information pertaining to long-term maintenance of these measures, and a construction schedule.

_____ Existing and proposed mapping and plans (recommended scale of 1" = 50', or greater detail), which illustrates the following at a minimum:

☐ North arrow
☐ Legend
☐ Vicinity map
☐ Existing and proposed topography (minimum of 2-foot contours recommended)
☐ Property lines
☐ Perennial and intermittent streams
☐ Mapping of predominant soils from USDA soils surveys as well as the location of any site-specific test bore hole investigations that may have been conducted and information identifying the hydrologic characteristics and structural properties of soils used in the installation of stormwater management facilities
☐ Boundaries of existing predominant vegetation and proposed limits of clearing and grading
☐ Location and boundaries of natural feature protection and conservation areas (e.g.,wetlands, lakes, ponds, aquifers, public drinking water supplies, etc.) and applicable setbacks (e.g., stream buffers, drinking water well setbacks, septic drainfield setbacks, building setbacks, etc.)
☐ Identification of any on-site or adjacent water bodies included on the Virginia 303(d) list of impaired waters
☐ Current land use and location of existing and proposed roads, buildings, parking lots and other impervious areas
☐ Location and description of any planned demolition of existing structures, roads, etc.
☐ Proposed land use(s) with a tabulation of the percentage of surface area to be adapted to various uses, including but not limited to planned locations of utilities, roads, parking lots, stormwater management facilities, and easements
☐ Location of existing and proposed utilities [e.g., water (including wells), sewer (including septic systems), gas, electric, telecommunications, cable TV, etc.] and easements
☐ Earthwork specifications
☐ Show the BMP name, **geographic coordinates** and design of both structural and non-structural stormwater control measures, including maintenance access and limits of disturbance
☐ Storm drainage plans for site areas not draining to any BMP(s)
☐ Location of existing and proposed conveyance systems, such as storm drains, inlets, catch basins, channels, lateral groundwater movement interceptors (French drains, agric. tile drains, etc.), swales, and areas of overland flow, including grades, dimensions, and direction of flow
☐ Final drainage patterns and flow paths
☐ Location of floodplain/floodway limits and relationship of site to upstream and downstream properties and drainage systems

PROJECT NAME: _____ SUBMITTAL#: _____

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☐ Location of all contributing drainage areas and points of stormwater discharge, receiving surface waters or karst features into which stormwater discharges, the pre-development and post-development conditions for drainage areas, and the potential impacts of site stormwater on adjoining parcels
☐ Location and dimensions of proposed channel modifications, such as bridge or culvert crossings
☐ Final stabilization and landscaping plans

_____ Hydrologic and hydraulic analysis, including the following:

☐ Site map with locations of design points and drainage areas (size in acres) for runoff calculations
☐ Identification and calculation of stormwater site design credits, if any apply
☐ Summary description of the water quantity and water quality compliance strategy.
☐ Time of concentration (and associated flow paths)
☐ Imperviousness of the entire site and each drainage area
☐ NRCS runoff curve numbers or volumetric runoff coefficients
☐ A hydrologic analysis for the existing (pre-development) conditions, including runoff rates, volumes, and velocities, showing the methodologies used and supporting calculations
☐ A hydrologic analysis for the proposed (post-development) conditions, including runoff rates, volumes, and velocities, showing the methodologies used and supporting calculations
☐ Hydrologic and hydraulic analysis of the stormwater management system for all applicable design storms
☐ Pollution load and load reduction requirements and calculations
☐ Final good engineering and sizing calculations for stormwater control measures, including contributing drainage areas, storage, and outlet configurations, verifying compliance with the water quality and water quantity requirements of the regulations
☐ Stage-discharge or outlet rating curves and inflow and outflow hydrographs for storage facilities
☐ Final analysis of the potential downstream impacts/effects of the project, where necessary
☐ Downstream analysis, where detention is proposed
☐ Dam safety and breach analysis, where necessary

_____ Representative cross-section and profile drawings and details of stormwater control measures and conveyances which include the following:
☐ Existing and proposed structural elevations (e.g., inverts of pipes, manholes, etc.)
☐ Design water surface elevations
☐ Structural details of BMP designs, outlet structures, embankments, spillways, grade control structures, conveyance channels, etc.

_____ Applicable construction and material specifications, including references to applicable material and construction standards (ASTM, etc.)

_____ Landscaping plans for stormwater control measures and any site reforestation or revegetation

PROJECT NAME: _____ SUBMITTAL#: _____

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_____ Long term operations and maintenance plan/agreement as governed by 9VAC25-870-112 of the Virginia Stormwater Management Program Regulations.

_____ Evidence of acquisition of all applicable local and non-local permits

_____ Waiver/exception requests

_____ Evidence of acquisition of all necessary legal agreements (e.g., easements, covenants, land trusts, etc.)

_____ Applicable supporting documents and studies (e.g., infiltration tests, geotechnical investigations, TMDLs, flood studies, etc.)

_____ Other required permits: _____

REVIEW CONSISTENCY WITH DEQ GM 15-2003

❑ The site will be restored to its predevelopment condition after completion of construction and final stabilization.

❑ The project does not significantly alter the predevelopment runoff characteristics of the land surface after completion of construction and final stabilization. [*Verify that runoff characteristics have been reviewed for the project and that areas of the right-of-way considered Forest/Open Space meet the operational conditions contained in Table 1 of the Virginia Runoff Reduction Method Instructions and Documentation (must be bush-hogged no more than 4 times per year and maintained in a natural vegetated state*]

❑ The project will be managed such that less than one (1) acre of land disturbance occurs on a daily basis. [*Verify that appropriate notes have been added to the plan prohibiting 1 acre or more of disturbance daily*]

❑ The disturbed land where work has been completed will be stabilized on a daily basis. [*Verify that notes on the plan stipulate proper stabilization to occur on a daily basis*]

❑ The environment is protected from erosion and sedimentation damage associated with the land disturbing activity. [*Verify that the Erosion and Sediment Control plan has been developed and the appropriate checklist has been completed*]

❑ Verify that the following conditions and language have been incorporated into the Erosion and Sediment Control Plan for the project to provide assurances:

"DTI must design, install, implement and maintain pollution prevention measures to:

- Minimize the discharge of pollutants from equipment and vehicle washing, wheel wash water, and other wash waters;
- Minimize the exposure of building materials, building products, construction wastes,

PROJECT NAME: _____ SUBMITTAL#: _____

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trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on-site to precipitation and to stormwater;

- Minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures;
- Prohibit the discharge of wastewater from the washout of concrete;
- Prohibit the discharge of wastewater from the washout and cleanout of stucco, paint, form release oils, curing compounds, and other construction materials; and
- Prohibit the discharge of fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance."

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APPENDIX C

Federal Energy Regulatory Commission Upland Erosion Revegetation and Maintenance Plan (Plan)

Federal Energy Regulatory Commission

Office of
Energy Projects

May 2013

UPLAND EROSION CONTROL, REVEGETATION, AND MAINTENANCE PLAN

Washington, DC 20426

MAY 2013 VERSION

UPLAND EROSION CONTROL, REVEGETATION, AND MAINTENANCE PLAN

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UPLAND EROSION CONTROL, REVEGETATION, AND MAINTENANCE PLAN (PLAN)

I. APPLICABILITY

A. The intent of this Plan is to assist project sponsors by identifying baseline mitigation measures for minimizing erosion and enhancing revegetation. Project sponsors shall specify in their applications for a new FERC authorization and in prior notice and advance notice filings, any individual measures in this Plan they consider unnecessary, technically infeasible, or unsuitable due to local conditions and fully describe any alternative measures they would use. Project sponsors shall also explain how those alternative measures would achieve a comparable level of mitigation.

Once a project is authorized, project sponsors can request further changes as variances to the measures in this Plan (or the applicant's approved plan). The Director of the Office of Energy Projects (Director) will consider approval of variances upon the project sponsor's written request, if the Director agrees that a variance:

1. provides equal or better environmental protection;

2. is necessary because a portion of this Plan is infeasible or unworkable based on project-specific conditions; or

3. is specifically required in writing by another federal, state, or Native American land management agency for the portion of the project on its land or under its jurisdiction.

Sponsors of projects planned for construction under the automatic authorization provisions in the FERC's regulations must receive written approval for any variances in advance of construction.

Project-related impacts on wetland and waterbody systems are addressed in the staff's Wetland and Waterbody Construction and Mitigation Procedures (Procedures).

II. SUPERVISION AND INSPECTION

A. ENVIRONMENTAL INSPECTION

1. At least one Environmental Inspector is required for each construction spread during construction and restoration (as defined by section V). The number and experience of Environmental Inspectors assigned to each construction spread shall be appropriate for the length of the construction spread and the number/significance of resources affected.

2. Environmental Inspectors shall have peer status with all other activity inspectors.

3. Environmental Inspectors shall have the authority to stop activities that violate the environmental conditions of the FERC's Orders, stipulations of other environmental permits or approvals, or landowner easement agreements; and to order appropriate corrective action.

B. RESPONSIBILITIES OF ENVIRONMENTAL INSPECTORS

At a minimum, the Environmental Inspector(s) shall be responsible for:

1. Inspecting construction activities for compliance with the requirements of this Plan, the Procedures, the environmental conditions of the FERC's Orders, the mitigation measures proposed by the project sponsor (as approved and/or modified by the Order), other environmental permits and approvals, and environmental requirements in landowner easement agreements.

2. Identifying, documenting, and overseeing corrective actions, as necessary to bring an activity back into compliance;

3. Verifying that the limits of authorized construction work areas and locations of access roads are visibly marked before clearing, and maintained throughout construction;

4. Verifying the location of signs and highly visible flagging marking the boundaries of sensitive resource areas, waterbodies, wetlands, or areas with special requirements along the construction work area;

5. Identifying erosion/sediment control and soil stabilization needs in all areas;

6. Ensuring that the design of slope breakers will not cause erosion or direct water into sensitive environmental resource areas, including cultural resource sites, wetlands, waterbodies, and sensitive species habitats;

7. Verifying that dewatering activities are properly monitored and do not result in the deposition of sand, silt, and/or sediment into sensitive environmental resource areas, including wetlands, waterbodies, cultural resource sites, and sensitive species habitats; stopping dewatering activities if such deposition is occurring and ensuring the design of the discharge is changed to prevent reoccurrence; and verifying that dewatering structures are removed after completion of dewatering activities;

8. Ensuring that subsoil and topsoil are tested in agricultural and residential areas to measure compaction and determine the need for corrective action;

9. Advising the Chief Construction Inspector when environmental conditions (such as wet weather or frozen soils) make it advisable to restrict or delay construction activities to avoid topsoil mixing or excessive compaction;

10. Ensuring restoration of contours and topsoil;

11. Verifying that the soils imported for agricultural or residential use are certified as free of noxious weeds and soil pests, unless otherwise approved by the landowner;

12. Ensuring that erosion control devices are properly installed to prevent sediment flow into sensitive environmental resource areas (e.g., wetlands, waterbodies, cultural resource sites, and sensitive species habitats) and onto roads, and determining the need for additional erosion control devices;

13. Inspecting and ensuring the maintenance of temporary erosion control measures at least:

    a. on a daily basis in areas of active construction or equipment operation;

    b. on a weekly basis in areas with no construction or equipment operation; and

    c. within 24 hours of each 0.5 inch of rainfall;

14. Ensuring the repair of all ineffective temporary erosion control measures within 24 hours of identification, or as soon as conditions allow if compliance with this time frame would result in greater environmental impacts;

15. Keeping records of compliance with the environmental conditions of the FERC's Orders, and the mitigation measures proposed by the project sponsor in the application submitted to the FERC, and other federal or state environmental permits during active construction and restoration;

16. Identifying areas that should be given special attention to ensure stabilization and restoration after the construction phase; and

17. Verifying that locations for any disposal of excess construction materials for beneficial reuse comply with section III.E.

III. PRECONSTRUCTION PLANNING

The project sponsor shall do the following before construction:

A. CONSTRUCTION WORK AREAS

1. Identify all construction work areas (e.g., construction right-of-way, extra work space areas, pipe storage and contractor yards, borrow and disposal areas, access roads) that would be needed for safe construction. The project sponsor must ensure that appropriate cultural resources and biological surveys are conducted, as determined necessary by the appropriate federal and state agencies.

2. Project sponsors are encouraged to consider expanding any required cultural resources and endangered species surveys in anticipation of the need for activities outside of authorized work areas.

3. Plan construction sequencing to limit the amount and duration of open trench sections, as necessary, to prevent excessive erosion or sediment flow into sensitive environmental resource areas.

B. DRAIN TILE AND IRRIGATION SYSTEMS

1. Attempt to locate existing drain tiles and irrigation systems.

2. Contact landowners and local soil conservation authorities to determine the locations of future drain tiles that are likely to be installed within 3 years of the authorized construction.

3. Develop procedures for constructing through drain-tiled areas, maintaining irrigation systems during construction, and repairing drain tiles and irrigation systems after construction.

4. Engage qualified drain tile specialists, as needed to conduct or monitor repairs to drain tile systems affected by construction. Use drain tile specialists from the project area, if available.

C. GRAZING DEFERMENT

Develop grazing deferment plans with willing landowners, grazing permittees, and land management agencies to minimize grazing disturbance of revegetation efforts.

D. ROAD CROSSINGS AND ACCESS POINTS

Plan for safe and accessible conditions at all roadway crossings and access points during construction and restoration.

E. DISPOSAL PLANNING

Determine methods and locations for the regular collection, containment, and disposal of excess construction materials and debris (e.g., timber, slash, mats, garbage, drill cuttings and fluids, excess rock) throughout the construction process. Disposal of materials for beneficial reuse must not result in adverse environmental impact and is subject to compliance with all applicable survey, landowner or land management agency approval, and permit requirements.

F. AGENCY COORDINATION

The project sponsor must coordinate with the appropriate local, state, and federal agencies as outlined in this Plan and/or required by the FERC's Orders.

1. Obtain written recommendations from the local soil conservation authorities or land management agencies regarding permanent erosion control and revegetation specifications.

2. Develop specific procedures in coordination with the appropriate agencies to prevent the introduction or spread of invasive species, noxious weeds, and soil pests resulting from construction and restoration activities.

3. Develop specific procedures in coordination with the appropriate agencies and landowners, as necessary, to allow for livestock and wildlife movement and protection during construction.

4. Develop specific blasting procedures in coordination with the appropriate agencies that address pre- and post-blast inspections; advanced public notification; and mitigation measures for building foundations, groundwater wells, and springs. Use appropriate methods (e.g., blasting mats) to prevent damage to nearby structures and to prevent debris from entering sensitive environmental resource areas.

G. SPILL PREVENTION AND RESPONSE PROCEDURES

The project sponsor shall develop project-specific Spill Prevention and Response Procedures, as specified in section IV of the staff's Procedures. A copy must be filed with the Secretary of the FERC (Secretary) prior to construction and made available in the field on each construction spread. The filing requirement does not apply to projects constructed under the automatic authorization provisions in the FERC's regulations.

H. RESIDENTIAL CONSTRUCTION

For all properties with residences located within 50 feet of construction work areas, project sponsors shall: avoid removal of mature trees and landscaping within the construction work area unless necessary for safe operation of construction equipment, or as specified in landowner agreements; fence the edge of the construction work area for a distance of 100 feet on either side of the residence; and restore all lawn areas and landscaping immediately following clean up operations, or as specified in landowner agreements. If seasonal or other weather conditions prevent compliance with these time frames, maintain and monitor temporary erosion controls (sediment barriers and mulch) until conditions allow completion of restoration.

I. WINTER CONSTRUCTION PLANS

If construction is planned to occur during winter weather conditions, project sponsors shall develop and file a project-specific winter construction plan with the FERC application. This filing requirement does not apply to projects constructed under the automatic authorization provisions of the FERC's regulations.

The plan shall address:

1. winter construction procedures (e.g., snow handling and removal, access road construction and maintenance, soil handling under saturated or frozen conditions, topsoil stripping);

2. stabilization and monitoring procedures if ground conditions will delay restoration until the following spring (e.g., mulching and erosion controls, inspection and reporting, stormwater control during spring thaw conditions); and

3. final restoration procedures (e.g., subsidence and compaction repair, topsoil replacement, seeding).

IV. INSTALLATION

A. APPROVED AREAS OF DISTURBANCE

1. Project-related ground disturbance shall be limited to the construction right-of-way, extra work space areas, pipe storage yards, borrow and disposal areas, access roads, and other areas approved in the FERC's Orders. Any project-related ground disturbing activities outside these areas will require prior Director approval. This requirement does not apply to activities needed to comply with the Plan and Procedures (i.e., slope breakers, energy-dissipating devices, dewatering structures, drain tile system repairs) or minor field realignments and workspace shifts per landowner needs and requirements that do not affect other landowners or sensitive environmental resource areas. All construction or restoration activities outside of authorized areas are subject to all applicable survey and permit requirements, and landowner easement agreements.

2. The construction right-of-way width for a project shall not exceed 75 feet or that described in the FERC application unless otherwise modified by a FERC Order. However, in limited, non-wetland areas, this construction right-of-way width may be expanded by up to 25 feet without Director approval to accommodate full construction right-of-way topsoil segregation and to ensure safe construction where topographic conditions (e.g., side-slopes) or soil limitations require it. Twenty-five feet of extra construction right-of-way width may also be used in limited, non-wetland or non-forested areas for truck turn-arounds where no reasonable alternative access exists.

   Project use of these additional limited areas is subject to landowner or land management agency approval and compliance with all applicable survey and permit requirements. When additional areas are used, each one shall be identified and the need explained in the weekly or biweekly construction reports to the FERC, if required. The following material shall be included in the reports:

   a. the location of each additional area by station number and reference to previously filed alignment sheets, or updated alignment sheets showing the additional areas;

   b. identification of the filing at FERC containing evidence that the additional areas were previously surveyed; and

c. a statement that landowner approval has been obtained and is available in project files.

Prior written approval of the Director is required when the authorized construction right-of-way width would be expanded by more than 25 feet.

B. TOPSOIL SEGREGATION

1. Unless the landowner or land management agency specifically approves otherwise, prevent the mixing of topsoil with subsoil by stripping topsoil from either the full work area or from the trench and subsoil storage area (ditch plus spoil side method) in:

   a. cultivated or rotated croplands, and managed pastures;

   b. residential areas;

   c. hayfields; and

   d. other areas at the landowner's or land managing agency's request.

2. In residential areas, importation of topsoil is an acceptable alternative to topsoil segregation.

3. Where topsoil segregation is required, the project sponsor must:

   a. segregate at least 12 inches of topsoil in deep soils (more than 12 inches of topsoil); and

   b. make every effort to segregate the entire topsoil layer in soils with less than 12 inches of topsoil.

4. Maintain separation of salvaged topsoil and subsoil throughout all construction activities.

5. Segregated topsoil may not be used for padding the pipe, constructing temporary slope breakers or trench plugs, improving or maintaining roads, or as a fill material.

6. Stabilize topsoil piles and minimize loss due to wind and water erosion with use of sediment barriers, mulch, temporary seeding, tackifiers, or functional equivalents, where necessary.

C. DRAIN TILES

1. Mark locations of drain tiles damaged during construction.

2. Probe all drainage tile systems within the area of disturbance to check for damage.

3. Repair damaged drain tiles to their original or better condition. Do not use filter-covered drain tiles unless the local soil conservation authorities and the landowner agree. Use qualified specialists for testing and repairs.

4. For new pipelines in areas where drain tiles exist or are planned, ensure that the depth of cover over the pipeline is sufficient to avoid interference with drain tile systems. For adjacent pipeline loops in agricultural areas, install the new pipeline with at least the same depth of cover as the existing pipeline(s).

D. IRRIGATION

Maintain water flow in crop irrigation systems, unless shutoff is coordinated with affected parties.

E. ROAD CROSSINGS AND ACCESS POINTS

1. Maintain safe and accessible conditions at all road crossings and access points during construction.

2. If crushed stone access pads are used in residential or agricultural areas, place the stone on synthetic fabric to facilitate removal.

3. Minimize the use of tracked equipment on public roadways. Remove any soil or gravel spilled or tracked onto roadways daily or more frequent as necessary to maintain safe road conditions. Repair any damages to roadway surfaces, shoulders, and bar ditches.

F. TEMPORARY EROSION CONTROL

Install temporary erosion controls immediately after initial disturbance of the soil. Temporary erosion controls must be properly maintained throughout construction (on a daily basis) and reinstalled as necessary (such as after backfilling of the trench) until replaced by permanent erosion controls or restoration is complete.

1. Temporary Slope Breakers

a. Temporary slope breakers are intended to reduce runoff velocity and divert water off the construction right-of-way. Temporary slope

breakers may be constructed of materials such as soil, silt fence, staked hay or straw bales, or sand bags.

b. Install temporary slope breakers on all disturbed areas, as necessary to avoid excessive erosion. Temporary slope breakers must be installed on slopes greater than 5 percent where the base of the slope is less than 50 feet from waterbody, wetland, and road crossings at the following spacing (closer spacing shall be used if necessary):

Slope (%)	Spacing (feet)
5 - 15	300
>15 - 30	200
>30	100

c. Direct the outfall of each temporary slope breaker to a stable, well vegetated area or construct an energy-dissipating device at the end of the slope breaker and off the construction right-of-way.

d. Position the outfall of each temporary slope breaker to prevent sediment discharge into wetlands, waterbodies, or other sensitive environmental resource areas.

2. Temporary Trench Plugs

Temporary trench plugs are intended to segment a continuous open trench prior to backfill.

a. Temporary trench plugs may consist of unexcavated portions of the trench, compacted subsoil, sandbags, or some functional equivalent.

b. Position temporary trench plugs, as necessary, to reduce trenchline erosion and minimize the volume and velocity of trench water flow at the base of slopes.

3. Sediment Barriers

Sediment barriers are intended to stop the flow of sediments and to prevent the deposition of sediments beyond approved workspaces or into sensitive resources.

a. Sediment barriers may be constructed of materials such as silt fence, staked hay or straw bales, compacted earth (e.g., driveable berms across travelways), sand bags, or other appropriate materials.

b. At a minimum, install and maintain temporary sediment barriers across the entire construction right-of-way at the base of slopes greater than 5 percent where the base of the slope is less than 50 feet from a waterbody, wetland, or road crossing until revegetation is successful as defined in this Plan. Leave adequate room between the base of the slope and the sediment barrier to accommodate ponding of water and sediment deposition.

c. Where wetlands or waterbodies are adjacent to and downslope of construction work areas, install sediment barriers along the edge of these areas, as necessary to prevent sediment flow into the wetland or waterbody.

4. Mulch

a. Apply mulch on all slopes (except in cultivated cropland) concurrent with or immediately after seeding, where necessary to stabilize the soil surface and to reduce wind and water erosion. Spread mulch uniformly over the area to cover at least 75 percent of the ground surface at a rate of 2 tons/acre of straw or its equivalent, unless the local soil conservation authority, landowner, or land managing agency approves otherwise in writing.

b. Mulch can consist of weed-free straw or hay, wood fiber hydromulch, erosion control fabric, or some functional equivalent.

c. Mulch all disturbed upland areas (except cultivated cropland) <u>before</u> seeding if:

(1) final grading and installation of permanent erosion control measures will not be completed in an area within 20 days after the trench in that area is backfilled (10 days in residential areas), as required in section V.A.1; or

(2) construction or restoration activity is interrupted for extended periods, such as when seeding cannot be completed due to seeding period restrictions.

d. If mulching <u>before</u> seeding, increase mulch application on all slopes within 100 feet of waterbodies and wetlands to a rate of 3 tons/acre of straw or equivalent.

e. If wood chips are used as mulch, do not use more than 1 ton/acre and add the equivalent of 11 lbs/acre available nitrogen (at least 50 percent of which is slow release).

f. Ensure that mulch is adequately anchored to minimize loss due to wind and water.

g. When anchoring with liquid mulch binders, use rates recommended by the manufacturer. Do not use liquid mulch binders within 100 feet of wetlands or waterbodies, except where the product is certified environmentally non-toxic by the appropriate state or federal agency or independent standards-setting organization.

h. Do not use synthetic monofilament mesh/netted erosion control materials in areas designated as sensitive wildlife habitat, unless the product is specifically designed to minimize harm to wildlife. Anchor erosion control fabric with staples or other appropriate devices.

V. RESTORATION

A. CLEANUP

1. Commence cleanup operations immediately following backfill operations. Complete final grading, topsoil replacement, and installation of permanent erosion control structures within 20 days after backfilling the trench (10 days in residential areas). If seasonal or other weather conditions prevent compliance with these time frames, maintain temporary erosion controls (i.e., temporary slope breakers, sediment barriers, and mulch) until conditions allow completion of cleanup.

   If construction or restoration unexpectedly continues into the winter season when conditions could delay successful decompaction, topsoil replacement, or seeding until the following spring, file with the Secretary for the review and written approval of the Director, a winter construction plan (as specified in section III.I). This filing requirement does not apply to projects constructed under the automatic authorization provisions of the FERC's regulations.

2. A travel lane may be left open temporarily to allow access by construction traffic if the temporary erosion control structures are installed as specified in section IV.F. and inspected and maintained as specified in sections II.B.12 through 14. When access is no longer required the travel lane must be removed and the right-of-way restored.

3. Rock excavated from the trench may be used to backfill the trench only to the top of the existing bedrock profile. Rock that is not returned to the trench shall be considered construction debris, unless approved for use as mulch or for some other use on the construction work areas by the landowner or land managing agency.

4. Remove excess rock from at least the top 12 inches of soil in all cultivated or rotated cropland, managed pastures, hayfields, and residential areas, as well as other areas at the landowner's request. The size, density, and distribution of rock on the construction work area shall be similar to adjacent areas not disturbed by construction. The landowner or land management agency may approve other provisions in writing.

5. Grade the construction right-of-way to restore pre-construction contours and leave the soil in the proper condition for planting.

6. Remove construction debris from all construction work areas unless the landowner or land managing agency approves leaving materials onsite for beneficial reuse, stabilization, or habitat restoration.

7. Remove temporary sediment barriers when replaced by permanent erosion control measures or when revegetation is successful.

B. PERMANENT EROSION CONTROL DEVICES

1. Trench Breakers

a. Trench breakers are intended to slow the flow of subsurface water along the trench. Trench breakers may be constructed of materials such as sand bags or polyurethane foam. Do not use topsoil in trench breakers.

b. An engineer or similarly qualified professional shall determine the need for and spacing of trench breakers. Otherwise, trench breakers shall be installed at the same spacing as and upslope of permanent slope breakers.

c. In agricultural fields and residential areas where slope breakers are not typically required, install trench breakers at the same spacing as if permanent slope breakers were required.

d. At a minimum, install a trench breaker at the base of slopes greater than 5 percent where the base of the slope is less than 50 feet from a waterbody or wetland and where needed to avoid draining a waterbody or wetland. Install trench breakers at wetland boundaries, as specified in the Procedures. Do not install trench breakers within a wetland.

2. Permanent Slope Breakers

a. Permanent slope breakers are intended to reduce runoff velocity, divert water off the construction right-of-way, and prevent sediment deposition into sensitive resources. Permanent slope breakers may be constructed of materials such as soil, stone, or some functional equivalent.

b. Construct and maintain permanent slope breakers in all areas, except cultivated areas and lawns, unless requested by the landowner, using spacing recommendations obtained from the local soil conservation authority or land managing agency.

In the absence of written recommendations, use the following spacing unless closer spacing is necessary to avoid excessive erosion on the construction right-of-way:

Slope (%)	Spacing (feet)
5 - 15	300
>15 - 30	200
>30	100

c. Construct slope breakers to divert surface flow to a stable area without causing water to pool or erode behind the breaker. In the absence of a stable area, construct appropriate energy-dissipating devices at the end of the breaker.

d. Slope breakers may extend slightly (about 4 feet) beyond the edge of the construction right-of-way to effectively drain water off the disturbed area. Where slope breakers extend beyond the edge of the construction right-of-way, they are subject to compliance with all applicable survey requirements.

C. SOIL COMPACTION MITIGATION

1. Test topsoil and subsoil for compaction at regular intervals in agricultural and residential areas disturbed by construction activities. Conduct tests on the same soil type under similar moisture conditions in undisturbed areas to approximate preconstruction conditions. Use penetrometers or other appropriate devices to conduct tests.

2. Plow severely compacted agricultural areas with a paraplow or other deep tillage implement. In areas where topsoil has been segregated, plow the subsoil before replacing the segregated topsoil.

If subsequent construction and cleanup activities result in further compaction, conduct additional tilling.

3. Perform appropriate soil compaction mitigation in severely compacted residential areas.

D. REVEGETATION

1. General

a. The project sponsor is responsible for ensuring successful revegetation of soils disturbed by project-related activities, except as noted in section V.D.1.b.

b. Restore all turf, ornamental shrubs, and specialized landscaping in accordance with the landowner's request, or compensate the landowner. Restoration work must be performed by personnel familiar with local horticultural and turf establishment practices.

2. Soil Additives

Fertilize and add soil pH modifiers in accordance with written recommendations obtained from the local soil conservation authority, land management agencies, or landowner. Incorporate recommended soil pH modifier and fertilizer into the top 2 inches of soil as soon as practicable after application.

3. Seeding Requirements

a. Prepare a seedbed in disturbed areas to a depth of 3 to 4 inches using appropriate equipment to provide a firm seedbed. When hydroseeding, scarify the seedbed to facilitate lodging and germination of seed.

b. Seed disturbed areas in accordance with written recommendations for seed mixes, rates, and dates obtained from the local soil conservation authority or the request of the landowner or land management agency. Seeding is not required in cultivated croplands unless requested by the landowner.

c. Perform seeding of permanent vegetation within the recommended seeding dates. If seeding cannot be done within those dates, use appropriate temporary erosion control measures discussed in section IV.F and perform seeding of permanent vegetation at the beginning of the next recommended seeding season. Dormant seeding or temporary

seeding of annual species may also be used, if necessary, to establish cover, as approved by the Environmental Inspector. Lawns may be seeded on a schedule established with the landowner.

d. In the absence of written recommendations from the local soil conservation authorities, seed all disturbed soils within 6 working days of final grading, weather and soil conditions permitting, subject to the specifications in section V.D.3.a through V.D.3.c.

e. Base seeding rates on Pure Live Seed. Use seed within 12 months of seed testing.

f. Treat legume seed with an inoculant specific to the species using the manufacturer's recommended rate of inoculant appropriate for the seeding method (broadcast, drill, or hydro).

g. In the absence of written recommendations from the local soil conservation authorities, landowner, or land managing agency to the contrary, a seed drill equipped with a cultipacker is preferred for seed application.

Broadcast or hydroseeding can be used in lieu of drilling at double the recommended seeding rates. Where seed is broadcast, firm the seedbed with a cultipacker or roller after seeding. In rocky soils or where site conditions may limit the effectiveness of this equipment, other alternatives may be appropriate (e.g., use of a chain drag) to lightly cover seed after application, as approved by the Environmental Inspector.

VI. OFF-ROAD VEHICLE CONTROL

To each owner or manager of forested lands, offer to install and maintain measures to control unauthorized vehicle access to the right-of-way. These measures may include:

A. signs;

B. fences with locking gates;

C. slash and timber barriers, pipe barriers, or a line of boulders across the right-of-way; and

D. conifers or other appropriate trees or shrubs across the right-of-way.

VII. POST-CONSTRUCTION ACTIVITIES AND REPORTING

A. MONITORING AND MAINTENANCE

1. Conduct follow-up inspections of all disturbed areas, as necessary, to determine the success of revegetation and address landowner concerns. At a minimum, conduct inspections after the first and second growing seasons.

2. Revegetation in non-agricultural areas shall be considered successful if upon visual survey the density and cover of non-nuisance vegetation are similar in density and cover to adjacent undisturbed lands. In agricultural areas, revegetation shall be considered successful when upon visual survey, crop growth and vigor are similar to adjacent undisturbed portions of the same field, unless the easement agreement specifies otherwise.

   Continue revegetation efforts until revegetation is successful.

3. Monitor and correct problems with drainage and irrigation systems resulting from pipeline construction in agricultural areas until restoration is successful.

4. Restoration shall be considered successful if the right-of-way surface condition is similar to adjacent undisturbed lands, construction debris is removed (unless otherwise approved by the landowner or land managing agency per section V.A.6), revegetation is successful, and proper drainage has been restored.

5. Routine vegetation mowing or clearing over the full width of the permanent right-of-way in uplands shall not be done more frequently than every 3 years. However, to facilitate periodic corrosion/leak surveys, a corridor not exceeding 10 feet in width centered on the pipeline may be cleared at a frequency necessary to maintain the 10-foot corridor in an herbaceous state. In no case shall routine vegetation mowing or clearing occur during the migratory bird nesting season between April 15 and August 1 of any year unless specifically approved in writing by the responsible land management agency or the U.S. Fish and Wildlife Service.

6. Efforts to control unauthorized off-road vehicle use, in cooperation with the landowner, shall continue throughout the life of the project. Maintain signs, gates, and permanent access roads as necessary.

B. REPORTING

1. The project sponsor shall maintain records that identify by milepost:

   a. method of application, application rate, and type of fertilizer, pH modifying agent, seed, and mulch used;

   b. acreage treated;

   c. dates of backfilling and seeding;

   d. names of landowners requesting special seeding treatment and a description of the follow-up actions;

   e. the location of any subsurface drainage repairs or improvements made during restoration; and

   f. any problem areas and how they were addressed.

2. The project sponsor shall file with the Secretary quarterly activity reports documenting the results of follow-up inspections required by section VII.A.1; any problem areas, including those identified by the landowner; and corrective actions taken for at least 2 years following construction.

   The requirement to file quarterly activity reports with the Secretary does not apply to projects constructed under the automatic authorization, prior notice, or advanced notice provisions in the FERC's regulations.

APPENDIX D

Federal Energy Regulatory Commission Wetland and Waterbody Construction and Mitigation Procedures (Procedures)

Federal Energy Regulatory Commission

Office of Energy Projects

May 2013

WETLAND AND WATERBODY CONSTRUCTION AND MITIGATION PROCEDURES

Washington, DC 20426

MAY 2013 VERSION

WETLAND AND WATERBODY CONSTRUCTION AND MITIGATION PROCEDURES

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WETLAND AND WATERBODY
CONSTRUCTION AND MITIGATION PROCEDURES (PROCEDURES)

I. APPLICABILITY

A. The intent of these Procedures is to assist project sponsors by identifying baseline mitigation measures for minimizing the extent and duration of project-related disturbance on wetlands and waterbodies. Project sponsors shall specify in their applications for a new FERC authorization, and in prior notice and advance notice filings, any individual measures in these Procedures they consider unnecessary, technically infeasible, or unsuitable due to local conditions and fully describe any alternative measures they would use. Project sponsors shall also explain how those alternative measures would achieve a comparable level of mitigation.

Once a project is authorized, project sponsors can request further changes as variances to the measures in these Procedures (or the applicant's approved procedures). The Director of the Office of Energy Projects (Director) will consider approval of variances upon the project sponsor's written request, if the Director agrees that a variance:

1. provides equal or better environmental protection;

2. is necessary because a portion of these Procedures is infeasible or unworkable based on project-specific conditions; or

3. is specifically required in writing by another federal, state, or Native American land management agency for the portion of the project on its land or under its jurisdiction.

Sponsors of projects planned for construction under the automatic authorization provisions in the FERC's regulations must receive written approval for any variances in advance of construction.

Project-related impacts on non-wetland areas are addressed in the staff's Upland Erosion Control, Revegetation, and Maintenance Plan (Plan).

B. DEFINITIONS

1. "Waterbody" includes any natural or artificial stream, river, or drainage with perceptible flow at the time of crossing, and other permanent waterbodies such as ponds and lakes:

   a. "minor waterbody" includes all waterbodies less than or equal to 10 feet wide at the water's edge at the time of crossing;

   b. "intermediate waterbody" includes all waterbodies greater than 10 feet wide but less than or equal to 100 feet wide at the water's edge at the time of crossing; and

   c. "major waterbody" includes all waterbodies greater than 100 feet wide at the water's edge at the time of crossing.

2. "Wetland" includes any area that is not in actively cultivated or rotated cropland and that satisfies the requirements of the current federal methodology for identifying and delineating wetlands.

II. PRECONSTRUCTION FILING

A. The following information must be filed with the Secretary of the FERC (Secretary) prior to the beginning of construction, for the review and written approval by the Director:

1. site-specific justifications for extra work areas that would be closer than 50 feet from a waterbody or wetland; and

2. site-specific justifications for the use of a construction right-of-way greater than 75-feet-wide in wetlands.

B. The following information must be filed with the Secretary prior to the beginning of construction. These filing requirements do not apply to projects constructed under the automatic authorization provisions in the FERC's regulations:

1. Spill Prevention and Response Procedures specified in section IV.A;

2. a schedule identifying when trenching or blasting will occur within each waterbody greater than 10 feet wide, within any designated coldwater fishery, and within any waterbody identified as habitat for federally-listed threatened or endangered species. The project sponsor will revise the schedule as necessary to provide FERC staff at least 14 days advance notice. Changes within this last 14-day period must provide for at least 48 hours advance notice;

3. plans for horizontal directional drills (HDD) under wetlands or waterbodies, specified in section V.B.6.d;

4. site-specific plans for major waterbody crossings, described in section V.B.9;

5. a wetland delineation report as described in section VI.A.1, if applicable; and

6. the hydrostatic testing information specified in section VII.B.3.

III. ENVIRONMENTAL INSPECTORS

A. At least one Environmental Inspector having knowledge of the wetland and waterbody conditions in the project area is required for each construction spread. The number and experience of Environmental Inspectors assigned to each construction spread shall be appropriate for the length of the construction spread and the number/significance of resources affected.

B. The Environmental Inspector's responsibilities are outlined in the Upland Erosion Control, Revegetation, and Maintenance Plan (Plan).

IV. PRECONSTRUCTION PLANNING

A. The project sponsor shall develop project-specific Spill Prevention and Response Procedures that meet applicable requirements of state and federal agencies. A copy must be filed with the Secretary prior to construction and made available in the field on each construction spread. This filing requirement does not apply to projects constructed under the automatic authorization provisions in the FERC's regulations.

1. It shall be the responsibility of the project sponsor and its contractors to structure their operations in a manner that reduces the risk of spills or the accidental exposure of fuels or hazardous materials to waterbodies or wetlands. The project sponsor and its contractors must, at a minimum, ensure that:

a. all employees handling fuels and other hazardous materials are properly trained;

b. all equipment is in good operating order and inspected on a regular basis;

c. fuel trucks transporting fuel to on-site equipment travel only on approved access roads;

d. all equipment is parked overnight and/or fueled at least 100 feet from a waterbody or in an upland area at least 100 feet from a wetland boundary. These activities can occur closer only if the Environmental Inspector determines that there is no reasonable alternative, and the

project sponsor and its contractors have taken appropriate steps (including secondary containment structures) to prevent spills and provide for prompt cleanup in the event of a spill;

e. hazardous materials, including chemicals, fuels, and lubricating oils, are not stored within 100 feet of a wetland, waterbody, or designated municipal watershed area, unless the location is designated for such use by an appropriate governmental authority. This applies to storage of these materials and does not apply to normal operation or use of equipment in these areas;

f. concrete coating activities are not performed within 100 feet of a wetland or waterbody boundary, unless the location is an existing industrial site designated for such use. These activities can occur closer only if the Environmental Inspector determines that there is no reasonable alternative, and the project sponsor and its contractors have taken appropriate steps (including secondary containment structures) to prevent spills and provide for prompt cleanup in the event of a spill;

g. pumps operating within 100 feet of a waterbody or wetland boundary utilize appropriate secondary containment systems to prevent spills; and

h. bulk storage of hazardous materials, including chemicals, fuels, and lubricating oils have appropriate secondary containment systems to prevent spills.

2. The project sponsor and its contractors must structure their operations in a manner that provides for the prompt and effective cleanup of spills of fuel and other hazardous materials. At a minimum, the project sponsor and its contractors must:

a. ensure that each construction crew (including cleanup crews) has on hand sufficient supplies of absorbent and barrier materials to allow the rapid containment and recovery of spilled materials and knows the procedure for reporting spills and unanticipated discoveries of contamination;

b. ensure that each construction crew has on hand sufficient tools and material to stop leaks;

c. know the contact names and telephone numbers for all local, state, and federal agencies (including, if necessary, the U. S. Coast Guard and the National Response Center) that must be notified of a spill; and

d. follow the requirements of those agencies in cleaning up the spill, in excavating and disposing of soils or other materials contaminated by a spill, and in collecting and disposing of waste generated during spill cleanup.

B. AGENCY COORDINATION

The project sponsor must coordinate with the appropriate local, state, and federal agencies as outlined in these Procedures and in the FERC's Orders.

V. WATERBODY CROSSINGS

A. NOTIFICATION PROCEDURES AND PERMITS

1. Apply to the U.S. Army Corps of Engineers (COE), or its delegated agency, for the appropriate wetland and waterbody crossing permits.

2. Provide written notification to authorities responsible for potable surface water supply intakes located within 3 miles downstream of the crossing at least 1 week before beginning work in the waterbody, or as otherwise specified by that authority.

3. Apply for state-issued waterbody crossing permits and obtain individual or generic section 401 water quality certification or waiver.

4. Notify appropriate federal and state authorities at least 48 hours before beginning trenching or blasting within the waterbody, or as specified in applicable permits.

B. INSTALLATION

1. Time Window for Construction

Unless expressly permitted or further restricted by the appropriate federal or state agency in writing on a site-specific basis, instream work, except that required to install or remove equipment bridges, must occur during the following time windows:

a. coldwater fisheries - June 1 through September 30; and

b. coolwater and warmwater fisheries - June 1 through November 30.

2. Extra Work Areas

a. Locate all extra work areas (such as staging areas and additional spoil storage areas) at least 50 feet away from water's edge, except where

the adjacent upland consists of cultivated or rotated cropland or other disturbed land.

b. The project sponsor shall file with the Secretary for review and written approval by the Director, site-specific justification for each extra work area with a less than 50-foot setback from the water's edge, except where the adjacent upland consists of cultivated or rotated cropland or other disturbed land. The justification must specify the conditions that will not permit a 50-foot setback and measures to ensure the waterbody is adequately protected.

c. Limit the size of extra work areas to the minimum needed to construct the waterbody crossing.

3. General Crossing Procedures

a. Comply with the COE, or its delegated agency, permit terms and conditions.

b. Construct crossings as close to perpendicular to the axis of the waterbody channel as engineering and routing conditions permit.

c. Where pipelines parallel a waterbody, maintain at least 15 feet of undisturbed vegetation between the waterbody (and any adjacent wetland) and the construction right-of-way, except where maintaining this offset will result in greater environmental impact.

d. Where waterbodies meander or have multiple channels, route the pipeline to minimize the number of waterbody crossings.

e. Maintain adequate waterbody flow rates to protect aquatic life, and prevent the interruption of existing downstream uses.

f. Waterbody buffers (e.g., extra work area setbacks, refueling restrictions) must be clearly marked in the field with signs and/or highly visible flagging until construction-related ground disturbing activities are complete.

g. Crossing of waterbodies when they are dry or frozen and not flowing may proceed using standard upland construction techniques in accordance with the Plan, provided that the Environmental Inspector verifies that water is unlikely to flow between initial disturbance and final stabilization of the feature. In the event of perceptible flow, the project sponsor must comply with all applicable Procedure requirements for "waterbodies" as defined in section I.B.1.

4. Spoil Pile Placement and Control

a. All spoil from minor and intermediate waterbody crossings, and upland spoil from major waterbody crossings, must be placed in the construction right-of-way at least 10 feet from the water's edge or in additional extra work areas as described in section V.B.2.

b. Use sediment barriers to prevent the flow of spoil or silt-laden water into any waterbody.

5. Equipment Bridges

a. Only clearing equipment and equipment necessary for installation of equipment bridges may cross waterbodies prior to bridge installation. Limit the number of such crossings of each waterbody to one per piece of clearing equipment.

b. Construct and maintain equipment bridges to allow unrestricted flow and to prevent soil from entering the waterbody. Examples of such bridges include:

(1) equipment pads and culvert(s);
(2) equipment pads or railroad car bridges without culverts;
(3) clean rock fill and culvert(s); and
(4) flexi-float or portable bridges.

Additional options for equipment bridges may be utilized that achieve the performance objectives noted above. Do not use soil to construct or stabilize equipment bridges.

c. Design and maintain each equipment bridge to withstand and pass the highest flow expected to occur while the bridge is in place. Align culverts to prevent bank erosion or streambed scour. If necessary, install energy dissipating devices downstream of the culverts.

d. Design and maintain equipment bridges to prevent soil from entering the waterbody.

e. Remove temporary equipment bridges as soon as practicable after permanent seeding.

f. If there will be more than 1 month between final cleanup and the beginning of permanent seeding and reasonable alternative access to the right-of-way is available, remove temporary equipment bridges as soon as practicable after final cleanup.

g. Obtain any necessary approval from the COE, or the appropriate state agency for permanent bridges.

6. Dry-Ditch Crossing Methods

a. Unless approved otherwise by the appropriate federal or state agency, install the pipeline using one of the dry-ditch methods outlined below for crossings of waterbodies up to 30 feet wide (at the water's edge at the time of construction) that are state-designated as either coldwater or significant coolwater or warmwater fisheries, or federally-designated as critical habitat.

b. Dam and Pump

(1) The dam-and-pump method may be used without prior approval for crossings of waterbodies where pumps can adequately transfer streamflow volumes around the work area, and there are no concerns about sensitive species passage.

(2) Implementation of the dam-and-pump crossing method must meet the following performance criteria:

(i) use sufficient pumps, including on-site backup pumps, to maintain downstream flows;
(ii) construct dams with materials that prevent sediment and other pollutants from entering the waterbody (e.g., sandbags or clean gravel with plastic liner);
(iii) screen pump intakes to minimize entrainment of fish;
(iv) prevent streambed scour at pump discharge; and
(v) continuously monitor the dam and pumps to ensure proper operation throughout the waterbody crossing.

c. Flume Crossing

The flume crossing method requires implementation of the following steps:

(1) install flume pipe after blasting (if necessary), but before any trenching;

(2) use sand bag or sand bag and plastic sheeting diversion structure or equivalent to develop an effective seal and to divert stream flow through the flume pipe (some modifications to the stream bottom may be required to achieve an effective seal);

(3) properly align flume pipe(s) to prevent bank erosion and streambed scour;

(4) do not remove flume pipe during trenching, pipelaying, or backfilling activities, or initial streambed restoration efforts; and

(5) remove all flume pipes and dams that are not also part of the equipment bridge as soon as final cleanup of the stream bed and bank is complete.

d. Horizontal Directional Drill

For each waterbody or wetland that would be crossed using the HDD method, file with the Secretary for the review and written approval by the Director, a plan that includes:

(1) site-specific construction diagrams that show the location of mud pits, pipe assembly areas, and all areas to be disturbed or cleared for construction;

(2) justification that disturbed areas are limited to the minimum needed to construct the crossing;

(3) identification of any aboveground disturbance or clearing between the HDD entry and exit workspaces during construction;

(4) a description of how an inadvertent release of drilling mud would be contained and cleaned up; and

(5) a contingency plan for crossing the waterbody or wetland in the event the HDD is unsuccessful and how the abandoned drill hole would be sealed, if necessary.

The requirement to file HDD plans does not apply to projects constructed under the automatic authorization provisions in the FERC's regulations.

7. Crossings of Minor Waterbodies

Where a dry-ditch crossing is not required, minor waterbodies may be crossed using the open-cut crossing method, with the following restrictions:

a. except for blasting and other rock breaking measures, complete instream construction activities (including trenching, pipe installation, backfill, and restoration of the streambed contours) within 24 hours.

Streambanks and unconsolidated streambeds may require additional restoration after this period;

b. limit use of equipment operating in the waterbody to that needed to construct the crossing; and

c. equipment bridges are not required at minor waterbodies that do not have a state-designated fishery classification or protected status (e.g., agricultural or intermittent drainage ditches). However, if an equipment bridge is used it must be constructed as described in section V.B.5.

8. Crossings of Intermediate Waterbodies

Where a dry-ditch crossing is not required, intermediate waterbodies may be crossed using the open-cut crossing method, with the following restrictions:

a. complete instream construction activities (not including blasting and other rock breaking measures) within 48 hours, unless site-specific conditions make completion within 48 hours infeasible;

b. limit use of equipment operating in the waterbody to that needed to construct the crossing; and

c. all other construction equipment must cross on an equipment bridge as specified in section V.B.5.

9. Crossings of Major Waterbodies

Before construction, the project sponsor shall file with the Secretary for the review and written approval by the Director a detailed, site-specific construction plan and scaled drawings identifying all areas to be disturbed by construction for each major waterbody crossing (the scaled drawings are not required for any offshore portions of pipeline projects). This plan must be developed in consultation with the appropriate state and federal agencies and shall include extra work areas, spoil storage areas, sediment control structures, etc., as well as mitigation for navigational issues. The requirement to file major waterbody crossing plans does not apply to projects constructed under the automatic authorization provisions of the FERC's regulations.

The Environmental Inspector may adjust the final placement of the erosion and sediment control structures in the field to maximize effectiveness.

10. Temporary Erosion and Sediment Control

Install sediment barriers (as defined in section IV.F.3.a of the Plan) immediately after initial disturbance of the waterbody or adjacent upland.

Sediment barriers must be properly maintained throughout construction and reinstalled as necessary (such as after backfilling of the trench) until replaced by permanent erosion controls or restoration of adjacent upland areas is complete. Temporary erosion and sediment control measures are addressed in more detail in the Plan; however, the following specific measures must be implemented at stream crossings:

a. install sediment barriers across the entire construction right-of-way at all waterbody crossings, where necessary to prevent the flow of sediments into the waterbody. Removable sediment barriers (or driveable berms) must be installed across the travel lane. These removable sediment barriers can be removed during the construction day, but must be re-installed after construction has stopped for the day and/or when heavy precipitation is imminent;

b. where waterbodies are adjacent to the construction right-of-way and the right-of-way slopes toward the waterbody, install sediment barriers along the edge of the construction right-of-way as necessary to contain spoil within the construction right-of-way and prevent sediment flow into the waterbody; and

c. use temporary trench plugs at all waterbody crossings, as necessary, to prevent diversion of water into upland portions of the pipeline trench and to keep any accumulated trench water out of the waterbody.

11. Trench Dewatering

Dewater the trench (either on or off the construction right-of-way) in a manner that does not cause erosion and does not result in silt-laden water flowing into any waterbody. Remove the dewatering structures as soon as practicable after the completion of dewatering activities.

C. RESTORATION

1. Use clean gravel or native cobbles for the upper 1 foot of trench backfill in all waterbodies that contain coldwater fisheries.

2. For open-cut crossings, stabilize waterbody banks and install temporary sediment barriers within 24 hours of completing instream construction activities. For dry-ditch crossings, complete streambed and bank stabilization before returning flow to the waterbody channel.

3. Return all waterbody banks to preconstruction contours or to a stable angle of repose as approved by the Environmental Inspector.

4. Install erosion control fabric or a functional equivalent on waterbody banks at the time of final bank recontouring. Do not use synthetic monofilament

mesh/netted erosion control materials in areas designated as sensitive wildlife habitat unless the product is specifically designed to minimize harm to wildlife. Anchor erosion control fabric with staples or other appropriate devices.

5. Application of riprap for bank stabilization must comply with COE, or its delegated agency, permit terms and conditions.

6. Unless otherwise specified by state permit, limit the use of riprap to areas where flow conditions preclude effective vegetative stabilization techniques such as seeding and erosion control fabric.

7. Revegetate disturbed riparian areas with native species of conservation grasses, legumes, and woody species, similar in density to adjacent undisturbed lands.

8. Install a permanent slope breaker across the construction right-of-way at the base of slopes greater than 5 percent that are less than 50 feet from the waterbody, or as needed to prevent sediment transport into the waterbody. In addition, install sediment barriers as outlined in the Plan.

   In some areas, with the approval of the Environmental Inspector, an earthen berm may be suitable as a sediment barrier adjacent to the waterbody.

9. Sections V.C.3 through V.C.7 above also apply to those perennial or intermittent streams not flowing at the time of construction.

D. POST-CONSTRUCTION MAINTENANCE

1. Limit routine vegetation mowing or clearing adjacent to waterbodies to allow a riparian strip at least 25 feet wide, as measured from the waterbody's mean high water mark, to permanently revegetate with native plant species across the entire construction right-of-way. However, to facilitate periodic corrosion/leak surveys, a corridor centered on the pipeline and up to 10 feet wide may be cleared at a frequency necessary to maintain the 10-foot corridor in an herbaceous state. In addition, trees that are located within 15 feet of the pipeline that have roots that could compromise the integrity of the pipeline coating may be cut and removed from the permanent right-of-way. Do not conduct any routine vegetation mowing or clearing in riparian areas that are between HDD entry and exit points.

2. Do not use herbicides or pesticides in or within 100 feet of a waterbody except as allowed by the appropriate land management or state agency.

3. Time of year restrictions specified in section VII.A.5 of the Plan (April 15 – August 1 of any year) apply to routine mowing and clearing of riparian areas.

VI. WETLAND CROSSINGS

A. GENERAL

1. The project sponsor shall conduct a wetland delineation using the current federal methodology and file a wetland delineation report with the Secretary before construction. The requirement to file a wetland delineation report does not apply to projects constructed under the automatic authorization provisions in the FERC's regulations.

   This report shall identify:

   a. by milepost all wetlands that would be affected;

   b. the National Wetlands Inventory (NWI) classification for each wetland;

   c. the crossing length of each wetland in feet; and

   d. the area of permanent and temporary disturbance that would occur in each wetland by NWI classification type.

   The requirements outlined in this section do not apply to wetlands in actively cultivated or rotated cropland. Standard upland protective measures, including workspace and topsoiling requirements, apply to these agricultural wetlands.

2. Route the pipeline to avoid wetland areas to the maximum extent possible. If a wetland cannot be avoided or crossed by following an existing right-of-way, route the new pipeline in a manner that minimizes disturbance to wetlands. Where looping an existing pipeline, overlap the existing pipeline right-of-way with the new construction right-of-way. In addition, locate the loop line no more than 25 feet away from the existing pipeline unless site-specific constraints would adversely affect the stability of the existing pipeline.

3. Limit the width of the construction right-of-way to 75 feet or less. Prior written approval of the Director is required where topographic conditions or soil limitations require that the construction right-of-way width within the boundaries of a federally delineated wetland be expanded beyond 75 feet. Early in the planning process the project sponsor is encouraged to identify site-specific areas where excessively wide trenches could occur and/or where spoil piles could be difficult to maintain because existing soils lack adequate unconfined compressive strength.

4. Wetland boundaries and buffers must be clearly marked in the field with signs and/or highly visible flagging until construction-related ground disturbing activities are complete.

5. Implement the measures of sections V and VI in the event a waterbody crossing is located within or adjacent to a wetland crossing. If all measures of sections V and VI cannot be met, the project sponsor must file with the Secretary a site-specific crossing plan for review and written approval by the Director before construction. This crossing plan shall address at a minimum:

   a. spoil control;

   b. equipment bridges;

   c. restoration of waterbody banks and wetland hydrology;

   d. timing of the waterbody crossing;

   e. method of crossing; and

   f. size and location of all extra work areas.

6. Do not locate aboveground facilities in any wetland, except where the location of such facilities outside of wetlands would prohibit compliance with U.S. Department of Transportation regulations.

B. INSTALLATION

1. Extra Work Areas and Access Roads

   a. Locate all extra work areas (such as staging areas and additional spoil storage areas) at least 50 feet away from wetland boundaries, except where the adjacent upland consists of cultivated or rotated cropland or other disturbed land.

   b. The project sponsor shall file with the Secretary for review and written approval by the Director, site-specific justification for each extra work area with a less than 50-foot setback from wetland boundaries, except where adjacent upland consists of cultivated or rotated cropland or other disturbed land. The justification must specify the site-specific conditions that will not permit a 50-foot setback and measures to ensure the wetland is adequately protected.

   c. The construction right-of-way may be used for access when the wetland soil is firm enough to avoid rutting or the construction right-of-way has been appropriately stabilized to avoid rutting (e.g., with timber riprap, prefabricated equipment mats, or terra mats).

      In wetlands that cannot be appropriately stabilized, all construction equipment other than that needed to install the wetland crossing shall

use access roads located in upland areas. Where access roads in upland areas do not provide reasonable access, limit all other construction equipment to one pass through the wetland using the construction right-of-way.

d. The only access roads, other than the construction right-of-way, that can be used in wetlands are those existing roads that can be used with no modifications or improvements, other than routine repair, and no impact on the wetland.

2. Crossing Procedures

a. Comply with COE, or its delegated agency, permit terms and conditions.

b. Assemble the pipeline in an upland area unless the wetland is dry enough to adequately support skids and pipe.

c. Use "push-pull" or "float" techniques to place the pipe in the trench where water and other site conditions allow.

d. Minimize the length of time that topsoil is segregated and the trench is open. Do not trench the wetland until the pipeline is assembled and ready for lowering in.

e. Limit construction equipment operating in wetland areas to that needed to clear the construction right-of-way, dig the trench, fabricate and install the pipeline, backfill the trench, and restore the construction right-of-way.

f. Cut vegetation just above ground level, leaving existing root systems in place, and remove it from the wetland for disposal.

The project sponsor can burn woody debris in wetlands, if approved by the COE and in accordance with state and local regulations, ensuring that all remaining woody debris is removed for disposal.

g. Limit pulling of tree stumps and grading activities to directly over the trenchline. Do not grade or remove stumps or root systems from the rest of the construction right-of-way in wetlands unless the Chief Inspector and Environmental Inspector determine that safety-related construction constraints require grading or the removal of tree stumps from under the working side of the construction right-of-way.

h. Segregate the top 1 foot of topsoil from the area disturbed by trenching, except in areas where standing water is present or soils are

saturated. Immediately after backfilling is complete, restore the segregated topsoil to its original location.

i. Do not use rock, soil imported from outside the wetland, tree stumps, or brush riprap to support equipment on the construction right-of-way.

j. If standing water or saturated soils are present, or if construction equipment causes ruts or mixing of the topsoil and subsoil in wetlands, use low-ground-weight construction equipment, or operate normal equipment on timber riprap, prefabricated equipment mats, or terra mats.

k. Remove all project-related material used to support equipment on the construction right-of-way upon completion of construction.

3. Temporary Sediment Control

Install sediment barriers (as defined in section IV.F.3.a of the Plan) immediately after initial disturbance of the wetland or adjacent upland. Sediment barriers must be properly maintained throughout construction and reinstalled as necessary (such as after backfilling of the trench). Except as noted below in section VI.B.3.c, maintain sediment barriers until replaced by permanent erosion controls or restoration of adjacent upland areas is complete. Temporary erosion and sediment control measures are addressed in more detail in the Plan.

a. Install sediment barriers across the entire construction right-of-way immediately upslope of the wetland boundary at all wetland crossings where necessary to prevent sediment flow into the wetland.

b. Where wetlands are adjacent to the construction right-of-way and the right-of-way slopes toward the wetland, install sediment barriers along the edge of the construction right-of-way as necessary to contain spoil within the construction right-of-way and prevent sediment flow into the wetland.

c. Install sediment barriers along the edge of the construction right-of-way as necessary to contain spoil and sediment within the construction right-of-way through wetlands. Remove these sediment barriers during right-of-way cleanup.

4. Trench Dewatering

Dewater the trench (either on or off the construction right-of-way) in a manner that does not cause erosion and does not result in silt-laden water flowing into any wetland. Remove the dewatering structures as soon as practicable after the completion of dewatering activities.

C. RESTORATION

1. Where the pipeline trench may drain a wetland, construct trench breakers at the wetland boundaries and/or seal the trench bottom as necessary to maintain the original wetland hydrology.

2. Restore pre-construction wetland contours to maintain the original wetland hydrology.

3. For each wetland crossed, install a trench breaker at the base of slopes near the boundary between the wetland and adjacent upland areas. Install a permanent slope breaker across the construction right-of-way at the base of slopes greater than 5 percent where the base of the slope is less than 50 feet from the wetland, or as needed to prevent sediment transport into the wetland. In addition, install sediment barriers as outlined in the Plan. In some areas, with the approval of the Environmental Inspector, an earthen berm may be suitable as a sediment barrier adjacent to the wetland.

4. Do not use fertilizer, lime, or mulch unless required in writing by the appropriate federal or state agency.

5. Consult with the appropriate federal or state agencies to develop a project-specific wetland restoration plan. The restoration plan shall include measures for re-establishing herbaceous and/or woody species, controlling the invasion and spread of invasive species and noxious weeds (e.g., purple loosestrife and phragmites), and monitoring the success of the revegetation and weed control efforts. Provide this plan to the FERC staff upon request.

6. Until a project-specific wetland restoration plan is developed and/or implemented, temporarily revegetate the construction right-of-way with annual ryegrass at a rate of 40 pounds/acre (unless standing water is present).

7. Ensure that all disturbed areas successfully revegetate with wetland herbaceous and/or woody plant species.

8. Remove temporary sediment barriers located at the boundary between wetland and adjacent upland areas after revegetation and stabilization of adjacent upland areas are judged to be successful as specified in section VII.A.4 of the Plan.

D. POST-CONSTRUCTION MAINTENANCE AND REPORTING

1. Do not conduct routine vegetation mowing or clearing over the full width of the permanent right-of-way in wetlands. However, to facilitate periodic corrosion/leak surveys, a corridor centered on the pipeline and up to 10 feet wide may be cleared at a frequency necessary to maintain the 10-foot corridor in an herbaceous state. In addition, trees within 15 feet of the pipeline with roots that could compromise the integrity of pipeline coating may be selectively cut and removed from the permanent right-of-way. Do not conduct any routine vegetation mowing or clearing in wetlands that are between HDD entry and exit points.

2. Do not use herbicides or pesticides in or within 100 feet of a wetland, except as allowed by the appropriate federal or state agency.

3. Time of year restrictions specified in section VII.A.5 of the Plan (April 15 – August 1 of any year) apply to routine mowing and clearing of wetland areas.

4. Monitor and record the success of wetland revegetation annually until wetland revegetation is successful.

5. Wetland revegetation shall be considered successful if all of the following criteria are satisfied:

    a. the affected wetland satisfies the current federal definition for a wetland (i.e., soils, hydrology, and vegetation);

    b. vegetation is at least 80 percent of either the cover documented for the wetland prior to construction, or at least 80 percent of the cover in adjacent wetland areas that were not disturbed by construction;

    c. if natural rather than active revegetation was used, the plant species composition is consistent with early successional wetland plant communities in the affected ecoregion; and

    d. invasive species and noxious weeds are absent, unless they are abundant in adjacent areas that were not disturbed by construction.

6. Within 3 years after construction, file a report with the Secretary identifying the status of the wetland revegetation efforts and documenting success as defined in section VI.D.5, above. The requirement to file wetland restoration reports with the Secretary does not apply to projects constructed under the automatic authorization, prior notice, or advance notice provisions in the FERC's regulations.

    For any wetland where revegetation is not successful at the end of 3 years after construction, develop and implement (in consultation with a

professional wetland ecologist) a remedial revegetation plan to actively revegetate wetlands. Continue revegetation efforts and file a report annually documenting progress in these wetlands until wetland revegetation is successful.

VII. HYDROSTATIC TESTING

A. NOTIFICATION PROCEDURES AND PERMITS

1. Apply for state-issued water withdrawal permits, as required.

2. Apply for National Pollutant Discharge Elimination System (NPDES) or state-issued discharge permits, as required.

3. Notify appropriate state agencies of intent to use specific sources at least 48 hours before testing activities unless they waive this requirement in writing.

B. GENERAL

1. Perform 100 percent radiographic inspection of all pipeline section welds or hydrotest the pipeline sections, before installation under waterbodies or wetlands.

2. If pumps used for hydrostatic testing are within 100 feet of any waterbody or wetland, address secondary containment and refueling of these pumps in the project's Spill Prevention and Response Procedures.

3. The project sponsor shall file with the Secretary before construction a list identifying the location of all waterbodies proposed for use as a hydrostatic test water source or discharge location. This filing requirement does not apply to projects constructed under the automatic authorization provisions of the FERC's regulations.

C. INTAKE SOURCE AND RATE

1. Screen the intake hose to minimize the potential for entrainment of fish.

2. Do not use state-designated exceptional value waters, waterbodies which provide habitat for federally listed threatened or endangered species, or waterbodies designated as public water supplies, unless appropriate federal, state, and/or local permitting agencies grant written permission.

3. Maintain adequate flow rates to protect aquatic life, provide for all waterbody uses, and provide for downstream withdrawals of water by existing users.

4. Locate hydrostatic test manifolds outside wetlands and riparian areas to the maximum extent practicable.

D. DISCHARGE LOCATION, METHOD, AND RATE

1. Regulate discharge rate, use energy dissipation device(s), and install sediment barriers, as necessary, to prevent erosion, streambed scour, suspension of sediments, or excessive streamflow.

2. Do not discharge into state-designated exceptional value waters, waterbodies which provide habitat for federally listed threatened or endangered species, or waterbodies designated as public water supplies, unless appropriate federal, state, and local permitting agencies grant written permission.

APPENDIX E

General Notes

TABLE 6-1

GENERAL EROSION AND SEDIMENT CONTROL NOTES

ES-1: Unless otherwise indicated, all vegetative and structural erosion and sediment control practices will be constructed and maintained according to minimum standards and specifications of the Virginia Erosion and Sediment Control Handbook and Virginia Regulations 4VAC50-30 Erosion and Sediment Control Regulations.

ES-2: The plan approving authority must be notified one week prior to the pre-construction conference, one week prior to the commencement of land disturbing activity, and one week prior to the final inspection.

ES-3: All erosion and sediment control measures are to be placed prior to or as the first step in clearing.

ES-4: A copy of the approved erosion and sediment control plan shall be maintained on the site at all times.

ES-5: Prior to commencing land disturbing activities in areas other than indicated on these plans (including, but not limited to, off-site borrow or waste areas), the contractor shall submit a supplementary erosion control plan to the owner for review and approval by the plan approving authority.

ES-6: The contractor is responsible for installation of any additional erosion control measures necessary to prevent erosion and sedimentation as determined by the plan approving authority.

ES-7: All disturbed areas are to drain to approved sediment control measures at all times during land disturbing activities and during site development until final stabilization is achieved.

ES-8: During dewatering operations, water will be pumped into an approved filtering device.

ES-9: The contractor shall inspect all erosion control measures periodically and after each runoff-producing rainfall event. Any necessary repairs or cleanup to maintain the effectiveness of the erosion control devices shall be made immediately.

NOTE: General Notes incorporated into plans must use the current regulatory reference to 9VAC25-840 (and not 4VAC50-30, as cited above).

The following additional notes may be required by DEQ if a SWM Plan Waiver or CGP waiver is granted.

Additional Notes:

- *The project may not significantly alter the predevelopment runoff characteristics of the land surface after completion of construction and final stabilization;*
- The project may not significantly alter the predevelopment runoff characteristics of the land surface after the completion of construction and final stabilization.
- The project will be managed so that less than one (1) acre of land disturbance occurs on a daily basis.
- The disturbed land where work has been completed is adequately stabilized on a daily basis.
- The environment must be protected from erosion and sedimentation damage associated with the land-disturbing activity.
- ACP, LLC and/or the construction activity operator must design, install, implement and maintain pollution prevention measures to:
    - *Minimize the discharge of pollutants from equipment and vehicle washing, wheel wash water, and other wash waters;*
    - *Minimize the exposure of building materials, building products, construction wastes, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on-site to precipitation and to stormwater;*
    - *Minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures;*
    - *Prohibit the discharge of wastewater from the washout of concrete;*
    - *Prohibit the discharge of wastewater from the washout and cleanout of stucco, paint, form release oils, curing compounds, and other construction materials;*
    - *Prohibit the discharge of fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance; and*
    - *Minimize the exposure of waste materials to precipitation by closing or covering waste containers during precipitation events.*
- ACP, LLC must provide reasonable assurance to DEQ that all of the above conditions will be satisfied. This may be accomplished by incorporating these conditions into an Erosion and Sediment Control Plan developed for the project.

APPENDIX F

Linear Utility Projects Guidance

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER DIVISION

Subject: **Guidance Memo No. 15-2003**
Postdevelopment Stormwater Management Implementation Guidance for Linear Utility Projects under the Virginia Stormwater Management Program Regulation, 9VAC25-870

To: Regional Directors and Local VSMP Administrators

From: Melanie D. Davenport, Director Melanie D. Davenport

Date: April 23, 2015

Copies: James Golden, Jeff Steers, Fred Cunningham, Joan Salvati, Allan Brockenbrough, Jerome Brooks, Regional Stormwater Compliance Managers

Summary:

Section 76 (Linear Development Projects) of the Virginia Stormwater Management Program (VSMP) Regulation, 9VAC25-870, sets forth the postdevelopment stormwater management requirements for linear development projects. The purpose of this guidance document is to clarify the implementation of Section 76 with regards to the construction of linear utilities (e.g., waterlines, sewer lines, electric lines, telephone lines, oil and gas distribution pipelines, etc.) and was developed for use by the Department and local VSMP Authorities.

Electronic Copy:

An electronic copy of this guidance document in PDF format is available for staff internally on DEQNET, and for the general public on DEQ's website at: http://www.deq.virginia.gov/Programs/Water/Laws,Regulations,Guidance/Guidance/WaterPermitGuidance.aspx.

Contact Information:

Please contact Drew Hammond, Office of Stormwater Management, at (804) 698-4037 or Andrew.Hammond@deq.virginia.gov with any questions regarding the application of this guidance.

Disclaimer:

This document is provided as guidance and, as such, sets forth standard operating procedures for the agency. However, it does not mandate or prohibit any particular action not otherwise required or prohibited by law or regulation. If alternative proposals are made, such proposals will be reviewed and accepted or denied based on their technical adequacy and compliance with appropriate laws and regulations.

Postdevelopment Stormwater Management Implementation Guidance for Linear Utility Projects under the Virginia Stormwater Management Program Regulation, 9VAC25-870

Definitions:

"Land disturbance" or "land-disturbing activity" means a manmade change to the land surface that potentially changes its runoff characteristics including clearing, grading, or excavation, except that the term shall not include those exemptions specified in § 62.1-44.15:34 of the Code of Virginia.

"Linear development project" means a land-disturbing activity that is linear in nature such as, but not limited to, (i) the construction of electric and telephone utility lines, and natural gas pipelines; (ii) construction of tracks, rights-of-way, bridges, communication facilities and other related structures of a railroad company; (iii) highway construction projects; (iv) construction of stormwater channels and stream restoration activities; and (v) water and sewer lines. Private subdivision roads or streets shall not be considered linear development projects.

"Postdevelopment" refers to conditions that reasonably may be expected or anticipated to exist after completion of the land development activity on a specific site.

"Predevelopment" refers to the conditions that exist at the time that plans for the land development of a tract of land are submitted to the VSMP authority. Where phased development or plan approval occurs (preliminary grading, demolition of existing structures, roads and utilities, etc.), the existing conditions at the time prior to the first item being submitted shall establish predevelopment conditions.

"Stabilized" means land that has been treated to withstand normal exposure to natural forces without incurring erosion damage.

"Stormwater management plan" means a document(s) containing material for describing methods for complying with the requirements of the VSMP Regulation, 9VAC25-870.

"Virginia Stormwater Management Program (VSMP) authority" means an authority approved by the Board after September 13, 2011 to operate a Virginia Stormwater Management Program or the Department.

Regulatory Text:

9VAC25-870-76. Linear development projects.

Linear development projects shall control postdevelopment stormwater runoff in accordance with a site-specific stormwater management plan or a comprehensive watershed stormwater management plan developed in accordance with these regulations.

Guidance:

Section 76 of the VSMP Regulation, 9VAC25-870, establishes the requirement that linear development projects control postdevelopment stormwater runoff in accordance with a site-specific stormwater management plan or a comprehensive watershed stormwater management plan. The purpose of this guidance document is to clarify the implementation of Section 76 with regard to the construction of linear utilities (e.g., waterlines, sewer lines, electric lines, telephone lines, oil and gas distribution pipelines, etc.) and was developed for use by the Department and local VSMP Authorities.

The VSMP Regulation does not distinguish between various types of linear development projects such as aboveground or underground utilities, highway construction, rights-of-way, bridges, tracks and related structures of a railroad company. The Department of Environmental Quality (DEQ) recognizes that the construction of aboveground or underground linear utilities may not result in changes to the predevelopment runoff characteristics of the land surface after the completion of construction and final stabilization. Also, the application of the postdevelopment water quantity and water quality controls to these types of projects and the preparation and implementation of a stormwater management plan may provide minimum water quality benefit. Examples of such projects include:

- The installation of underground utilities (e.g., waterlines, sewer lines, oil and gas distribution pipelines) beneath existing impervious cover (e.g., asphalt pavement, concrete pavement) that will be returned to its predevelopment condition after the completion of construction and final stabilization;

- The installation of underground utilities (e.g., waterlines, sewer lines, oil and gas distribution pipelines) beneath existing pervious cover (e.g., forest/open space, managed turf) that will be returned to its predevelopment condition after the completion of construction and final stabilization; or

- The installation of aboveground (i.e., overhead) utility lines.

DEQ staff or the local VSMP authority should utilize their best professional judgment when evaluating aboveground or underground linear utility projects. If the project will not result in significant changes to the predevelopment runoff characteristics of the land surface after the completion of construction and final stabilization, then DEQ or the local VSMP authority, at their discretion, may waive the requirement for the preparation and implementation of a stormwater management plan. DEQ recognizes that on a site specific basis a stormwater management plan may be required especially if the linear utility project will significantly alter the predevelopment runoff characteristics of the land surface.

In addition, the construction of aboveground or underground linear utilities may be conducted without requiring coverage under the General VPDES Permit for Discharges of Stormwater from Construction Activities (Construction General Permit) provided that:

- The project does not significantly alter the predevelopment runoff characteristics of the land surface after the completion of construction and final stabilization;

- The project is managed so that less than one (1) acre of land disturbance occurs on a daily basis;

- The disturbed land where work has been completed is adequately stabilized on a daily basis;

- The environment is protected from erosion and sedimentation damage associated with the land-disturbing activity;

- The owner and/or construction activity operator designs, installs, implements, and maintains pollution prevention measures to:

    - Minimize the discharge of pollutants from equipment and vehicle washing, wheel wash water, and other wash waters;

    - Minimize the exposure of building materials, building products, construction wastes, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on-site to precipitation and to stormwater;

    - Minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures;

    - Prohibit the discharge of wastewater from the washout of concrete;

    - Prohibit the discharge of wastewater from the washout and cleanout of stucco, paint, form release oils, curing compounds, and other construction materials; and

    - Prohibit the discharge of fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance.

- The owner and/or construction activity operator provides reasonable assurance to DEQ or the local VSMP Authority that all of the above conditions will be satisfied. This may be accomplished by incorporating these conditions into an erosion and sediment control plan developed for the project.

As previously noted, DEQ staff or the local VSMP authority should utilize their best professional judgment when evaluating aboveground or underground linear utility projects. If the owner and/or construction activity operator provides reasonable assurance to DEQ or the local VSMP Authority that all of the aforementioned conditions will be satisfied, then the linear utility project may be conducted without requiring coverage under the Construction General Permit. Please note that this does not relieve the owner and/or construction activity operator from complying with any and all other applicable federal, state, and local requirements. DEQ or the local VSMP Authority reserves the right to require a registration statement for Construction General Permit coverage if the aforementioned conditions are not satisfied.

If the linear utility project will significantly alter the predevelopment runoff characteristics of the land surface requiring postdevelopment stormwater management or if other site specific conditions warrant Construction General Permit coverage, DEQ or the local VSMP authority may require a registration statement for permit coverage.

APPENDIX G

ACP Specific Requirements

Per the request received from DEQ by letter dated May 16, 2016 for the Atlantic Coast Pipeline (ACP) Project, DETI has agreed to incorporate the following more stringent conditions into the planning and implementation phases of Erosion and Sediment Control (ESC) and Stormwater Management (SWM) for ACP:

1. In addition to ACP, LLC's internal review process, individual project-specific plans will be submitted to DEQ for review and approval. Any additional ESC or SWM project-specific planning activities that occur after October 19, 2018 shall be done pursuant to Va. Code for Annual Standards and Specifications (AS&S) § 62.1-44.15:31 and § 62.1-44.15:55D.

Following the project's cancellation in July 2020, and in accordance with correspondence between ACP, LLC and DEQ on March 18, 2021, approval of changes to individual plans that qualify for review and approval will be done under the Annual Standards & Specifications by a Virginia DEQ certified SWM and/or ESC reviewer (which may be a third-party contractor). Signature will be provided by the AS&S holder's Program Administrator (which must be an employee of the AS&S holder) on the AS&S Entity Information Sheet.

2. Given the nature of critical infrastructure, the project-specific Erosion and Sediment Control and Stormwater Management plans and DEQ approval will be made available to DEQ and may be made available to others as agreed upon in a memorandum to be negotiated between ACP, LLC and DEQ.

3. Inspection reports conducted by ACP, LLC as well as complaint logs and complaint responses will be submitted to DEQ upon request.

4. ACP, LLC will provide for payment to DEQ of reasonable costs incurred by DEQ to hire additional technical expertise to assist DEQ in plan review and compliance activities for the ACP project, as articulated in the MOA with DEQ for the Atlantic Coast Pipeline project.

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- White Paper Water Quality Addendum Page 346
- LULC and Field Change Clarification Page 366

VIRGINIA ACP STORMWATER QUANTITY COMPLIANCE METHODOLOGY (WHITE PAPER)

Memorandum

To:	Ben Leach – DEQ
Cc:	Robert Hare – DETI
From:	Alla Flaksman – ERM, Stephen Lindsay – ERM, Doug Beisch – Stantec, Glenn Muckley – Stantec
Date:	February 16, 2018
Subject:	Virginia ACP Stormwater Quantity Compliance Methodology

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EXECUTIVE SUMMARY

The following is intended to provide background clarity as to the stormwater management compliance strategy for the Atlantic Coast Pipeline (ACP) project and serve as documentation and explanatory information to the Virginia Department of Environmental Quality (DEQ) Water Program's Office of Stormwater Management to demonstrate the compliance approach for the Virginia Stormwater Management Program (VSMP) Part IIB Technical Criteria, specifically with 9VAC25-870-66 for water quantity for the project. The methodology herein has been developed with consideration for the "2017 Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management for Construction and Maintenance of Gas Transmission Facility Projects in Virginia" for Dominion Energy Transmission, Inc. (DETI), approved July 5, 2017 (DETI AS&S). It is understood that the methodology defined herein shall be appended to the approved DETI AS&S as a special project and utilized to provide additional clarity for the ACP project beyond that which the AS&S provides. This document is generally referred to as the "White Paper" below and in various project support documents.

This White Paper defines a stepwise process for evaluation, calculation, and documentation of water quantity compliance for the ACP, and the below provides additional detail on process refinement for pipeline and access road areas.

As noted under this White Paper, the stormwater management approach centers on maintaining existing sheet flow patterns and converting existing shallow concentrated flows intercepted by the ROW to sheet flow,

where practicable. As such, access road compliance with 9VAC25-870-66 is sought primarily through 9VAC25-870-66.D, through an Environmental Site Design (ESD) approach whereby measures (waterbars, flow diffusers, gravel diaphragms, ditches, check dams, etc) are integrated within the right of way (ROW) / roadway construction footprint, where feasible, and restoration practices are employed which minimize changes to runoff parameters. Documentation provided for sheet flow will demonstrate, if practices are installed and maintained properly, that A) areas will leave the practices / ROW in sheet flow, and B) that increased volumes of sheet flow in aggregate from these practices have been evaluated for "impacts on down-gradient properties or resources" and are not anticipated to" cause or contribute to erosion, sedimentation, or flooding of down gradient properties or resources". Where not feasible to maintain sheet flow per the above, concentrated flow outfalls are addressed through satisfaction of 9VAC25-870-66.B and 9VAC25-870-66.C for channel protection and flood protection, respectively.

CERTIFICATION

The Virginia ACP Stormwater Quantity Compliance Methodology, or White Paper, was developed by Environmental Resources Management, Inc. (ERM) and Stantec Consulting Services Inc. (Stantec).

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1.0 INTRODUCTION

The Atlantic Coast Pipeline (ACP) project consists of approximately 600 miles of interstate natural gas transmission pipeline and associated laterals in West Virginia, Virginia, and North Carolina. Approximately 307 miles of transmission pipeline and over 100 miles of permanent access roads are located in Virginia. A 50-foot wide permanent right-of-way (ROW) will be maintained along the pipeline and a 30-foot wide permanent ROW will be maintained for permanent access roads.

The purpose of this memorandum is to discuss the approach and compliance methodology for the pipeline ROW and permanent access roads for complying with Virginia's water quantity criteria set forth in 9VAC 25-870-66.

The general overview of the process to achieve water quantity compliance is illustrated using a flow chart presented in Attachment 1 and discussed in the following sections.

2.0 WATER QUANTITY FOR PIPELINE RIGHT-OF-WAY

Compliance with the requirements at 9 VAC 25-870-66 for the pipeline ROW and access roads will primarily be achieved by demonstrating that runoff leaves the permanent maintained ROW as sheet flow. Specifically, the mechanism through which compliance is achieved will be 9 VAC 25-870-66.D. The methodology involves the following steps.

1. Delineate the drainage area to each permanent waterbar and culvert, perform hydrologic computations, and size required end treatments to demonstrate that project runoff will leave the permanent maintained ROW as sheet flow at that location. To ensure sheet flow, all waterbars and cross-culverts (those not conveying jurisdictional waters) will be implemented with an end treatment. Specific end treatment sizing and type is dependent on hydraulic loading. See Section 6 below for additional detail.

2. Assess the potential for sheet flow to re-concentrate downgradient of the permanent maintained ROW. If it appears sheet flow re-concentration might occur within 100 feet of the permanent maintained ROW, provide additional intermediate points of analysis to assess the potential for increased volumes of sheet flow and impacts on downgradient properties or resources. If no re-concentration occurs within the 100-foot buffer,

provide a point of analysis were re-concentration occurs at properties downstream.

The evaluation to be performed is discussed in more detail in the following sections.

2.1 Permanent Waterbar Sheet Flow Computations

Permanent waterbars are required to be installed along the pipeline ROW in accordance with the FERC Upland Erosion Control, Revegetation, and Maintenance Plan (FERC Plan) to slow runoff velocity, direct water off the ROW and prevent sediment deposition into sensitive resources. Specifically, permanent waterbars will be installed upgradient of all wetland, waterbody and road crossings (which allows us to isolate project drainage contributions from cross-drainage needed to convey larger streams). At other locations along the ROW and access roads, spacing for permanent waterbars will generally follow the table below.

Recommended Spacing for Permanent Waterbars (FERC Plan V.B.2)

Trench Slope (%)	Spacing (feet)
5 to 15	300
> 15 to 30	200
> 30	100

It is noted that there are over 6,500 permanent waterbars along the pipeline ROW in Virginia.

While this memorandum focuses on permanent waterbars, it should be noted that temporary waterbars will be used during active construction to manage runoff on the temporary and permanent ROW. The transition from temporary to permanent waterbars is discussed in the VA ACP Stormwater Pollution Prevention Plan (SWPPP) and in the construction sequence in the Erosion and Sediment Control Plan Notes sheets. Additionally, maintenance requirements for permanent waterbars and related stormwater best management practices (BMPs) to remain in place once construction is complete and the pipeline is operational are addressed in the VA ACP SWPPP, Section 8.6. Additional waterbar and culvert end treatment maintenance information is provided in the construction plans.

Hydrologic computations will be performed at each permanent waterbar and cross-culvert to demonstrate that runoff will leave the permanent

maintained ROW or access road as sheet flow. The specific methodology to be applied is described below.

1. The drainage area to each permanent waterbar or culvert will be delineated.

2. The SCS Runoff Curve Number Method will be used to compute the peak runoff rate for storm events (1, 2 and 10-year events). Industry standard software programs and equations, such as HydroCAD, HEC-HMS or similar, will be used to perform hydrologic computations in accordance with Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55) methodology. The time of concentration for each catchment will be computed primarily using the watershed lag method described in Chapter 15 of the Engineering Handbook, Part 630 Hydrology. Where the watershed lag method is not appropriate (curve numbers <50 or >95), the TR-55 flow path segment or similar industry accepted methods may be used as well. Alternatively, a conservative time of concentration of 5 minutes may be utilized.

3. At the terminus of the permanent waterbar or cross-culvert, an end treatment element will be added to transition discharges captured at the waterbar or cross-culvert to a sheet flow condition. The standards and specifications for end treatments are provided on the construction plans and have been adapted from other design references. End treatments shall refer to those features defined under Section 6 of this document, and consist of Standard Stone Aprons (SSA) and Flow Diffusers. See Attachment 4 for additional information regarding SSA, and See Attachments 4 and 5 for design and additional references for Flow Diffuser standards and specifications basis of design. For the purposes of this project, a flow diffuser is defined as a permanent non-erosive outlet for concentrated runoff constructed to diffuse flow uniformly through a stone matrix onto a stabilized area in the form of shallow, low velocity, sheet flow.

For examples of a waterbar calculation see Figure 7.7. Per Section 6.1.2 and relevant references, the slope of the receiving area downgradient of the flow diffuser should not exceed 30 percent. Exceedances of the recommended slope limit are likely to occur in some locations in the western part of the commonwealth. Where the slope of the downgradient receiving area exceeds 30 percent, the allowable discharge rate per foot of flow diffuser will be reduced by 50 percent to 0.125 cubic feet per second (cfs) per foot. Per FERC requirements in areas with slopes greater than 30 percent, reduced permanent waterbar spacing of no more than 100 feet is used, as compared with permanent waterbar spacing of 200 feet in project

areas where the slope is less than 30 percent. Given that FERC has determined that permanent waterbar spacing of 100 feet (as opposed to 200 feet) is appropriate for these steep slope areas, the consultant team similarly elected to reduce the allowable hydraulic loading to the flow diffusers to half of the amount normally allowed (i.e., reduction from 0.250 cfs per foot to 0.125 cfs per foot). It should also be noted that, where the pipeline ROW slope exceeds 30 percent, best in class (BIC) steep slope incremental controls will be utilized which will provide further protection. An example of BIC incremental controls that could be applied includes further reduction of the permanent waterbar spacing to less than 100 feet.

The following section presents the methodology for assessing impacts to downgradient property and resources due to potential increases in the volume of sheet flow, as required by 9 VAC 25-870-66.D.

2.2 Downgradient Channel Adequacy Evaluation

At this stage of the pipeline ROW analysis it has been demonstrated that runoff leaving the permanent maintained ROW is in a sheet flow condition (i.e., non-erosive velocity and flow depth less than 0.1 feet). To achieve compliance with 9 VAC 25-870-66.D it is necessary to demonstrate that increased volumes of sheet flow are not expected to adversely impact downgradient property or resources. The analysis includes an evaluation of the anticipated channel velocities in the receiving drainage feature, and an assessment (where manmade channels are present or other improvements adjacent to natural channels, such as structures or land uses, which may be subject to localized flooding) of whether localized flooding is anticipated to occur. The first check on the receiving channels is performed by assessing the potential for the sheet flow leaving the permanent maintained ROW to re-concentrate within 100 feet of the permanent maintained ROW. Sheet flow will be assumed to have the potential to re-concentrate if a drainage feature, identified through inspection of the topographic data, or delineated waterbody is encountered. A point of analysis will be established at the point of flow re-concentration and the pre- and post-construction hydrologic conditions evaluated. The specific methodology to be applied is described below.

1. Firstly, the designer reviews available topographic mapping, land use mapping, flood mapping, and aerial mapping resources to identify if there are manmade receiving channels or manmade improvements (e.g. yards, agricultural fields, structures, roads, trails, etc.) within the potential flood-prone area of natural channels in the immediate vicinity which may experience localized flooding. Localized flooding is flooding which is

likely to cause property damage or unsafe conditions. If localized flooding is of any concern based on the review, flow depths are calculated for the 10-year event in manmade channels and natural channels. Both 2-year velocity and 10-year flow depth (where necessary) comparisons are performed via a single section analysis using best available topography at a downstream point of aggregated sheet flow defined under the analysis. See Attachment 1 – Water Quantity Compliance Flow Chart for additional information. If 10-year flow depths are not expected to be contained (without attenuation) within the stormwater conveyance system (i.e. localized flooding is expected to occur), volume mitigation is provided for the 10-year storm to reduce post-development discharges to pre-development, as necessary. Volume mitigation (as discussed in Section 6) is provided though storage in drainage features such as flow diffusers, gravel diaphragms, check dams, and waterbar storage.

2. Once the area has been screened for localized flooding, those drainage areas with increased sheet flow volumes must be evaluated to determine if receiving channels are adversely impacted. Where there is a low probability for the sheet flow leaving the permanent maintained ROW to re-concentrate downgradient of the ROW (re-concentration is of concern if it occurs within 100 feet of the permanent ROW) it is then necessary to evaluate whether increased volumes of sheet flow will have an impact on downgradient property or resources. If volumes of sheet flow from the drainage area in question have increased, then a representative point of analysis is provided in the receiving channel. Points of analysis are selected where incremental sheet flow releases are aggregated in the receiving channel. If post-development (2-year) channel velocities are expected to increase (without accounting for runoff storage mitigation practices) then the ability to offset the increase in volume, for example by accounting for storage behind the upgradient permanent waterbar/flow diffuser, will be evaluated. Upon demonstrating that any increase in the volume of sheet flow is mitigated by storage in these practices, the team has provided assurance that flows have been mitigated such that there is no anticipated impact on downgradient property or resources and compliance with the requirements at 9 VAC 25-870-66.D is achieved for that drainage area.

3. If a drainage feature exists within 100 feet of the 50-foot wide maintained permanent ROW there is assumed to be potential for the sheet flow to re-concentrate and possibly impact downgradient property or resources. An additional point of analysis will be established at the point of flow re-concentration and the pre- and post-construction hydrologic conditions will be evaluated.

If the post-construction velocity is less than or equal to the pre-construction velocity at the additional point of analysis, there is no anticipated impact on downgradient property or resources and compliance with the requirements at 9 VAC 25-870-66 D is achieved for that drainage area. Velocities will be calculated using 2 significant figures. If post-development (2-year) channel velocities are expected to increase (without accounting for runoff storage mitigation practices) then the ability to offset the increase in volume, for example by accounting for storage behind the upgradient permanent waterbar/flow diffuser, will be evaluated. Upon demonstrating that any increase in the volume of sheet flow is mitigated by storage in these practices, the team has provided assurance that flows have been mitigated such that there is no anticipated impact on downgradient property or resources and compliance with the requirements at 9 VAC 25-870-66.D is achieved for that drainage area.

4. If volume mitigation is not sufficient to demonstrate that localized flooding and impacts to receiving channels are appropriately mitigated, or in instances where project drainage cannot be dispersed as sheet flow, the designer must then default to the energy balance method and size controls (utilizing the appropriate improvements factor) to achieve the point of discharge standard for the concentrated discharge location.

As 9VAC25-870-66.D does not define quantifiable metrics for evaluation of sheet flow by design storm event or a threshold for margin of calculation error, but clearly does anticipate “increased” volumes of sheet flow. If localized flooding is not of concern, the general compliance approach is to mimic pre-development velocities (within the computed accuracy of 2 significant figures) or to provide volumetric mitigation of increases in sheet flow.

For the pipeline ROW itself, in the absence of access roads (or other new impervious cover) the team anticipates that the restoration plan (restoration of the disturbed ROW area back to a “forest/open space” condition) will achieve most of the runoff management compliance objectives. As discussed in Section 2.2.3 of the approved Dominion Energy Transmission, Inc. (DETI) 2017 Standards and Specifications wherein it is stated that for portions of pipeline that traverse prior developed lands, DETI does not expect to provide improvements to existing runoff conditions if pre-development conditions are restored. Where increased volumes of sheet flow are expected from the pipeline ROW, the compliance approach will be the same as that outlined above, with the goal of maintaining sheet flow and volumetric mitigation for increases.

Mitigation options are addressed in Section 6 and include, but are not limited to, reconfiguring permanent waterbars and/or implementation of best management practices (BMPs) to restore the pre-construction flow conditions at the point of analysis. If standard sizing for flow dissipation measures is not sufficient to demonstrate there is no localized flooding for 10-year, 24-hour depth and the channel velocities for 2-year events are mitigated, as necessary, designers will evaluate the potential to add additional practices or increase the size of practices to offset the increase in the volume of sheet flow by accounting for storage behind the upgradient permanent waterbar / flow diffuser elements. Upon demonstrating that any increase in the volume of sheet flow is mitigated, the team has provided reasonable assurance that there is no impact on downgradient property or resources and compliance with the requirements at 9 VAC 25-870-66.D is achieved for that drainage area.

3.0 WATER QUANTITY FOR ACCESS ROADS

Compliance with the requirements at 9 VAC 25-870-66 for access roads will be achieved by demonstrating that runoff leaves the access road ROW as sheet flow where possible (i.e., 9 VAC 25-870-66 D) in the same manner as the ROW. Where it is not feasible to achieve sheet flow leaving the access road ROW, compliance will be achieved using the Energy Balance method (i.e., 9 VAC 25-870-66 B.3).

A discussion of the types of access roads utilized for the ACP project as well as the information to be provided documenting existing and proposed access road conditions is presented in Section 3.1. The methodology for achieving compliance with the water quantity requirements is presented in Sections 3.2 through 3.5.

The water quantity analysis will be performed for only those access roads where there is potential for a material change to the existing stormwater runoff characteristics. The identification of these roads is presented in Section 3.1.

3.1 Access Road Engineering Details

In accordance with the approved DETI 2017 Standards and Specifications Appendix B, access roads will be grouped into four categories based on the extent of improvements required to prepare the road for use to support the project. Depending on the improvements, the impact on stormwater runoff characteristics will range from no expected impact to a material impact. Specifically, the four categories are defined below; all

access roads, or access road segments, will be assigned a category that is depicted on the corresponding alignment sheet and access road plans.

1. Existing road with no improvements proposed – includes those existing roads that are in a condition such that no improvements are needed to prepare the road for use to support the project (e.g., asphalt surfaced roads).

2. Existing road with minor improvements proposed – includes those existing roads that contain either a compacted earth or gravel surface and the current road configuration (i.e., width, grade, etc.) is adequate to support the project. Roads in this category may receive supplemental gravel to improve the surface condition; however, the footprint of the road would not be expanded (i.e., no additional impervious surface is proposed).

3. Existing road with major improvements proposed – includes those existing roads that will receive an expanded footprint (i.e., the impervious surface post-construction may exceed that existing pre-construction) in order to prepare the road for use to support the project.

4. New road – includes roads not located within the limits of an existing road.

No post-construction stormwater management criteria will apply to access roads in categories 1 and 2 because the roads are existing and there is no additional impervious surface proposed. Access roads in categories 3 and 4 involve improvements that could potentially result in a material change to the existing stormwater runoff characteristics as a result of the addition of impervious surface, and therefore are the subject of the access road water quantity analysis. However, note that most of the proposed roads are within existing dirt / gravel road footprints. As such, the new versus existing road designation noted herein relates specifically to the nature of impervious cover change. To remain conservative the consultant team deemed many roads new for purposes of stormwater evaluation even though some existing gravel may exist within the footprint. Further, the area outside of the proposed impervious access roads (i.e. the shoulder on both sides of roadway) is utilized with a consistent pre-development land cover for the purpose of pre- to post-development comparison. This is a conservative approach given the siting of proposed roads along existing road traces (whereas most of the roads are deemed new for purposes of stormwater compliance) and conservative assumptions for the addition of impervious cover, and the nature of the proposed post- stabilization approach to establish scrub-shrub conditions for vegetated areas outside

of the impervious width (scrub-shrub curve numbers for these residual areas, if used, would be lower than reversion to pre-development land cover). Additional documentation may be provided upon field construction mobilization as to the extent of existing gravel limits, if necessary, should additional analysis and/or plan modification be required to address field constraints.

Engineering details will be provided for all permanent access roads, including plan, profile and typical cross-sections depicting the existing and proposed improvements, approximate limits of cut and fill and existing or proposed drainage elements. Engineering details for access roads are depicted on plans associated with the project. For existing permanent access roads, documentation describing the basis for any assumptions as to the extent of existing impervious surfaces will be provided. Documentation that will be evaluated includes the Virginia Geographic Information Network (VGIN) land cover data, aerial photography, field reconnaissance notes and site-specific photographs, where available. For examples of how existing access road conditions forming the basis of the water quantity analysis are documented refer to Section 7.

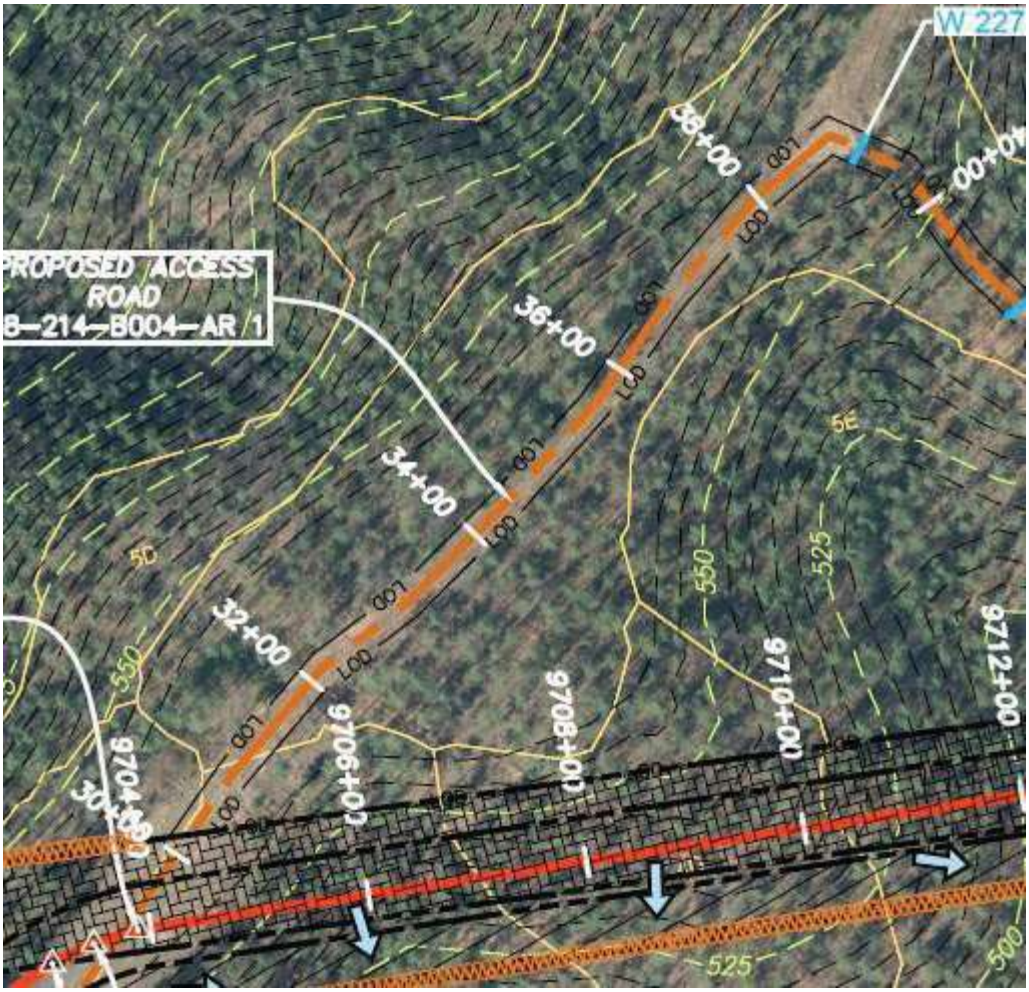
3.2 Scenario 1 – Ridgetop Conditions

Segments of access roads located along ridgetops have a small drainage area contributing to the downgradient edge of the access road ROW (an example access road ridgetop scenario is presented in the figure below). At these locations runoff will leave the access road ROW as sheet flow since the length of the contributing drainage area will be significantly less than 100 feet, the generally accepted minimum flow path length at which point sheet flow becomes shallow concentrated or channel flow. However, there is likely to be a small increase in runoff volume due to the increase in impervious area. An analysis similar to that described in Section 2.2 will be performed to demonstrate there is no impact on downgradient property or resources. Options for mitigating an increase in runoff volume include installing a gravel diaphragm or flow diffuser at the downgradient edge of the access road ROW and accounting for storage within or behind the element. Other options that may be considered include minimizing the width of the impervious surface or rehabilitation of the access road by infilling the voids in the access road stone with soil to achieve an effective curve number that is lower than that for gravel alone.

Upon demonstrating that any increase in the volume of sheet flow is mitigated, there is assumed to be no impact on downgradient property or

resources and compliance with the requirements at 9VAC 25-870-66 D is achieved for that drainage area.

Access Road along Ridgetop



3.3 Scenario 2 – Segments with Waterbars

Access road waterbars are used where an access road is ascending or descending a slope generally perpendicular to the topographic contours such that there is very little to no off-site runoff contribution (see example location in the figure below). At these locations, an analysis similar to that described in Sections 2.1 and 2.2 will be performed for each waterbar to demonstrate that: 1) runoff leaves the access road ROW as sheet flow and 2) any increase in runoff volume as a result of new impervious area and/or change in pre-construction hydrologic conditions will be mitigated through runoff volume reduction strategies. Options for mitigating an increase in runoff volume include accounting for storage behind the upgradient permanent waterbar/flow diffuser elements and accounting for storage within roadside ditches. In some instances, other

options that may be considered include minimizing the width of the impervious surface or rehabilitation of the access road by infilling the voids in the access road stone with soil to achieve an effective curve number that is lower than that for gravel alone.

Upon demonstrating that any increase in the volume of sheet flow is mitigated, there is assumed to be no impact on downgradient property or resources and compliance with the requirements at 9 VAC 25-870-66 D is achieved for that drainage area.

Access Road Waterbars

3.4 Scenario 3 – Conversion to Sheet Flow Conditions

Access roads that exist in locations where the surface topography is at an angle to the road will generally be constructed with a roadside ditch and periodic ditch relief culverts. Where feasible (i.e., generally at locations with relatively small contributing watersheds upgradient of the access road ROW), the concentrated flow discharging from the ditch and culvert system will be converted to sheet flow using standard stone aprons and flow diffuser elements prior to leaving the access road ROW. An analysis similar to that described in Section 2.1 will be performed to demonstrate that the runoff leaves the access road ROW as sheet flow. The increase in runoff volume will be assessed in accordance with the methodology identified in Section 2.2 to demonstrate there is no impact on downgradient property or resources. Options for mitigating an increase in runoff volume include accounting for storage within the roadside ditch and behind the flow diffuser at the base of the fill slope. Other options that may be considered include minimizing the width of the impervious

surface or removal and rehabilitation/restoration of the access roads to reduce runoff.

Upon demonstrating that any increase in the volume of sheet flow is mitigated, there is assumed to be no impact on downgradient property or resources and compliance with the requirements at 9 VAC 25-870-66 D is achieved for that drainage area.

3.5 Scenario 4 – Segments with Roadside Ditch and Culvert

Where it is not feasible to achieve sheet flow leaving the access road ROW, compliance will be achieved using the Energy Balance method (i.e., 9 VAC 25-870-66 B.3). Software programs, such as HydroCAD, HEC-HMS or similar, will be used to perform hydrologic computations in accordance with NRCS TR-55 methodology using the 1-year, 24-hour storm event.

The Energy Balance method equations, as presented in 9 VAC 25-870-66 B.3.a are provided below.

Equation 1 $Q_{Developed}$? $/Fx\frac{(Q_{Pre\text{-}Developed} x RV_{Pre\text{-}Developed})}{RV_{Developed}}$

Equation 2 $Q_{Developed}$? $Q_{Pre-Developed}$

Where: $Q_{Developed}$ = The allowable peak flow rate of runoff from the developed site

IF = Improvement Factor (0.8 for sites > 1 acre, 0.9 for sites ?1 acre)

$RV_{Developed}$ = The volume of runoff from the site in the developed condition

$Q_{Pre\text{-}Developed}$ = The peak flow rate of runoff from the site in the pre-developed condition

$RV_{Pre\text{-}Developed}$ = The volume of runoff from the site in the pre-developed condition

$Q_{Developed}$ need never be less than the following:

Equation 3 $\frac{(Q_{Forest} x RV_{Forest})}{RV_{Developed}}$

Where: Q_{Forest} = The peak flow rate of runoff from the site in a forested condition

RV_{Forest} = The volume of runoff from the site in a forested condition

$RV_{Developed}$ = The volume of runoff from the site in the developed condition

Where the Energy Balance is applied stormwater BMPs will be required to reduce the runoff peak flow rate and volume. Options for complying with the Energy Balance include accounting for storage within the roadside ditch; rehabilitation and restoration of access roads to remove impervious cover; and minimizing the width of the impervious surface. In the event access road rehabilitation is applied, supporting computations and details will be provided with the corresponding access road submission.

Upon demonstrating that the Energy Balance is satisfied, compliance with the requirements at 9 VAC 25-870-66 B.3 is achieved for that drainage area.

3.6 Typical Access Road Water Quantity Analysis Package

The access road water quantity analysis is to be presented for each access road or for each group of access roads that connect or are located adjacent to each other as dictated by the topography and hydrography of the local area.

A typical package will include a description of site pre-development and post-development conditions, summary of compliance with water quantity regulations for each segment of the road, and supporting calculations. See Section 7 for additional detail regarding documentation.

4.0 BASIS FOR INPUT DATA

The data to be used in the analysis discussed in Sections 2 and 3 is identified in the following sections.

4.1 Land Cover

The baseline land cover data is obtained as a Land Cover product in a raster and vector data format from the Virginia Land Cover Map Service publicly made available by the VGIN. The VGIN Land Cover product

classifies the land cover using the classification scheme developed by VGIN and its partners. The VGIN Land Cover product aims to provide improved land coverage data to assist localities in planning and implementation of stormwater management programs. This evaluation utilizes the categories of the VGIN Land Cover product. The data set used for the pre-development land cover condition in this analysis is the VGIN Land Cover product. Data utilized is sourced from the following: https://vgin.maps.arcgis.com/home/item.html?id=6ae731623ff847df91df767877db0eae.

The data maintained by VGIN is understood to be compiled from sources ranging in dates per the below: "1 meter Land Cover Dataset based on a 12 item classification scheme. This statewide dataset is divided into tiled imagery from the Virginia Base Mapping Program (VBMP) orthophotography between the dates of 2011 and 2015."

The data set for the post-development land cover condition in this analysis is developed using the baseline land cover data and the following assumptions for each new and existing major upgrade permanent access road:

1. the access road is approximately 16 feet wide and surfaced with gravel; and

2. all areas categorized as Forest within the pipeline permanent and temporary ROW will be converted to the scrub-shrub land cover category.

To facilitate the evaluation of water quantity, runoff curve numbers are assigned to each land cover classification using the land cover descriptions presented in the TR-55 manual and the Virginia Stormwater Management Handbook. The correlation of the land cover categories with TR-55 land cover descriptions and the associated curve numbers is presented in Attachment 2.

4.2 Topography

The stormwater analysis utilizes the best consistently-available topography, which is derived from several different sources, including VGIN LiDAR and project-specific LiDAR. Since multiple sources are utilized the contour intervals vary with location. Specific sources are noted within the water quantity analysis packages.

4.3 Soils

The Hydrologic Soil Group (HSG) classification is obtained from the Soil Survey Geographic Database (SSURGO) publicly available from the United States Department of Agriculture (USDA) NRCS. The HSG D is assigned in cases where the HSG is listed as A/D, B/D, or C/D. In cases where HSG was not listed, HSG was assigned as presented in White Paper Attachment 3.

4.4 Storm Events and Precipitation Depths

Runoff volumes and peak flow rates are calculated for the 1-year, 24-hour; 2-year, 24-hour; and 10-year, 24-hour storm events as needed in the water quantity analysis. Precipitation depths are obtained from the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service. The precipitation depths for each storm were obtained from NOAA as iso-contours.

5.0 COMPLIANCE STRATEGIES

Several key aspects to the water quantity compliance strategy are included here.

5.1 Pipeline Area Restoration and Rehabilitation Strategies

Per 2017 DETI AS&S:

"The forestry and vegetative management practices employed by DETI within the right-of-way comply with the VRRM recommendations for open space. Where the right-of-way consists of forest or open space conditions prior to the construction activity, and will remain in a forested or open space condition under post-developed conditions (e.g., undisturbed or restored to a hydrologically functional state and all surfaces will remain as permeable surfaces which are mowed no more than once every three years, in accordance with FERC Plan Guidelines or maintained in accordance with Table 1 referenced above), runoff curve numbers are identical under the Virginia Runoff Reduction Method.

Further the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) provides additional guidance and background on the development of natural scrub-shrub habitat. Per the NRCS Fish and Wildlife Habitat Management Leaflet Number 42 "Scrub-shrub Birds" (January 2007).

Under Natural Regeneration on page six, "The process of natural regeneration is slow, inexpensive, and, where not constrained by other considerations, should be the favored option. A disturbance such as grazing, lightly disking, burning, or mowing, may be necessary to begin this process. After scrub-shrub has been established, periodic management is necessary to maintain it in an early successional stage."

Additionally, on page 6 "Planting should only be done where there is no natural source of regeneration or when a rapid result is required."

As such, it is anticipated that successional regeneration will provide for a long-term scrub-shrub condition in terms of representative species and right-of-way maintenance practices; however, this may take time. As such, given the breadth of activities proposed, it has been discussed that a component of the permanent stabilization be modified to include a seed source of select scrub-shrub species. This would initiate a jumpstart of successional processes and to provide more near-term assurance that scrub-shrub conditions will be established.

As a commitment to this result, Dominion would ensure that the permanent seed mix be adjusted within the permanent right-of-way to incorporate a minimum percentage (e.g., 3-10%) of early successional scrub-shrub species to establish a seed source for scrub-shrub development consistent with the plan for seeding and planting for the adjacent restoration of the temporary right-of-way.

Select species will be identified that promote this land cover consistent with the TR-55 definition for scrub-shrub, and Dominion will incorporate species that are shown for the temporary right-of-way seeding palette under the current Restoration and Rehabilitation (R&R) Plan to be planted within the permanent 50-foot ROW. This is understood to further ensure final stabilization conditions will provide for hydrologic functionality noted under scrub-shrub and are consistent with maintenance practices under DETI AS&S.

Updates will be reflected in the ACP Restoration and Rehabilitation Plan, as necessary. Land cover CN's for permanent ROW consistent with scrub-scrub under TR-55 are provided under Attachment 2.

5.2 Volumetric Offsets Evaluation

In areas where increased volumes of sheet flow may indicate an increase in downstream channel velocity, when increases in velocity are noted (percent increase computed using two significant figures), aggressive

pursuit of compliance is sought through assurance that additional detention volumes are provided in offset. To evaluate efficacy of volumetric offsets, the methodology was used as defined under Technical Release 55 Urban Hydrology for Small Watersheds (TR-55), Chapter 6.

In lieu of detailed modeling through a TR-55 modeling interface, an alternative process was utilized to assess aggregate volumes of sheet flow as defined under TR-55 Chapter 6 – Storage Volumes for Detention Basin. This method is also identified under the DEQ Plan Reviewer for Stormwater Management Certification Course, and may be utilized to assess the storage volume required (Vs) in relation to the post-development calculated runoff volume (Vr) with a conservative and reasonable Factor of Safety (FOS) of 1.25. This method is utilized across the project; however, individual practice and structure routings may be applied, if necessary.

Per Chapter 6 (page 6-2), "Use figure 6-1 estimate storage volume (Vs) required or peak outflow discharge (qo). The most frequent application is to estimate Vs, for which the required inputs are runoff volume (Vr), qo, and peak inflow discharge (qi). To estimate qo, the required inputs are Vr, Vs, and qi."

For the purposes of the project, Vs (required storage) was determined utilizing Figure 6-1, for a Type II distribution of the relevant storm event (2-year or 10-year event) and "Worksheet 6a: Detention basin storage, Peak outflow discharge (q_o) known" under TR-55 Appendix D-7. See Section 7 below regarding documentation of this methodology. TR-55 pages 6-2 and D-7 are provided under Attachment 4.

6.0 MITIGATION MEASURES

The following provides discussion regarding treatments and measures used to either maintain sheet flow, address volumes associated with sheet flow areas, or to address energy balance compliance, as applicable.

6.1 Sheet Flow Maintenance and Increased Volumes Evaluation

Per the flow chart under Attachment 1, the primary compliance path is through maintenance of sheet flow leaving the project. The below is intended to provide an overview of the basic components.

6.1.1 Standard Stone Apron – Flow Assessment and Detail Development

The following is intended to provide background to the consulting team's approach to very conservatively demonstrate that waterbar and culvert feature outlet flows discharge in a sheet flow condition. Additionally, this assessment has been used in developing standardized details and flow-based triggers for use in stormwater management plan evaluation Water Quantity Calculations Package.

Modified Apron Evaluation

The consultant team evaluated depth and flow values across the modified apron at the outfall of culverts and waterbars along the access roads and pipeline to ensure sheet flow at the outfall of the apron. This effort utilized the weir equation (Source: Chapter 5, VSWMH,1999), see Equation 6.1 below, to calculate a discharge at the outfall of the apron with varying apron lengths analyzed. Assumptions used in the weir equation include a dimensionless weir coefficient of 3.0, and a constant depth of water over the weir of 0.1 feet (ft), understood as a threshold depth for sheet flow conformance specific to the project.

Equation 6.1: Weir Equation

$$Qw = Cw \times L \times h^{1.5}$$

Where: Qw = weir discharge, cfs

Cw = dimensionless weir coefficient

L = Length of weir, ft

h = hydraulic head, ft

Once flow values were obtained, the design team determined the normal depth within the practice leading to the apron for reference only. The analysis centered on providing a conservative documentation of sheet flow depths (0.1 foot of less) leaving a stone apron weir. The normal depth in a waterbar for reference was determined using Bentley Systems FlowMaster v8i for a representative v-ditch with 2:1 ft/ft (H:V) side slopes, an 8% longitudinal slope, and a manning's n of 0.041. To determine the normal depth of flow through culverts of various sizes, Bentley Systems CulvertMaster v3.3 software was utilized to model each

culvert size at each of the specified weir lengths and corresponding discharges for a point of reference. Assumptions used in this assessment include a culvert length of 24 ft, the standard design slope for each culvert size per the project culvert design under Section 6.3, projecting inlet conditions, and a Manning's roughness coefficient for corrugated metal pipe (CMP) of 0.024. See Table 6.1 below.

Table 6.1: Conservative End Treatment Weir Discharges (0.1 feet Deep)

				Depth in Culvert, ft (via CulvertMaster computation)						
	Length of Weir (ft)	**Calculated Weir Discharge (cfs)**	**Corresponding Depth in Waterbar (ft)**	**12"**	**18"**	**24"**	**30"**	**36"**	**42"**	**48"**
SSA Type 1	2	0.190	0.21	0.14	0.12	-	-	-	-	-
SSA Type 1	3	0.285	0.25	0.17	0.15	-	-	-	-	-
SSA Type 2	4	0.379	0.28	0.19	0.17	0.17	-	-	-	-
SSA Type 2	5	0.474	0.30	0.21	0.19	0.19	0.19	-	-	-
SSA Type 2	6	0.569	0.32	0.23	0.21	0.21	0.21	0.22	-	-

Standard Detail Development

This modified apron evaluation and the sheet flow velocity check analysis was utilized to develop standard stone apron details which are then implemented across the project at the lower end of the 10-year flow range. This defines typical apron sizes for 12 to 18-inch diameter culverts and waterbars that receive 10-year flows between 0 cfs and 0.569 cfs. See the estimated flow triggers per the draft SSA under Attachment 4. For flows between 0 cfs and 0.284 cfs, a SSA Type 1 is selected. Once flows exceed 0.284 cfs and remain equal to or less than 0.569 cfs, a SSA Type 2 will be provided. Should flows exceed approximately 0.569 cfs, a flow diffuser (See Section 6.1.2) will be employed unless concentrated flow conditions are understood to apply at the end of feature, such as at concentrated channels and jurisdictional features (areas of energy balance). See construction details for SSA Type 1 and Type 2 (Figures 6.1, 6.2, and 6.3). See the estimated flow ranges used to derive triggers for SSA's under Attachment 4. All SSA's will be designed using the 10-year storm event.

Figure 6.1: Standard Stone Apron (SSA) Type 1 and Type 2 (Detail 1)

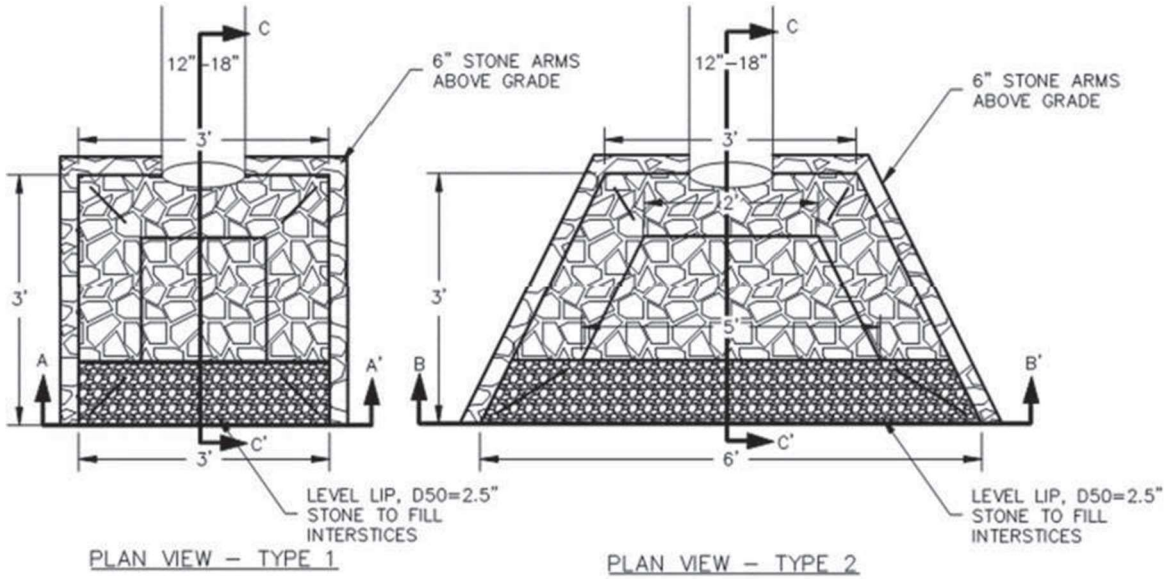


Figure 6.2: Standard Stone Apron (SSA) Type 1 & Type 2 (Detail 2)

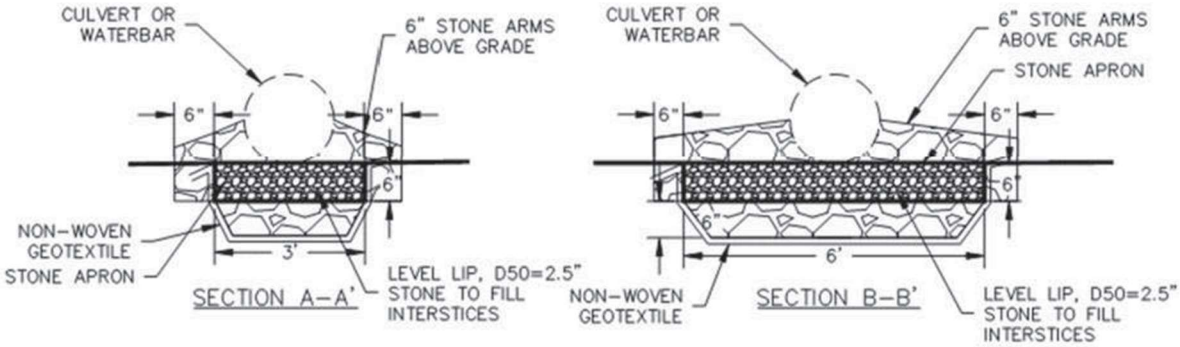
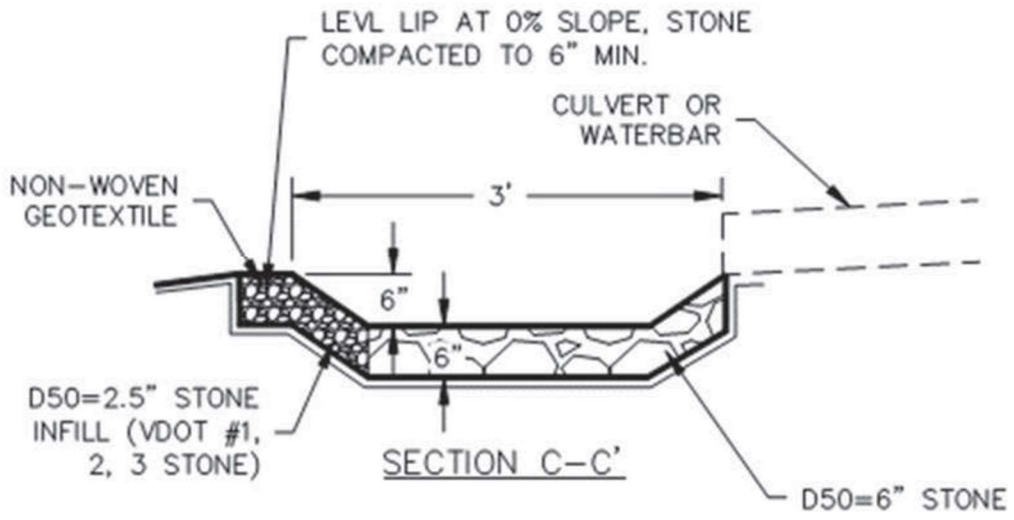


Figure 6.3: Standard Stone Apron (SSA) Type 1 & Type 2 (Detail 3)



6.1.2 Flow Diffuser Basis of Design and Constructability Optimization

As noted above, a Flow Diffuser will be provided as a feature end treatment when flows exceed 0.569 cfs as part of the overall stormwater management water quantity compliance approach. All Flow Diffusers will be designed using the 10-year storm event. Similar water quantity / flow transition standards in Virginia, such as Virginia Standard and Specification 3.21 – Level Spreader (VESCH), designed based on the 10-year storm event, cite a 1.0 cfs per linear foot of weir length; however, in effort to find a more conservative approach the consultant team reviewed similar state standards for maintenance of sheet flow.

As such, the Flow Diffuser details provided herein have been developed following review of similar state standards, such as the Maine Level Spreader in Section 8.3 of the Maine Stormwater Best Management Practices Manual, September 2010, which mirrors the 0.25 cfs per linear feet design value, and the H.R.C Research Series Report No. 10 – Analysis of Flow Through Porous Media as Applied to Gabion Dams Regarding the Storage and Release of Storm Water Runoff, NAHB/NRC Designated Housing Research Center at Penn State, August 1992 (Penn State Analysis). Additionally, several project constraints have been considered, including practical implementation in pursuit of sheet flow maintenance, Virginia-specific needs for conformance under 9VAC25-870-66.D, and Virginia specific constructability, namely downstream sheet flow

definition held to 100 feet, Virginia best practice (inclusive of Virginia Department of Conservation and Recreation – *Technical Bulletin No. 2, Hydrologic Modeling and Design in Karst*), and modification of the downstream steep slope limitations per similar standards (e.g. Maine Level Spreader) through mitigation efforts (0.125 cfs / linear foot sizing in areas 30% and greater downstream of the practice).

The structure has two main components, the first being the flow through the stone berm and the second being the weir flow once the berm is crested. To estimate the flow through the stone berm, Darcy's Law / Equation was utilized. The equation was optimized within standard hydraulic conductivity ranges to produce a peak flow rate of 0.25 cfs per linear foot when the headwater condition is at the berm crest height. The rating curve then utilizes the results of Darcy's Equation up to the berm height capped at 0.25 cfs per linear foot of weir length, which is equivalent to the 10-year flow (based on the Penn State study and state references). As such, the 10-year storm is established at the top of the stone berm, and the resultant flow through the berm is maintained in sheet flow. The composite rating curve for the Flow Diffuser complex (stone sump and stone berm) combines the stone berm segment (8 inches of stone) and the weir equation to estimate flows that overtop the berm. The weir equation utilizes a conservative weir coefficient of 3.0. In areas where detailed routing models for the flow diffusers are required this rating curve will be utilized. See White Paper Attachment 4 for rating curve information.

Given some of the project terrain and to augment the BIC approach employed by ACP, the project team has committed to additional design restrictions when downstream slopes exceed 30%. In this instance, the 0.25 cfs per linear foot of weir crest length requirement will be reduced to 0.125 cfs. This effectively doubles standard flow diffuser spacing, ensuring more diffuse distribution of flows, and will theoretically reduce the depths of sheet flows within these more sensitive slope areas.

Further, to address additional constructability, stability, and adaptation for project use, a series of additional diffuser improvements include:

- The addition of a one foot wide level lip at zero percent grade, tying out to existing downstream grade to provide enhanced sheet flow transition (See Figures 6.4 and 6.5 below);
- The incorporation of two types of diffuser practices to accommodate normal construction (side slopes 2:1 or flatter) and more space constrained environments (side slopes steeper than 2:1) such as adjacent to access roads;
- The addition of a woven geotextile fabric on the downstream sump trench face and a non-woven geotextile on the bottom of the

facility in typical facilities as a best practice to promote flow through the level lip with drainage capability through the sump floor (if applicable);

- Weeps are needed in instances where an impermeable liner is used or when HSG C or D soils are encountered in Flow Diffuser construction. Weeps have been proposed to address two concerns, namely:
    - Karst – Where Flow Diffusers are sited within defined limits of Karst geology (whether on plans or as noted under field conditions) or Karst indicative features, "such as rock outcrops, sinkholes, springs, caves, etc." (Technical Bulletin No. 2, Virginia Department of Conservation and Recreation – Hydrologic Modeling and Design in Karst) are identified within the immediate downstream area – a liner is desirable to inhibit exfiltration from the facility. Additionally, underdrains or weeps are needed to drain the facilities in accordance with Technical Bulletin No. 2 where it is desirable in that: "Inlet and outlet structures should be designed to provide diffuse discharge of water; avoid concentration of flows. Under drains are preferred to provide gradual discharge of water and to avoid prolonged ponding of water." The general intention of the development strategy is to maintain existing drainage patterns to the extent practicable. In addition, the Flow Diffusers are intended to provide general attenuative effects, while providing diffuse discharge in pursuit of conditions endorsed by Technical Bulletin No. 2, while meeting the applicable subsection(s) of 9VAC25-870-66.
    - Within HSG C and D – It is understood that sump storage may take longer to exit via exfiltration, evaporation, etc. where Flow Diffuser footprints are sited within identified HSG C and D soils. As such, weeps are proposed where Flow Diffuser footprints are sited within C and D soils. (General Note – Whether in Karst or in C or D HSG soils field engineering will be required to accommodate myriad field conditions and outfall configurations related to weeps.)
- Incorporation of a stone sump area, which may be expanded to allow for flexibility in the field regarding materials and the addition of storage, as the need arises.
- Field adjustment factors for increased length should high groundwater table conditions be found during construction (See Attachment 4.10).

See construction details for Flow Diffusers (Figure 6.4 and 6.5) below.

Figure 6.4: Flow Diffuser (Side Slopes 2:1 or Less Steep)

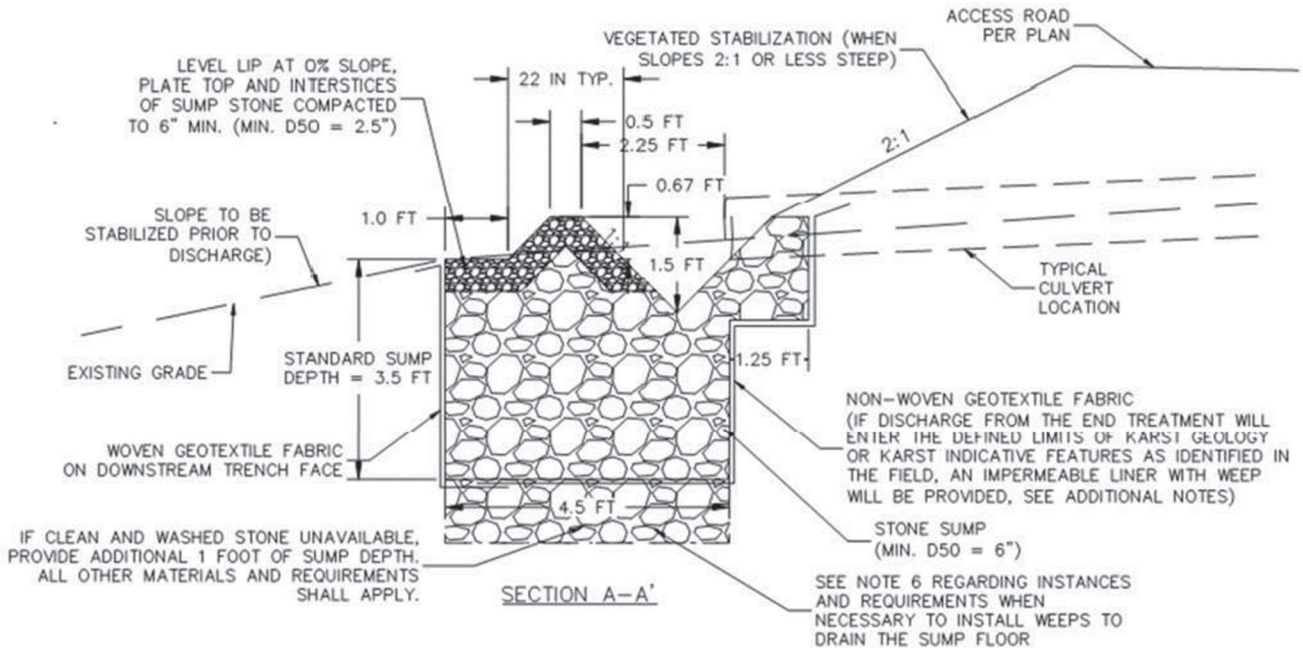
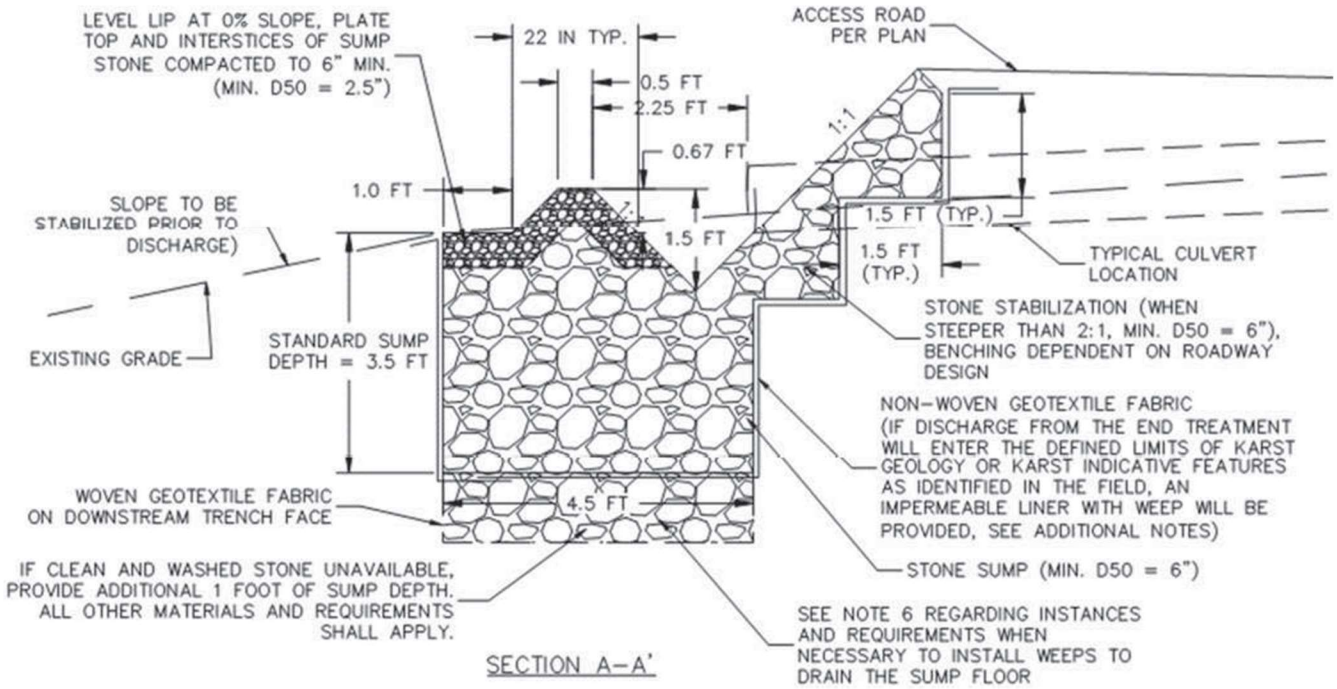


Figure 6.5: Flow Diffuser (Side Slopes Steeper than 2:1)



Flow Diffuser sizing will be provided under the Water Quantity Package per the following:

Sizing standardization, which provides for upsizing of features for standard construction practices in the field will be provided on the construction plans. Generally, the standard sizing will start at a minimum weir length of 6 feet and increase in 2 feet increments. Sizing upgrades for the areas subject to decreased flow (0.125 cfs) sizing criteria will also be upsized per the standard sizing categories.

See Attachment 4 for additional information regarding standard sizing of Flow Diffusers.

As noted, in areas where facilities discharge directly to a Karst feature, and thus receive an impermeable liner, and in areas with HSG C and HSG D soils, the Flow Diffusers will be provided with the ability to weep / drain the sump condition. These instances will be identified on the construction plans. Weeping will be provided in these instances, primarily through a gravel trench (6 inches by 6 inches), or french drain composed of VDOT #57 Stone wrapped in a non-woven geotextile fabric. Modifications to french drains / weeps to address field conditions / constraints will be provided on construction record drawings.

Additional Sump Volume to Address Unwashed Stone

To address the settling of fines through the potential use of unwashed stone, the flow diffuser detail has been enhanced with the option for additional gravel sump storage. To estimate the volume of fines associated with the unwashed stone, it was conservatively estimated that 5% of the total stone weight was made up of fine material. Based on the volume of stone per linear foot of flow diffuser and standard densities for gravel and loose dirt, a fine material volume estimate and corresponding required sump storage were developed. This volume of sediment corresponded to a required sump depth, taking a porosity of 0.4 into account, of 0.86 feet. This depth was conservatively increased to 1 foot and is listed as a requirement if un-washed stone is to be used in the construction of the flow diffuser. Notes requiring these adjustments to provide for field flexibility and long-term improved facility efficacy are provided on the construction plans.

Diffuser Sediment Loading

To estimate the necessary maintenance frequency of the proposed flow diffusers, sediment loading estimates based on guidance from the

Chesapeake Bay TMDL Action Plan Guidance GM15-2005 were analyzed. To conservatively assess the pipeline ROW the Forested TSS loading rates per River Basin were averaged to yield a 60.56 lbs/acre/year loading rate. Assuming maintenance is required once sediment has reached 50% of the total provided storage volume, cleanout would be required approximately once every 160 years. To conservatively assess the access roads the Regulated Urban Impervious loading rates per River Basin were averaged to yield a 682.23 lbs/acre/year loading rate. Assuming maintenance is required once sediment has reached 50% of the total provided storage volume, cleanout would be required approximately once every 14 years. Due to the lifespans noted in both the pipeline ROW and access road sections and with the 1-year inspection frequency as defined in the flow diffuser maintenance specifications, the requirement for clean-out becomes more of an inspection based protocol than a strict yearly mandate.

Maintenance requirements for the Flow Diffusers are provided on the construction plans.

Flow Diffuser Construction in High Groundwater Table Conditions

The Standard Sump Depth as defined per the Flow Diffuser detail (3.5 feet) will need to be adjusted by the contractor in the field in the event that High Groundwater Table (HGWT) conditions are encountered. In these circumstances the contractor shall determine the Effective Sump Depth based on the HGWT influence, and then will increase the sizing of the flow diffuser to be installed by multiplying the Flow Diffuser Length Per Plan by the appropriate Flow Diffuser Length Multiplier, which has been incorporated into the Flow Diffuser detail. These Length Multipliers were developed by estimating the effective volumes on a per linear foot basis and correlating the volume associated with the reduced sump depths to that of the typical Flow Diffuser detail (Attachment 4). Also, see Attachment A4.10 for additional detail.

6.1.3 Sheet Flow Downstream Velocity Assessment

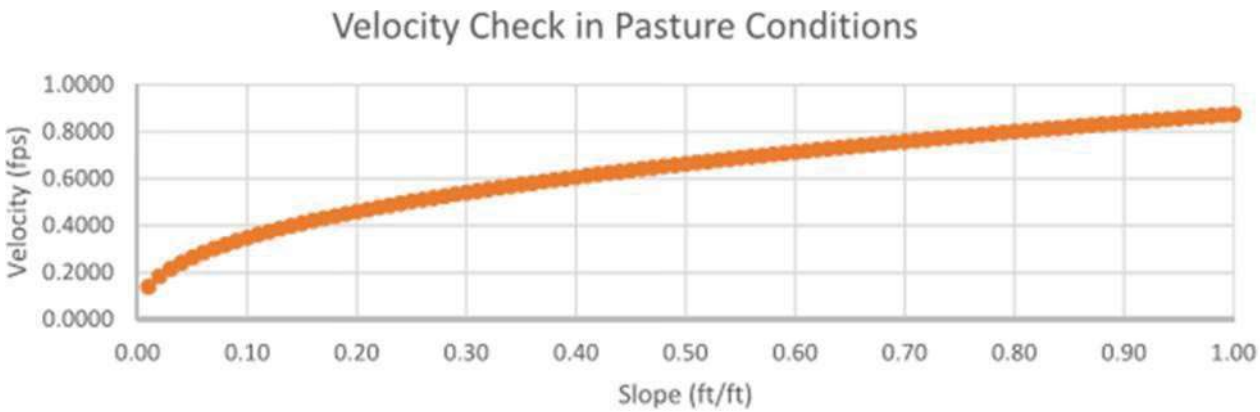
Sheet Flow Velocity Check

To address how areas outside the ROW (which are often forested without dense herbaceous cover) will be protected, the team has utilized assumptions of a pasture-like stabilization mix for the slope permissible velocity analysis. The question centers on whether this analysis is sufficiently conservative for downstream areas which may be higher slope and/or may have forested rather than herbaceous land covers. The team

evaluated the issue utilizing the travel time equation for sheet flow contained in TR-55 (Equation 3-3). The equation was utilized for sheet flow lengths of 100 ft. to assess the travel time and associated velocity. In these instances, the original assumptions of pasture-like conditions are compared to those for forested conditions (to be conservative, the team utilized the sheet flow Manning's roughness value of 0.4 for Woods with light underbrush). As shown below in Figures 6.6 and 6.7, the increased roughness associated with wooded areas reduces the velocities to well within permissible ranges, even for steeper slope non-pasture areas. Permissible velocity ranges are between 1.9 and 6 fps depending on channel slope, lining material, and soil erodibility as shown in VESCH Chapter 3, Table 3.18-A, attached. For example, whereas a receiving area with a pasture-like land cover originally utilizing a Manning's n of 0.15 on a 20% slope (0.2 ft/ft vertical to horizontal) would yield a velocity of 0.41 fps, the same analysis of sheet flow for discharges to Woods with light underbrush would yield a velocity of 0.19 fps. See Attachment 4 for tabular curve development noted under figures below.

Figure 6.6: Velocity Check in Wooded Conditions

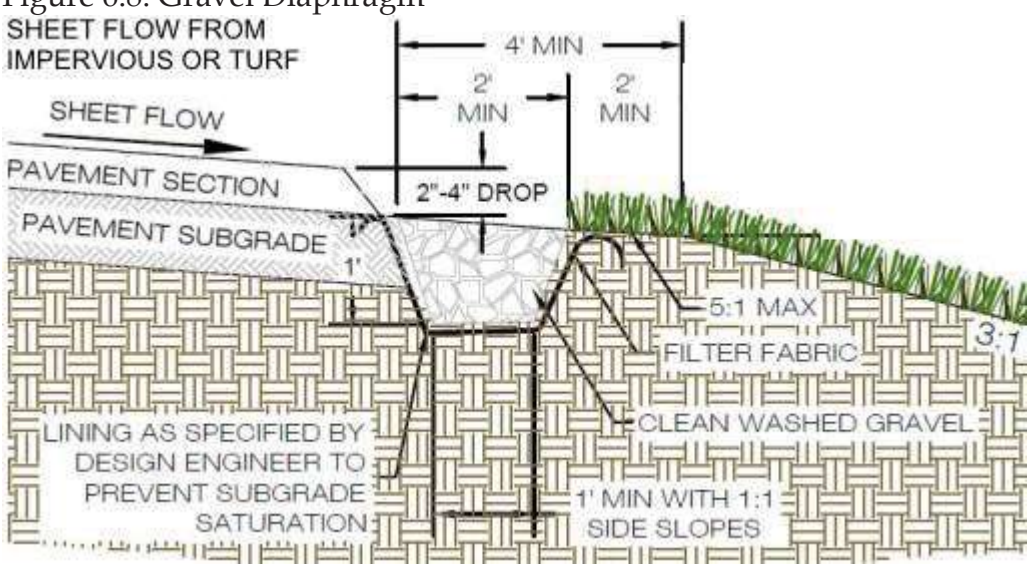
Figure 6.7: Velocity Check in Pasture Conditions



6.1.4 Access Road Ridgetop Condition – Gravel Diaphragm

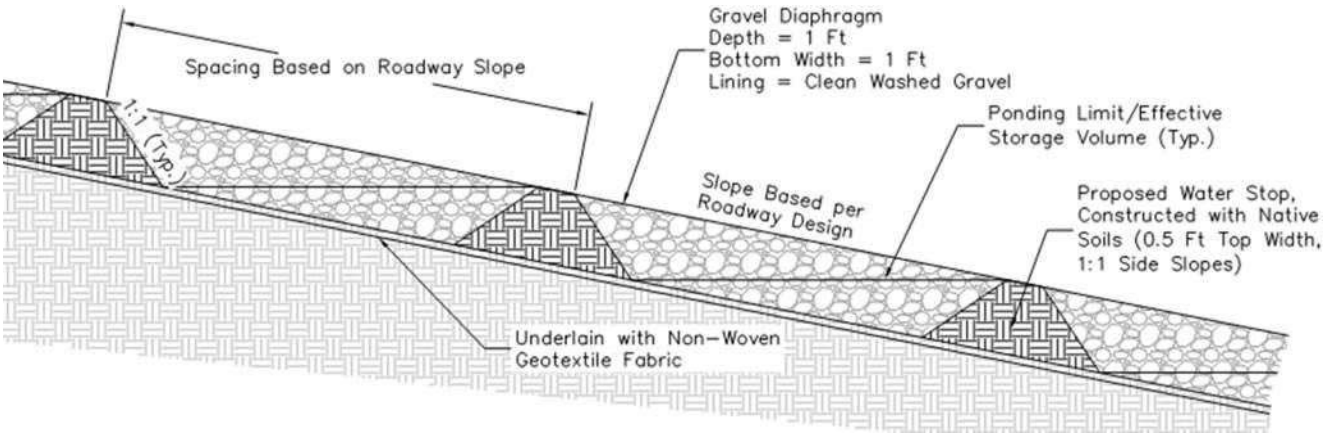
Generally, the minimal impervious area introduced by the access road improvements may be considered sheet flow where the roads are constructed in a ridgetop, or crowned, geometry given the limited flow length and adjacent topography. However, to further ensure sheet flow under water quantity criteria, a Gravel Diaphragm (generally shown under Figure 6.8) will be provided in areas where re-concentration may occur within the 100-foot buffer. As such, these will be identified to accompany road construction in areas, as applicable. Increases in Gravel Diaphragm dimensions to provide additional volumetric offset, if necessary, are understood to be conservative. As such, no deviation or exception from DEQ should apply. Expanded sizes of Gravel Diaphragms, if applicable, will be identified individually within the design packages.

Figure 6.8: Gravel Diaphragm



Because ridgetop road conditions will generally traverse ascending/descending ridgetop roads, it is important to consider A) constructability, B) effectiveness, and C) conservative volumetric quantification for gravel diaphragms utilized for purposes of addressing volumetric offsets. Water stops will be provided in gravel diaphragms to discourage flow through the gravel trench where this is not intended.

Figure 6.9: Gravel Diaphragm with Water Stops



The water stops will be constructed of native soil material per Figure 6.2. The water stops will be provided in gravel diaphragms according to roadway slopes as defined on the construction documents. See Water Stop Spacing in Table 6.3 below.

Table 6.10: Water Stop Construction Cross Section

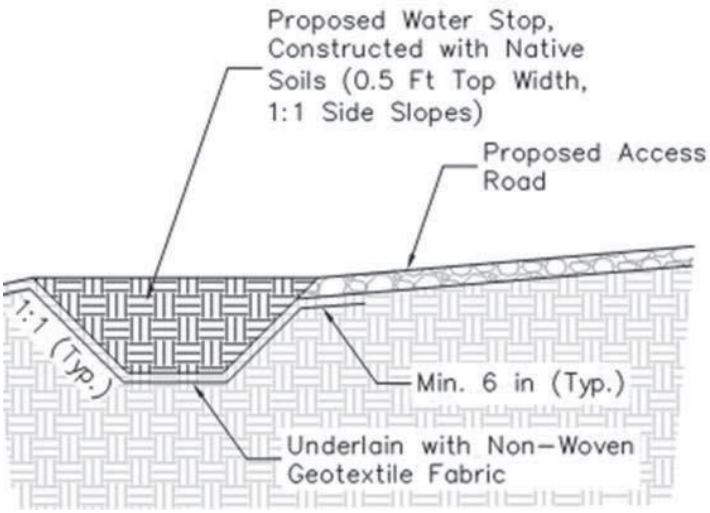


Table 6.2: Gravel Diaphragm Water Stop Spacing

Water Stop Spacing:

Roadway Slope	Water Stop Spacing
0% – 5%	21 FT
+5% – 10%	11 FT
+10% – 15%	8 FT
+15% – 20%	6 FT
+20% – 40%	4 FT

6.2 Concentrated Stormwater Discharges From Project Areas

Where it is not possible for the consultant team to maintain sheet flow, where the complexity of drainage patterns may indicate, or more expeditious and conservative application of the energy balance equation may be more applicable, Channel Protection (9VAC25-870-66.B) and Flood Protection (9VAC25-870-66.C) criteria shall apply. Additionally, where the complexity of drainage patterns may indicate or more expeditious and conservative application of the energy balance equation may be more applicable, satisfaction of water quantity criteria may also be met through Channel Protection (9VAC25-870-66.B) and Flood Protection (9VAC25-870-66.C) criteria at the discretion of the designer. The following provides general discussion as to the compliance approach in these situations; however, further strategy and detail may be provided under individual spread design packages.

6.2.1 Channel Protection – 9VAC25-870-66.B

Where concentrated flows leave the site, principally at areas of jurisdictional culvert crossings, 9VAC25-870-66.B will apply. In these instances, the energy balance equation will apply to the area of improvement that drains to the concentrated flow point leaving the site.

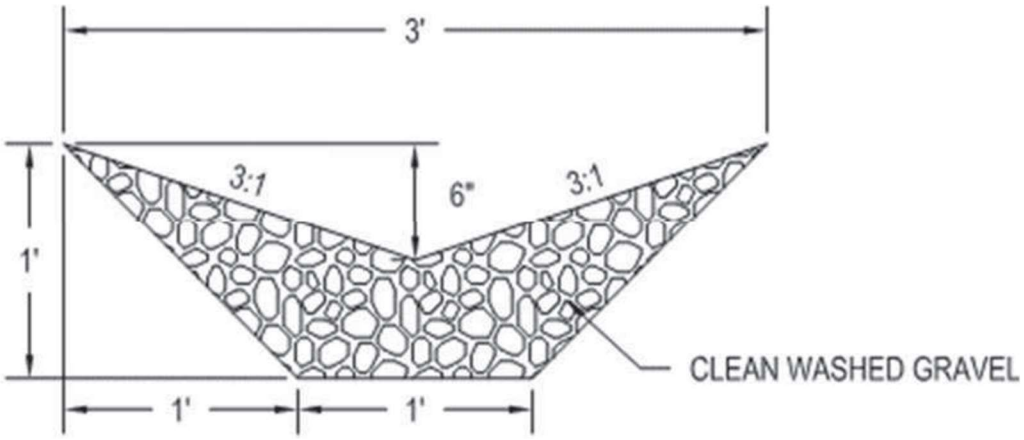
Generally, the stormwater management strategy (particularly for access roads) centers on providing separation of runoff from onsite improvements from that of offsite, undisturbed areas. This is addressed through several possible ways generally, or as specifically designed and documented to address nuanced site constraints under the Water Quantity Package, if applicable.

One option generally employed in areas that require energy balance equation satisfaction is the Culvert Flanking Strategy (See Attachment 4),

whereby use of cross culverts to Flow Diffusers, ditches, microtopography, or some other conveyance option may be employed to A) contain onsite drainage and provide detention / release control and B) bifurcate onsite flows from offsite flows. This is accomplished by "flanking" a primary cross culvert, which carries offsite bypass flows through the project, with smaller culvert / diffuser complexes just upstream within the roadway section. Flow from these diffusers are still intended to outfall in sheet flow per the Flow Diffuser sizing; however, these areas are generally included in the energy balance applicable area to remain conservative and avoid design /documentation iteration.

Further, there may areas of energy balance that are required where proposed access road improvements are in ridgetop condition. In these instances, options include expanding the size and storage volume of standard Gravel Diaphragms to address volume control locally. Or another option is to provide a Gravel Diversion Trench (see Figure 6.11 below) to control areas of runoff and direct them to downstream storage practices.

Figure 6.11: Gravel Diversion Trench



6.2.2 Flood Protection – 9VAC25-870-66.C

Similarly, where Channel Protection applies, Flood Protection will also be demonstrated in accordance with 9VAC25-870-66.C. In these instances, the 10-year storm requirements will be addressed. Generally, this will be demonstrated with modeling of project improvements, including Flow Diffusers to demonstrate 10-year flow attenuation. Available aerial photography, topography, FEMA Flood Insurance Rate Maps (FIRM), or local digital GIS floodplain mapping will be utilized in review. Documentation will be provided under Spreadsheet Tab / Attachment 14

– Flood Protection. See Section 7 for additional detail regarding template documentation.

6.3 Culvert Design

Standardized culvert sizing is employed for the project in areas of intended sheet flow and concentrated flow discharges. The proposed culverts are sized for the 10-year, 24-hour peak flow rate using design charts for circular pipe flow presented in Appendix 8C-61 of the Virginia Department of Transportation (VDOT) Drainage Manual. The culverts are proposed to be constructed using corrugated metal pipe with approximate Manning's roughness coefficient of 0.024. The design limits the headwater depth to the diameter of the culvert. For example, the design maximum headwater depth for a 12-inch culvert is 12 inches. The design slope and maximum discharge capacity for each culvert size is selected using design charts for circular pipe flow considering headwater depth equivalent to culvert diameter and outlet velocity of six feet per second (fps) for 12-inch diameter culverts and eight fps for all other culverts. Culvert size is selected so that the calculated 10-year, 24-hour post-development peak flow rate is no more than 90 percent of the culvert maximum discharge capacity. The final culvert slope is to be adjusted in the field, as needed, to convey the required peak flow rate and to maintain an acceptable discharge velocity. The table below identifies the design criteria for each size culvert considered under standard sizing. In instances where designs may exceed these standards, such as offsite flow bypass, a site specific culvert design will be provided and documented under detailed submittals.

Table 6.3: Standard Culvert Design

Culvert Design					
Diameter of Culvert (inches)	Maximum Headwater (inches)	Design Velocity (fps)	Design Slope (feet/feet)	Maximum Discharge Capacity (cfs)	Maximum Allowable Peak Flow Rate (cfs)
12	12	6	0.06	4.5	4.1
18	18	8	0.06	14	12.6
24	24	8	0.04	25	22.5
30	30	8	0.03	40	36
36	36	8	0.023	55	49.5
42	42	8	0.019	75	67.5
48	48	8	0.017	100	90

7.0 TEMPLATE DOCUMENTATION

To provide a template for analysis, documentation, and review, the consultant team developed a standardized reporting structure that includes a cover memorandum (Overall Water Quantity Narrative) for the Spread on a pipeline and access road basis. The memo provides general information and reference to Appendices that are provided in a consistent framework that is included here:

A. Water Quantity Compliance Summary Tables
B. Figures: Precipitation Values
C. Figures: Drainage Features
D. Figures: Pre-Development Land Cover
E. Figures: Post-Development Land Cover
F. Figures: FEMA Floodplain Map
G. ACP Water Quantity Calculations Packages
H. TR-55 Modeling Reports
I. Figures: Hydrologic Soil Groups & Geologically Sensitive Features

The key components, Appendix A – Water Quantity Compliance Summary Tables, Appendices C, D, and E – Mapping Components, and Appendix G – ACP Water Quantity Calculations Packages are discussed in more detail below.

7.1 Memo Appendix A – Compliance Summary Tables

The first appendix is intended to provide an overall understanding for key points of analysis (POA's), whether they relate to sheet flow analysis or concentrated flow analysis, and what regulatory section has been satisfied. An example Compliance Summary Table is provided on Figure 7.1 below.

Figure 7.1: Example Water Quantity Compliance Summary Table

Atlantic Coast Pipeline

Atlantic Coast Pipeline (ACP)
Water Quantity Calculations Compliance Summary

Access Road / Pipeline ID: XXXX - XXXXX - XXX

Sheet Flow (9VAC25-870-66.D) Areas - Compliance Summary

Starting Station	Ending Station	D/S Point of Analysis	Aggregate Drainage Areas	Sheet Flow End Treatment Provided?	Initial Sheet Flow Complaince - D/S Aggregate Check			Sheet Flow Compliance with Mitigation Measures - D/S Aggregate Recheck, if necessary		Compliance Achieved Through
					Velocity Evaluation Performed Satisfactorily (per flowchart)?	Localized Flooding Evaluation Performed Satisfactorily (per flowchart)?	Mitigation Measures Required?	Velocity Evaluation Performed Satisfactorily (per flowchart)?	Localized Flooding Evaluation Performed Satisfactorily (per flowchart)?	
3+50	9+50			Yes	Yes	Yes	No	Yes	Yes	9VAC25-870-66.D
0+00	9+50			Yes			Yes	Enter Value	Enter Value	ERROR - RECHECK
				Yes			Yes	Enter Value	Enter Value	ERROR - RECHECK
				Yes			Yes	Enter Value	Enter Value	ERROR - RECHECK
				Yes			Yes	Enter Value	Enter Value	ERROR - RECHECK
				Yes			Yes	Enter Value	Enter Value	ERROR - RECHECK

Concentrated Flow (9VAC25-870-66.B & 9VAC25-870-66.C) Areas - Compliance Summary

Starting Station	Ending Station	Point of Compliance	Aggregate Drainage Areas	Conforms with 1-YR Energy Balance?	Conformance with 10-YR Flood Protection Criteria?	Energy Balance Compliance Achieved Through	Energy Balance Notes	Flood Protection Compliance Achieved Through	Flood Protection Notes
				Yes	Yes	9VAC25-870-66.B	-	9VAC25.870-66.C	No D/S Flooding Apparent, but 10-YR Attenuation Provided
				No	No	No	-	No	
						No	-	No	
						No	-	No	
						No	-	No	

1) Note: Areas cited under this Sheet Flow (9VAC25-870-66.D) Areas - Compliance Summary are consistent with project regulatory compliance approach and maintain sheet via end treatment measures defined.

2) Note: Velocity checks for downstream (d/s) aggregate areas of sheet flow are conservative. Compliance strategy seeks to generally adderess velocity through a net zero change (above and beyond regulatory requirements of 9VAC25-870-66.D) approach when comparing downstream velocities to 2 signficant figures. Note there may be several downstream POAs assessed to remain conservative.

3) Note: Areas cited under this Concentrated Flow (9VAC25-870-66.B & 9VAC25-870-66.C) Areas - Compliance Summary are consistent with project regulatory compliance approach and meet VSMP Regulations 9VAC25-870-66.B and 9VAC25-870-66.C.

4) See individual water quantity compliance packages for additional compliance detail.

5) Flowchart refernces noted refer to Water Quantity Compliance Flow Chart per the White Paper.

7.2 Mapping Components

Several mapping components will be included with each access road and pipeline ROW Water Quantity Package to support the calculations in the Water Quantity Calculations Spreadsheet. Graphics depicting the site topography, identified waterbodies and wetlands, ROW limits, drainage features, delineated watersheds, and access road stationing are included in the cover memorandum (Overall Water Quantity Narrative) Appendix C. Additional mapping displaying the delineated drainage areas in respect to hydrologic soils groups and the pre-development and post-development landcover can be found in Appendices D and E of the cover memorandum (Overall Water Quantity Narrative), respectively.

Figure 7.2: Example Post-Development Conditions Land Cover

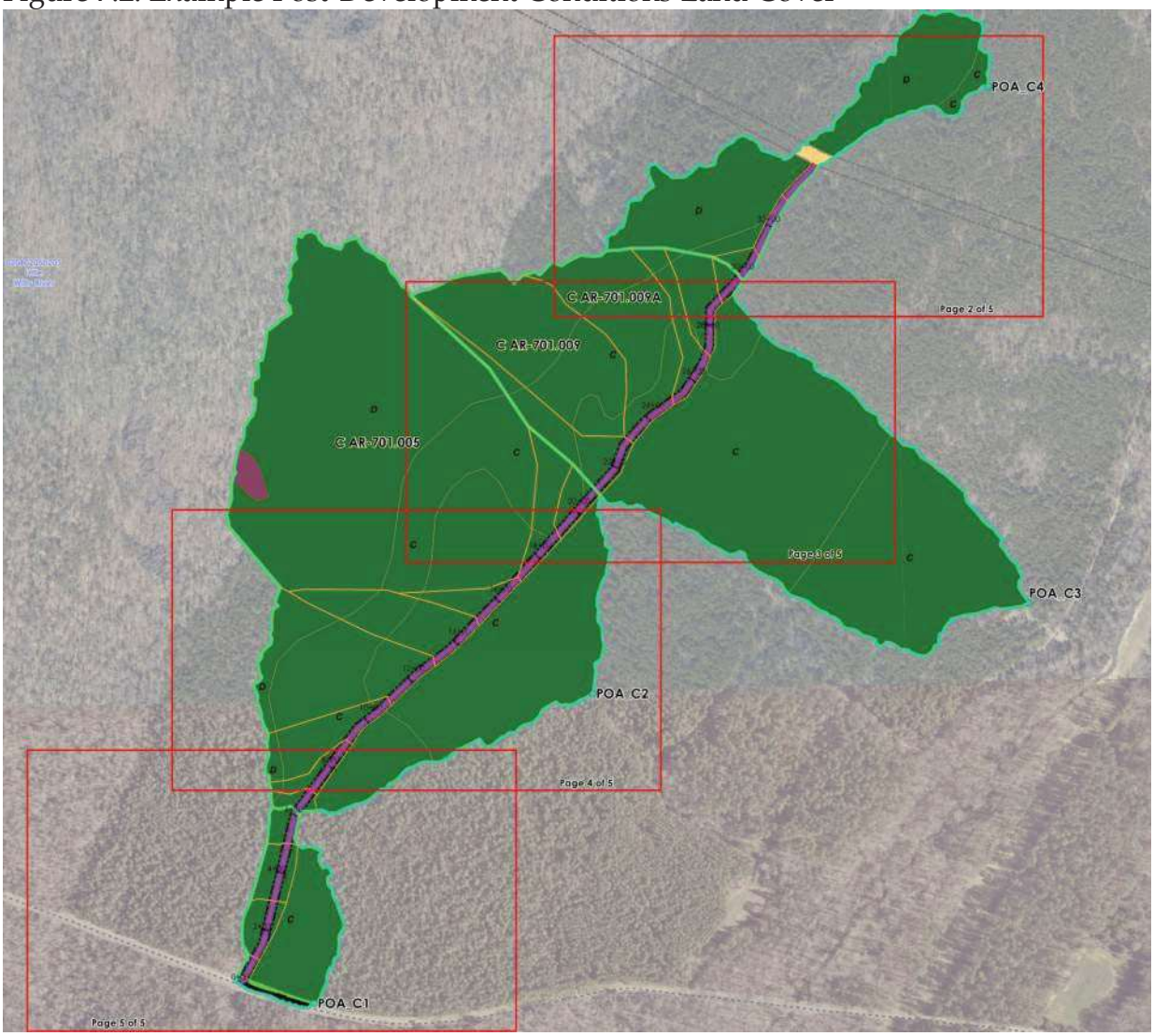
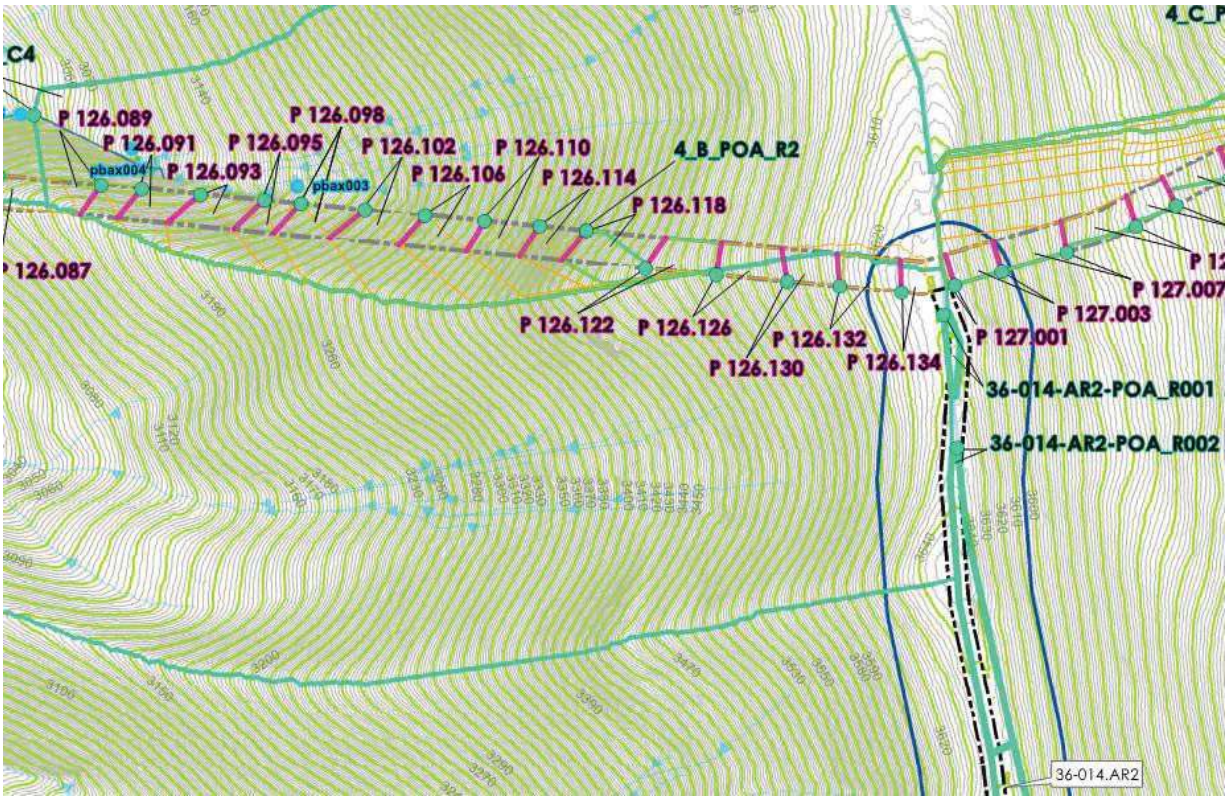


Figure 7.3: Example Drainage Feature Map



7.3 Water Quantity Calculations Package Template

To provide basic, concise reporting across the project, a template was developed in spreadsheet format (Microsoft Excel 2016) for a consistent framework for analysis, documentation, and review. While deviations are necessary dependent on individual access road or pipeline specifics and applicability, the format below is provided in a spreadsheet format.

<u>Project Data and Preliminary Hydrology</u>

The following is intended to provide some background on the process, calculations, and reporting structure utilized for the pipeline and access road water quantity compliance package spreadsheet template. Generally, calculation cells are noted in grey, input cells noted in orange, and modifications to the template / custom notations are highlighted in blue (custom notations are needed in instances where practice sizing is increased beyond standards, and other similar conditions where the spreadsheet is limiting).

Spreadsheet Cover Sheets – Includes project specifics in the orange data input cells.

Spreadsheet Cover Sheet 1 – Includes general information for the specific access road or pipeline. Information includes spread name, County location, access road identification (if applicable), access road category (if applicable), VSMP technical criteria, 12 Digit Watershed Location, and Virginia 6th Order HUC ID. A list of template attachments to be completed and appended are also provided. See the list below for additional information.

Spreadsheet Cover Sheet 2 – Includes Water Quantity Analysis Narrative to highlight aspects of the particular access road or pipeline covered under this review. Additional data sources specific to the review are noted, including topography, land use, soils, wetlands / waters delineation, aerial photography. Space for additional notes is also provided, if necessary.

Water Quantity Calculation Package Spreadsheet Tabs / Attachments to be completed and appended include:

Spreadsheet Tabs / Attachments 1 and 2 – Pre and post-development drainage area and curve number (CN) calculations. These attachments contain feature (waterbars, culverts, etc) drainage areas, as well as aggregated drainage areas for subsequently identified points of analyses through downstream review. These data entries are provided from GIS analyses. Curve number and Manning's n reference tables are documented under the White Paper Attachment 2.

Figure 7.4: Example Spreadsheet Tab / Attachment 1 – Pre-development CN Calculations

1 - VGIN Land Cover Data - Pre

Land Cover Classification	11				21				22			
Hydrologic Soil Group	A	B	C	D	A	B	C	D	A	B	C	D
CN Table 1	100	100	100	100	98	98	98	98	98	98	98	98
CN Table 2[1]	100	100	100	100	98	98	98	98	98	98	98	98

DA ID								
07-001-A009-AR1_POA_C1				0.48	0.03		0.29	0.03
C 157.001				0.04				
C 157.002				0.03				
C 157.003				0.07	0.03			0.03

91				98				99				100			
A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
30	67	70	77	30	48	65	73	98	98	98	98	72	82	87	89
40	67	70	77	40	48	65	73	98	98	98	98	72	82	87	89

				DA (acres)	CN Calculated	CN Table	CN Utilized
				48.01	55	1	55
				1.87	51	1	51
				0.09	55	1	55
				15.66	51	1	51

Curve Number Limitations – Note Curve Numbers less than 40 are problematic under the TR-55 framework and will produce unreliable results for flow and volume calculations (essentially, discharges and volumes cannot be relied upon and are indeterminate for CN<40 due to underlying limitations in the compliance methodology). The TR-55 manual notes for a CN of less than 40, another procedure should be used to determine runoff.

Given many of the existing project soils and land uses, many areas of very low CN may be noted. With the large initial abstraction of greater than 3 inches for any CNs less than 40 and the limitations of the TR-55 modeling equations (graphical peak discharge method), alternative approaches were discussed. However due to the Commonwealth's stormwater management compliance framework being reliant on the methodologies outlined in TR-55, an alternative, conservative approach to upward adjust the Curve Numbers was derived if the spreadsheet results are utilized in lieu of more sophisticated hydrologic modeling. To resolve the limitations of the graphical peak discharge method in the spreadsheet, the consultant team is conservatively increasing CNs where composite CN's are below the TR-55 threshold of 40 to produce values that would fit within the modeling parameters and therefore could be analyzed in both the pre- and post-development scenarios.

To address this manual adjustment, while still calculating the CNs per the land use and soil classifications, the consultant team added in additional columns on the VGIN Land Cover Data, Attachments 1 and 2. These changes have been highlighted in blue and are conservatively used throughout the remainder of the spreadsheet for all calculations. The underlying individual land cover/soil constituents which are less than 40 (and create the issue when composited) are upward adjusted to 40 (for both pre and post-development). In this regard, when a predevelopment composite CN (Water Quantity Calculations Package Attachment 1 - VGIN Land Cover Data – Pre, Calculated CN column) is less than 40, a second adjusted CN table (CN Table 2 under Water Quantity Calculations Package Attachments 1 and 2) will be utilized for both the pre-development and post-development CN calculations. This CN Table 2 provides for upward adjustment of all constituent land cover CNs that are less than 40 under TR-55 to CN of 40. The composite curve number will then be generated by this CN Table 2. The exception will be when the post-development CN decreases to below 40 (due to a resultant scrub-shrub land use for instance) from a pre-development CN equal to or greater than 40. In this instance the calculated composite post-development curve number will be raised to a minimum of 40 so that a

determinant result may be evaluated in the post-development condition. This has the effect of inflating the curve numbers to allow for determinate results using the TR-55 graphical peak discharge method, while maintaining a similar relative difference between pre and post-development. It should be noted that this adjustment approach has a tendency to overestimate runoff and thusly artificially inflate practice sizing, and as such is conservative. If the conservative peak discharge computations in the spreadsheet are problematic in a given instance, designers are encouraged to model the scenario using unadjusted CNs in a modeling package such as TR-20 to produce results which are not inflated by this workaround due to limitations of TR-55 hydrology for CN less than 40.

Spreadsheet Tab Attachment 2 (cont.) – Tabulation of Land Cover Changes (Percentages of Total Drainage Area). This tab presents the tabulation of land cover changes provided to address 9VAC25-870-55.B.8.h

Spreadsheet Tabs / Attachments 3 and 4 – Pre-development and post-development times of concentration (Tc) definition. These tabs include cells to define NOAA Atlas 14 rainfall amounts for the 1-year, 2-year and 10-year storm events based on Precipitation Figures under each Overall Water Quantity Narrative, areas to demonstrate the manner in which these rainfall values were defined (rainfall contours generated from NOAA rainfall data), the average basin slope cell, and an option cell to allow Tc default to 5 minutes to remain conservative.

In accordance with the United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS) Part 630 Hydrology National Engineering Handbook, Chapter 15 – Time of Concentration (Chapter 15), Tc's are preliminarily estimated using the Watershed lag method (average basin slope). See White Paper Attachment 6 for documentation of the GIS Average Basin Slope method definition procedure for the project. Composite Curve Number information from Spreadsheet Tab Attachments 1 and 2 are utilized for calculations of watershed flow length. The average basin slope from GIS data analysis are entered, and an option for conservatively using a 5 minute Tc is provided for smaller watersheds. This is often generally utilized within the project improvement footprint where drainage areas are less than 5 acres. The inputs then calculate the watershed lag time, which is then converted to

Tc, if the default of 5 minutes is not utilized. Where CNs are below 50 or above 95 and not defaulted to 5 minutes an alternate methodology (flow segment method per TR-55) will be used and documented under the Spreadsheet Tabs / Attachments 3 and 4. See White Paper Attachment 6 for Average Basin Slope Method definition protocols used for the project.

Figure 7.5: Example Spreadsheet Tab / Attachment 4 – Post-development Times of Concentration (Tc) definition

4 - Post - Tc Definition

P2yr (in) = 3.0

P10yr (in) = 4.3

P1yr (in) = 2.5

DA ID	DA (acres)	CN	Flow Length (ft)	Avg. Watershed Slope (%)	Default Tc of 5 min? (Yes / No)	Calc'd Lag (hr)	Calc'd Tc (hr)	Used Tc (hr)	Used Tc (min)
4A_F_POA_C1	122.92	49	3749	35.64	No	0.350	0.584	0.584	35
4A_F_POA_C2	53.20	54	2268	43.78	No	0.186	0.310	0.310	19
4A_F_POA_C3	#####	40	62269	49.05	No	3.583	5.971	5.971	358
4A_F_POA_R1	0.62	49	157	55.75	Yes	0.022	0.037	0.083	5
P 155.073	0.05	48	35	16.60	Yes	0.012	0.021	0.083	5
P 155.075	0.05	48	35	15.69	Yes	0.013	0.021	0.083	5
P 155.077	0.02	48	20	8.44	Yes	0.011	0.019	0.083	5
P 155.079	0.05	48	35	8.45	Yes	0.017	0.029	0.083	5
P 155.081	0.01	48	13	6.56	Yes	0.009	0.015	0.083	5
P 155.083	0.05	48	35	21.16	Yes	0.011	0.018	0.083	5
P 155a.001	0.13	45	61	52.91	Yes	0.012	0.020	0.083	5
P 155a.003	0.10	41	52	57.44	Yes	0.011	0.019	0.083	5
P 155a.004	0.11	62	56	41.66	Yes	0.008	0.013	0.083	5
P 155a.005	0.15	49	67	36.61	Yes	0.014	0.023	0.083	5
P 155a.007	0.08	48	46	17.17	Yes	0.015	0.025	0.083	5

Spreadsheet Tab / Attachment 5 - TR-55 Calculation – This attachment provides documentation of peak flow calculations in accordance with TR-55 Chapter 4, Graphical Peak Discharge Method. The preliminary results will be reviewed for assessment of sheet flow. The Spreadsheet Tab / Attachment 5 utilizes interpolated values from Table F-1 of TR-55 to tabulate the graphical peak discharge calculations, coefficients (C0, C1, and C2) associated with the Ia/P ratio, initial abstraction (Ia) to precipitation ratio (P). These equations are used to assist in the automation of the flow calculations and have been reviewed to be generally consistent with TR-55 modeled flows.

Figure 7.6: Spreadsheet Tab / Attachment 5 – TR-55 Calculation

TR-55 Peak Flow Computations for DA		4A_F_POA_C1		Predevelopment	
		2 yr	10 yr		
qp	Peak Discharge	3.94	25.22	cfs	
qu	Unit Peak Discharge	275.31	336.89	csm/in	TR-55 Equation
Am	Drainage Area	0.192	0.192	sqmi	122.94 Ac
Q	Runoff Volume	0.07	0.39	in	SCS CN Equation
		33.230	173.933	cu ft	
		0.763	3.993	ac-ft	3.230
	Wetland Area	0.0	0.0	sqmi	
Fp	Pond/Swamp Adjst.	1.00	1.00		
	Tc	0.58	0.58	hr	
	Rainfall Distribution	II	II		
	Storm Frequency	2	10	yr	
	24 hr Rainfall, P	3.00	4.30	in	
	Ia	2.08	2.08	in	TR-55 Equation
	CN	49.0	49.0		
	Ia/P	0.694	0.484		
	C0	2.29219	2.38440	TR-55 Nomograph Interpolation	
	C1	-0.63724	-0.62943	TR-55 Nomograph Interpolation	
	C2	-0.02310	-0.07288	TR-55 Nomograph Interpolation	

<u>Simplified, Conservative Sheet Flow Review – Point of Analysis (POA)</u>

<u>Definition and Screening</u>

The below provides for the process as to review feature outfall conformance to sheet flow and preliminarily review the potential for impacts of increased volumes of sheet flow (on an aggregate basis) to downstream properties. Using the attachments in this section and the process defined under the White Paper, the conservative assumptions herein may screen areas and allow for focusing of more detailed assessment, only on an as needed basis. No modeling, detailed routing, or accounting for storage is provided under this section.

Spreadsheet Tab / Attachment 6 – Waterbar Assessment & Calculations – This attachment preliminarily evaluates waterbars by feature using tabular TR-55 peak flows from Attachment 5. This is intended to demonstrate sheet flow by feature and what end treatments (Standard Stone Apron Type 1, Standard Stone Apron Type 2), or Flow Diffusers) are required. These features will be aggregated in later evaluation steps, starting with Spreadsheet Tab / Attachment 9.

Figure 7.7: Example Spreadsheet Tab / Attachment 6 – Waterbar Assessment & Calculations

DA	Waterbar ID	Length	Drainage Area	2-YR Peak Q	10-YR Peak Q	Ex Slope Leaving Practice	D/S Land Cover	End Treatment Selection	Standard Stone Apron - Type 1 or Type 2				
									2-YR Velocity	10-Yr Runoff Depth	Permiss. Velocity	Depth	Velocity
		ft	acres	cfs	cfs	(ft/ft)	Forested or Pasture?	(Type 1 / 2 / Flow Diffuser)	fps	ft	fps	Pass / Fail	Pass / Fail
4A_F_POA_C1	4A_F_POA_C1	16	122.92	3.94	25.22	0.03	Forested	Flow Diffuser	N/A	N/A	N/A	N/A	N/A
4A_F_POA_C2	4A_F_POA_C2	16	53.20	6.43	26.27	0.01	Forested	Flow Diffuser	N/A	N/A	N/A	N/A	N/A
4A_F_POA_C3	4A_F_POA_C3	16	13,290.42	0.00	130.48	0.02	Forested	Flow Diffuser	N/A	N/A	N/A	N/A	N/A
4A_F_POA_R1	4A_F_POA_R1	16	0.62	0.06	0.36	0.03	Forested	Type 2	0.10	0.07	2.25	PASS	PASS
P 155.073	P 155.073	16	0.05	0.00	0.03	0.23	Forested	Type 1	0.22	0.02	2.25	PASS	PASS
P 155.075	P 155.075	16	0.05	0.00	0.03	0.17	Forested	Type 1	0.20	0.02	2.25	PASS	PASS
P 155.077	P 155.077	16	0.02	0.00	0.01	0.22	Forested	Type 1	0.22	0.01	2.25	PASS	PASS
P 155.079	P 155.079	16	0.05	0.00									
P 155.081	P 155.081	16	0.01	0.00									
P 155.083	P 155.083	16	0.05	0.00									
P 155a.001	P 155a.001	16	0.13	0.00									
P 155a.003	P 155a.003	16	0.10	0.00									
P 155a.004	P 155a.004	16	0.11	0.07									
P 155a.005	P 155a.005	16	0.15	0.02									

Flow Diffuser								
Flow Diffuser Req'd	Calc'd Diffuser Length	Proposed Diffuser Length	Flow / foot of Weir Crest Length Req'd based on D/S Slope	Flow / ft of Weir Crest	Flow / ft of Weir Crest based on D/S Slope Met?	Less than 0.1 Acre / foot Length of Crest?	D/S Condition Concen-trated w/in 100 FT	Sheet Flow Maintained ?
Yes / No	ft	ft	cfs / ft	cfs / ft	(Yes / No)	(Yes / No)	(Yes / No)	(Yes / No)
Yes	100.9	1229.2	0.250	0.021	Yes	Yes	yes	No
Yes	105.1	532.0	0.250	0.049	Yes	Yes	yes	No
Yes	521.9	132904.2	0.250	0.001	Yes	Yes	yes	No
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes
No	N/A	N/A	N/A	N/A	N/A	N/A	no	Yes

Spreadsheet Tab / Attachment 7 – Documentation of Ridgetop Sheet Flow Condition – This attachment simply documents that the limited lateral flow from roads within the ridgetop sections of road leave the road / ROW in sheet flow, what stations these conditions occur, and whether or not a downstream concentrated condition exists within the 100 foot ROW buffer. Evaluation of aggregate effects of increased volumes of sheet flow will be provided in subsequent steps.

Figure 7.8: Example Spreadsheet Tab / Attachment 6 – Documentation of Ridgetop Sheet Flow Condition

Starting Station	Ending Station	Rd Type	Left Lateral Imperv Flow Length ft	Right Lateral Imperv Flow Length ft	Side of Road	Imperv Flow = Shallow Conc. [3] ft	Imperv Disconnect (Yes/No)	D/S Condition Conc. (Yes/No)	Criteria Satisfied? (Yes/No)	If No, Add'l D/S Measure for Satisfaction ?
0+00	21+50	F	8	8	R	75	Yes	Yes	No	GD
0+00	21+50	F	8	8	L	75	Yes	Yes	No	GD

Spreadsheet Tab / Attachment 8 – Culverts Definition and Outfall Assessment – Similar to Attachment 6, this provides documentation of sheet flow leaving proposed culverts and what end treatments (Standard Stone Apron Type 1, Standard Stone Apron Type 2, or Flow Diffusers) are required.

Figure 7.9: Example Spreadsheet Tab / Attachment 8 – Culverts Definition and Outfall Assessment

DA	Culvert ID	Drainage Area	2-YR Peak Q	10-YR Peak Q	Pipe Material	Pipe n	Pipe Slope	Design Pipe Diameter	Capacity	Ex Slope Leaving Practice	D/S Land Cover	End Treatment Selection
		acres	cfs	cfs			%	in	cfs	(ft/ft)	Forested or Pasture?	(Type 1 / 2 / Flow Diffuser)
C158.015	C158.015	1.23	0.24	1.36	CMP	0.024	6.00%	12	4.73	0.17	Forested	Flow Diffuser
C158.017	C158.017	0.02	0.02	0.05	CMP	0.024	6.00%	12	4.73	0.10	Forested	Type 1
C158.018	C158.018	0.42	0.03	0.22	CMP	0.024	6.00%	12	4.73	0.10	Forested	Type 1
C158.023	C158.023	1.21	0.13	0.87	CMP	0.024	6.00%	12	4.73	0.10	Forested	Flow Diffuser
C158.024	C158.024	0.80	0.09	0.58	CMP	0.024	6.00%	12	4.73	0.10	Forested	Flow Diffuser
C158.025	C158.025	0.68	0.06	0.43	CMP	0.024	6.00%	12	4.73	0.10	Forested	Type 2
C158.026	C158.026	1.21	0.13	0.87	CMP	0.024	6.00%	12	4.73	0.10	Forested	Flow Diffuser
C159.009	C159.009	1.94	0.33	1.95	CMP	0.024	6.00%	12	4.73	0.69	Forested	Flow Diffuser
C159.011	C159.011											
C159.013	C159.013											
C159.015	C159.015											
C159.016	C159.016											
C159.017	C159.017											
C159.019	C159.019											
C159.020	C159.020											

Standard Stone Apron - Type 1 or Type 2					Flow Diffuser								
2-YR Velocity	10-Yr Runoff Depth	Permiss. Velocity	Depth	Velocity	Flow Diffuser Req'd	Calc'd Diffuser Length	Proposed Diffuser Length	Flow / foot of Weir Crest Length Req'd based on D/S Slope	Flow / ft of Weir Crest	Flow / ft of Weir Crest based on D/S Slope Met?	Less than 0.1 Acre / foot Length of Crest?	D/S Condition Concen-trated w/in 100 FT	Sheet Flow Maintained ?
fps	ft	fps	Pass / Fail	Pass / Fail	Yes / No	ft	ft	cfs / ft	cfs / ft	(Yes / No)	(Yes / No)	(Yes / No)	(Yes / No)
N/A	N/A	N/A	N/A	N/A	Yes	5.5	12.3	0.250	0.111	Yes	Yes	Yes	No
0.16	0.03	2.25	PASS	PASS	No	N/A	N/A	N/A	N/A	N/A	N/A	Yes	No
0.16	0.09	2.25	PASS	PASS	No	N/A	N/A	N/A	N/A	N/A	N/A	Yes	No
N/A	N/A	N/A	N/A	N/A	Yes	3.5	12.1	0.250	0.072	Yes	Yes	Yes	No
N/A	N/A	N/A	N/A	N/A	Yes	2.3	8.0	0.250	0.072	Yes	Yes	Yes	No
0.16	0.08	2.25	PASS	PASS	No	N/A	N/A	N/A	N/A	N/A	N/A	Yes	No
N/A	N/A	N/A	N/A	N/A	Yes	3.5	12.1	0.250	0.072	Yes	Yes	Yes	No
N/A	N/A	N/A	N/A	N/A	Yes	15.6	19.4	0.125	0.101	Yes	Yes	No	Yes
N/A	N/A	N/A	N/A	N/A	Yes	32.6	36.8	0.125	0.111	Yes	Yes	No	Yes
N/A	N/A	N/A	N/A	N/A	Yes	34.7	34.7	0.125	0.125	Yes	Yes	No	Yes
N/A	N/A	N/A	N/A	N/A	Yes	12.8	12.8	0.125	0.125	Yes	Yes	No	Yes
N/A	N/A	N/A	N/A	N/A	Yes	15.5	15.5	0.125	0.125	Yes	Yes	No	Yes
N/A	N/A	N/A	N/A	N/A	Yes	33.8	33.8	0.125	0.125	Yes	Yes	No	Yes
N/A	N/A	N/A	N/A	N/A	Yes	20.6	20.6	0.125	0.125	Yes	Yes	No	Yes
N/A	N/A	N/A	N/A	N/A	Yes	9.0	10.2	0.125	0.111	Yes	Yes	No	Yes

Detailed Review and Modeling

To this point, no detailed modeling for further review has been performed, rather only the areas that require further analysis have been identified. The following provides discussion of the steps that are being taken to review these areas for A) sheet flow areas that may require further evaluation, modeling, or mitigation measures to document no apparent impacts to downstream properties due to increased volumes of sheet flow, and B) areas of concentrated flow that may require further evaluation, modeling, or mitigation measures to document conformance with the energy balance equation. POA naming conventions for the project are provided below for both access roads and pipeline segments.

Access road:

Culverts, waterbars naming is based on the sheet No. It uses the same naming convention as shown on the alignment sheets.

- Culvert: C SheetNo.Numerical numbers. For example, C E146.001
- Waterbar: W SheetNo.Numerical numbers. For example, W E146.001
- POA-R: Access road name_POA_R#. For example 07-001-A009-AR 1_POA_R1
- POA-C: Access road name_POA_C#. For example, 07-001-A009-AR 1_POA_C1
- POA: these are for the points further downstream if there are any. For example, 07-001-A009-AR 1_POA_1
- Energy balance drainage area: Access road name_EB#. For example, 07-001-A009-AR 1_EB1.
- Use the same naming ID for the drainage area of the above points

Pipeline:

- Waterbar: Use the naming IDs provided in GIS
- POA-R: Spreadname_letter_POA-R1. For example, staff 1 will use 11_A_POA_R1. Staff B will use 11_B_POA_R1. (Different letter as it involves different groups of people.)
- POA-C: Spreadname_letter_POA-C1. For example, starting with 11_A_POA_C1 for staff 1, starting with 11_B_POA_C1 for staff 2.
- Energy balance drainage area: Spreadname_letter_EB#. For example, starting with 11_A_EB1 for staff 1. starting with 11_B_EB1 for staff 2.

Methodology for Defining Points of Concentrated Flow**:**

1. Utilizing available data, in order of reliability
    a. Streams and Wetlands

   b. Aerial photography
   c. Available Topography
2. Engineering judgement is used to approximate
   a. The existence of a concentrated flow feature
   b. The estimated geometry of the feature
3. The process will generally conform to:
   a. Where a Stream or Wetland exists a concentrated flow feature is confirmed.
   b. In areas outside Streams and Wetlands review/documentation, aerial photography may confirm the existence of a concentrated flow feature (e.g. ditch).
   c. Finally, topography provides for visual assessment of discrete concentrated flow paths. Note that sections of the project exist within steep, often karst, terrain of western Virginia. As such, broad and steep headwater drainages or ravines often do not contain defined concentrated flow paths.
4. Once the concentrated flow feature is identified, the available data is utilized in concert, where practicable to estimate channel geometry. This includes.
   a. Section is pulled if possible from the available topography. Slopes are estimated based on available topography, which may include the averaging of two slopes in areas of transition and large gaps between contours.
   b. Information such as delineation of ordinary high water and bank width metrics are used to approximate near channel features, which are then nested within the section pulled from available topography, to the extent practicable. Where delineation information is not available, aerial photography may be used to estimate approximate channel width.
   c. Finally, if no delineation or aerial information is useful, the topo will be relied on.
5. The following notes may be considered under this process:
   a. Existing flow paths may contain sheet flow and shallow concentrated flow depending on location and terrain characteristics.
   b. Some potential hydrologic benefits of the roadway development approach may include:

i. the elongation of Tc flow paths
ii. incremental storage along ditch lines with substantially lower slopes than existing grade, even prior to implementation of check dams
iii. use of both elongated flow paths and ditch features to break existing shallow concentrated flow paths and return to sheet flow.

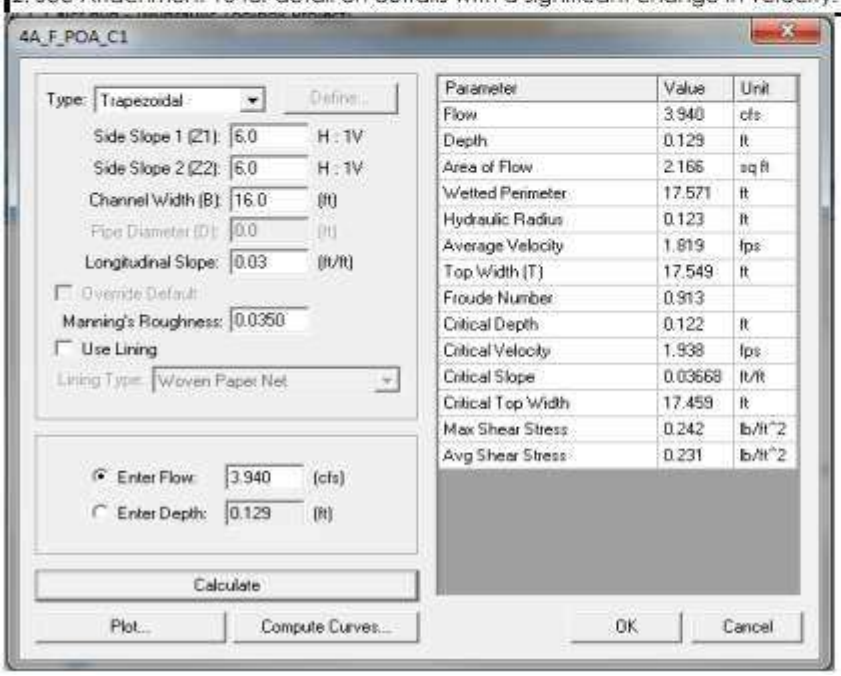
Spreadsheet Tab / Attachment 9 – Sheet Flow Aggregate Downstream Check – Velocity checks are performed for a POA downstream (POA-C) to assess whether the post-development velocity of increased volumes of sheet flow is noted as increased for velocities with two significant figures. Should this be the case and all upstream checks are deemed consistent with the compliance approach, then sheet flow is maintained and conformance with 9VAC25-870-66.D may be satisfied.

Figure 7.10: Example Spreadsheet Tab / Attachment 9 – Sheet Flow Aggregate Downstream Check

Sheet Flow Downstream Velocity Comparison				
Sheet Flow POA	Aggregated Drainage Areas	Pre Velocity (fps)	Post Velocity (fps)	% Velocity Change
ID		2-YR	2-YR	2-YR
4A_F_POA_C1	122.92	1.82	1.82	0.0%
4A_F_POA_C2	53.2	1.40	1.40	0.0%
4A_F_POA_C3	13290.42	4.64	4.64	0.0%

Notes:

1. No accounting for storage of upstream facilities has been included in this unrouted flow comparison.
2. See Attachment 10 for detail on outfalls with a significant change in velocity.



For the purposes of comparing pre-development to post-development velocities in the downstream channel, Manning's roughness coefficients were conservatively selected for each section based upon best available data and engineering judgement. The roughness coefficients remain consistent between the pre- and post-development modeling. The results of this comparative analysis require mitigation measures to contain all volume increases when any velocity increase is noted.

For those areas that an increase is shown due to increased volumes of sheet flow, mitigation steps may be required and further modeling is performed and documented in accordance with the White Paper under further steps below.

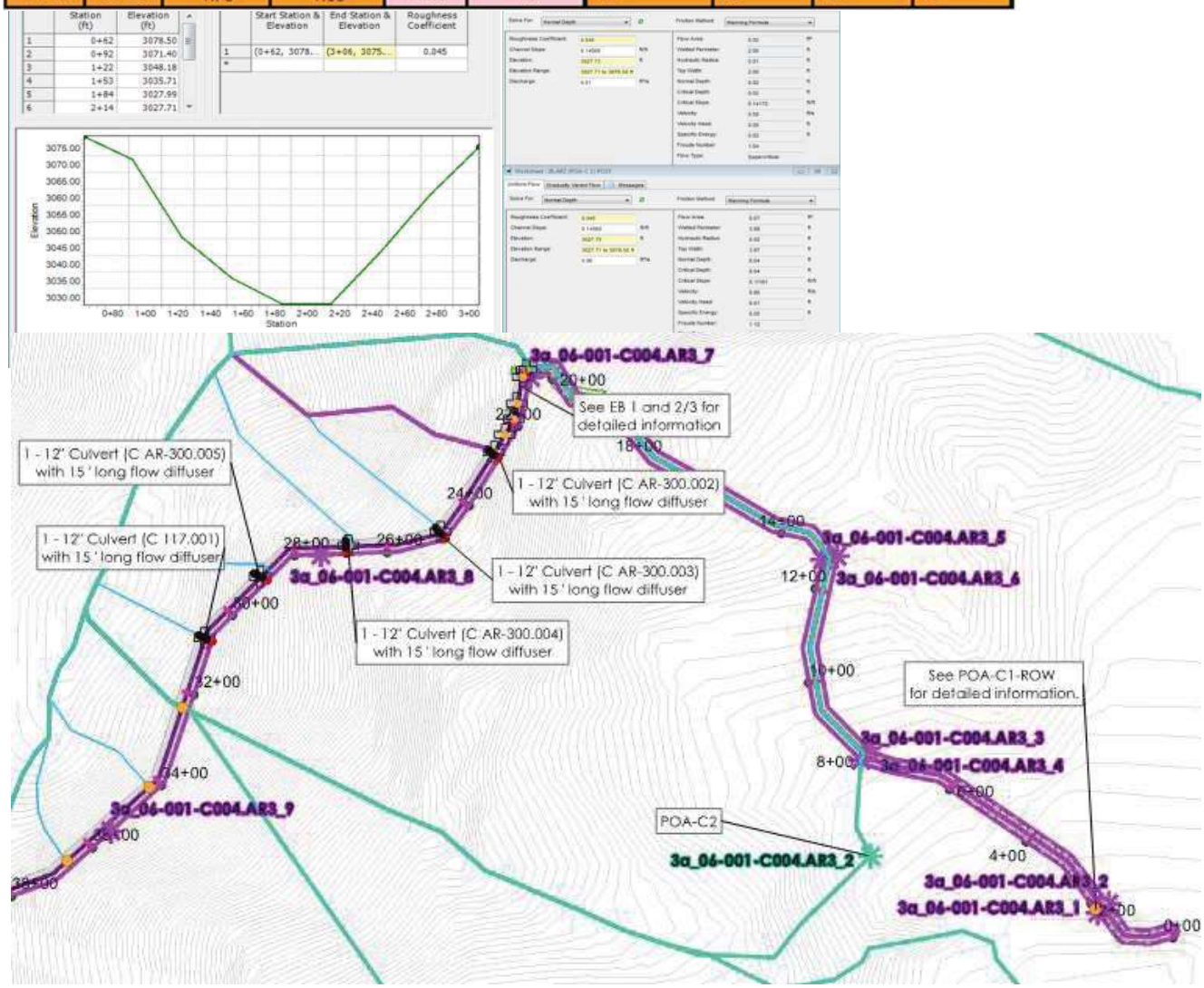
Spreadsheet Tab / Attachment 10A – Mitigation for Sheet Flow – This attachment will provide detail on the modeling that is performed to demonstrate how practices are used collectively to meet either sheet flow or concentrated flow compliance objectives. Velocities are compared for the 2-year storm event, pre-development to post-development unrouted, and flow depths are similarly compared for the 10-year storm event. Documentation of the proposed mitigation strategies are provided and a discussion of the area of concern is included along with any modeling support and additional documentation (i.e. detailed routings, Vs/Vr comparisons, or other modeling results) underneath each table.

Figure 7.11: Example Spreadsheet Tab / Attachment 10a – Mitigation for Sheet Flow

POA =					C1-ROW				
Starting Station	Ending Station	Existing Vel (fps)	Postdevelopment Vel (fps)	% Vel Change	Change within +1% of Pre	1-Storage Accounting / Modeling	2-Roadway redux to 12 feet	3-Road Rehab	Energy Balance Needed
		2-YR	2-YR (Unrouted)	2-YR	(Yes/No)	(Yes/No)	(Yes/No)	(Yes/No)	(Yes/No)
0+00	18+88	1.08	1.50	38.9%	No	Yes	No	No	No

Note: Upstream C2 aggregate storage (below) criteria satisfied. C1 was evaluated for additional ROW improvements only.

POA =					C2				
Starting Station	Ending Station	Existing Vel (fps)	Postdevelopment Vel (fps)	% Vel Change	Change within +1% of Pre	1-Storage Accounting / Modeling	2-Roadway redux to 12 feet	3-Road Rehab	Energy Balance Needed
		2-YR	2-YR (Unrouted)	2-YR	(Yes/No)	(Yes/No)	(Yes/No)	(Yes/No)	(Yes/No)
21+50	32+35	1.75	1.88	7.4%	No	Yes	No	No	No

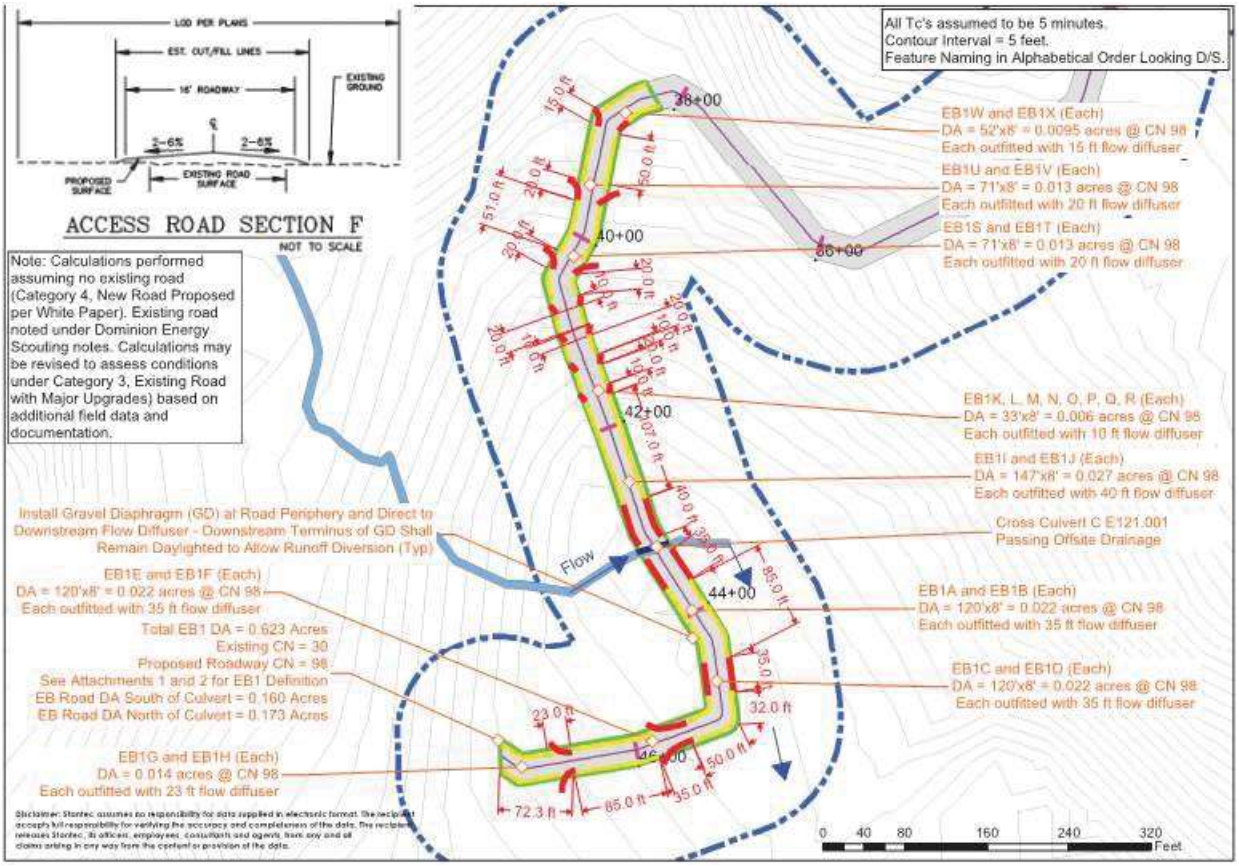


Spreadsheet Tab / Attachment 10B – Mitigation for Concentrated Flow – Similar to Spreadsheet Tab / Attachment 10A this tab includes measures and modeling approach notes to provide compliance with the energy balance requirements, as applicable. Several different types of modeling software are utilized to perform detailed routed modeling, see applicable modeling software under Section 8 below. Energy Balance compliance documentation, with routed peak flows and runoff volumes, is provided under Spreadsheet Tab / Attachment 13.

Figure 7.12: Example Spreadsheet Tab / Attachment 10b – Mitigation for Concentrated Flow

POA =					EB-1				
Starting Station	Ending Station	Existing flow (cfs)	Postdevelopment flow (cfs)	% flow Change	Change within +1% of Pre	1-Storage Accounting / Modeling	2-Roadway redux to 12 feet	3-Road Rehab	Energy Balance Needed
		1-YR	1-YR (Unrouted)	1-YR	(Yes/No)	(Yes/No)	(Yes/No)	(Yes/No)	(Yes/No)
38+00	47+20	0.00	0.90	#DIV/0!	#DIV/0!	Yes	No	No	No

POA =					EB-2				
Starting Station	Ending Station	Existing flow (cfs)	Postdevelopment flow (cfs)	% flow Change	Change within +1% of Pre	1-Storage Accounting / Modeling	2-Roadway redux to 12 feet	3-Road Rehab	Energy Balance Needed
		1-YR	1-YR (Unrouted)	1-YR	(Yes/No)	(Yes/No)	(Yes/No)	(Yes/No)	(Yes/No)
8+25	11+00	0.00	0.13	#DIV/0!	#DIV/0!	Yes	No	No	No



Spreadsheet Tab / Attachment 11 – TR-55 Unrouted Flow – This attachment provides a summary of the unrouted TR-55 flows from mitigation efforts defined under both Overall Water Quantity Narrative Attachments 10a and 10b.

Figure 7.13: Example Spreadsheet Tab / Attachment 11 – TR-55 Unrouted Flow

PEAK FLOW SUMMARY										
Outfall	Concen-trated?	Existing Peak Discharge (cfs)			Postdevelopment Peak Discharge (cfs)			Percent Difference		
ID	(Yes/No)	1-YR	2-YR	10-YR	1-YR	2-YR	10-YR	1-YR	2-YR	10-YR
POA-EB1	Yes	0.00	0.00	0.00	0.11	0.16	0.31	#DIV/0!	#DIV/0!	#DIV/0!
POA-EB2/3	Yes	0.00	0.00	0.01	0.18	0.22	0.32	#DIV/0!	#DIV/0!	3100.0%

Notes:

1. TR-55 Modeling of Mitigation Efforts (Sheet Flow & Concentrated Flow).

Spreadsheet Tab / Attachment 12 – TR-55 Routed Flow and Volume Summary – This attachment provides a summary of the routed TR-55 flows from the mitigation efforts defined under both Overall Water Quantity Narrative Attachments 10 and 10A.

Figure 7.14: Example Spreadsheet Tab / Attachment 12 – TR-55 Routed Flow and Volume Summary

PEAK FLOW SUMMARY										
Outfall	Concen-trated?	Existing Peak Discharge (cfs)			Postdevelopment Peak Discharge (cfs)			Percent Difference		
ID	(Yes/No)	1-YR	2-YR	10-YR	1-YR	2-YR	10-YR	1-YR	2-YR	10-YR
POA-EB1	Yes	0.00	0.00	0.00	0.00	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!
POA-EB2/3	Yes	0.00	0.00	0.01	0.00	0.00	0.01	#DIV/0!	#DIV/0!	0.0%

RUNOFF VOLUME SUMMARY										
Outfall	Concen-trated?	Existing Volume (ac-ft)			Proposed Volume (ac-ft)			Percent Difference		
ID	(Yes/No)	1-YR	2-YR	10-YR	1-YR	2-YR	10-YR	1-YR	2-YR	10-YR
POA-EB1	Yes	0.000	0.000	0.000	0.000	0.000	0.001	#DIV/0!	#DIV/0!	#DIV/0!
POA-EB2/3	Yes	0.000	0.000	0.003	0.000	0.000	0.005	#DIV/0!	#DIV/0!	66.7%

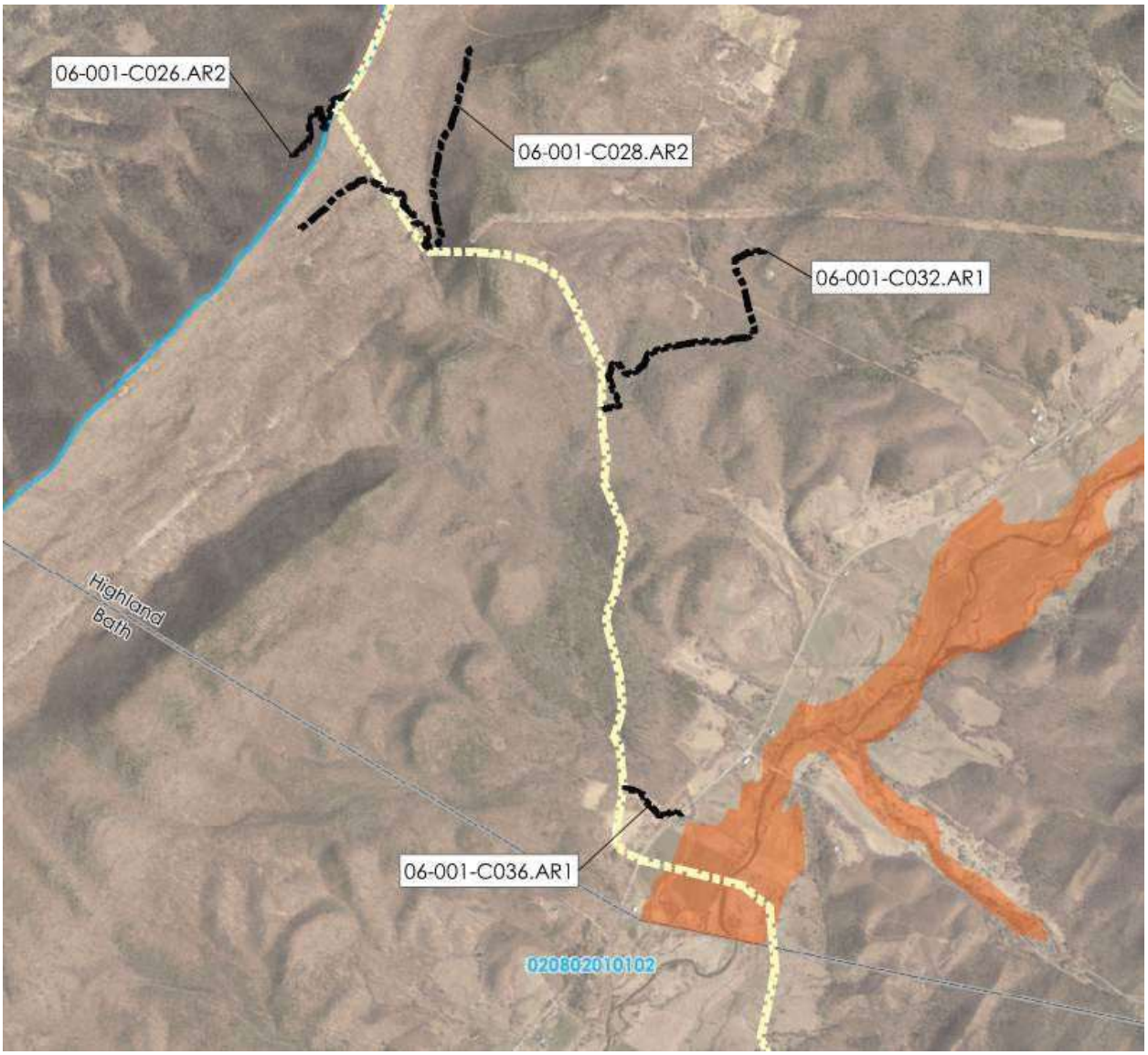
Spreadsheet Tab / Attachment 13 – Flow / Energy Balance Summary – This attachment combines the outfalls and flow information from Overall Water Quantity Narrative Attachments 11 and 12 to further document where energy balance is required, and how it is met in terms of allowable flow.

Figure 7.15: Example Spreadsheet Tab / Attachment 13 – Flow / Energy Balance Summary

Outfall	Concen-trated? (Yes/No)	Storm Event	I.F.	Storm Flow Summary			RV Pre (ac-ft)	RV Post (ac-ft)	Q Allowable (cfs)	Meets E.B. (Yes / No)	Flow Attenuation (Yes/No)
				Ex	Prop	Change in Flow (%)					
				Peak (CFS)	Peak (CFS)						
4A_F_POA_C1	yes	1	0.8	0.00	0.00	#DIV/0!	0.000	0.000	#DIV/0!	#DIV/0!	Yes
		2	0.8	0.00	0.00	#DIV/0!	N/A	N/A	N/A	N/A	Yes
		10	0.8	0.00	0.00	#DIV/0!	N/A	N/A	N/A	N/A	Yes
4A_F_POA_C2	yes	1	0.8	0.00	0.00	#DIV/0!	0.000	0.000	#DIV/0!	#DIV/0!	Yes
		2	0.8	0.00	0.00	#DIV/0!	N/A	N/A	N/A	N/A	Yes
		10	0.8	0.00	0.00	#DIV/0!	N/A	N/A	N/A	N/A	Yes
4A_F_POA_C3	yes	1	0.8	0.00	0.00	#DIV/0!	0.000	0.000	#DIV/0!	#DIV/0!	Yes
		2	0.8	0.00	0.00	#DIV/0!	N/A	N/A	N/A	N/A	Yes
		10	0.8	0.03	0.03	0.00	N/A	N/A	N/A	N/A	Yes

Spreadsheet Tab / Attachment 14 – Flood Protection – For those concentrated flow areas, a demonstration of Flood Protection is provided here. Documentation will be provided to address Flood Protection criteria (9VAC25-870-66.C). FEMA Flood Insurance Rate Maps (FIRM) or local digital GIS floodplain mapping will be provided/depicted, if applicable. Note that some areas of access road improvements may be through existing regulated floodplains. The construction of these access roads is understood to be of limited footprint, no net fill, work to be performed at or near existing grade, and the topdressing of stone in areas of existing gravel. As such, no impact to the existing regulated floodplain is intended. See the individual cover memo (Overall Water Quantity Narrative) for specific information or exceptions.

Figure 7.16: Example Spreadsheet Tab / Attachment 14 – Flood Protection



Spreadsheet Tab / Attachment 15 – Modeling Summaries – This provides detailed modeling results for review as necessary, including CulvertMaster, or other programs, as applicable. Given their significant size, TR-55 modeling results (PondPack, HydroCAD, etc) are combined under the cover memorandum (Overall Water Quantity Narrative) Appendix H for reference, as necessary.

Spreadsheet Tab / Attachment 16 – Roadside Channel Design – Each access road has been designed utilizing an array of typical sections established for the project. Several of these sections involve the implementation of roadside channels. Spreadsheet Tab / Attachment 16 utilizes the flows developed on Tab / Attachment 5 along with proposed slopes and single section modeling runs to define minimum channel depths, average shear stress, and proposed channel linings. The majority of the analysis on this tab is performed outside of the spreadsheet and compiled in this location for documentation.

Figure 7.17: Example Spreadsheet Tab / Attachment 16 – Roadside Channel Design

Spread	Access Road	Station Start	Station Stop	Channel Slope (ft/ft)	Channel Sizing				Channel Lining				
					10-Yr Flow (cfs)[1]	Channel Type	10-Yr Flow Depth (ft)	Min. Channel Depth (ft)	2-Yr Flow (cfs)[1]	2-Yr Flow Area (sf)	2-Yr Wetted Perimeter (ft)	2-Yr Average Shear Stress (lb/sf)	Channel Lining
3A	06-001-C004.AR3	21+50	22+74	0.138	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined
3A	06-001-C004.AR3	22+74	24+74	0.105	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined
3A	06-001-C004.AR3	24+74	26+75	0.281	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined
3A	06-001-C004.AR3	26+75	28+75	0.378	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined
3A	06-001-C004.AR3	28+75	30+77	0.407	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined
3A	06-001-C004.AR3	30+77	32+32	0.143	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined
3A	06-001-C004.AR3	32+32	34+22	0.213	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined
3A	06-001-C004.AR3	34+22	36+58	0.063	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined
3A	06-001-C004.AR3	36+58	38+18	0.194	0.00	Type I	0.00	1.00	0.00	0.00	0.00	#DIV/0!	Grass Lined

Notes:

1. Flows taken from Water Quantity Spreadsheet Attachment 5 "TR-55 Flow Calculation"
2. Average Shear Stress Calculated using the following equation: t = 62.4*slope*(flow area/wetted perimeter)
3. Flow Depths, Areas, and Wetted Perimeters taken from Flowmaster Modeling Results
4. Minimum Freeboard of 0.1 feet is provided in the 10-Yr Storm Event
5. Slope for each roadside ditch section was estimated by taking the approximate elevation at the starting and ending stations and dividing the change in elevation by the length of the section.
6. All blue cells were manually entered because the points of analyses generate no flow up to the 10-year storm event and are beyond the computational limits of the TR-55 methodology.
7. Typical channel geometries and permissible shear stress values noted below per previous ERM plan submittal package.

Reference 1. Typical Channel Geometry

Roadside Ditch Geometry	Bottom Width (feet)	Side Slope (run/rise)
Type I	0	2
Type II	2	2
Type III	4	2

Reference 2. Allowable Shear Stress

Lining Type	Manning's roughness coefficient, n	Permissible Shear Stress (lbs/ft²)
Grass Lined	0.035	0.398
Riprap (D_{50} = 6 in)	0.069	2.4
Riprap (D_{50} = 12 in)	0.08	4.8

Generally, note that changes to standard spreadsheet columns and calculations will be made in blue text and noted, where applicable for additional clarity.

Storage Volume Estimation

Outside of the overall Water Quantity Calculation Spreadsheet, an additional spreadsheet was developed to assist in estimating the volume attenuation provided by the proposed practices. This spreadsheet is utilized when assessing the storage volume to runoff volume relationship described herein and documented in TR-55. The spreadsheet also provides an outlet structure cross section for the flow diffuser that can be utilized if detailed routed modeling efforts are required. Additional discussion on how the stage storage curves and associated volumes per practice were developed is provided below.

Flow Diffuser – The flow diffuser stage storage curve was developed utilizing a cross sectional area subdivision of the proposed flow diffuser geometry. Areas of open storage and stone void space storage were differentiated and a porosity of 0.4 was assigned to all void storage areas. The stage storage curve was then developed utilizing these areas and unitized volumes along with an inputted flow diffuser length to estimate the overall diffuser storage volume. A rectangular weir section is similarly populated based on the inputted flow diffuser length assuming that the weir crest is located at the base of the stone berm where the structure ties-out to existing grade.

Waterbar – The waterbar stage storage curve was developed utilizing a conservative trapezoidal section with a 0.17 ft bottom width, typical 2:1 side slopes, and a standard depth of 6 inches. The stage storage curve was then developed utilizing this geometry along with a standard waterbar length of 16 feet for the access roads and a modified length for the pipeline ROW applications.

Check Dam – The check dam stage storage curve was developed utilizing a conservative v-ditch section with typical 2:1 side slopes and a standard depth of 6 inches. The stage storage curve was then developed utilizing this geometry along with a standard ponding length of 5 feet, per a conservative 20% roadway slope.

Gravel Diaphragm – The gravel diaphragm stage storage curve was developed utilizing a trapezoidal section with a 1 ft depth, 1 ft bottom width and typical 2:1 side slopes. The stage storage curve was then

developed utilizing this geometry along with an effective length, a porosity of 0.4, and a percent usable volume estimate of 33% to remain conservative in most situations. The 33 percent usable volume reduces the storage volume of the diaphragm conservatively based on an estimated cross sectional area reduction for a roadway slope of 40%. Should it be necessary to credit volumes in excess of this conservative level, this will be documented specifically under the Water Quantity Calculations Package.

Project specific checklists are included under Attachment 7

8.0 SOFTWARE MODELING PACKAGES

Software programs utilized in this White Paper and water quantity analysis packages include:

Bentley Systems FlowMaster v8i

Bentley Systems CulvertMaster v3.3

Bentley Systems PondPack v8i

Federal Highways Administration, Hydraulic Toolbox 4.1 or Later

NRCS, Win TR-55, Version 1.00.10

Autodesk Inc., Hydraflow Hydrographs Extension for AutoCAD Civil 3D 2011, Version 8

HydroCAD Software Solutions LLC, HydroCAD Stormwater Modeling 10.0 or Later

HEC-HMS Version 4.0 or Later

Esri ArcGIS Desktop (Versions 10.3 & 10.4)

Esri ArcGIS Spatial Analyst Extension (Versions 10.3 & 10.4)

Esri Arc Hydro Tools (Versions 10.3 & 10.4)

9.0 REFERENCES

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Chapter 8 - Culverts, Drainage Manual. Virginia Department of Transportation, 2017.

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United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) Wildlife Habitat Council Fish and Wildlife Habitat Management Leaflet Number 42 "Scrub-shrub Birds", January 2007.

Virginia Erosion & Sediment Control Handbook, Virginia Department of Environmental Quality, Third Edition, 1992.

ATTACHMENTS

Attachment 1 – Water Quantity Compliance Flow Chart

Attachment 2 – Curve Number Assignments

Table A2.1: Land cover and associated classifications (descriptions, Curve Numbers, roughness coefficients, shallow and concentrated flow surface conditions)

Table A2.2: Pre-Development and Post-Development Land Cover Categories

Attachment A.2.3: TR-55 Curve Number Limitation Evaluation

Attachment 3 – Hydrologic Soil Group Assignments for Soils without a SSURGO Classification

Attachment 4 – Mitigation Measures Assessment Computations

Table A4.1: TR-55 Sheet Flow Velocity Assessment (Wooded & Pasture)

Table A4.2: Diffuser Sedimentation Estimates

Table A4.3: Storage Volume Calculator

Table A4.4: Standard Diffuser Sizing and Details

Table A4.5: Diffuser Unit Rating Curves

Figure A4.6: Gravel Diaphragm Water Stop

Figure A4.7: Culvert Flanking Strategy

Figure A4.8: Gravel Diversion Trench and Ridgetop Runoff Collection and Diffuser Strategy

Figure A4.9: TR-55 – Vs/Vr Worksheets

Figure A4.10: Flow Diffuser Construction in High Groundwater Table Conditions

Attachment 5 – References: Standards and Specifications for Flow Diffusers

A5.1: H.R.C Research Series Report No. 10 – Analysis of Flow Through Porous Media as Applied to Gabion Dams Regarding the Storage and Release of Storm Water Runoff, NAHB/NRC Designated Housing Research Center at Penn State, August 1992

A5.2: Maine Level Spreader – Section 8.3, Maine Stormwater Best Management Practices Manual, September 2010

Attachment 6 – Procedure: Calculating Average Basin Slope

ATTACHMENTS

Attachment 1 – Water Quantity Compliance Flow Chart

Water Quantity Compliance Flow Chart

Rev. 12/20/2017

Sheet Flow

Does flow from practices leave ROW as sheet flow?

Yes

No

Is there reconcentration within 100 FT buffer?

Implement controls to establish sheet flow?

No

Establish POA's where flow leaves ROW (POA-R's) and where flow reconcentrates at drainage features at Points of Reconcentration (POA-C's).

- Velocity Evaluation: Is the post-development 2-yr, 24-hr computed flow velocity equal to or less than the pre-development 2-yr, 24 hr computed flow velocity?
  - *Note: The flow velocity is computed using 2 significant figures.
- Localized Flooding: Is the post-development 10-yr, 24-hr computed flow depth contained within the drainage feature?

Establish POA's where flow reconcentrates at drainage features at Points of Reconcentration (POA-C's).

- Velocity Evaluation: Is the post-development 2-yr, 24-hr computed flow velocity equal to or less than the pre-development 2-yr, 24 hr computed flow velocity?

*Note: The flow velocity is computed using 2 significant figures.

- Localized Flooding: Is the post-development 10-yr, 24-hr computed flow depth contained within the drainage feature?

9VAC25-870-66.D Satisfied

9VAC25-870-66.D Satisfied

Implement mitigation measures. Utilize option A or B.

Option A

- Velocity Evaluation: After implementing initial mitigation measures, is the post-development 2-yr, 24-hr computed flow velocity less than or equal to the pre-development 2-yr, 24 hr computed flow velocity?
  - *Note: The flow velocity is computed using 2 significant figures.
- Localized Flooding: Is the post-development 10-yr, 24-hr computed flow depth contained within the drainage feature?

Option B

- Provide Volumetric Offset Storage with a 25% Factor of Safety as computed using TR-55 Worksheet B. The Factor of Safety is established considering the computational limitation of this worksheet.

ROW (Right-of-Way); POA

Number)

Concentrated Flow

Demonstrate confe with Energy Balanc 1-yr, 24-hr storm even

9VAC25-870-66.B Satisfied

Concentrated Flow

9VAC25-870-66.D

Satisfied

Apply All Concentrated Flow Criterion Under 9VAC25-870-66 Sub-Parts
B & C

Demonstrate conformance with the flood protection criteria for the 10-yr 24-hr storm event. Is the post-development 10-yr, 24-hr computed flow depth contained within the drainage feature?

9VAC25-870-66.C Satisfied ✔

Attachment 2 – Curve Number Assignments

Table A2.1: Land cover and associated classifications (descriptions, Curve Numbers, roughness coefficients, shallow and concentrated flow surface conditions)

Table A2.2: Pre-Development and Post-Development Land Cover Categories

Attachment A2.3: TR-55 Curve Number Limitation Evaluation

Table A2.1: Land cover and associated classifications (descriptions, Curve Numbers, roughness coefficients, shallow and concentrated flow surface conditions)

Land Cover Category	VGIN Classification	VGIN Classification #	Land Cover Description	VGIN Reference Section (See Note 1)	Curve Number (CN) (See Note 2 and 3) Hydrologic Soil Group A	B	C	D	TR-55 Land Cover Description	Roughness Coefficient (Manning's n) for Sheet Flow (See Note 4) n	Surface Description	Shallow Concentrated Flow Surface Condition (See Note 5)
Turf Grass	Turf Grass	71	The Turf Grass classification includes vegetation (primarily grasses) planted in developed settings for erosion control or aesthetic purposes, as well as natural herbaceous vegetation and undeveloped land, including upland grasses and forbs. Examples include but are not limited to recreational areas, lawns, and vacant lands. Any grasses or managed turf that fall into this description will be included if the land is less than 1 acre in size, or visually determined to be recreational from the imagery.	2.3.4.1	39	61	74	80	TR-55, Table 2-2a, Open Space (lawns, parks, golf courses, cemeteries, etc.), good condition (grass cover > 75%)	0.15	Short grass, prairie	Unpaved
Impervious	Extracted Buildings, driveways, parking lots, roads, etc.; External Local & Statewide Impervious data	21/22	The Extracted and External classification includes areas characterized by a high percentage of constructed materials such as asphalt and concrete, buildings and parking lots, and infrastructure such as roads and rail-roads. Buildings features are represent residential and commercial building foot-prints. Roads features represent automotive thoroughfares. The information was derived from statewide data such as linear roadway centerline features, roadway classification (interstate, highway, or secondary roadway), specific VDOT (Virginia Department of Transportation) attribution such as number of lanes, lane width and hard shoulder width. Ancillary roads features are linear features that were not considered to be roadway centerlines or streams, but were visible on the aerial photography. These features may be driveways, wide hiking or ATV trails, logging roads, jeep trails, private roadways, or other similar features. Railroads features represent locomotive railway centerlines and are represented as linear features. Other Impervious surface features are polygonal features representing other potential impervious surfaces (e.g., large parking lots).	2.3.6.1	98	98	98	98	TR-55, Table 2-2a, Paved parking lots, roofs, driveways, etc.	0.01	Smooth surfaces (concrete, asphalt, gravel, or bare soil)	Paved
Forest	Forest	41	The Forest classification includes areas characterized by tree cover of natural or semi-natural woody vegetation, including deciduous, ever-green, and mixed foliage types. Any area that is not encompassed by a 1 acre circle is characterized as Tree. The Deciduous Forest class includes all band spectrums for the leaf-off trees and those with browning leaves. The Coniferous Forest class includes mixed foliage and evergreen trees. The Forest Shadow class includes the darker color bands associated with the shadows produced in more mountainous or hilly forested areas.	2.3.7.1	30	55	70	77	TR-55, Table 2-2c, Woods. Good hydrologic condition.	0.8	Woods, dense underbrush	Unpaved
Forest	Tree	42	The Tree classification includes areas characterized by tree cover of natural or semi-natural woody vegetation, less than or equal to an acre in size. This class includes deciduous, evergreen, and mixed foliage types.	2.3.8.1	30	55	70	77	TR-55, Table 2-2c, Woods. Good hydrologic condition.	0.8	Woods, dense underbrush	Unpaved
Wood/Grass	Harvested/ Disturbed Forest	61	The Harvested/Disturbed Forest classification includes areas of forest clear-cut, temporary clearing of vegetation, and other dynamically changing land cover due to land use activities. These features are categorized where there is 30% canopy cover or less.	2.3.9.1	32	58	72	79	TR-55, Table 2-2c, Woods-grass combination (orchard or tree farm. Good hydrologic condition.	0.4	Woods, light underbrush	Unpaved
Shrub/Scrub	Shrub / Scrub	51	The Shrub/Scrub classification is characterized by natural or semi-natural woody vegetation with aerial stems generally less than 6 meters tall as well as evergreen and deciduous species of true shrubs, young trees, and those that are small or stunted due to environmental conditions. This feature includes easement fields, stunted tree growth around wetland features, and any additional patches of stunted trees and turf that do not fit into the other	2.3.10.1	30	48	65	73	TR-55, Table 2-2c, Brush. Good hydrologic condition.	0.8	Woods, dense underbrush	Unpaved
Agriculture	Pastureland	81	The Pastureland classification includes areas of grasses, legumes, or grass-legume mixtures planted for live-stock grazing or the production of seed or hay crops. The land may be used only for pasture in rotation with crops, or more or less permanently used for this purpose. Any grasses or managed turf that fall into this description, or otherwise cannot be categorized as cropland or recreational will be included here if the land is greater than 1 acre in size.	2.3.3.1	39	61	74	80	TR-55, Table 2-2c, Pasture, grassland, or range - continuous forage for grazing. Good hydrologic condition.	0.17	Cultivated soils, residue cover >20%	Unpaved

Table A2.1 Continued: Land cover and associated classifications (descriptions, Curve Numbers, roughness coefficients, shallow concentrated flow surface conditions, and VRRM Land Cover)

					Curve Number (CN) (See Note 2 and 3)					Roughness Coefficient		
					Hydrologic Soil Group							
Land Cover Category	VGIN Classification	VGIN Classification #	Land Cover Description	VGIN Reference Section (See Note 1)	A	B	C	D	TR-55 Land Cover Description	n	Surface Description	Shallow Concentrated Flow Surface Condition (See Note 5)
Agriculture	Cropland	82	The Cropland classification includes areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber, or is maintained in developed settings for specific purposes. Examples include row crops, small grain, fallow (tilled with sparse vegetative cover), feeding operations, orchards, groves, vineyards, nurseries, and other horticultural areas. Any grasses or managed turf that fall into this description, or otherwise cannot be categorized as pastureland will be included here if the land is less than 1 acre in size.	2.3.2.1	67	78	85	89	TR-55, Table 2-2b, Row crops, straight row. Good hydrologic condition.	0.17	Cultivated soils, residue cover >20%	Unpaved
Wetlands	NWI/Other	91	The NWI/Other classification includes all NWI (National Wetlands Inventory) Woody Wetland areas where forest or shrub land vegetation accounts for 25% to 100% of the cover and the soil or substrate is periodically saturated with or covered with water. This classification also includes all NWI Emergent Wetland features where perennial herbaceous vegetation accounts for 25% to 100% of the cover and the soil or substrate is periodically saturated with or covered with water.	2.3.11.1	30	55	70	77	TR-55, Table 2-2c, Woods. Good hydrologic condition.	0.4	Woods, light underbrush	Unpaved
Barren	Barren	31	The Barren classification includes areas with little or no vegetation characterized by bedrock, desert pavement, beach and other sand/rock/clay accumulations, as well as areas of extractive mining activities with significant surface expression. Example features include but are not limited to beaches, volcanic material, slides, quarries, strip mines, and gravel pits. Vegetation, if present, would be more widely spaced than that of the Scrub/Shrub category, and would have limited ability to support life (such as clearing due natural fire, flood, etc.). Disturbed Forest is defined as land that is in a transitional state where barren characteristics may be inferred, but there are no sizable areas that are purely barren.	2.3.5.1	77	86	91	94	TR-55, Table 2-2b, Fallow, bare soil.	0.01	Smooth surfaces (concrete, asphalt, gravel, or bare soil)	Paved
Water	Water	11	The Water classification includes all areas of open water; typically 25% or greater pixel cover of water, and all areas characterized by perennial cover of ice/snow and includes drainage network and basins such as rivers, streams, lakes, canals, waterways, reservoirs, ponds, bays, estuaries, and ocean as defined by the NHD (National Hydrography Dataset).	2.3.1.1	100	100	100	100	No capture of stormwater.	n/a	n/a	n/a
Permanent ROW	Shrub / Scrub	98	The Permanent ROW is being treated as Shrub/Scrub which is characterized by natural or semi-natural woody vegetation with aerial stems generally less than 6 meters tall as well as evergreen and deciduous species of true shrubs, young trees, and those that are small or stunted due to environmental conditions. This feature includes easement fields, stunted tree growth around wetland features, and any additional patches of stunted trees and turf that do not fit into the other classifications.	2.3.10.1	30	48	65	73	TR-55, Table 2-2c, Brush. Good hydrologic condition.	0.8	Woods, dense underbrush	Unpaved
Gravel	n/a	99	The Gravel classification represents the post-development road surface associated with Major Upgrade and Proposed New access roads. The estimated road width is no more than 16 feet in the Post-Development condition.	n/a	98	98	98	98	TR-55, Table 2-2a, Paved parking lots, roofs, driveways, etc.	0.01	Smooth surfaces (concrete, asphalt, gravel, or bare soil)	Paved

Notes:

1. VGIN Reference: Technical Plan of Operations. Virginia Statewide Land Cover Data Development. WorldView Solutions Inc. Prepared for Virginia Information Technologies Agency and Virginia Department of Environmental Quality. May 6, 2016. Version 7.0. Accessed September 2017. <http://www.vita.virginia.gov/uploadedFiles/VITA_Main_Public/ISP/VGIN/Land_Cover/LandCover_TechnicalPlanOfOperations_v7_20160506.pdf>
2. TR 55: Technical Release 55 Urban Hydrology for Small Watersheds (TR-55). United States Department of Agriculture and Natural Resources Conservation Service. 1986.
3. The Curve Numbers are derived from TR-55 (see Note 2), referenced by the Virginia Stormwater Management Handbook, 4-4.4.3, C.
4. The Curve Numbers associated with gravel have been conservatively estimated as impervious area. The design team may request modification of these values upon future design guidance and agency approval.
5. The Roughness coefficients (Manning's n) for Sheet Flow is derived from TR-55 (see Note 2), Table 3-1 that is also presented in the Virginia Stormwater Management Handbook, Table 4-9a.
6. The surface condition associated with Shallow Concentrated Flow is presented in both in TR-55 (see Note 2), Figure 3-1 and the Virginia Stormwater Management Handbook, 4-4.3.3.E.2.b.
7. VRRM: Guidance Memo No. 16-2011- Updated Virginia Runoff Reduction Method Compliance Spreadsheets - Version 3.0, May 2, 2016.

Table A2.2: Pre-Development and Post-Development Land Cover Categories

Pre-Development Condition Land Cover Category	Post-Development Condition Land Cover Category
Turf Grass	Turf Grass, unless access road surface;Gravel for access road surfaces only
Impervious	Impervious
Forest, Tree	Shrub/Scrub, unless access road surface;Gravel for access road surfaces only
Wood/Grass	Shrub/Scrub, unless access road surface;Gravel for access road surfaces only
Shrub/Scrub	Shrub/Scrub, unless access road surface;Gravel for access road surfaces only
Agriculture (Cropland)	Agriculture (Cropland) unless access road surface;Gravel for access road surfaces only
Agriculture (Pastureland)	Agriculture (Pastureland) unless access road surface;Gravel for access road surfaces only
Wetlands	Wetlands, unless access road surface;Gravel for access road surfaces only
Barren	Barren, unless access road surface;Gravel for access road surfaces only
Water	Water

Attachment A.2.3 – TR-55 Curve Number Limitation Evaluation

The following is provided for additional support of the TR-55 Curve Number procedure noted under the White Paper Section 7.3 for the purposes of producing a conservative determinant flow for evaluations for curve numbers less than 40. The following is excerpted from White Paper comment response provided by ACP to DEQ on 2/16/2018.

From Section 7.3 (page 46) of the Virginia ACP Stormwater Quantity Compliance Methodology, or White Paper, submitted to DEQ on February 7, 2018:

> *Curve Number Limitations – Note Curve Numbers less than 40 are problematic under the TR-55 framework and will produce unreliable results for flow and volume calculations (essentially, discharges and volumes cannot be relied upon and are indeterminate for CN<40 due to underlying limitations in the compliance methodology). The TR-55 manual notes for a CN of less than 40, another procedure should be used to determine runoff.*
>
> *Given many of the existing project soils and land uses, many areas of very low CN may be noted. With the large initial abstraction of greater than 3 inches for any CNs less than 40 and the limitations of the TR-55 modeling equations (graphical peak discharge method), alternative approaches were discussed. However due to the Commonwealth's stormwater management compliance framework being reliant on the methodologies outlined in TR-55, an alternative, conservative approach to upward adjust the Curve Numbers was derived if the spreadsheet results are utilized in lieu of more sophisticated hydrologic modeling. To resolve the limitations of the graphical peak discharge method in the spreadsheet, the consultant team is conservatively increasing CNs where composite CN's are below the TR-55 threshold of 40 to produce values that would fit within the modeling parameters and therefore could be analyzed in both the pre- and post-development scenarios.*
>
> *To address this manual adjustment, while still calculating the CNs per the land use and soil classifications, the consultant team added in additional columns on the VGIN Land Cover Data, Attachments 1 and 2. These changes have been highlighted in blue and are conservatively used throughout the remainder of the spreadsheet for all calculations. The underlying individual land cover/soil constituents which are less than 40 (and create the issue when composited) are upward adjusted to 40 (for both pre and post-development). In this regard, when a predevelopment composite CN (Water Quantity Calculations Package Attachment 1 - VGIN Land Cover Data – Pre, Calculated CN column) is less than 40, a second adjusted CN table (CN Table 2 under Water Quantity Calculations Package Attachments 1 and 2) will be utilized for both the pre-development and post-development CN calculations. This CN Table 2 provides for upward adjustment of all constituent land cover CNs that are less than 40 under TR-55 to CN of 40. The composite curve number will then be generated by this CN Table 2. The exception will be when the post-development CN decreases to below 40 (due to a resultant scrub-shrub land use for instance) from a pre-development CN equal to or greater than 40. In this instance the*

calculated composite post-development curve number will be raised to a minimum of 40 so that a determinant result may be evaluated in the post-development condition. This has the effect of inflating the curve numbers to allow for determinate results using the TR-55 graphical peak discharge method, while maintaining a similar relative difference between pre and post-development. It should be noted that this adjustment approach has a tendency to overestimate runoff and thusly artificially inflate practice sizing, and as such is conservative. If the conservative peak discharge computations in the spreadsheet are problematic in a given instance, designers are encouraged to model the scenario using unadjusted CNs in a modeling package such as TR-20 to produce results which are not inflated by this workaround due to limitations of TR-55 hydrology for CN less than 40.

In doing this CN adjustment, it is noted by DEQ that there are some instances and anomalies whereby the differential from predevelopment to postdevelopment curve numbers are altered and may go down from traditional TR-55 CN calculations. This generally occurs in areas of very low existing CNs, or A Hydrologic Group (HSG) Soils.

Even though the feature sizing would remain conservative with the methodology described above, we understand the concern may be that the relative change in pre to postdevelopment peak flow and volume may be low in these instances. To aid in communications DEQ provided spreadsheet examples of the identified areas for ACP review.

Stantec Consulting Services Inc. (Stantec) reviewed the spreadsheet information provided by DEQ and performed additional hydrologic modeling in Bentley Systems PondPack v8i (PondPack). Because of the TR-55 limitations noted above, Stantec utilized the TR-20 Method Unit Hydrograph Simulation setting under PondPack to run the actual computed modeling pre and postdevelopment flow results. The actual modeled flow differential was compared against conservative spreadsheet TR-55 model results. Note the information provided by DEQ follows two drainage areas identified by DEQ previously that were discussed on 1/15/18. Stantec provided a prior TR20 evaluation of those previously via email on 1/16/18, and for completeness these two areas are shown in the first two lines of Attachment 1 - Drainage Area TR-20 Assessment Summary. Modeling summaries are provided under Attachment 2.

Note in all forty cases reviewed, the spreadsheet calculations provided:

1. conservatively high flows that would be used for feature sizing over TR-20 flows and
2. flow differentials (pre to post) that equal (1) or exceed (39) the actual TR-20 modeled flow differentials.

Based on the above, the calculations remain conservative for purpose of regulatory compliance. As such, no changes to either the calculations or methodology are proposed. If DEQ needs more specific assurances for some particular subwatershed which is submitted with the detailed design packages, we suggest that you request similar TR-20 based flow comparisons at that time.

Attachment 1 - Drainage Area TR-20 Assessment Summary
Attachment 2 – PondPack Modeling Results

Attachment 1 - Drainage Area TR-20 Assessment Summary

Drainage Area Data									10-Year Flow (cfs)						Spreadsheet Conservative and Compliance Assessment Summary		
									PondPack			Sprdsht Adjusted j					
DA ID	DA Pre (ac)	DA Post (ac)	Tc Pre (hrs)	Tc Post (hrs)	Sprdsht Pre CN	Sprdsht Post CN	Actual Pre CN[1]	Actual Post CN[1]	Pre	Post	PondPack (cfs)	Pre	Post	Sprdsht (cfs)	Sprdsht Conservative for Feature Sizing?	Sprdsht > PondPack > 0 = Conservative?	Regulatory Compliance Met?
C AR_304.10	1.12	1.12	0.083	0.083	40	44	30	35	0.000	0.003	0.003	0.090	0.200	0.110	Yes	Yes	Yes
C AR_304.13	2.64	2.64	0.083	0.083	44	45	36	38	0.009	0.015	0.006	0.460	0.530	0.070	Yes	Yes	Yes
36-014-AR2-POA_R001	0.04	0.04	0.083	0.083	40	72	30	67	0.000	0.086	0.086	0.004	0.121	0.117	Yes	Yes	Yes
36-014-AR2-POA_R002	0.32	0.32	0.083	0.083	40	56	30	49	0.000	0.110	0.110	0.028	0.324	0.296	Yes	Yes	Yes
36-014-AR2-POA_R003	0.4	0.4	0.083	0.083	40	51	30	43	0.000	0.013	0.013	0.036	0.225	0.189	Yes	Yes	Yes
36-014-AR2-POA_R004	1.16	1.16	0.117	0.100	40	46	30	37	0.000	0.005	0.005	0.089	0.257	0.169	Yes	Yes	Yes
36-014-AR2-POA_R005	0.35	0.35	0.083	0.083	40	57	30	50	0.000	0.146	0.146	0.031	0.391	0.360	Yes	Yes	Yes
36-014-AR2-POA_R006	1.62	1.62	0.181	0.136	40	51	30	42	0.000	0.034	0.034	0.100	0.712	0.613	Yes	Yes	Yes
36-014-AR2-POA_R007	0.81	0.81	0.086	0.083	40	55	30	47	0.000	0.169	0.169	0.072	0.885	0.813	Yes	Yes	Yes
C AR305.001	1.77	1.77	0.083	0.083	40	46	30	37	0.000	0.008	0.008	0.160	0.429	0.269	Yes	Yes	Yes
C AR305.002	2.05	2.05	0.149	0.130	40	45	30	36	0.000	0.007	0.007	0.139	0.350	0.211	Yes	Yes	Yes
C AR305.002A	2.87	2.87	0.214	0.192	40	44	30	35	0.000	0.007	0.007	0.162	0.351	0.189	Yes	Yes	Yes
C AR305.003	6.18	6.18	0.287	0.251	40	45	30	36	0.000	0.021	0.021	0.166	0.391	0.225	Yes	Yes	Yes
C AR305.003A	1.55	1.55	0.088	0.083	40	47	30	38	0.000	0.009	0.009	0.135	0.448	0.313	Yes	Yes	Yes
06_001_C037.AR2_AOA_C15	4.21	4.22	0.120	0.117	40	41	30	32	0.000	0.000	0.000	0.317	0.397	0.080	Yes	Yes	Yes
06_001_C037.AR2_AOA_C2	1.82	1.82	0.083	0.083	40	45	30	36	0.000	0.006	0.006	0.164	0.387	0.223	Yes	Yes	Yes
06_001_C037.AR2_AOA_R1	10.8	10.8	0.133	0.133	40	42	30	33	0.000	0.009	0.009	0.770	1.145	0.375	Yes	Yes	Yes
C AR_304.1	0.87	0.88	0.083	0.083	40	45	30	36	0.000	0.003	0.003	0.078	0.187	0.109	Yes	Yes	Yes
C AR_304.10*	1.7	1.7	0.083	0.083	40	41	30	32	0.000	0.000	0.000	0.153	0.189	0.036	Yes	Yes	Yes
C AR_304.11	2.41	2.41	0.084	0.083	40	42	30	33	0.000	0.002	0.002	0.217	0.323	0.106	Yes	Yes	Yes
C AR_304.15	1.09	1.09	0.083	0.083	40	44	30	35	0.000	0.003	0.003	0.098	0.202	0.103	Yes	Yes	Yes
C AR_304.16	2.04	2.04	0.083	0.083	40	40	30	31	0.000	0.000	*0.000*	0.183	0.183	*0.000*	Yes	Equal	Yes
C AR_304.19	0.76	0.76	0.083	0.083	40	48	30	40	0.000	0.008	0.008	0.068	0.230	0.162	Yes	Yes	Yes
C AR_304.2	0.44	0.44	0.083	0.083	40	47	30	38	0.000	0.003	0.003	0.040	0.120	0.080	Yes	Yes	Yes
C AR_304.22	2.41	2.41	0.093	0.090	40	41	30	32	0.000	0.000	0.000	0.206	0.258	0.052	Yes	Yes	Yes
C AR_304.22a	2.32	2.32	0.096	0.093	40	41	30	32	0.000	0.000	0.000	0.195	0.244	0.049	Yes	Yes	Yes
C AR_304.24	1.2	1.2	0.083	0.083	40	41	30	32	0.000	0.000	0.000	0.108	0.134	0.025	Yes	Yes	Yes
C AR_304.24a	1.98	1.98	0.092	0.087	40	42	30	33	0.000	0.002	0.002	0.170	0.260	0.090	Yes	Yes	Yes
C AR_304.25	0.37	0.37	0.083	0.083	40	49	30	41	0.000	0.005	0.005	0.033	0.138	0.104	Yes	Yes	Yes
C AR_304.26a	0.06	0.06	0.083	0.083	40	96	30	95	0.000	0.313	0.313	0.005	0.384	0.379	Yes	Yes	Yes
C AR_304.26b	0.05	0.05	0.083	0.083	40	54	30	47	0.000	0.010	0.010	0.004	0.040	0.036	Yes	Yes	Yes
C AR_304.28c	0.92	0.92	0.083	0.083	43	45	35	38	0.002	0.005	0.003	0.145	0.195	0.050	Yes	Yes	Yes
C AR_304.4	1.24	1.24	0.083	0.083	40	44	30	35	0.000	0.003	0.003	0.112	0.229	0.117	Yes	Yes	Yes
C AR_304.47a	0.16	0.16	0.083	0.083	40	42	30	33	0.000	0.000	0.000	0.014	0.021	0.007	Yes	Yes	Yes
C AR_304.47b	0.12	0.12	0.083	0.083	40	98	30	98	0.000	0.634	0.634	0.011	0.787	0.776	Yes	Yes	Yes
C AR_304.48	0.46	0.46	0.083	0.083	40	47	30	38	0.000	0.003	0.003	0.041	0.125	0.083	Yes	Yes	Yes
C AR_304.49	2.34	2.33	0.105	0.094	40	44	30	35	0.000	0.006	0.006	0.188	0.405	0.217	Yes	Yes	Yes
C AR_304.5	1.01	1.01	0.083	0.083	40	44	30	35	0.000	0.003	0.003	0.091	0.187	0.096	Yes	Yes	Yes
C AR_304.8	2.4	2.4	0.083	0.083	40	46	30	37	0.000	0.011	0.011	0.216	0.580	0.364	Yes	Yes	Yes
C AR_304.9	1.99	1.98	0.083	0.083	40	41	30	32	0.000	0.000	0.000	0.179	0.220	0.041	Yes	Yes	Yes

Notes:

1) TR20 flows from PondPack are based on actual CN information.

2) Spreadsheet conservative flows as noted per White Paper that are below 40 are adjusted updward so as to compute a determinant flow value.

3) P1yr=2.5 inches, P2yr=3.0 inches, P10yr=4.3 inches

4) The following Tc's were adjusted conservatively based on assessment of 3e review files: 36-014-AR2-POA_R007, C AR305.003, C AR305.003A

5) Only one reviewed DA ID (C AR_304.16) is not represented conservatively; however, the flow differential is equal to that of the TR-20 model results.

6) Regulatory Compliance = Flows are conservatively high / features conservatively sized, and flow deltas from pre to post in spreadsheet are >= TR20 actual results.

Attachment 2 – PondPack Modeling Results

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	Master Network Summary	1
Type II	Time-Depth Curve, 10 years	6
06_001_C037.AR2_AOA_C15Post		
	Unit Hydrograph Summary, 10 years	8
06_001_C037.AR2_AOA_C15Pre		
	Unit Hydrograph Summary, 10 years	10
06_001_C037.AR2_AOA_C2Post		
	Unit Hydrograph Summary, 10 years	12
06_001_C037.AR2_AOA_C2Pre		
	Unit Hydrograph Summary, 10 years	14
06_001_C037.AR2_AOA_R1Post		
	Unit Hydrograph Summary, 10 years	16
06_001_C037.AR2_AOA_R1Pre		
	Unit Hydrograph Summary, 10 years	18
36-014-AR2-POA_R001 Post		
	Unit Hydrograph Summary, 10 years	20
36-014-AR2-POA_R001 Pre		
	Unit Hydrograph Summary, 10 years	22
36-014-AR2-POA_R002 Post		
	Unit Hydrograph Summary, 10 years	24
36-014-AR2-POA_R002 Pre		
	Unit Hydrograph Summary, 10 years	26
36-014-AR2-POA_R003 Post		
	Unit Hydrograph Summary, 10 years	28
36-014-AR2-POA_R003 Pre		
	Unit Hydrograph Summary, 10 years	30
36-014-AR2-POA_R004 Post		
	Unit Hydrograph Summary, 10 years	32
36-014-AR2-POA_R004 Pre		
	Unit Hydrograph Summary, 10 years	34
36-014-AR2-POA_R005 Post		
	Unit Hydrograph Summary, 10 years	36
36-014-AR2-POA_R005 Pre		
	Unit Hydrograph Summary, 10 years	38

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36-014-AR2-POA_R006Post	Unit Hydrograph Summary, 10 years	40
36-014-AR2-POA_R006Pre	Unit Hydrograph Summary, 10 years	42
36-014-AR2-POA_R007Post	Unit Hydrograph Summary, 10 years	44
36-014-AR2-POA_R007Pre	Unit Hydrograph Summary, 10 years	46
C AR_304.10 Post	Unit Hydrograph Summary, 10 years	48
C AR_304.10 Pre	Unit Hydrograph Summary, 10 years	50
C AR_304.10*Post	Unit Hydrograph Summary, 10 years	52
C AR_304.10*Pre	Unit Hydrograph Summary, 10 years	54
C AR_304.11Post	Unit Hydrograph Summary, 10 years	56
C AR_304.11Pre	Unit Hydrograph Summary, 10 years	58
C AR_304.13 Post	Unit Hydrograph Summary, 10 years	60
C AR_304.13 Pre	Unit Hydrograph Summary, 10 years	62
C AR_304.15Post	Unit Hydrograph Summary, 10 years	64
C AR_304.15Pre	Unit Hydrograph Summary, 10 years	66
C AR_304.16Post	Unit Hydrograph Summary, 10 years	68
C AR_304.16Pre	Unit Hydrograph Summary, 10 years	70
C AR_304.19Post	Unit Hydrograph Summary, 10 years	72

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C AR_304.1Post

Unit Hydrograph Summary, 10 years 76

C AR_304.1Pre

Unit Hydrograph Summary, 10 years 78

C AR_304.22aPost

Unit Hydrograph Summary, 10 years 80

C AR_304.22aPre

Unit Hydrograph Summary, 10 years 82

C AR_304.22Post

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C AR_304.22Pre

Unit Hydrograph Summary, 10 years 86

C AR_304.24aPost

Unit Hydrograph Summary, 10 years 88

C AR_304.24aPre

Unit Hydrograph Summary, 10 years 90

C AR_304.24Post

Unit Hydrograph Summary, 10 years 92

C AR_304.24Pre

Unit Hydrograph Summary, 10 years 94

C AR_304.25Post

Unit Hydrograph Summary, 10 years 96

C AR_304.25Pre

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C AR_304.26aPost

Unit Hydrograph Summary, 10 years 100

C AR_304.26aPre

Unit Hydrograph Summary, 10 years 102

C AR_304.26bPost

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C AR_304.28cPost

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C AR_304.2Post

Unit Hydrograph Summary, 10 years 112

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C AR_304.47aPost

Unit Hydrograph Summary, 10 years 116

C AR_304.47aPre

Unit Hydrograph Summary, 10 years 118

C AR_304.47bPost

Unit Hydrograph Summary, 10 years 120

C AR_304.47bPre

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C AR_304.48Post

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C AR_304.48Pre

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C AR_304.49Post

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C AR_304.49Pre

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C AR_304.4Post

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C AR_304.4Pre

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C AR_304.5Post

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C AR_304.5Pre

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C AR_304.8Post

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C AR_304.9Post

Unit Hydrograph Summary, 10 years 144

C AR_304.9Pre

Unit Hydrograph Summary, 10 years 146

C AR305.001Post

Unit Hydrograph Summary, 10 years 148

C AR305.001Pre

Unit Hydrograph Summary, 10 years 150

C AR305.002APost

Unit Hydrograph Summary, 10 years 152

C AR305.002APre

Unit Hydrograph Summary, 10 years 154

C AR305.002Post

Unit Hydrograph Summary, 10 years 156

C AR305.002Pre

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C AR305.003APre

Unit Hydrograph Summary, 10 years 162

C AR305.003Post

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C AR305.003Pre

Unit Hydrograph Summary, 10 years 166

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ft³)	Time to Peak (hours)	Peak Flow (ft³/s)
06_001_C037.AR2_AOA_C15Post	10-YR	10	0.000	0.000	0.00000
06_001_C037.AR2_AOA_C15Pre	10-YR	10	0.000	0.000	0.00000
06_001_C037.AR2_AOA_C2Post	10-YR	10	171.000	24.000	0.00635
06_001_C037.AR2_AOA_C2Pre	10-YR	10	0.000	0.000	0.00000
06_001_C037.AR2_AOA_R1Post	10-YR	10	65.000	24.000	0.00914
06_001_C037.AR2_AOA_R1Pre	10-YR	10	0.000	0.000	0.00000
36-014-AR2-POA_R001 Post	10-YR	10	212.000	11.950	0.08615
36-014-AR2-POA_R001 Pre	10-YR	10	0.000	0.000	0.00000
36-014-AR2-POA_R002 Post	10-YR	10	427.000	12.000	0.10955
36-014-AR2-POA_R002 Pre	10-YR	10	0.000	0.000	0.00000
36-014-AR2-POA_R003 Post	10-YR	10	247.000	12.050	0.01281
36-014-AR2-POA_R003 Pre	10-YR	10	0.000	0.000	0.00000
36-014-AR2-POA_R004 Post	10-YR	10	167.000	18.150	0.00512
36-014-AR2-POA_R004 Pre	10-YR	10	0.000	0.000	0.00000
36-014-AR2-POA_R005 Post	10-YR	10	520.000	12.000	0.14592
36-014-AR2-POA_R005 Pre	10-YR	10	0.000	0.000	0.00000
36-014-AR2-POA_R006Post	10-YR	10	848.000	12.450	0.03433
36-014-AR2-POA_R006Pre	10-YR	10	0.000	0.000	0.00000
36-014-AR2-POA_R007Post	10-YR	10	881.000	12.000	0.16912
36-014-AR2-POA_R007Pre	10-YR	10	0.000	0.000	0.00000
C AR305.001Post	10-YR	10	255.000	18.100	0.00783
C AR305.001Pre	10-YR	10	0.000	0.000	0.00000
C AR305.002APost	10-YR	10	152.000	23.950	0.00743
C AR305.002APre	10-YR	10	0.000	0.000	0.00000
C AR305.002Post	10-YR	10	192.000	23.950	0.00712
C AR305.002Pre	10-YR	10	0.000	0.000	0.00000
C AR305.003APost	10-YR	10	314.000	17.500	0.00905
C AR305.003APre	10-YR	10	0.000	0.000	0.00000

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ft³)	Time to Peak (hours)	Peak Flow (ft³/s)
C AR305.003Post	10-YR	10	570.000	24.000	0.02140
C AR305.003Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.10 Post	10-YR	10	60.000	24.000	0.00292
C AR_304.10 Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.10*Post	10-YR	10	0.000	0.000	0.00000
C AR_304.10*Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.11Post	10-YR	10	15.000	24.000	0.00207
C AR_304.11Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.13 Post	10-YR	10	536.000	17.500	0.01545
C AR_304.13 Pre	10-YR	10	248.000	24.000	0.00921
C AR_304.15Post	10-YR	10	59.000	24.000	0.00285
C AR_304.15Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.16Post	10-YR	10	0.000	0.000	0.00000
C AR_304.16Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.19Post	10-YR	10	262.000	13.450	0.00775
C AR_304.19Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.1Post	10-YR	10	83.000	24.000	0.00307
C AR_304.1Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.22Post	10-YR	10	0.000	0.000	0.00000
C AR_304.22Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.22aPost	10-YR	10	0.000	0.000	0.00000
C AR_304.22aPre	10-YR	10	0.000	0.000	0.00000
C AR_304.24Post	10-YR	10	0.000	0.000	0.00000
C AR_304.24Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.24aPost	10-YR	10	12.000	24.000	0.00170
C AR_304.24aPre	10-YR	10	0.000	0.000	0.00000
C AR_304.25Post	10-YR	10	159.000	12.950	0.00524
C AR_304.25Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.26aPost	10-YR	10	800.000	11.900	0.31305
C AR_304.26aPre	10-YR	10	0.000	0.000	0.00000
C AR_304.26bPost	10-YR	10	51.000	12.000	0.00978
C AR_304.26bPre	10-YR	10	0.000	0.000	0.00000
C AR_304.28cPost	10-YR	10	186.000	17.500	0.00537
C AR_304.28cPre	10-YR	10	49.000	24.000	0.00240
C AR_304.2Post	10-YR	10	89.000	17.500	0.00258
C AR_304.2Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.47aPost	10-YR	10	1.000	24.000	0.00014
C AR_304.47aPre	10-YR	10	0.000	0.000	0.00000
C AR_304.47bPost	10-YR	10	1,702.000	11.900	0.63406
C AR_304.47bPre	10-YR	10	0.000	0.000	0.00000
C AR_304.48Post	10-YR	10	93.000	17.500	0.00267
C AR_304.48Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.49Post	10-YR	10	125.000	24.000	0.00608
C AR_304.49Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.4Post	10-YR	10	67.000	24.000	0.00324

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ft³)	Time to Peak (hours)	Peak Flow (ft³/s)
C AR_304.4Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.5Post	10-YR	10	54.000	24.000	0.00264
C AR_304.5Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.8Post	10-YR	10	345.000	18.100	0.01059
C AR_304.8Pre	10-YR	10	0.000	0.000	0.00000
C AR_304.9Post	10-YR	10	0.000	0.000	0.00000
C AR_304.9Pre	10-YR	10	0.000	0.000	0.00000

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ft³)	Time to Peak (hours)	Peak Flow (ft³/s)
10 Post	10-YR	10	60.000	24.000	0.00292
10 Pre	10-YR	10	0.000	0.000	0.00000
13 Post	10-YR	10	536.000	17.500	0.01545
13 Pre	10-YR	10	248.000	24.000	0.00921
O-100	10-YR	10	12.000	24.000	0.00170
O-101	10-YR	10	0.000	0.000	0.00000
O-102	10-YR	10	159.000	12.950	0.00524
O-103	10-YR	10	0.000	0.000	0.00000
O-104	10-YR	10	800.000	11.900	0.31305
O-105	10-YR	10	0.000	0.000	0.00000
O-106	10-YR	10	51.000	12.000	0.00978
O-107	10-YR	10	49.000	24.000	0.00240
O-108	10-YR	10	186.000	17.500	0.00537
O-109	10-YR	10	0.000	0.000	0.00000
O-110	10-YR	10	67.000	24.000	0.00324
O-111	10-YR	10	0.000	0.000	0.00000
O-112	10-YR	10	1.000	24.000	0.00014
O-113	10-YR	10	0.000	0.000	0.00000
O-114	10-YR	10	1,702.000	11.900	0.63406
O-115	10-YR	10	0.000	0.000	0.00000
O-116	10-YR	10	93.000	17.500	0.00267
O-117	10-YR	10	0.000	0.000	0.00000
O-118	10-YR	10	125.000	24.000	0.00608
O-119	10-YR	10	0.000	0.000	0.00000
O-120	10-YR	10	54.000	24.000	0.00264
O-121	10-YR	10	0.000	0.000	0.00000
O-122	10-YR	10	345.000	18.100	0.01059
O-123	10-YR	10	0.000	0.000	0.00000
O-124	10-YR	10	0.000	0.000	0.00000
O-49	10-YR	10	0.000	0.000	0.00000
O-50	10-YR	10	212.000	11.950	0.08615
O-51	10-YR	10	0.000	0.000	0.00000

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ft³)	Time to Peak (hours)	Peak Flow (ft³/s)
O-52	10-YR	10	427.000	12.000	0.10955
O-53	10-YR	10	0.000	0.000	0.00000
O-54	10-YR	10	247.000	12.050	0.01281
O-55	10-YR	10	0.000	0.000	0.00000
O-56	10-YR	10	167.000	18.150	0.00512
O-57	10-YR	10	0.000	0.000	0.00000
O-58	10-YR	10	520.000	12.000	0.14592
O-59	10-YR	10	0.000	0.000	0.00000
O-60	10-YR	10	848.000	12.450	0.03433
O-61	10-YR	10	0.000	0.000	0.00000
O-62	10-YR	10	881.000	12.000	0.16912
O-63	10-YR	10	0.000	0.000	0.00000
O-64	10-YR	10	255.000	18.100	0.00783
O-65	10-YR	10	0.000	0.000	0.00000
O-66	10-YR	10	192.000	23.950	0.00712
O-67	10-YR	10	0.000	0.000	0.00000
O-68	10-YR	10	152.000	23.950	0.00743
O-69	10-YR	10	0.000	0.000	0.00000
O-70	10-YR	10	570.000	24.000	0.02140
O-71	10-YR	10	0.000	0.000	0.00000
O-72	10-YR	10	314.000	17.500	0.00905
O-73	10-YR	10	0.000	0.000	0.00000
O-74	10-YR	10	0.000	0.000	0.00000
O-75	10-YR	10	0.000	0.000	0.00000
O-76	10-YR	10	171.000	24.000	0.00635
O-77	10-YR	10	0.000	0.000	0.00000
O-78	10-YR	10	65.000	24.000	0.00914
O-79	10-YR	10	0.000	0.000	0.00000
O-80	10-YR	10	83.000	24.000	0.00307
O-81	10-YR	10	0.000	0.000	0.00000
O-82	10-YR	10	0.000	0.000	0.00000
O-83	10-YR	10	0.000	0.000	0.00000
O-84	10-YR	10	15.000	24.000	0.00207
O-85	10-YR	10	0.000	0.000	0.00000
O-86	10-YR	10	59.000	24.000	0.00285
O-87	10-YR	10	0.000	0.000	0.00000
O-88	10-YR	10	0.000	0.000	0.00000
O-89	10-YR	10	0.000	0.000	0.00000
O-90	10-YR	10	262.000	13.450	0.00775
O-91	10-YR	10	0.000	0.000	0.00000
O-92	10-YR	10	89.000	17.500	0.00258
O-93	10-YR	10	0.000	0.000	0.00000
O-94	10-YR	10	0.000	0.000	0.00000
O-95	10-YR	10	0.000	0.000	0.00000
O-96	10-YR	10	0.000	0.000	0.00000

Subsection: Master Network Summary

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ft^3)	Time to Peak (hours)	Peak Flow (ft^3/s)
O-97	10-YR	10	0.000	0.000	0.00000
O-98	10-YR	10	0.000	0.000	0.00000
O-99	10-YR	10	0.000	0.000	0.00000

Time-Depth Curve: 10-YR	
Label	10-YR
Start Time	0.000 hours
Increment	0.100 hours
End Time	24.000 hours
Return Event	10 years

CUMULATIVE RAINFALL (in)
Output Time Increment = 0.100 hours
Time on left represents time for first value in each row.

Time (hours)	Depth (in)	Depth (in)	Depth (in)	Depth (in)	Depth (in)
0.000	0.0	0.0	0.0	0.0	0.0
0.500	0.0	0.0	0.0	0.0	0.0
1.000	0.0	0.0	0.1	0.1	0.1
1.500	0.1	0.1	0.1	0.1	0.1
2.000	0.1	0.1	0.1	0.1	0.1
2.500	0.1	0.1	0.1	0.1	0.1
3.000	0.1	0.2	0.2	0.2	0.2
3.500	0.2	0.2	0.2	0.2	0.2
4.000	0.2	0.2	0.2	0.2	0.2
4.500	0.2	0.2	0.2	0.3	0.3
5.000	0.3	0.3	0.3	0.3	0.3
5.500	0.3	0.3	0.3	0.3	0.3
6.000	0.3	0.3	0.4	0.4	0.4
6.500	0.4	0.4	0.4	0.4	0.4
7.000	0.4	0.4	0.4	0.4	0.5
7.500	0.5	0.5	0.5	0.5	0.5
8.000	0.5	0.5	0.5	0.5	0.6
8.500	0.6	0.6	0.6	0.6	0.6
9.000	0.6	0.6	0.7	0.7	0.7
9.500	0.7	0.7	0.7	0.7	0.8
10.000	0.8	0.8	0.8	0.8	0.8
10.500	0.9	0.9	0.9	0.9	1.0
11.000	1.0	1.0	1.1	1.1	1.2
11.500	1.2	1.3	1.5	1.8	2.4
12.000	2.8	2.9	3.0	3.0	3.1
12.500	3.1	3.2	3.2	3.2	3.3
13.000	3.3	3.3	3.3	3.4	3.4
13.500	3.4	3.4	3.4	3.5	3.5
14.000	3.5	3.5	3.5	3.5	3.5
14.500	3.6	3.6	3.6	3.6	3.6
15.000	3.6	3.6	3.7	3.7	3.7
15.500	3.7	3.7	3.7	3.7	3.7
16.000	3.7	3.7	3.8	3.8	3.8
16.500	3.8	3.8	3.8	3.8	3.8
17.000	3.8	3.8	3.8	3.9	3.9

Subsection: Time-Depth Curve Label: Type II	17.500	3.9	3.9	3.9	3.9

Return Event: 10 years
Storm Event: 10-YR

Subsection: Time-Depth Curve
Label: Type II

Return Event: 10 years
Storm Event: 10-YR

CUMULATIVE RAINFALL (in)
Output Time Increment = 0.100 hours
Time on left represents time for first value in each row.

Time (hours)	Depth (in)	Depth (in)	Depth (in)	Depth (in)	Depth (in)
18.000	3.9	3.9	3.9	3.9	3.9
18.500	4.0	4.0	4.0	4.0	4.0
19.000	4.0	4.0	4.0	4.0	4.0
19.500	4.0	4.0	4.0	4.0	4.0
20.000	4.0	4.1	4.1	4.1	4.1
20.500	4.1	4.1	4.1	4.1	4.1
21.000	4.1	4.1	4.1	4.1	4.1
21.500	4.1	4.1	4.1	4.1	4.1
22.000	4.2	4.2	4.2	4.2	4.2
22.500	4.2	4.2	4.2	4.2	4.2
23.000	4.2	4.2	4.2	4.2	4.2
23.500	4.2	4.2	4.2	4.2	4.2
24.000	4.3	(N/A)	(N/A)	(N/A)	(N/A)

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.117 hours
Area (User Defined)	4.220 acres

Computational Time Increment	0.016 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	32.000
Area (User Defined)	4.220 acres
Maximum Retention (Pervious)	21.3 in
Maximum Retention (Pervious, 20 percent)	4.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.117 hours

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ft³/
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0.078 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.312 hours
Total unit time, Tb	0.390 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.120 hours
Area (User Defined)	4.210 acres

Computational Time Increment	0.016 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	4.210 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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0.080 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.320 hours
Total unit time, Tb	0.400 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.820 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00635 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00635 ft^3/s

Drainage Area	
SCS CN (Composite)	36.000
Area (User Defined)	1.820 acres
Maximum Retention (Pervious)	17.8 in
Maximum Retention (Pervious, 20 percent)	3.6 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	172.486 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	171.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.820 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.820 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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ft³/
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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.133 hours
Area (User Defined)	10.770 acres

Computational Time Increment	0.018 hours
Time to Peak (Computed)	23.993 hours
Flow (Peak, Computed)	0.00916 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00914 ft^3/s

Drainage Area	
SCS CN (Composite)	33.000
Area (User Defined)	10.770 acres
Maximum Retention (Pervious)	20.3 in
Maximum Retention (Pervious, 20 percent)	4.1 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	68.239 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	65.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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ft³/
s

0.089 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.355 hours
Total unit time, Tb	0.443 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.133 hours
Area (User Defined)	10.770 acres

Computational Time Increment	0.018 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft^3/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	10.770 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.133 hours

0

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18

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48

3.

43

2

0.749

1.670

91.
75
32
3
ft³/
s

0.089 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.355 hours
Total unit time, Tb	0.443 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.045 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.933 hours
Flow (Peak, Computed)	0.08802 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.950 hours
Flow (Peak Interpolated Output)	0.08615 ft³/s

Drainage Area	
SCS CN (Composite)	67.000
Area (User Defined)	0.045 acres
Maximum Retention (Pervious)	4.9 in
Maximum Retention (Pervious, 20 percent)	1.0 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	1.3 in
Runoff Volume (Pervious)	212.606 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	212.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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43

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0.749

1.670

0.61186 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.045 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.045 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749

1.670

0.61186 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.316 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	12.022 hours
Flow (Peak, Computed)	0.11943 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.000 hours
Flow (Peak Interpolated Output)	0.10955 ft³/s

Drainage Area	
SCS CN (Composite)	49.000
Area (User Defined)	0.316 acres
Maximum Retention (Pervious)	10.4 in
Maximum Retention (Pervious, 20 percent)	2.1 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.4 in
Runoff Volume (Pervious)	428.859 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	427.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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43

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0.749

1.670

4.29661 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.316 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.316 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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43

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0.749

1.670

4.29661 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.397 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	12.044 hours
Flow (Peak, Computed)	0.01282 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.050 hours
Flow (Peak Interpolated Output)	0.01281 ft³/s

Drainage Area	
SCS CN (Composite)	43.000
Area (User Defined)	0.397 acres
Maximum Retention (Pervious)	13.3 in
Maximum Retention (Pervious, 20 percent)	2.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.2 in
Runoff Volume (Pervious)	248.008 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	247.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

0

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43

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0.749

1.670

5.39795 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.397 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.397 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

0

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43

2

0.749

1.670

5.39795 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.100 hours
Area (User Defined)	1.161 acres

Computational Time Increment	0.013 hours
Time to Peak (Computed)	18.133 hours
Flow (Peak, Computed)	0.00513 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	18.150 hours
Flow (Peak Interpolated Output)	0.00512 ft³/s

Drainage Area	
SCS CN (Composite)	37.000
Area (User Defined)	1.161 acres
Maximum Retention (Pervious)	17.0 in
Maximum Retention (Pervious, 20 percent)	3.4 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	168.233 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	167.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.100 hours

0

.0

13

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0.749

1.670

13.
15
49
6
ft³/
s

0.067 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.267 hours
Total unit time, Tb	0.333 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.117 hours
Area (User Defined)	1.161 acres

Computational Time Increment	0.016 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.161 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.117 hours

0

.0

16

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48

3.

43

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0.749

1.670

11.
24
35
5
ft³/
s

0.078 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.312 hours
Total unit time, Tb	0.390 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.348 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	12.022 hours
Flow (Peak, Computed)	0.15544 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.000 hours
Flow (Peak Interpolated Output)	0.14592 ft³/s

Drainage Area	
SCS CN (Composite)	50.000
Area (User Defined)	0.348 acres
Maximum Retention (Pervious)	10.0 in
Maximum Retention (Pervious, 20 percent)	2.0 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.4 in
Runoff Volume (Pervious)	522.071 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	520.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

0

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48

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43

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0.749

1.670

4.73171 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.348 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.348 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

0

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11

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48

3.

43

2

0.749

1.670

4.73171 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.136 hours
Area (User Defined)	1.625 acres

Computational Time Increment	0.018 hours
Time to Peak (Computed)	12.439 hours
Flow (Peak, Computed)	0.03437 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.450 hours
Flow (Peak Interpolated Output)	0.03433 ft³/s

Drainage Area	
SCS CN (Composite)	42.000
Area (User Defined)	1.625 acres
Maximum Retention (Pervious)	13.8 in
Maximum Retention (Pervious, 20 percent)	2.8 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.1 in
Runoff Volume (Pervious)	853.928 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	848.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	
Receding/Rising, Tr/Tp	

Unit peak, qp
Unit peak time, Tp

0.136 hours

0

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43

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0.749

1.670

13.
53
85
4
ft³/
s

0.091 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.363 hours
Total unit time, Tb	0.453 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.181 hours
Area (User Defined)	1.625 acres

Computational Time Increment	0.024 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.625 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.181 hours

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48

3.

43

2

0.749

1.670

10.
17
26
0
ft³/
s

0.121 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.483 hours
Total unit time, Tb	0.603 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.813 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	12.022 hours
Flow (Peak, Computed)	0.19900 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.000 hours
Flow (Peak Interpolated Output)	0.16912 ft³/s

Drainage Area	
SCS CN (Composite)	47.000
Area (User Defined)	0.813 acres
Maximum Retention (Pervious)	11.3 in
Maximum Retention (Pervious, 20 percent)	2.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.3 in
Runoff Volume (Pervious)	884.807 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	881.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	
Receding/Rising, Tr/Tp	

Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749

1.670

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42
4
ft³/
s

0.56 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.086 hours
Area (User Defined)	0.813 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft^3/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.813 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.086 hours

0

.0

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3.

43

2

0.749

1.670

10.
71
14
8
ft³/
s

0.57 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.229 hours
Total unit time, Tb	0.287 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.120 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00293 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00292 ft³/s

Drainage Area	
SCS CN (Composite)	35.000
Area (User Defined)	1.120 acres
Maximum Retention (Pervious)	18.6 in
Maximum Retention (Pervious, 20 percent)	3.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	61.062 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	60.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749

1.670

15.
22
84
8
ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.120 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.120 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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43

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0.749

1.670

15.
22
84
8
ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.700 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	32.000
Area (User Defined)	1.700 acres
Maximum Retention (Pervious)	21.3 in
Maximum Retention (Pervious, 20 percent)	4.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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43

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0.749

1.670

23.
11
46
6
ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.700 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft^3/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.700 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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43

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0.749

1.670

23.
11
46
6
ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	2.410 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00207 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00207 ft³/s

Drainage Area	
SCS CN (Composite)	33.000
Area (User Defined)	2.410 acres
Maximum Retention (Pervious)	20.3 in
Maximum Retention (Pervious, 20 percent)	4.1 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	15.196 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	15.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.084 hours
Area (User Defined)	2.410 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	2.410 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.084 hours

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6
ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.224 hours
Total unit time, Tb	0.280 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	2.640 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	17.522 hours
Flow (Peak, Computed)	0.01547 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	17.500 hours
Flow (Peak Interpolated Output)	0.01545 ft^3/s

Drainage Area	
SCS CN (Composite)	38.000
Area (User Defined)	2.640 acres
Maximum Retention (Pervious)	16.3 in
Maximum Retention (Pervious, 20 percent)	3.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.1 in
Runoff Volume (Pervious)	539.419 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	536.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	2.640 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00922 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00921 ft^3/s

Drainage Area	
SCS CN (Composite)	36.000
Area (User Defined)	2.640 acres
Maximum Retention (Pervious)	17.8 in
Maximum Retention (Pervious, 20 percent)	3.6 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	250.199 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	248.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.093 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00286 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00285 ft³/s

Drainage Area	
SCS CN (Composite)	35.000
Area (User Defined)	1.093 acres
Maximum Retention (Pervious)	18.6 in
Maximum Retention (Pervious, 20 percent)	3.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	59.590 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	59.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.093 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.093 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	2.036 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	31.000
Area (User Defined)	2.036 acres
Maximum Retention (Pervious)	22.3 in
Maximum Retention (Pervious, 20 percent)	4.5 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	2.036 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	2.036 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.755 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	13.422 hours
Flow (Peak, Computed)	0.00779 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	13.450 hours
Flow (Peak Interpolated Output)	0.00775 ft³/s

Drainage Area	
SCS CN (Composite)	40.000
Area (User Defined)	0.755 acres
Maximum Retention (Pervious)	15.0 in
Maximum Retention (Pervious, 20 percent)	3.0 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.1 in
Runoff Volume (Pervious)	263.540 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	262.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.755 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.755 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.880 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00307 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00307 ft^3/s

Drainage Area	
SCS CN (Composite)	36.000
Area (User Defined)	0.880 acres
Maximum Retention (Pervious)	17.8 in
Maximum Retention (Pervious, 20 percent)	3.6 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	83.400 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	83.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.870 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft^3/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.870 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.093 hours
Area (User Defined)	2.322 acres

Computational Time Increment	0.012 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	32.000
Area (User Defined)	2.322 acres
Maximum Retention (Pervious)	21.3 in
Maximum Retention (Pervious, 20 percent)	4.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.093 hours

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s

0.062 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.248 hours
Total unit time, Tb	0.310 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.096 hours
Area (User Defined)	2.322 acres

Computational Time Increment	0.013 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	2.322 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.096 hours

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ft³/
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0.064 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.256 hours
Total unit time, Tb	0.320 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.090 hours
Area (User Defined)	2.413 acres

Computational Time Increment	0.012 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	32.000
Area (User Defined)	2.413 acres
Maximum Retention (Pervious)	21.3 in
Maximum Retention (Pervious, 20 percent)	4.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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0
ft³/
s

0.060 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.240 hours
Total unit time, Tb	0.300 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.093 hours
Area (User Defined)	2.413 acres

Computational Time Increment	0.012 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	2.413 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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4
ft³/
s

0.062 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.248 hours
Total unit time, Tb	0.310 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.087 hours
Area (User Defined)	1.983 acres

Computational Time Increment	0.012 hours
Time to Peak (Computed)	24.000 hours
Flow (Peak, Computed)	0.00170 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00170 ft^3/s

Drainage Area	
SCS CN (Composite)	33.000
Area (User Defined)	1.983 acres
Maximum Retention (Pervious)	20.3 in
Maximum Retention (Pervious, 20 percent)	4.1 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	12.511 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	12.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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ft³/
s

0.058 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.232 hours
Total unit time, Tb	0.290 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.092 hours
Area (User Defined)	1.983 acres

Computational Time Increment	0.012 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.983 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.092 hours

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0.749

1.670

24.
42
26
2
ft³/
s

0.061 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.245 hours
Total unit time, Tb	0.307 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.202 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	32.000
Area (User Defined)	1.202 acres
Maximum Retention (Pervious)	21.3 in
Maximum Retention (Pervious, 20 percent)	4.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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16.
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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.202 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.202 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.368 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	12.922 hours
Flow (Peak, Computed)	0.00527 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.950 hours
Flow (Peak Interpolated Output)	0.00524 ft³/s

Drainage Area	
SCS CN (Composite)	41.000
Area (User Defined)	0.368 acres
Maximum Retention (Pervious)	14.4 in
Maximum Retention (Pervious, 20 percent)	2.9 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.1 in
Runoff Volume (Pervious)	159.529 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	159.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	

K Factor Receding/Rising, Tr/Tp
Unit peak, qp
Unit peak time, Tp

0.083 hours

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1.670

5.00364 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.368 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.368 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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5.00364 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.060 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.922 hours
Flow (Peak, Computed)	0.31919 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.900 hours
Flow (Peak Interpolated Output)	0.31305 ft³/s

Drainage Area	
SCS CN (Composite)	95.000
Area (User Defined)	0.060 acres
Maximum Retention (Pervious)	0.5 in
Maximum Retention (Pervious, 20 percent)	0.1 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	3.7 in
Runoff Volume (Pervious)	801.017 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	800.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	

K Factor Receding/Rising, Tr/Tp
Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749

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0.81581 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.060 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.060 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.81581 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.047 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	12.022 hours
Flow (Peak, Computed)	0.01150 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.000 hours
Flow (Peak Interpolated Output)	0.00978 ft³/s

Drainage Area	
SCS CN (Composite)	47.000
Area (User Defined)	0.047 acres
Maximum Retention (Pervious)	11.3 in
Maximum Retention (Pervious, 20 percent)	2.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.3 in
Runoff Volume (Pervious)	51.151 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	51.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.63905 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.047 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.047 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.63905 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.918 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	17.522 hours
Flow (Peak, Computed)	0.00538 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	17.500 hours
Flow (Peak Interpolated Output)	0.00537 ft³/s

Drainage Area	
SCS CN (Composite)	38.000
Area (User Defined)	0.918 acres
Maximum Retention (Pervious)	16.3 in
Maximum Retention (Pervious, 20 percent)	3.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.1 in
Runoff Volume (Pervious)	187.571 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	186.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.918 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00240 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00240 ft³/s

Drainage Area	
SCS CN (Composite)	35.000
Area (User Defined)	0.918 acres
Maximum Retention (Pervious)	18.6 in
Maximum Retention (Pervious, 20 percent)	3.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	50.049 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	49.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.440 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	17.522 hours
Flow (Peak, Computed)	0.00258 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	17.500 hours
Flow (Peak Interpolated Output)	0.00258 ft³/s

Drainage Area	
SCS CN (Composite)	38.000
Area (User Defined)	0.440 acres
Maximum Retention (Pervious)	16.3 in
Maximum Retention (Pervious, 20 percent)	3.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.1 in
Runoff Volume (Pervious)	89.903 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	89.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749

1.670

5.98262 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.440 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.440 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749

1.670

5.98262 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.160 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00014 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00014 ft³/s

Drainage Area	
SCS CN (Composite)	33.000
Area (User Defined)	0.160 acres
Maximum Retention (Pervious)	20.3 in
Maximum Retention (Pervious, 20 percent)	4.1 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	1.009 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	1.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749

1.670

2.17550 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.160 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.160 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749
1.670
2.17550 ft³/s
0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.117 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.922 hours
Flow (Peak, Computed)	0.64452 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.900 hours
Flow (Peak Interpolated Output)	0.63406 ft³/s

Drainage Area	
SCS CN (Composite)	98.000
Area (User Defined)	0.117 acres
Maximum Retention (Pervious)	0.2 in
Maximum Retention (Pervious, 20 percent)	0.0 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	4.0 in
Runoff Volume (Pervious)	1,705.033 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	1,702.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.749

1.670

1.59083 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.117 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.117 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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1.670

1.59083 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.457 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	17.522 hours
Flow (Peak, Computed)	0.00268 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	17.500 hours
Flow (Peak Interpolated Output)	0.00267 ft³/s

Drainage Area	
SCS CN (Composite)	38.000
Area (User Defined)	0.457 acres
Maximum Retention (Pervious)	16.3 in
Maximum Retention (Pervious, 20 percent)	3.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.1 in
Runoff Volume (Pervious)	93.377 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	93.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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6.21376 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	0.457 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	0.457 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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1.670

6.21376 ft³/s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.00 hours
Depth	4.3 in
Time of Concentration (Composite)	0.094 hours
Area (User Defined)	2.330 acres

Computational Time Increment	0.013 hours
Time to Peak (Computed)	24.01 hours
Flow (Peak, Computed)	0.00608 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00608 ft³/s

Drainage Area	
SCS CN (Composite)	35.000
Area (User Defined)	2.330 acres
Maximum Retention (Pervious)	18.6 in
Maximum Retention (Pervious, 20 percent)	3.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	127.034 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	125.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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0.063 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.251 hours
Total unit time, Tb	0.313 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.105 hours
Area (User Defined)	2.340 acres

Computational Time Increment	0.014 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	2.340 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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0.070 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.280 hours
Total unit time, Tb	0.350 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.240 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00324 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00324 ft³/s

Drainage Area	
SCS CN (Composite)	35.000
Area (User Defined)	1.240 acres
Maximum Retention (Pervious)	18.6 in
Maximum Retention (Pervious, 20 percent)	3.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	67.604 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	67.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.240 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.240 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.010 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	23.999 hours
Flow (Peak, Computed)	0.00264 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.00264 ft³/s

Drainage Area	
SCS CN (Composite)	35.000
Area (User Defined)	1.010 acres
Maximum Retention (Pervious)	18.6 in
Maximum Retention (Pervious, 20 percent)	3.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	55.065 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	54.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.010 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.010 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	2.400 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	18.122 hours
Flow (Peak, Computed)	0.01060 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	18.100 hours
Flow (Peak Interpolated Output)	0.01059 ft³/s

Drainage Area	
SCS CN (Composite)	37.000
Area (User Defined)	2.400 acres
Maximum Retention (Pervious)	17.0 in
Maximum Retention (Pervious, 20 percent)	3.4 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	347.765 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	345.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	2.400 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	2.400 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.980 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft^3/s

Drainage Area	
SCS CN (Composite)	32.000
Area (User Defined)	1.980 acres
Maximum Retention (Pervious)	21.3 in
Maximum Retention (Pervious, 20 percent)	4.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.990 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft^3/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.990 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.774 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	18.122 hours
Flow (Peak, Computed)	0.00784 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	18.100 hours
Flow (Peak Interpolated Output)	0.00783 ft³/s

Drainage Area	
SCS CN (Composite)	37.000
Area (User Defined)	1.774 acres
Maximum Retention (Pervious)	17.0 in
Maximum Retention (Pervious, 20 percent)	3.4 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	257.057 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	255.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.774 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.774 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.083 hours

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ft³/
s

0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.192 hours
Area (User Defined)	2.874 acres

Computational Time Increment	0.026 hours
Time to Peak (Computed)	23.987 hours
Flow (Peak, Computed)	0.00745 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	23.950 hours
Flow (Peak Interpolated Output)	0.00743 ft³/s

Drainage Area	
SCS CN (Composite)	35.000
Area (User Defined)	2.874 acres
Maximum Retention (Pervious)	18.6 in
Maximum Retention (Pervious, 20 percent)	3.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	156.720 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	152.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.192 hours

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ft³/
s

0.128 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.512 hours
Total unit time, Tb	0.640 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.214 hours
Area (User Defined)	2.874 acres

Computational Time Increment	0.029 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	2.874 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.214 hours

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0.143 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.571 hours
Total unit time, Tb	0.713 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.130 hours
Area (User Defined)	2.051 acres

Computational Time Increment	0.017 hours
Time to Peak (Computed)	23.989 hours
Flow (Peak, Computed)	0.00714 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	23.950 hours
Flow (Peak Interpolated Output)	0.00712 ft³/s

Drainage Area	
SCS CN (Composite)	36.000
Area (User Defined)	2.051 acres
Maximum Retention (Pervious)	17.8 in
Maximum Retention (Pervious, 20 percent)	3.6 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	194.389 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	192.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	

K Factor Receding/Rising, Tr/Tp
Unit peak, qp
Unit peak time, Tp

0.130 hours

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ft³/
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0.087 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.347 hours
Total unit time, Tb	0.433 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.149 hours
Area (User Defined)	2.051 acres

Computational Time Increment	0.020 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	2.051 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.397 hours
Total unit time, Tb	0.497 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.546 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	17.522 hours
Flow (Peak, Computed)	0.00906 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	17.500 hours
Flow (Peak Interpolated Output)	0.00905 ft³/s

Drainage Area	
SCS CN (Composite)	38.000
Area (User Defined)	1.546 acres
Maximum Retention (Pervious)	16.3 in
Maximum Retention (Pervious, 20 percent)	3.3 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.1 in
Runoff Volume (Pervious)	315.887 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	314.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

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ft³/
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0.056 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.088 hours
Area (User Defined)	1.546 acres

Computational Time Increment	0.012 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	1.546 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.088 hours

0

.0

12

ho

ur

s

48

3.

43

2

0.749

1.670

19.
90
60
0
ft³/
s

0.059 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.235 hours
Total unit time, Tb	0.293 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.251 hours
Area (User Defined)	6.185 acres

Computational Time Increment	0.033 hours
Time to Peak (Computed)	23.995 hours
Flow (Peak, Computed)	0.02144 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	24.000 hours
Flow (Peak Interpolated Output)	0.02140 ft³/s

Drainage Area	
SCS CN (Composite)	36.000
Area (User Defined)	6.185 acres
Maximum Retention (Pervious)	17.8 in
Maximum Retention (Pervious, 20 percent)	3.6 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	586.200 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	570.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.251 hours

0

.0

33

ho

ur

s

48

3.

43

2

0.749

1.670

27.
92
05
0
ft³/
s

0.167 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.669 hours
Total unit time, Tb	0.837 hours

Storm Event	10-YR
Return Event	10 years
Duration	24.000 hours
Depth	4.3 in
Time of Concentration (Composite)	0.287 hours
Area (User Defined)	6.185 acres

Computational Time Increment	0.038 hours
Time to Peak (Computed)	0.000 hours
Flow (Peak, Computed)	0.00000 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	0.000 hours
Flow (Peak Interpolated Output)	0.00000 ft³/s

Drainage Area	
SCS CN (Composite)	30.000
Area (User Defined)	6.185 acres
Maximum Retention (Pervious)	23.3 in
Maximum Retention (Pervious, 20 percent)	4.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	0.0 in
Runoff Volume (Pervious)	0.000 ft³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.000 ft³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	
Computational Time Increment	
Unit Hydrograph Shape Factor	
K Factor	

Receding/Rising, Tr/Tp Unit peak, qp
Unit peak time, Tp

0.287 hours

0

.0

38

ho

ur

s

48

3.

43

2

0.749

1.670

24.
41
82
8
ft³/
s

0.191 hours

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.765 hours
Total unit time, Tb	0.957 hours

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0

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Attachment 3 – Hydrologic Soil Group Assignments for Soils without a SSURGO Classification

Soil Name	HSG Assignment
Aquents, 0 to 2 percent slopes, frequently ponded	D
Dam	D
Gullied land	D
Industrial waste pond	D
Made Land	D
Mixed alluvial land	B
Mixed alluvium, poorly drained	B
Mixed alluvium, well drained	B
Pits and dumps	D
Pits, quarry	D
Rock land	D
Rock outcrop-Chilhowie complex, steep	D
Rock outcrop-Drall complex, steep	D
Rock outcrop-Frederick complex, sloping	D
Rock outcrop-Frederick complex, steep	D
Rock outcrop-Opequon complex, 55 to 100 percent slopes	D
Rubble land	D
Stony land	D
Udorthents, bouldery	D
Udorthents, dams	D
Udorthents, loamy	D
Udorthents, sandy	D
Udorthents, shaly	D
Udorthents, smoothed	D
Udorthents, smoothed, 0 to 25 percent slopes	D
Udorthents, smoothed, 3 to 35 percent slopes	D
Udorthents, smoothed-Urban land complex	D
Udorthents-Dumps complex	D
Udorthents-Rock outcrop complex, 15 to 100 percent slopes	D
Udorthents-Urban land complex, 0 to 45 percent slopes	D
Urban land	D
Urban land, 0 to 5 percent slopes	D
Urban land-Conetoe-Chesapeake-Tetotum complex, 2 to 40 percent slopes	D
Urban Land-Udorthents complex, 0 to 2 percent slopes	D

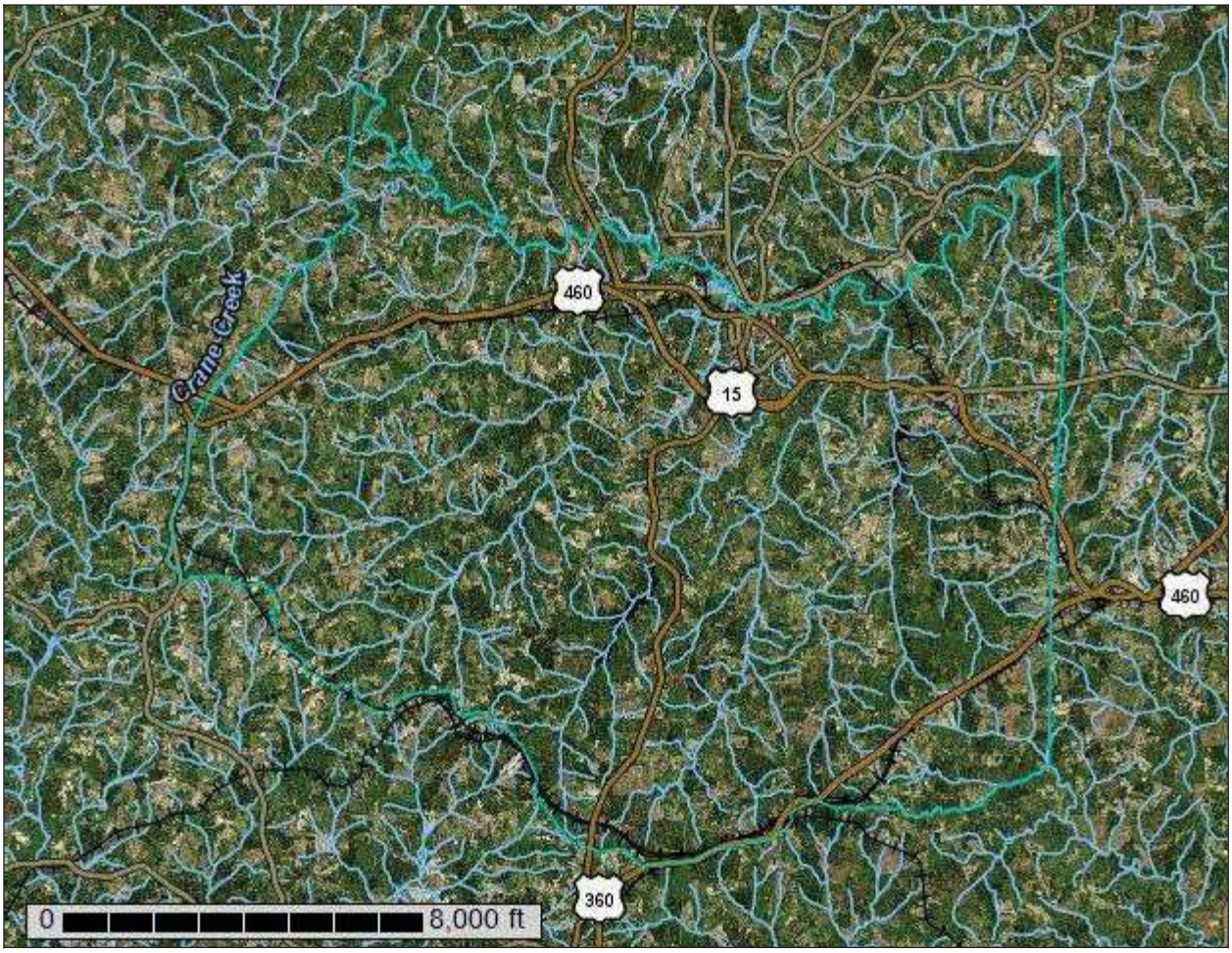
Note regarding Soils without Assigned HSGs: To facilitate computations of Curve Numbers (CNs) using the TR-55 methodology, Hydrologic Soil Groups (HSG) were assigned in cases where HSGs were not listed in the Soil Survey Geographic Database (SSURGO). The HSG assignment was determined using guidance from Appendix A of the TR-55 (Appendix A, Technical Release 55 Urban Hydrology for Small Watersheds, TR-55, United States Department of Agriculture and Natural Resources Conservation Service. 1986). Project specific field investigations were not considered to determine HSG assignments for soils. The majority of the soils were conservatively assigned HSG D based on the map unit name, which in most cases points to urban and industrial land use. To identify the appropriate HSG for mixed alluvial lands, the USDA Web Soil Survey was consulted to obtain more information. The mixed alluvial lands, both poorly and well drained, intersect the project areas primarily in Prince Edward County. (The Soil Resource Report is attached.) The typical profiles of both soils are silt loam. Therefore, the soil profile corresponds best to soil texture of HSG B - silt loam or loam, as listed in Appendix A of the TR-55. The typical capacity of the most limiting layer to transmit water is moderately high to high (0.57 to 1.98 in/hr) for both soils. The capacity to transmit water of both soils is greater than that noted to be typical for group B soils (0.15-0.30 in/hr) and group A soils (greater than 0.30 in/hr) as noted in Appendix A of the TR-55. The difference in the natural drainage class does not appear to be differentiating characteristic for association with Hydrologic Soil Groups as defined by the TR-55. Consequently, HSG B is an appropriate classification for all mixed alluvial lands.

United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Prince Edward County, Virginia



January 30, 2018

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ml	Mixed alluvium, poorly drained	0.0	0.0%
Mm	Mixed alluvium, well drained	0.0	0.0%
Totals for Area of Interest		**226,377.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the

scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Prince Edward County, Virginia

Ml-Mixed alluvium, poorly drained

Map Unit Setting

National map unit symbol: 4153
Mean annual precipitation: 37 to 62 inches
Mean annual air temperature: 45 to 70 degrees F
Frost-free period: 144 to 226 days
Farmland classification: Not prime farmland

Map Unit Composition

Mixed alluvium: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mixed Alluvium

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 30 inches: loam
H3 - 30 to 62 inches: loamy sand

Properties and qualities

Slope: 0 to 2 percent
Natural drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 2 to 8 inches
Frequency of flooding: Frequent
Available water storage in profile: Moderate (about 7.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydric soil rating: Yes

Mm-Mixed alluvium, well drained

Map Unit Setting

National map unit symbol: 4154
Mean annual precipitation: 37 to 62 inches
Mean annual air temperature: 45 to 70 degrees F
Frost-free period: 144 to 226 days
Farmland classification: Not prime farmland

Map Unit Composition

Mixed alluvium: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mixed Alluvium

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 5 inches: silt loam
H2 - 5 to 27 inches: silt loam
H3 - 27 to 79 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 48 to 79 inches
Frequency of flooding: Frequent
Available water storage in profile: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydric soil rating: No

Attachment 4 – Mitigation Measures Assessment Computations

Table A4.1: TR-55 Sheet Flow Velocity Assessment (Wooded & Pasture)

Table A4.2: Diffuser Sedimentation Estimates

Table A4.3: Storage Volume Calculator

Table A4.4: Standard Diffuser Sizing

Table A4.5: Diffuser Unit Rating Curve

Figure A4.6: Gravel Diaphragm Waterstop

Figure A4.7: Culvert Flanking Strategy

Figure A4.8: Gravel Diversion Trench

Figure A4.9: Vs/Vr Worksheets

Figure A4.10: Flow Diffuser Construction in High Groundwater Table Conditions

Table A4.1: TR-55 Sheet Flow Velocity Assessment (Wooded & Pasture)

Sheet Flow Equation		**= 0.007 * [((nL)^0.8) / (P2^0.5 * s^0.4)]**
Where:	Tt =	travel time (hr)
	L =	Length of overland flow (ft)
	n =	Mannings Roughness coefficient
	P2 =	2 year, 24 hour rainfall in inches
	s =	slope (ft/ft)

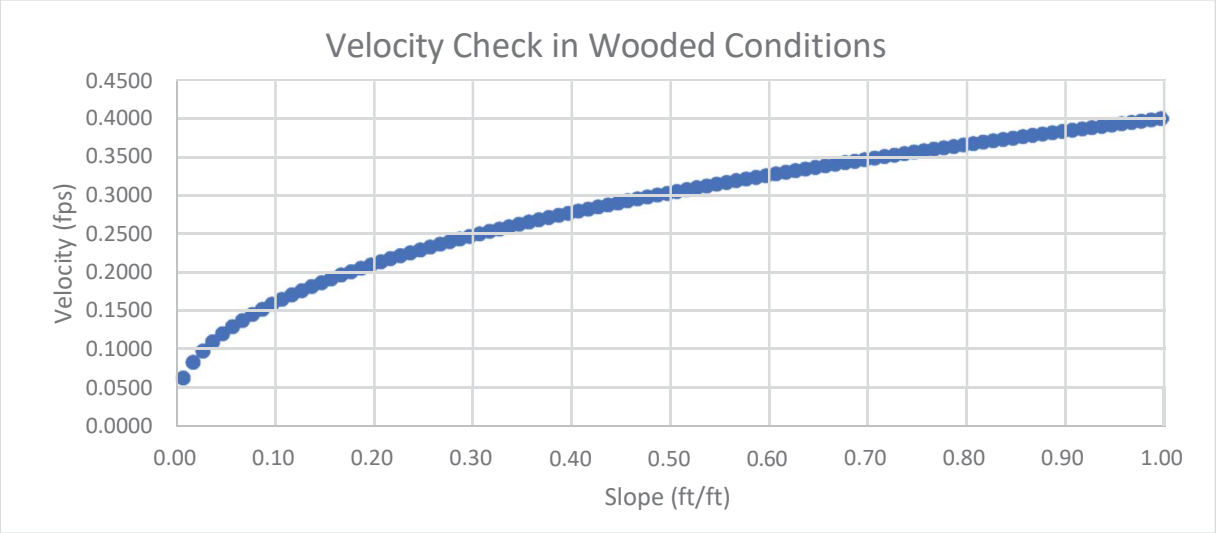
Assumptions:

L = 100
n = 0.4 for woods
n = 0.15 for pasture (short grass)
P2 = 3.7

Velocity Check in Wooded Conditions				Velocity Check in Pasture Conditions			
Slope (ft/ft)	**Tt (hr)**	**Tt (s)**	**Length/Tt (fps)**	**Slope (ft/ft)**	**Tt (hr)**	**Tt (s)**	**Length/Tt (fps)**
0.01	0.4392	1581.06	0.0632	0.01	0.2004	721.3943	0.1386
0.02	0.3328	1198.22	0.0835	0.02	0.1519	546.7146	0.1829
0.03	0.2830	1018.82	0.0982	0.03	0.1291	464.8621	0.2151
0.04	0.2522	908.08	0.1101	0.04	0.1151	414.3322	0.2414
0.05	0.2307	830.54	0.1204	0.05	0.1053	378.9524	0.2639
0.06	0.2145	772.12	0.1295	0.06	0.0979	352.2996	0.2838
0.07	0.2017	725.95	0.1377	0.07	0.0920	331.2329	0.3019
0.08	0.1912	688.20	0.1453	0.08	0.0872	314.0051	0.3185
0.09	0.1824	656.52	0.1523	0.09	0.0832	299.5544	0.3338
0.10	0.1748	629.43	0.1589	0.10	0.0798	287.1922	0.3482
0.11	0.1683	605.89	0.1650	0.11	0.0768	276.4494	0.3617
0.12	0.1625	585.16	0.1709	0.12	0.0742	266.9932	0.3745
0.13	0.1574	566.72	0.1765	0.13	0.0718	258.5802	0.3867
0.14	0.1528	550.17	0.1818	0.14	0.0697	251.0276	0.3984
0.15	0.1487	535.19	0.1868	0.15	0.0678	244.1947	0.4095
0.16	0.1449	521.55	0.1917	0.16	0.0661	237.9714	0.4202
0.17	0.1414	509.06	0.1964	0.17	0.0645	232.2700	0.4305
0.18	0.1382	497.55	0.2010	0.18	0.0631	227.0198	0.4405
0.19	0.1353	486.91	0.2054	0.19	0.0617	222.1628	0.4501
0.20	0.1325	477.02	0.2096	0.20	0.0605	217.6510	0.4595
0.21	0.1299	467.80	0.2138	0.21	0.0593	213.4445	0.4685
0.22	0.1275	459.18	0.2178	0.22	0.0582	209.5094	0.4773
0.23	0.1253	451.08	0.2217	0.23	0.0572	205.8171	0.4859
0.24	0.1232	443.47	0.2255	0.24	0.0562	202.3430	0.4942
0.25	0.1212	436.29	0.2292	0.25	0.0553	199.0658	0.5023
0.26	0.1193	429.50	0.2328	0.26	0.0544	195.9672	0.5103
0.27	0.1175	423.06	0.2364	0.27	0.0536	193.0311	0.5181
0.28	0.1158	416.95	0.2398	0.28	0.0528	190.2433	0.5256
0.29	0.1142	411.14	0.2432	0.29	0.0521	187.5916	0.5331
0.30	0.1127	405.60	0.2465	0.30	0.0514	185.0650	0.5404
0.31	0.1112	400.32	0.2498	0.31	0.0507	182.6535	0.5475
0.32	0.1098	395.26	0.2530	0.32	0.0501	180.3486	0.5545
0.33	0.1085	390.43	0.2561	0.33	0.0495	178.1423	0.5613
0.34	0.1072	385.79	0.2592	0.34	0.0489	176.0277	0.5681
0.35	0.1059	381.35	0.2622	0.35	0.0483	173.9985	0.5747
0.36	0.1047	377.07	0.2652	0.36	0.0478	172.0488	0.5812
0.37	0.1036	372.96	0.2681	0.37	0.0473	170.1735	0.5876
0.38	0.1025	369.01	0.2710	0.38	0.0468	168.3679	0.5939
0.39	0.1014	365.19	0.2738	0.39	0.0463	166.6276	0.6001
0.40	0.1004	361.51	0.2766	0.40	0.0458	164.9486	0.6062
0.41	0.0994	357.96	0.2794	0.41	0.0454	163.3274	0.6123
0.42	0.0985	354.53	0.2821	0.42	0.0449	161.7607	0.6182
0.43	0.0976	351.20	0.2847	0.43	0.0445	160.2453	0.6240
0.44	0.0967	347.99	0.2874	0.44	0.0441	158.7785	0.6298

0.45	0.0958	344.88	0.2900	0.45	0.0437	157.3576	0.6355
0.46	0.0950	341.86	0.2925	0.46	0.0433	155.9802	0.6411
0.47	0.0941	338.93	0.2950	0.47	0.0430	154.6442	0.6466
0.48	0.0934	336.09	0.2975	0.48	0.0426	153.3473	0.6521
0.49	0.0926	333.33	0.3000	0.49	0.0422	152.0878	0.6575
0.50	0.0918	330.64	0.3024	0.50	0.0419	150.8637	0.6629
0.51	0.0911	328.03	0.3048	0.51	0.0416	149.6734	0.6681
0.52	0.0904	325.50	0.3072	0.52	0.0413	148.5154	0.6733
0.53	0.0897	323.03	0.3096	0.53	0.0409	147.3881	0.6785
0.54	0.0891	320.62	0.3119	0.54	0.0406	146.2902	0.6836
0.55	0.0884	318.28	0.3142	0.55	0.0403	145.2204	0.6886
0.56	0.0878	315.99	0.3165	0.56	0.0400	144.1775	0.6936
0.57	0.0872	313.76	0.3187	0.57	0.0398	143.1603	0.6985
0.58	0.0866	311.58	0.3209	0.58	0.0395	142.1679	0.7034
0.59	0.0860	309.46	0.3231	0.59	0.0392	141.1991	0.7082
0.60	0.0854	307.39	0.3253	0.60	0.0390	140.2530	0.7130
0.61	0.0848	305.36	0.3275	0.61	0.0387	139.3288	0.7177
0.62	0.0843	303.38	0.3296	0.62	0.0385	138.4255	0.7224
0.63	0.0837	301.45	0.3317	0.63	0.0382	137.5424	0.7270
0.64	0.0832	299.55	0.3338	0.64	0.0380	136.6787	0.7316
0.65	0.0827	297.70	0.3359	0.65	0.0377	135.8336	0.7362
0.66	0.0822	295.89	0.3380	0.66	0.0375	135.0066	0.7407
0.67	0.0817	294.12	0.3400	0.67	0.0373	134.1970	0.7452
0.68	0.0812	292.38	0.3420	0.68	0.0371	133.4041	0.7496
0.69	0.0807	290.68	0.3440	0.69	0.0368	132.6273	0.7540
0.70	0.0803	289.01	0.3460	0.70	0.0366	131.8662	0.7583
0.71	0.0798	287.37	0.3480	0.71	0.0364	131.1201	0.7627
0.72	0.0794	285.77	0.3499	0.72	0.0362	130.3886	0.7669
0.73	0.0789	284.20	0.3519	0.73	0.0360	129.6712	0.7712
0.74	0.0785	282.65	0.3538	0.74	0.0358	128.9674	0.7754
0.75	0.0781	281.14	0.3557	0.75	0.0356	128.2768	0.7796
0.76	0.0777	279.65	0.3576	0.76	0.0354	127.5990	0.7837
0.77	0.0773	278.20	0.3595	0.77	0.0353	126.9335	0.7878
0.78	0.0769	276.76	0.3613	0.78	0.0351	126.2801	0.7919
0.79	0.0765	275.36	0.3632	0.79	0.0349	125.6382	0.7959
0.80	0.0761	273.98	0.3650	0.80	0.0347	125.0077	0.8000
0.81	0.0757	272.62	0.3668	0.81	0.0346	124.3881	0.8039
0.82	0.0754	271.28	0.3686	0.82	0.0344	123.7790	0.8079
0.83	0.0750	269.97	0.3704	0.83	0.0342	123.1804	0.8118
0.84	0.0746	268.68	0.3722	0.84	0.0341	122.5917	0.8157
0.85	0.0743	267.41	0.3740	0.85	0.0339	122.0127	0.8196
0.86	0.0739	266.16	0.3757	0.86	0.0337	121.4432	0.8234
0.87	0.0736	264.94	0.3775	0.87	0.0336	120.8829	0.8272
0.88	0.0733	263.73	0.3792	0.88	0.0334	120.3316	0.8310
0.89	0.0729	262.54	0.3809	0.89	0.0333	119.7889	0.8348
0.90	0.0726	261.37	0.3826	0.90	0.0331	119.2547	0.8385
0.91	0.0723	260.21	0.3843	0.91	0.0330	118.7288	0.8423
0.92	0.0720	259.08	0.3860	0.92	0.0328	118.2109	0.8459
0.93	0.0717	257.96	0.3877	0.93	0.0327	117.7008	0.8496
0.94	0.0714	256.86	0.3893	0.94	0.0326	117.1984	0.8533
0.95	0.0710	255.78	0.3910	0.95	0.0324	116.7033	0.8569
0.96	0.0708	254.71	0.3926	0.96	0.0323	116.2155	0.8605
0.97	0.0705	253.65	0.3942	0.97	0.0321	115.7348	0.8640
0.98	0.0702	252.61	0.3959	0.98	0.0320	115.2610	0.8676
0.99	0.0699	251.59	0.3975	0.99	0.0319	114.7938	0.8711

1.00	0.0696	250.58	0.3991	1.00	0.0318	114.3333	0.8746



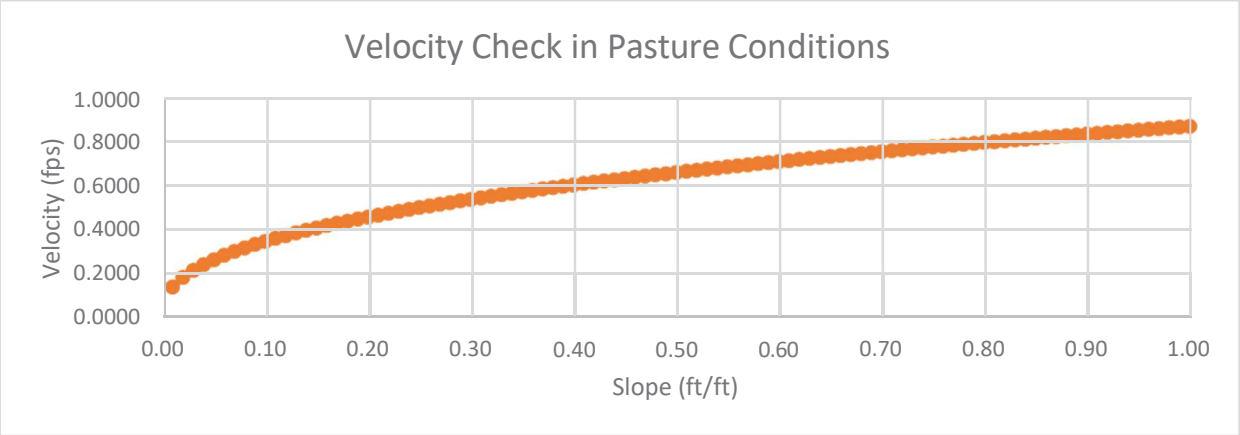


Table A4.2: Diffuser Sedimentation Estimates

Gravel Weight	105.00 lbs/CF	Gravel, Dry: https://www.engineeringtoolbox.com/dirt-mud-densities-d_1727.html
Area of Gravel Below Berm	22.32 SF	
Width	1.00 Ft	
Weight of Gravel per Linear foot of Diffuser	2343.60 LBS	
Percent of Fines in Unwashed Stones	5.00 %	
Weight of Fines per Linear Foot	117.18 LBS	
Density of Fines	76.00 LBS/CF	Dirt, Loose Dry: https://www.engineeringtoolbox.com/dirt-mud-densities-d_1727.html
Volume of Fines	1.54 CF	
Area of Fines per Linear Foot	1.54 SF	
Gravel Sump Porosity	0.40	
Required Sump Storage Area	3.85 SF	
Sump Width	4.50 Ft	
Required Sump Depth	0.86 Ft	

Table A4.2 continued: Diffuser Sedimentation Estimates

Drainage Area	1 AC	2 AC	5 AC	
CN	98	98	98	
Tc	5 min	5 min	5 min	
Diffuser Size	27.7 Ft	55.3 Ft	138.4 Ft	
TSS Loading	60.56 lbs/ac/yr	60.56 lbs/ac/yr	60.56 lbs/ac/yr	Estimated as the Average of the Forested Basin TSS Loadings (CBPA Guidance Doc)
Yearly Sediment Input	60.56 Lbs	121.12 Lbs	302.8 Lbs	
Density of Sediment	76.00 LBS/CF	76.00 LBS/CF	76.00 LBS/CF	Dirt, Loose Dry: https://www.engineeringtoolbox.com/dirt-mud-densities-d_1727.html
Volume of Sediment	0.79684 CF	1.5936842 CF	3.984211 CF	
Volume of Sediment per Linear Foot	0.02877 CF/FT	0.0288189 CF/FT	0.028788 CF/FT	
Area of Gravel Below Berm (no sump)	17.82 SF	17.82 SF	17.82 SF	
Open Storage Area	2.25 SF	2.25 SF	2.25 SF	
Volume of Storage per Linear Foot	9.378 CF	9.378 CF	9.378 CF	The stone storage with 0.4 porosity and full open storage to berm height
Total Storage Volume	259.771 CF	518.6034 CF	1297.915 CF	Diffuser Length times the storage per linear foot
Maintenance Required when Sediment Reaches X% of Total Storage	50 %	50 %	50 %	BMP Clearinghouse Rec's for Ext. Detention - Forebay to be excavated when 50% capacity is filled in
Cleanout Req'd Every X Years	163 Years	162.70582 Years	162.8824 Years	

Table III.1 - Forested loading rates by basin:

River Basin	TN (lbs/ac/yr)	TP (lbs/ac/yr)	TSS (lbs/ac/yr)
James	2.36	0.13	77.38
Potomac	5.29	0.13	79.91
Rappahannock	4.03	0.13	57.35
York	2.13	0.07	27.61

James	77.38	lbs/acre/yr
Potomac	79.91	lbs/acre/yr
Rappahanock	57.35	lbs/acre/yr
York	27.61	lbs/acre/yr
Average	60.5625	lbs/acre/yr

Table A4.2 continued: Diffuser Sedimentation Estimates

Drainage Area	1 AC	2 AC	5 AC	
CN	98	98	98	
Tc	5 min	5 min	5 min	
Diffuser Size	27.7 Ft	55.3 Ft	138.4 Ft	
TSS Loading	682.23 lbs/ac/yr	682.23 lbs/ac/yr	682.23 lbs/ac/yr	Estimated as the Average of the Major basin TSS Loadings for Regulated Urban Impervious Areas (CBPA Guidance Doc)
Yearly Sediment Input	682.23 Lbs	1364.46 Lbs	3411.15 Lbs	
Density of Sediment	76.00 LBS/CF	76.00 LBS/CF	76.00 LBS/CF	Dirt, Loose Dry: https://www.engineeringtoolbox.com/dirt-mud-densities-d_1727.html
Volume of Sediment	8.97671 CF	17.95342 CF	44.88355 CF	
Volume of Sediment per Linear Foot	0.32407 CF/FT	0.324655 CF/FT	0.324303 CF/FT	
Area of Gravel Below Berm (no sump)	17.82 SF	17.82 SF	17.82 SF	
Open Storage Area	2.25 SF	2.25 SF	2.25 SF	
Volume of Storage per Linear Foot	9.378 CF	9.378 CF	9.378 CF	The stone storage with 0.4 porosity and full open storage to berm height
Total Storage Volume	259.771 CF	518.6034 CF	1297.915 CF	Diffuser Length times the storage per linear foot
Maintenance Required when Sediment Reaches X% of Total Storage	50 %	50 %	50 %	BMP Clearinghouse Rec's for Ext. Detention - Forebay to be excavated when 50% capacity is filled in
Cleanout Req'd Every X Years	14.4691 Years	14.44302 Years	14.4587 Years	

Regulated Urban Impervious TSS Loadings

James	676.94 lbs/acre/yr
Potomac	1171.32 lbs/acre/yr
Rappahannock	423.97 lbs/acre/yr
York	456.68 lbs/acre/yr
Average	682.228 lbs/acre/yr

Table 2 b: Calculation Sheet for Estimating Existing Source Loads for the Potomac River Basin (* Based on Chesapeake Bay Program Watershed Model Phase 5.3.2)

Subsource	Pollutant	Total Existing Acres Served by MS4 (06/30/09)	2009 EOS Loading Rate (lbs/acre/yr)	Estimated Total POC Load Based on 2009 Progress Run (lbs/yr)
Regulated Urban Impervious	Nitrogen		16.66	
Regulated Urban Pervious			10.07	
Regulated Urban Impervious	Phosphorus		1.62	
Regulated Urban Pervious			0.41	
Regulated Urban Impervious	Total Suspended Solids		1,171.32	
Regulated Urban Pervious			175.6	

Table 2 b: Calculation Sheet for Estimating Existing Source Loads for the Potomac River Basin (* Based on Chesapeake Bay Program Watershed Model Phase 5.3.2)

Subsource	Pollutant	Total Existing Acres Served by MS4 (06/30/09)	2009 EOS Loading Rate (lbs/acre/yr)	Estimated Total POC Load Based on 2009 Progress Run (lbs/yr)
Regulated Urban Impervious	Nitrogen		16.66	
Regulated Urban Pervious			10.07	
Regulated Urban Impervious	Phosphorus		1.62	
Regulated Urban Pervious			0.41	
Regulated Urban Impervious	Total Suspended Solids		1,171.32	
Regulated Urban Pervious			175.6	

Table 2 d: Calculation Sheet for Estimating Existing Source Loads for the York River Basin (* Based on Chesapeake Bay Program Watershed Model Phase 5.3.2)

Subsource	Pollutant	Total Existing Acres Served by MS4 (06/30/09)	2009 EOS Loading Rate (lbs/acre/yr)	Estimated Total POC Load Based on 2009 Progress Run (lbs/yr)
Regulated Urban Impervious	Nitrogen		7.31	
Regulated Urban Pervious			7.65	
Regulated Urban Impervious	Phosphorus		1.51	
Regulated Urban Pervious			0.51	
Regulated Urban Impervious	Total Suspended Solids		456.68	
Regulated Urban Pervious			72.28	

Table 2 c: Calculation Sheet for Estimating Existing Source Loads for the Rappahannock River Basin (* Based on Chesapeake Bay Program Watershed Model Phase 5.3.2)

Subsource	Pollutant	Total Existing Acres Served by MS4 (06/30/09)	2009 EOS Loading Rate (lbs/acre/yr)	Estimated Total POC Load Based on 2009 Progress Run (lbs/yr)
Regulated Urban Impervious	Nitrogen		9.36	
Regulated Urban Pervious			5.34	
Regulated Urban Impervious	Phosphorus		1.41	
Regulated Urban Pervious			0.38	
Regulated Urban Impervious	Total Suspended Solids		423.97	
Regulated Urban Pervious			56.01	

Table A4.3: Storage Volume Calculator

STORMWATER PRACTICE STORAGE VOLUMES

Access Road or Pipeline ROW ID

POA ID

Flow Diffusers:

Total Number of Diffusers =	1		(Total Number of Diffusers within POA)
Total Diffuser Length =	6	ft	(Includes all diffusers associated with POA)
Outlet Structure Dimensions:			
Weir Length =	6	ft	
Outlet Elevation =	0	ft	
Berm Elevation =	0.6667	ft	
Side Slopes =	Vertical		
Total Flow Diffuser Volume	56.28	CF	

Outlet Structure XS

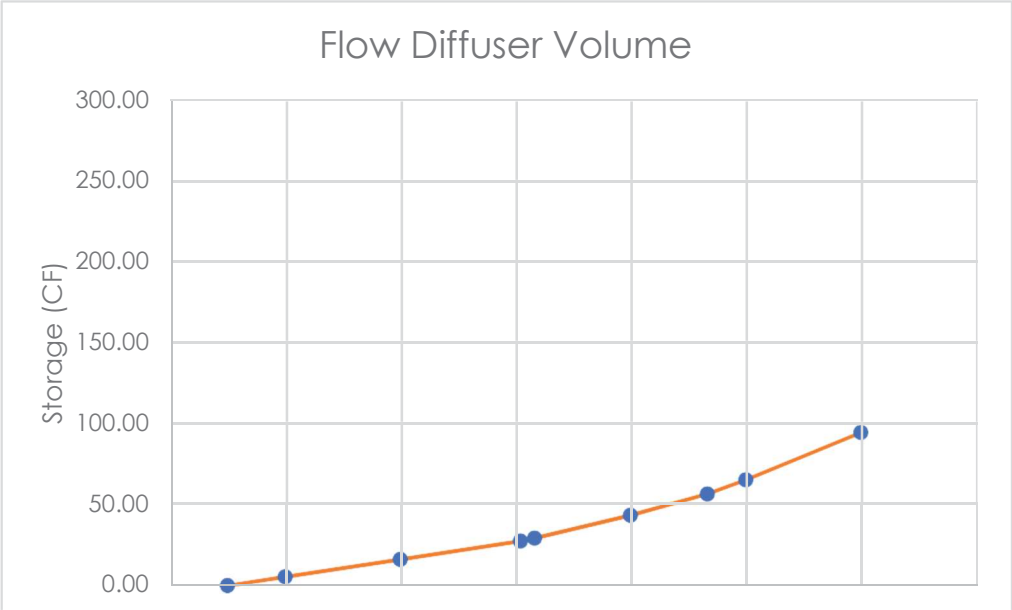
Length (ft)	Elev. (ft)
0	2
0	0
6	0
6	2

*Only Used in Detailed Routings

Flow Diffuser Volume Curve

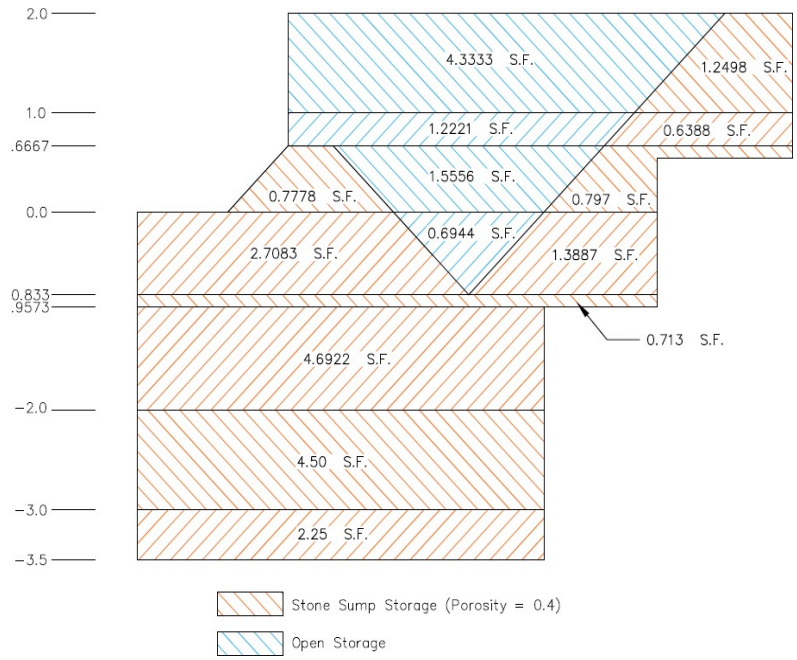
Stage (FT)	Cumulative Storage (CF)
-3.5	0.00
-3	5.40
-2	16.20
-0.9573	27.46
-0.8333	29.17
0	43.17
0.6667	56.28
1	65.15
2	94.15

Red Text = Proposed Storage Volume



*Volume Shown Above Proposed Storage for Detailed Routings Only, if Applicable

Elevation Area Diagram: Elevation Area Depiction based upon Provided Flow Diffuser Detail. Areas and Relative Elevations shown were utilized to develop the storage curve above.



Waterbars:

Total Number of Waterbars = 1 (Total Number of Waterbars within POA)

Single Waterbar Length = 16 ft (Length of one (1) Waterbar)

Outlet Structure Dimensions:

Total Weir Length = 2.17 ft

Weir Elevation = 0.5 ft

Side Slopes = 2:1

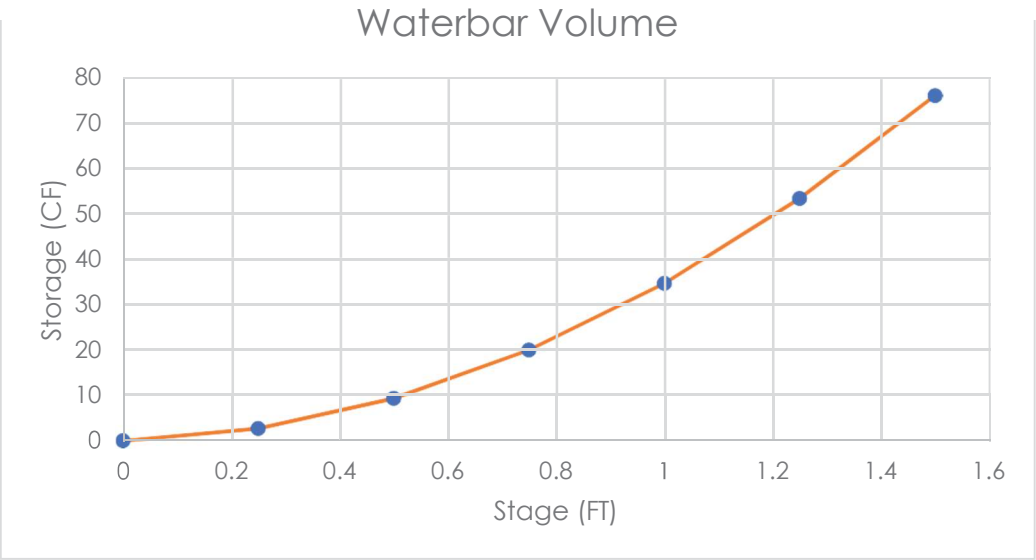
Total Waterbar Volume 9 CF

Waterbar Volume Curve

Stage (FT)	Cumulative Storage (CF)
0	0
0.25	2.68
0.5	9.36
0.75	20.04
1	34.72
1.25	53.4
1.5	76.08

Red Text = Proposed Storage Volume

*Volume Shown Above Proposed Storage for Detailed Routings Only, if Applicable



*Waterbar has a Storage Depth of 0.5 FT with an estimated Trapezoidal Section (Bottom Width of 0.17 FT, 2:1 Side Slopes)

Check Dams*:

Total Number of Check Dams =	1		(Total Number of Check Dams within POA)
Check Dam Ponding Length =	5	ft	(Assumes a channel slope of 20%)
Outlet Structure Dimensions:			
Total Weir Length =	2	ft	
Weir Elevation =	0.5	ft	
Side Slopes =	2:1		

Total Check Dam Volume 0 CF

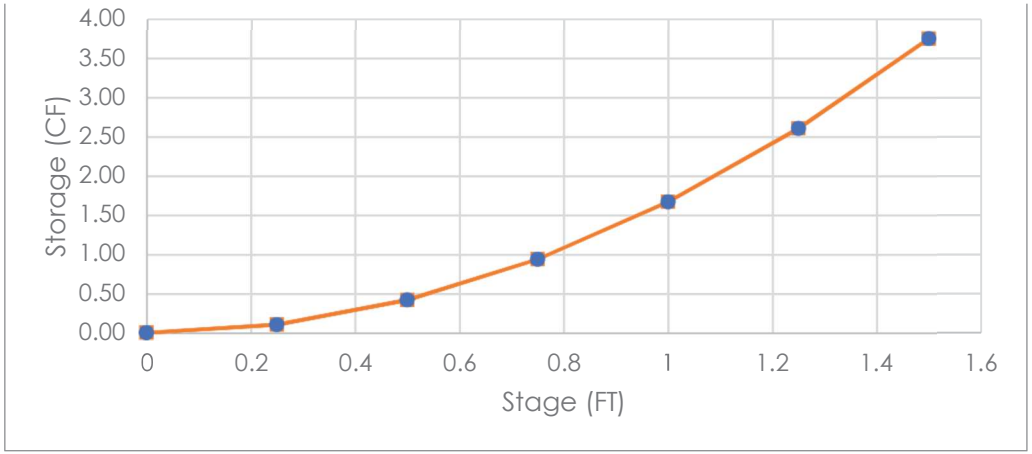
Check Dam Volume Curve

Stage (FT)	Cumulative Storage (CF)
0	0.00

0.25	0.10
0.5	0.42
0.75	0.94
1	1.67
1.25	2.60
1.5	3.75

Red Text = Proposed Storage Volume

*Volume Shown Above Proposed Storage for Detailed Routings Only, if Applicable



*Conservatively estimated all ditches as Type 1 (V-ditch) with 2:1 Side Slopes

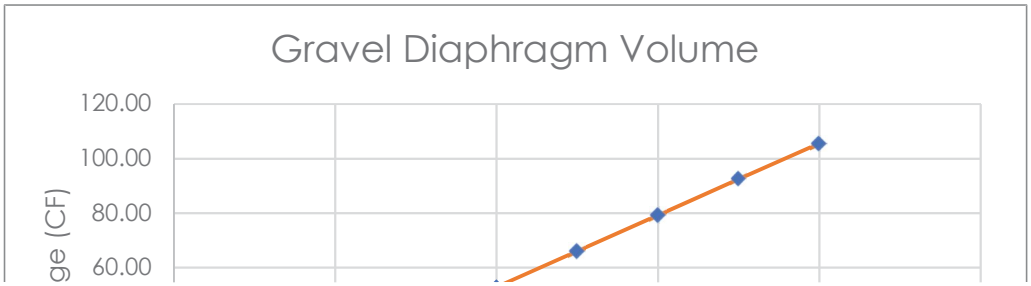
Gravel Diaphragm:

Length of Roadway =	100	(Centerline Length of Road)
Effective Length of Diaphragm =	200	ft (Assumes a channel slope of 20%)
Outlet Structure Dimensions:		
Total Weir Length =	200	ft
Weir Elevation =	1	ft
Side Slopes =	2:1	
Percent Usable Volume =	33	%

Total Gravel Diaphragm Volume 53 CF

Gravel Diaphragm Volume Curve

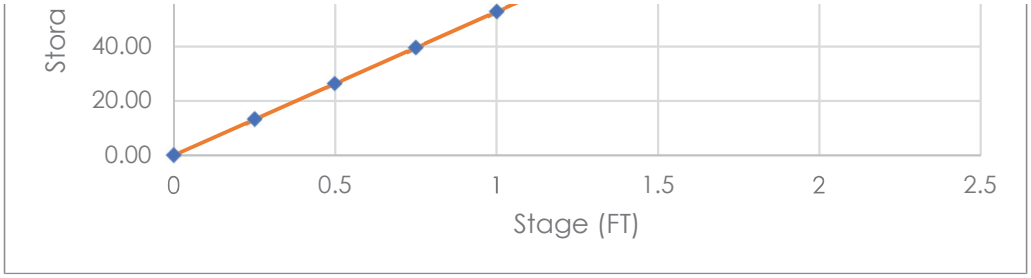
Stage (FT)	Cumulative Storage (CF)
0	0.00
0.25	13.20
0.5	26.40
0.75	39.60
1	52.80



1.25	66.00
1.5	79.20
1.75	92.40
2	105.60

Red Text = Proposed Storage Volume

*Volume Shown Above Proposed Storage for Detailed Routings Only, if Applicable



*Diaphragm has 1 FT Depth and Bottom Width, 1:1 Side Slopes, and a Pore Space of 0.4. Roadway Slope Percent Usable Volume conservatively estimated at 33% unless otherwise documented.

Cumulative Storage Volume **119 CF**

*For use in Vs/Vr Storage Volume Comparisons Only. Cumulative Practice Volumes shall not be used for detailed modeling/routings.

Table A4.4: Standard Diffuser Sizing

Discharge (cfs)	NYS Diffuser Sizing (FT @ 0.25cfs)	Standard Diffuser Size (FT)
0.100	0.40	-
0.200	0.80	-
0.300	1.20	-
0.400	1.60	-
0.500	2.00	-
0.600	2.40	6.00
0.700	2.80	6.00
0.800	3.20	6.00
0.900	3.60	6.00
1.000	4.00	6.00
1.100	4.40	6.00
1.200	4.80	6.00
1.300	5.20	6.00
1.400	5.60	6.00
1.500	6.00	6.00
1.600	6.40	8.00
1.700	6.80	8.00
1.800	7.20	8.00
1.900	7.60	8.00
2.000	8.00	8.00
2.100	8.40	10.00
2.200	8.80	10.00
2.300	9.20	10.00
2.400	9.60	10.00
2.500	10.00	10.00
2.600	10.40	12.00
2.700	10.80	12.00
2.800	11.20	12.00
2.900	11.60	12.00
3.000	12.00	12.00
3.100	12.40	14.00
3.200	12.80	14.00
3.300	13.20	14.00
3.400	13.60	14.00
3.500	14.00	14.00
3.600	14.40	16.00
3.700	14.80	16.00
3.800	15.20	16.00
3.900	15.60	16.00
4.000	16.00	16.00
4.100	16.40	18.00
4.200	16.80	18.00
4.300	17.20	18.00

4.400	17.60	18.00
4.500	18.00	18.00
4.600	18.40	20.00
4.700	18.80	20.00
4.800	19.20	20.00
4.900	19.60	20.00
5.000	20.00	20.00
5.100	20.40	22.00
5.200	20.80	22.00
5.300	21.20	22.00
5.400	21.60	22.00
5.500	22.00	22.00
5.600	22.40	24.00
5.700	22.80	24.00
5.800	23.20	24.00
5.900	23.60	24.00
6.000	24.00	24.00
6.100	24.40	26.00
6.200	24.80	26.00
6.300	25.20	26.00
6.400	25.60	26.00
6.500	26.00	26.00
6.600	26.40	28.00
6.700	26.80	28.00
6.800	27.20	28.00
6.900	27.60	28.00
7.000	28.00	28.00
7.100	28.40	30.00
7.200	28.80	30.00
7.300	29.20	30.00
7.400	29.60	30.00
7.500	30.00	30.00
7.600	30.40	32.00
7.700	30.80	32.00
7.800	31.20	32.00
7.900	31.60	32.00
8.000	32.00	32.00
8.100	32.40	34.00
8.200	32.80	34.00
8.300	33.20	34.00
8.400	33.60	34.00
8.500	34.00	34.00
8.600	34.40	36.00
8.700	34.80	36.00
8.800	35.20	36.00
8.900	35.60	36.00
9.000	36.00	36.00

9.100	36.40	38.00
9.200	36.80	38.00
9.300	37.20	38.00
9.400	37.60	38.00
9.500	38.00	38.00
9.600	38.40	40.00
9.700	38.80	40.00
9.800	39.20	40.00
9.900	39.60	40.00
10.000	40.00	40.00

MODIFIED FLOW DIFFUSER DETAIL
(SIDE SLOPES STEEPER THAN 2:1)

MODIFIED FLOW DIFFUSER DETAIL
(SIDE SLOPES 2:1 OR LESS STEEP)

STANDARD STONE APRON DETAILS

GRAVEL DIAPHRAGM
WATER STOP DETAILS

GRAVEL DIAPHRAGM

FLOW DIFFUSER CONSTRUCTION IN HIGH GROUNDWATER TABLE CONDITIONS

TABLE 1: FLOW DIFFUSER LENGTH MULTIPLIERS IN AREAS OF HGWT

	FLOW DIFFUSER LENGTH MULTIPLIER						
EFFECTIVE SUMP DEPTH BASED ON HGWT	3.5 FT SUMP	3 FT SUMP	2.5 FT SUMP	2 FT SUMP	1.5 FT SUMP	1 FT SUMP	0.5 FT SUMP
	1	1.11	1.25	1.42	1.64	1.95	1.98

SYM.	DATE	BY	REVISION INFORMATION	PROJECT/TASK APP.	
3	02/08/18	JEY	VDEQ COMMENT RESPONSE	-	SL
2	01/22/18	JEY	VDEQ COMMENT RESPONSE	-	SL

Environmental Resources Management

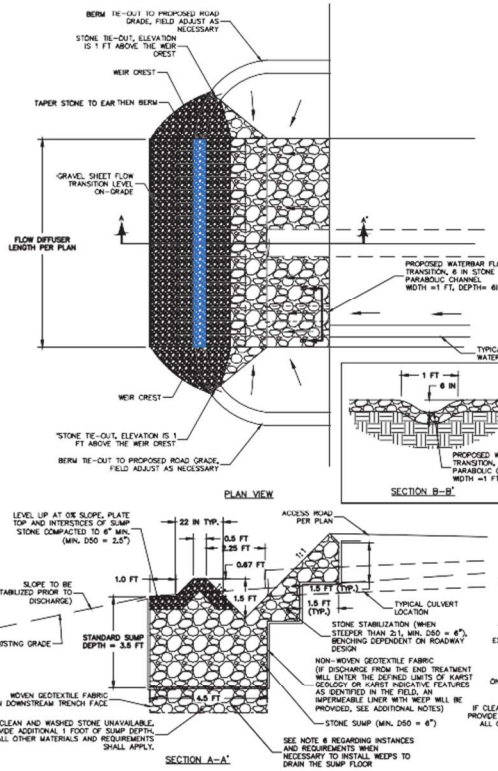
Atlantic Coast Pipeline, LLC
925 White Oaks Blvd. Bridgeport, West Virginia 26330 / 681-842-8000

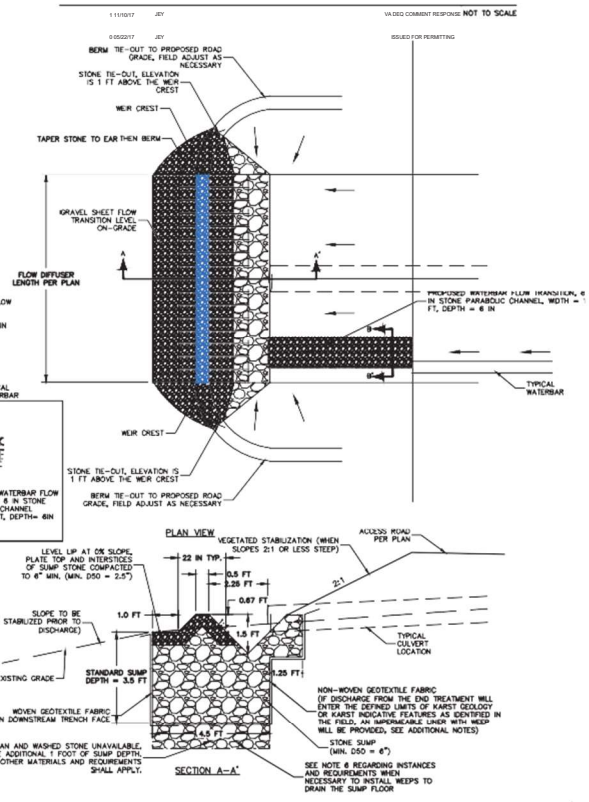
DRAWN:	EJB	05/22/2017
CHECKED:	JEY	05/22/2017
APP. FOR BID:		

TITLE:

ATLANTIC COAST PIPELINE
EROSION AND SEDIMENT CONTROL DETAILS

NOT TO SCALE





NOTES:

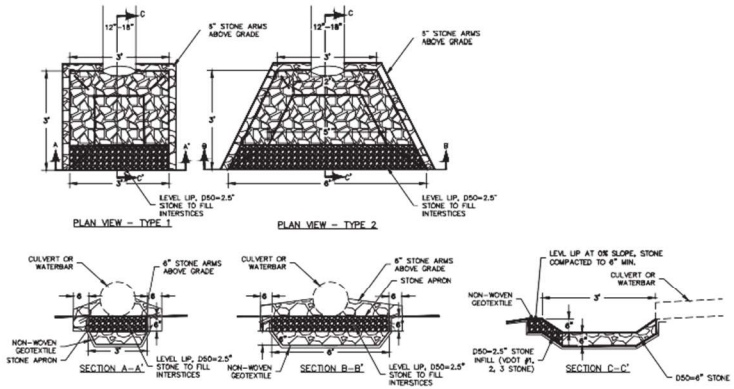
1. WEIR SIZING IN ACCORDANCE WITH WHITE PAPER, 0.25 CFS PER LF OF WEIR LENGTH (10-YR STORM), UNLESS DOWNSTREAM SLOPE EQUALS 30% OR GREATER (0.125 CFS/LF).
2. NON-WOVEN GEOTEXTILE FABRIC SHALL BE NON-WOVEN POLYPROPYLENE GEOTEXTILE, SUCH AS MIRAFI 700X, MIRAFI 70/20, N080, OR OWNER APPROVED EQUAL. THE FABRIC SHALL HAVE PUNCTURE RESISTANCE GREATER THAN 100 LBS, APPARENT OPENING SIZE GREATER THAN U.S. 70 SIEVE, AND 30 LBS. OF TENSILE STRENGTH AT 20% (MAXIMUM). ALL GEOTEXTILE FABRICS BEING INSTALLED ON A VERTICAL SLOPE SHALL BE CUT FLUSH WITH GRADE, SO AS NO GEOTEXTILE FABRIC SHALL BE VISIBLE.
3. WOVEN GEOTEXTILE FABRIC SHALL BE WOVEN HIGH-TENACITY POLYPROPYLENE GEOTEXTILE, SUCH AS MIRAFI 500X, ACF 5300N, OR OWNER APPROVED EQUAL. THE FABRIC SHALL HAVE PUNCTURE RESISTANCE GREATER THAN 700 LBS. APPARENT OPENING SIZE GREATER THAN U.S. 40 SIEVE, AND 315 LBS. OF TENSILE STRENGTH AT 10% (MAXIMUM).
4. IMPERMEABLE LINER (IF APPLICABLE) SHALL BE 30 MIL PVC INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.
5. STONE MATERIAL SIZE AS SPECIFIED PER DETAILS SHALL BE CLEAN AND WASHED (IF NATIVE MATERIAL, CLEAN AND WASHED SHALL, AT MINIMUM, MEAN POWERWASHING STONE ONSITE TO REMOVE FINES). ALTERNATIVELY, SHOULD CLEAN AND WASHED STONE NOT BE AVAILABLE AT THE FIELD LOCATION, AN ADDITIONAL SUMP STONE AREA MAY BE PROVIDED IN THE BOTTOM OF THE TRENCH PROFILE TO ACCOMMODATE POTENTIAL SEDIMENTATION.
6. IN AREAS WHERE FACILITIES DISCHARGE DIRECTLY WITHIN DEFINED LIMITS OF KARST GEOLOGY OR KARST INDICATIVE FEATURES AND IN AREAS WITH HSG C AND HSG D SOILS, THE FLOW DIFFUSERS WILL BE PROVIDED WITH THE ABILITY TO WEEP / DRAIN THE BOTTOM OF THE SUMP FLOOR. WEEPING WILL BE PROVIDED IN THESE INSTANCES, PRIMARILY THROUGH A GRAVEL TRENCH (6 INCHES BY 6 INCHES), OR FRENCH DRAIN COMPOSED OF VDOT #57 STONE WRAPPED IN A NON-WOVEN GEOTEXTILE FABRIC.
7. IN AREAS WHERE WATERBARS OUTLET TO A FLOW DIFFUSER, A FLOW TRANSITION IS REQUIRED TO TRANSFER FLOWS DOWN THE ROAD EMBANKMENT INTO THE DIFFUSER. THESE TRANSITIONS SHALL BE 6 INCH STONE WITH A GENERAL PARABOLIC SECTION (DEPTH = 6 IN, WIDTH = 1 FT.)
8. FLOW DIFFUSERS SHALL BE INSTALLED TO OUTFALL PARALLEL TO THE DOWN GRADIENT CONTOURS WITH THE LEVEL LIP ON GRADE WITH EXISTING GRADE AT A 0% SLOPE.
9. ALL DOWNSTREAM SLOPES SHALL REMAIN UNDISTURBED TO THE GREATEST EXTENT PRACTICABLE.
10. INSTALLATION SHALL BE PER ALIGNMENT SHEET PLAN AND DETAIL PLAN AND INSTALLATION SHALL BE APPROVED BY OWNER (ACP).
11. CONTRACTOR SHALL NOTIFY OWNER (ACP) IF FIELD CONDITIONS THREATEN OR PROHIBIT THE INSTALLATION OF THE FLOW DIFFUSER MEASURES PER DETAIL AND PLAN. SHOULD FIELD ALTERATION BE REQUIRED, CONTRACTOR SHALL OBTAIN OWNER (ACP) APPROVAL AND CAPTURE CHANGES UNDER CONSTRUCTION RECORD DRAWINGS. BASED ON COORDINATION WITH THE DEQ REPRESENTATIVE, SHOULD CUSTOM FIELD SOLUTIONS BE REQUIRED THAT SIGNIFICANTLY ALTER THE DRAINAGE AREA, FLOW DISCHARGE LOCATIONS OR AFFECTS OVERALL REGULATORY COMPLIANCE, THE CONTRACTOR SHALL BE RESPONSIBLE FOR COMMUNICATIONS TO FACILITATE APPROVAL OF THE ADJUSTMENTS BY THE OWNER (ACP) AND ITS REPRESENTATIVES AND COORDINATION AND APPROVAL BY DEQ.
12. CONTRACTOR SHALL BE RESPONSIBLE FOR ADJUSTMENTS AND/OR CORRECTIVE ACTIONS TO ADDRESS FIELD INSPECTIONS AND RECORD DRAWING CERTIFICATION.
13. CONTRACTOR RESPONSIBLE FOR COORDINATING INDIVIDUAL FACILITY ACCEPTANCE WITH OWNER (ACP) AT RECORD DRAWING COMPLETION.

MAINTENANCE:
LONG TERM MAINTENANCE OF THE FLOW DIFFUSER IS ESSENTIAL TO ENSURE ITS CONTINUED EFFECTIVENESS. THE FOLLOWING PROVISIONS SHOULD BE FOLLOWED. ANNUAL INSPECTION SHOULD BE PERFORMED, ANY SIGNS OF CHANNELIZATION AND DEFICIENCY SHOULD BE IMMEDIATELY REPAIRED.

1. INSPECTIONS: ONCE A YEAR, THE FLOW DIFFUSER POOL SHOULD BE INSPECTED FOR SEDIMENT ACCUMULATION AND DEBRIS THAT MAY REDUCE ITS CAPACITY. GENERAL STRUCTURAL INTEGRITY SHOULD BE REVIEWED AT THIS TIME. SHOULD STONE DISPLACEMENT OR EROSION BE NOTED, IT SHOULD BE REPAIRED IMMEDIATELY, AS APPLICABLE.
2. SEDIMENT REMOVAL: SEDIMENT BUILD UP WITHIN THE DRY STORAGE SUMP SHOULD BE REMOVED WHEN ANY ACCUMULATION IS NOTED. DISPOSE OF THE SEDIMENTS APPROPRIATELY.
3. DEBRIS: AS NEEDED REMOVE DEBRIS SUCH AS LEAF LITTER, BRANCHES AND TREE GROWTH FROM THE FLOW DIFFUSER.
4. MOWING: MOWING SHALL BE IN ACCORDANCE WITH ROW MAINTENANCE PROTOCOLS.

THE STANDARD SUMP DEPTH AS DEFINED PER THE FLOW DIFFUSER DETAIL SHALL BE 3.5 FEET UNLESS SPECIFICALLY NOTED OTHERWISE ON THE CONSTRUCTION PLANS OR IN THE EVENT THAT HIGH GROUNDWATER TABLE (HGWT) CONDITIONS ARE ENCOUNTERED IN THE FIELD. SHOULD HGWT CONDITIONS BE ENCOUNTERED WITHIN THE FOOTPRINT OF A PROPOSED FLOW DIFFUSER, THE CONTRACTOR SHALL NOTE THE DEPTH OF GROUNDWATER ENCOUNTERED AND DETERMINE THE EFFECTIVE SUMP DEPTH, OR THE DEPTH OF THE STONE THAT MAY BE CONSTRUCTED WITHOUT BEING EFFECTED BY THE GROUNDWATER ELEVATION. UPON DETERMINATION OF THE EFFECTIVE SUMP DEPTH BASED ON HGWT INFLUENCE, THE CONTRACTOR SHALL INCREASE THE SIZING OF THE FLOW DIFFUSER TO BE INSTALLED BY MULTIPLYING THE FLOW DIFFUSER LENGTH PER PLAN BY THE APPROPRIATE FLOW DIFFUSER LENGTH MULTIPLIER IN ACCORDANCE WITH THE TABLE 1 BELOW (FLOW DIFFUSER LENGTH MULTIPLIERS IN AREAS OF HGWT). CONTRACTOR SHALL BE RESPONSIBLE FOR NOTING THE SIZE, ORIENTATION, AND STANDARD DEPTHS ACHIEVED ON THE CONSTRUCTION RECORD DRAWINGS FOR ALL FLOW DIFFUSERS INSTALLED. SHOULD HGWT BE ENCOUNTERED, THE CONTRACTOR SHALL ALSO PROVIDE NOTATION REFERENCING THE EFFECTIVE SUMP DEPTH BASED ON HGWT, THE ASSOCIATED FLOW DIFFUSER LENGTH MULTIPLIER, AND THE FINAL DIFFUSER LENGTH BASED ON HGWT ON THE RECORD DRAWINGS.

CONTRACTOR SHALL BE RESPONSIBLE FOR INSTALLING FLOW DIFFUSERS PER PLAN LOCATIONS AND IN AN ORIENTATION THAT ALLOWS FOR THE ACHIEVEMENT OF SHEET FLOW DISCHARGE PERPENDICULAR TO THE EXISTING DOWNSTREAM GRADE. LIMITED ADJUSTMENTS FOR FIELD OPTIMIZATION (ADJUSTING ORIENTATION WITHIN THE ROW, ARCING OF THE FLOW DIFFUSER LENGTH, BREAKING ONE FLOW DIFFUSER INTO TWO OR MORE TO ACHIEVE THE SAME CAPTURE AND DIFFUSION PRACTICE, ETC) SHALL BE MADE ONLY UPON APPROVAL BY THE OWNER. SHOULD THE CONTRACTOR FAIL TO MEET THE DIFFUSER DIMENSIONS NOTED UNDER PLAN, FAIL TO MEET DIFFUSER LENGTHS ACHIEVED THROUGH THE ROUTINE IMPLEMENTATION OF TABLE 1, FAIL TO ORIENT A FLOW DIFFUSER APPROPRIATELY, OR FAIL TO PROVIDE LIMITED FEATURE ADJUSTMENT TO ADDRESS FIELD CONSTRAINTS WITH THE SAME VOLUMETRIC GOALS; A PLAN MODIFICATION WILL BE REQUIRED WHICH SHALL INCLUDE THE REVIEW AND APPROVAL OF ALTERNATE COMPLIANCE STRATEGIES BY DEQ.

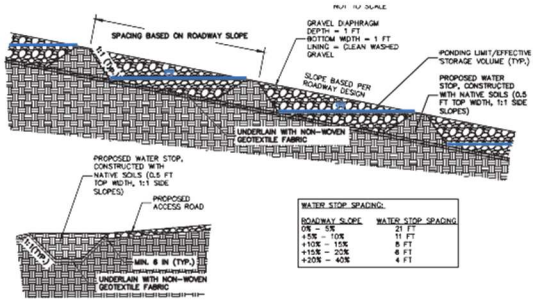


NOTES:

1. THE TYPE 1 STANDARD STONE APRON WILL BE USED WHERE THE 10-YEAR, 24-HOUR PEAK FLOW IS LESS THAN OR EQUAL TO 0.29 CFS.
2. THE TYPE 2 STANDARD STONE APRON WILL BE USED WHERE THE 10-YEAR, 24-HOUR PEAK FLOW IS BETWEEN 0.29 AND 0.57 CFS.
3. STANDARD STONE APRONS SHALL BE INSTALLED PARALLEL TO THE DOWN GRADIENT CONTOURS WITH THE LEVEL LIP ON GRADE WITH EXISTING GRADE AT A 0% SLOPE.
4. IN SOME LOCATIONS IT MAY BE NECESSARY FOR THE PIPE OR WATERBAR TO ENTER THE STANDARD STONE APRON FROM THE SIDE SUCH THAT THE LEVEL LIP IS ORIENTED PARALLEL TO THE DOWNGRADIENT CONTOURS.
5. IN AREAS WHERE WATERBARS OUTLET TO A STANDARD STONE APRON, A FLOW TRANSITION IS REQUIRED TO TRANSFER FLOWS DOWN THE ROAD EMBANKMENT INTO THE STONE APRON DIFFUSER. THESE TRANSITIONS SHALL BE 6 INCH STONE WITH A GENERAL PARABOLIC SECTION (DEPTH = 6 IN, WIDTH = 1 FT.)
6. ALL DOWNSTREAM SLOPES SHALL REMAIN UNDISTURBED TO THE GREATEST EXTENT PRACTICABLE.
7. CONTRACTOR SHALL NOTIFY OWNER IF ANY FIELD CONDITIONS THREATEN OR PROHIBIT THE INSTALLATION OF THE SSA MEASURES PER DETAIL AND PLAN
8. INSTALLATION SHALL BE PER ESC ALIGNMENT SHEET PLAN AND DETAIL PLAN AND INSTALLATION SHALL BE APPROVED BY THE OWNER.
9. CONTRACTOR SHALL BE RESPONSIBLE FOR ADJUSTMENTS AND/OR CORRECTIVE ACTIONS TO ADDRESS FIELD INSPECTIONS AND RECORD DRAWING CERTIFICATION.
10. CONTRACTOR RESPONSIBLE FOR COORDINATING INDIVIDUAL FACILITY ACCEPTANCE WITH OWNER AT RECORD DRAWING COMPLETION.

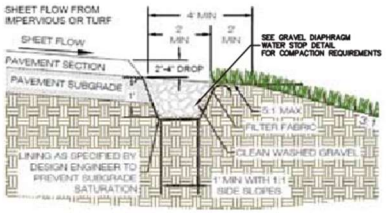
MAINTENANCE:
LONG TERM MAINTENANCE OF THE STONE APRON IS ESSENTIAL TO ENSURE ITS CONTINUED EFFECTIVENESS. THE FOLLOWING PROVISIONS SHOULD BE FOLLOWED. ANNUAL INSPECTION SHOULD BE PERFORMED, ANY SIGNS OF CHANNELIZATION AND DEFICIENCY SHOULD BE IMMEDIATELY REPAIRED.

1. INSPECTIONS: ONCE A YEAR, THE STONE APRON POOL SHOULD BE INSPECTED FOR SEDIMENT ACCUMULATION AND DEBRIS THAT MAY REDUCE ITS CAPACITY. GENERAL STRUCTURAL INTEGRITY SHOULD BE REVIEWED AT THIS TIME. SHOULD STONE DISPLACEMENT OR EROSION BE NOTED, IT SHOULD BE REPAIRED IMMEDIATELY, AS APPLICABLE.
2. SEDIMENT REMOVAL: SEDIMENT BUILD UP WITHIN THE DRY STORAGE SUMP SHOULD BE REMOVED WHEN ANY ACCUMULATION IS NOTED. DISPOSE OF THE SEDIMENTS APPROPRIATELY.
3. DEBRIS: AS NEEDED REMOVE DEBRIS SUCH AS LEAF LITTER, BRANCHES AND TREE GROWTH FROM THE STONE APRON.
4. MOWING: MOWING SHALL BE IN ACCORDANCE WITH ROW MAINTENANCE PROTOCOLS.



WATER STOP SPACING:

ROADWAY SLOPE	WATER STOP SPACING
0% - 5%	21 FT
+5% - 10%	11 FT
+10% - 15%	8 FT
+15% - 20%	6 FT
+20% - 40%	4 FT



NOTES:

1. IF SPRINGS, SEEPS OR OTHER GROUNDWATER IS ENCOUNTERED DURING THE INSTALLATION OF A GRAVEL DIAPHRAGM, PLAN MODIFICATIONS MUST BE PROVIDED AND COORDINATED WITH THE DEQ FIELD REPRESENTATIVE.

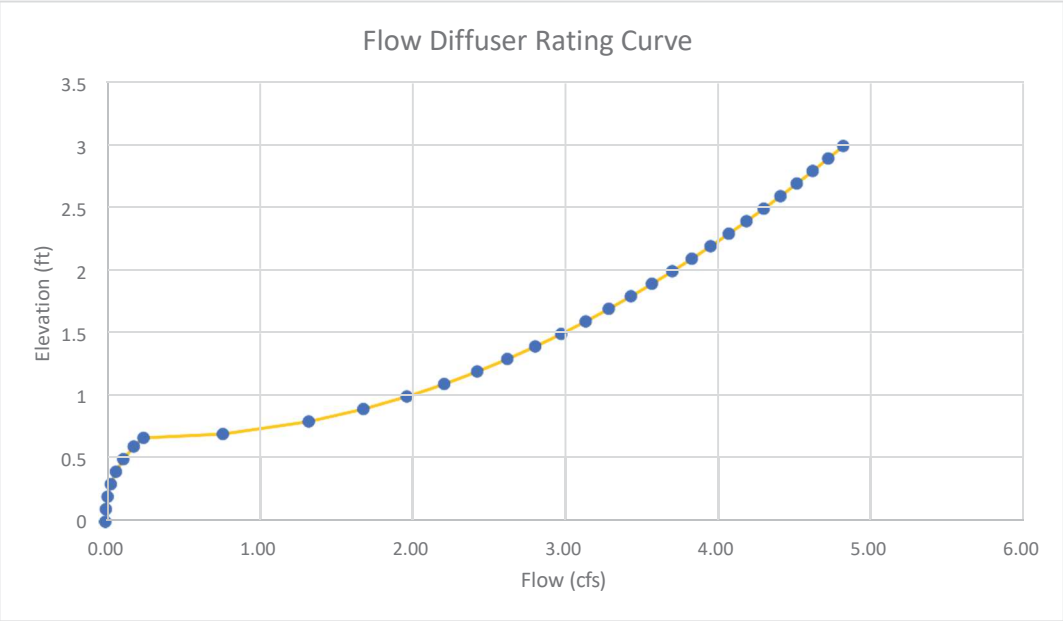
COMMONWEALTH OF VIRGINIA
14K
Registered Professional Engineer
No. 3 [illegible]
07-17-18
PROFESSIONAL ENGINEER

ERM

Table A4.5: Diffuser Unit Rating Curve

Length of Flow Diffuser 1 ft

Elevation	Flow Through Berm (cfs)	Flow Over Berm (cfs)	Total Flow (cfs)
0	0.00	0.00	0.00
0.1	0.00	0.00	0.00
0.2	0.01	0.00	0.01
0.3	0.04	0.00	0.04
0.4	0.07	0.00	0.07
0.5	0.12	0.00	0.12
0.6	0.19	0.00	0.19
0.67	0.25	0.00	0.25
0.7	0.25	0.52	0.77
0.8	0.25	1.08	1.33
0.9	0.25	1.44	1.69
1	0.25	1.72	1.97
1.1	0.25	1.97	2.22
1.2	0.25	2.18	2.43
1.3	0.25	2.38	2.63
1.4	0.25	2.56	2.81
1.5	0.25	2.73	2.98
1.6	0.25	2.89	3.14
1.7	0.25	3.04	3.29
1.8	0.25	3.19	3.44
1.9	0.25	3.33	3.58
2	0.25	3.46	3.71
2.1	0.25	3.59	3.84
2.2	0.25	3.71	3.96
2.3	0.25	3.83	4.08
2.4	0.25	3.95	4.20
2.5	0.25	4.06	4.31
2.6	0.25	4.17	4.42
2.7	0.25	4.27	4.52
2.8	0.25	4.38	4.63
2.9	0.25	4.48	4.73
3	0.25	4.58	4.83



q=k*i*A
q= Flow (CFS)
i=hydraulic gradient
A=Area Normal to Flow (SF)
k= hydraulic conductivity (ft/s)

i=(h1-h2)/l
h1=Depth Behind Berm (FT)
h2=Depth D/S of Berm (FT)
l=flow length through berm(FT)

Hydraulic Conductivity Range

Natural Wastewater Treatment Systems, Second Edition

By Ronald W. Crites, E. Joe Middlebrooks, Robert Bastian

TABLE 7.1
Typical Media Characteristics for Subsurface Flow Wetlands

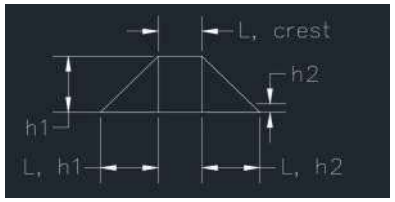
Media Type	Effective Size (D_{10}) (mm)	Porosity (n) (%)	Hydraulic Conductivity (K_s) (ft/d)
Coarse sand	2	28–32	328–3280
Gravelly sand	8	30–35	1640–16,400
Fine gravel	16	35–38	3280–32,800
Medium gravel	32	36–40	32,800–164,000
Coarse rock	128	38–45	164,000–820,000

Note: ft/d × 0.305 = m/d.

k
60500 ft/day Assumed Medium Gravel
2520.8333 ft/hr
42.013889 ft/min
0.7002315 ft/s

Darcy's Law

h1 (ft)	h2 (ft)	l, h1 (ft)	l, h2 (ft)	lcrest (ft)	l (ft)	i	k (ft/s)	A (sf)	q (cfs)
0.000	0.000	0.670	0.670	0.500	1.840	0.000	0.7000	0.000	0.000
0.100	0.015	0.570	0.655	0.500	1.725	0.049	0.7000	0.100	0.003
0.200	0.030	0.470	0.640	0.500	1.610	0.106	0.7000	0.200	0.015
0.300	0.045	0.370	0.625	0.500	1.495	0.171	0.7000	0.300	0.036
0.400	0.060	0.270	0.610	0.500	1.380	0.247	0.7000	0.400	0.069
0.500	0.075	0.170	0.595	0.500	1.265	0.336	0.7000	0.500	0.118
0.600	0.090	0.070	0.580	0.500	1.150	0.444	0.7000	0.600	0.186
0.670	0.100	0.000	0.570	0.500	1.070	0.533	0.7000	0.670	0.250



Weir Equation

Q=C*L*(h^.5)

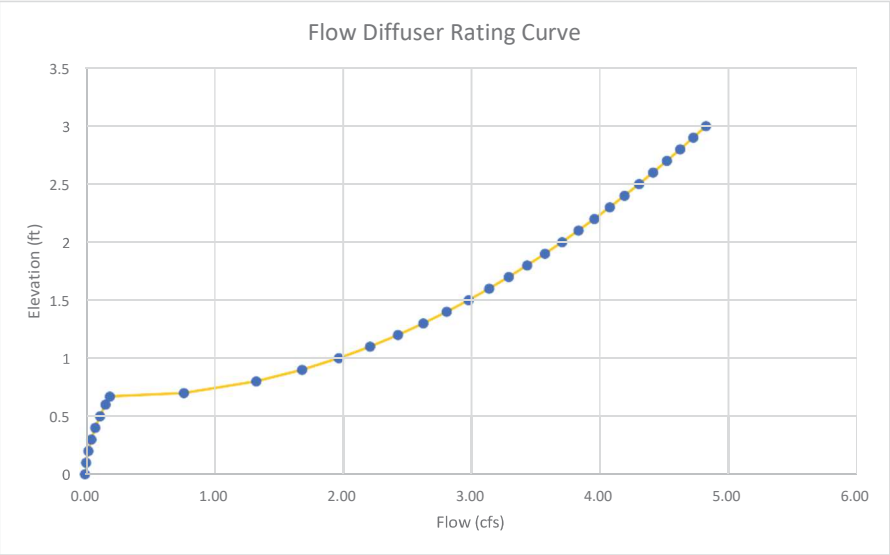
Q	-	Flow (cfs)
C	3	Weir Coefficient
L	1	Length of Diffuser (ft)
h	-	Height above weir (ft)

Elevation (ft)	Flow (cfs)
0.67	0.000
0.7	0.520
0.8	1.082
0.9	1.439
1	1.723
1.1	1.967
1.2	2.184
1.3	2.381
1.4	2.563
1.5	2.733
1.6	2.893
1.7	3.045
1.8	3.189
1.9	3.327
2	3.460
2.1	3.587
2.2	3.711
2.3	3.830
2.4	3.946
2.5	4.058
2.6	4.168
2.7	4.274
2.8	4.378
2.9	4.480
3	4.579

Figure A4.5: Gabion Flow Rating Curve (per Penn State)

Length of Flow Diffuser 1 ft

Elevation	Flow Through Berm (cfs)	Flow Over Berm (cfs)	Total Flow (cfs)
0	0.00	0.00	0.00
0.1	0.01	0.00	0.01
0.2	0.03	0.00	0.03
0.3	0.05	0.00	0.05
0.4	0.08	0.00	0.08
0.5	0.12	0.00	0.12
0.6	0.16	0.00	0.16
0.67	0.19	0.00	0.19
0.7	0.25	0.52	0.77
0.8	0.25	1.08	1.33
0.9	0.25	1.44	1.69
1	0.25	1.72	1.97
1.1	0.25	1.97	2.22
1.2	0.25	2.18	2.43
1.3	0.25	2.38	2.63
1.4	0.25	2.56	2.81
1.5	0.25	2.73	2.98
1.6	0.25	2.89	3.14
1.7	0.25	3.04	3.29
1.8	0.25	3.19	3.44
1.9	0.25	3.33	3.58
2	0.25	3.46	3.71
2.1	0.25	3.59	3.84
2.2	0.25	3.71	3.96
2.3	0.25	3.83	4.08
2.4	0.25	3.95	4.20
2.5	0.25	4.06	4.31
2.6	0.25	4.17	4.42
2.7	0.25	4.27	4.52
2.8	0.25	4.38	4.63
2.9	0.25	4.48	4.73
3	0.25	4.58	4.83



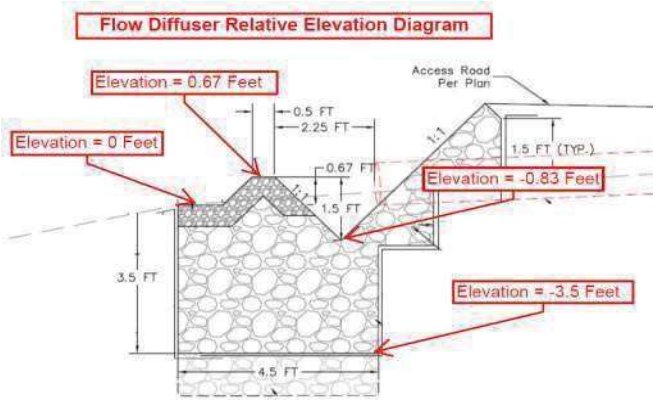
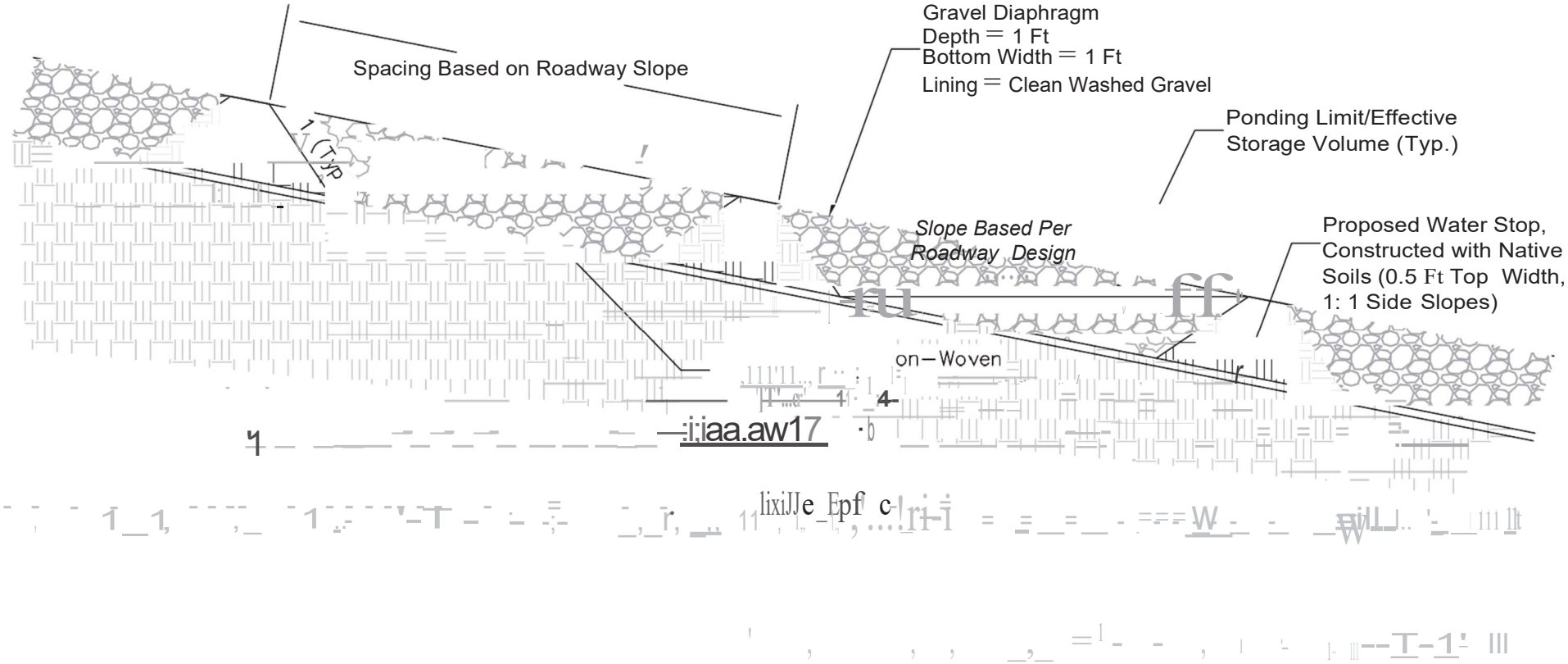
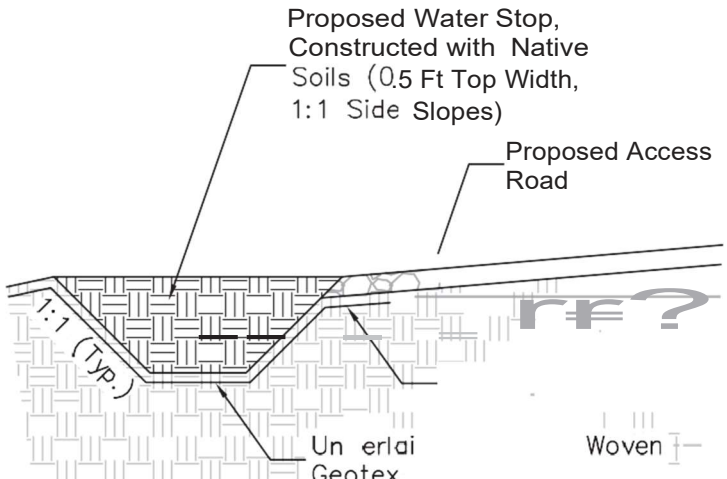


Figure A4.6: Gravel Diaphragm Water Stop





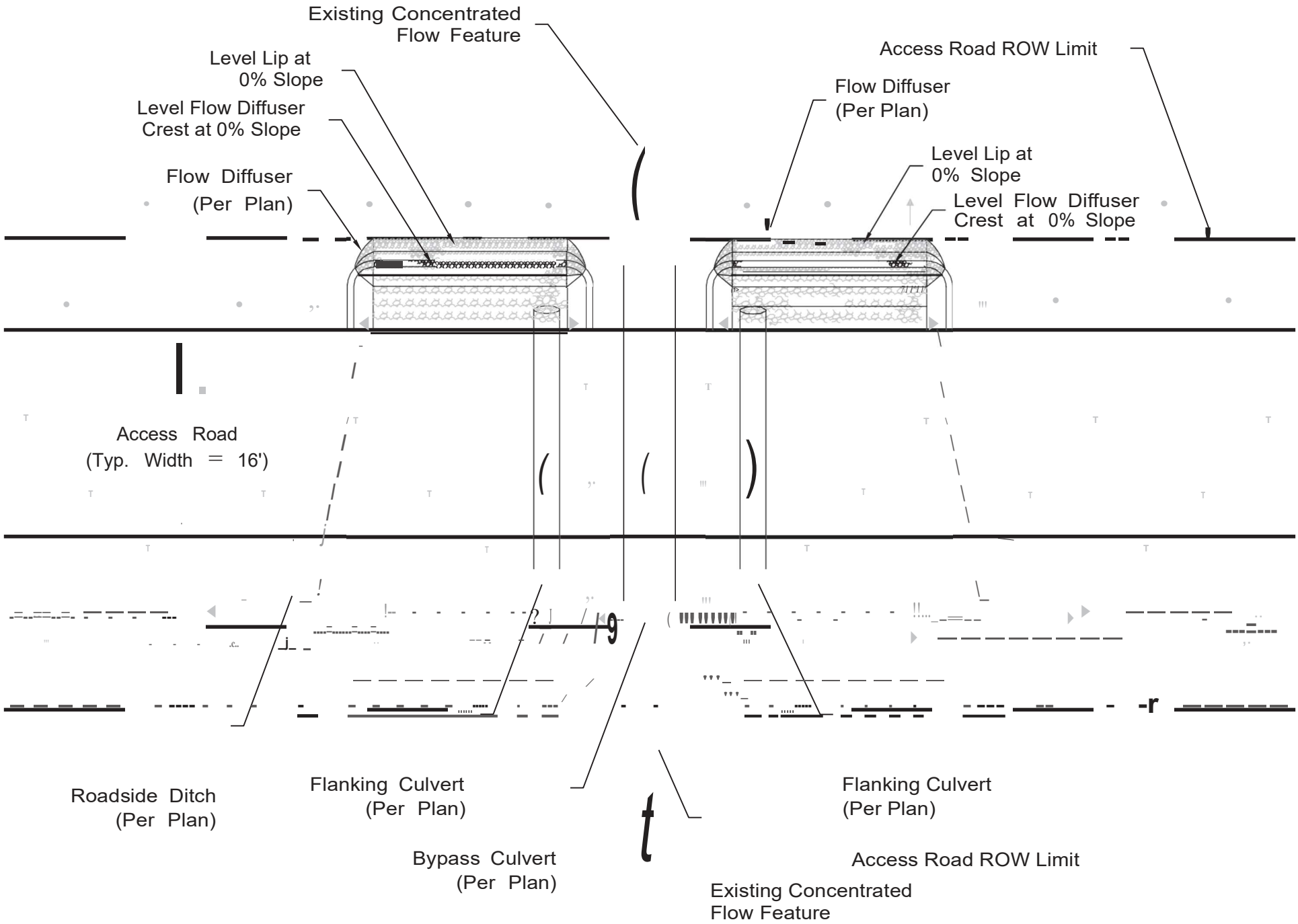
Water Stop Spacing:

Roadway Slope	Water Stop Spacing
0% - 5%	21 FT
+5% - 10%	11 FT
+10% - 15%	8 FT
+15% - 20%	6 FT
+20% - 40%	4 FT

Figure A4.6: Gravel Diaphragm Water Stop

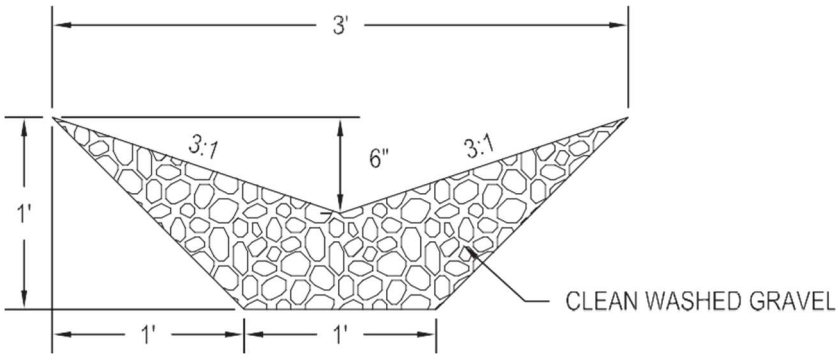
Conceptual Flanking Culvert/Diffuser Strategy for Flow Mitigation - NTS

Figure A4.7: Culvert Flanking Strategy

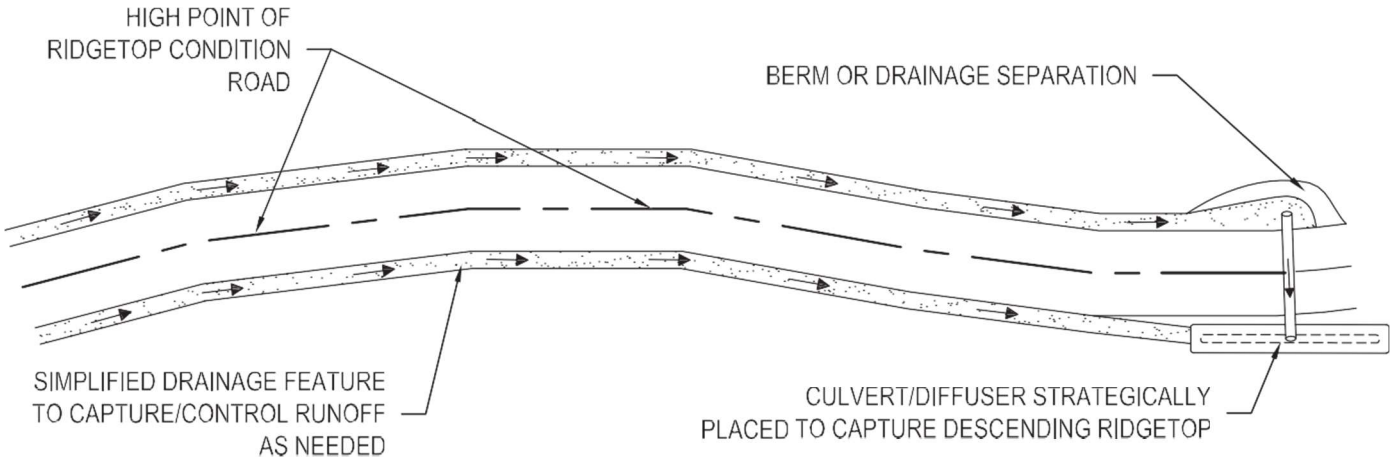


Note: Flow Diffuser should be constructed per the Flow Diffuser Details shown on the Erosion and Sediment Control Details sheet.

Figure A4.8: Gravel Diversion Trench and Ridgetop Runoff Collection and Diffuser Strategy



Detail: Gravel Diversion Trench and Ridgetop Runoff Collection and Diffuser Strategy



NOTES:

1. GRAVEL DIVERSION TRENCH (GDT) PROVIDED AS NECESSARY TO ENSURE SEGREGATION OF ONSITE RUNOFF FROM OFFSITE RUNOFF.
2. ADDITIONAL ACCEPTABLE CONTAINMENT AND DIVERSION PRACTICES MAY BE PROVIDED AS SPECIFIED UNDER THE WATER QUALITY COMPLIANCE CALCULATIONS PACKAGES, IF NECESSARY.

Detail: Ridgetop Runoff Collection and Diffuser Strategy

Figure A4.9: Vs/Vr Worksheets

Input requirements and procedures

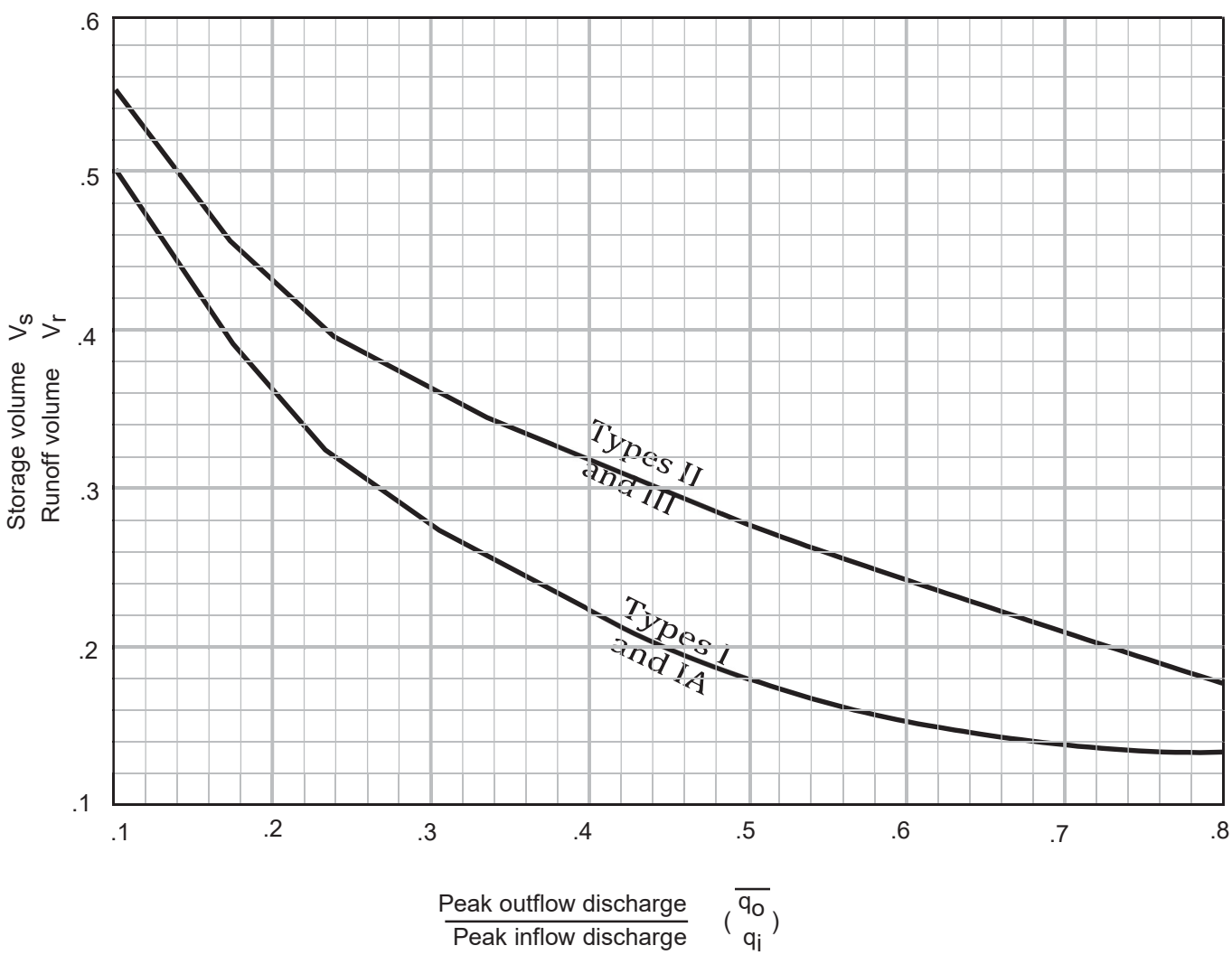
Use figure 6-1 estimate storage volume (V_s) required or peak outflow discharge (q_o). The most frequent application is to estimate V_s, for which the required inputs are runoff volume (V_r), q_o, and peak inflow discharge (q_i). To estimate q_o, the required inputs are V_r, V_s, and q_i.

Estimating V_s

Use worksheet 6a to estimate V_s, storage volume required, by the following procedure.

1. Determine q_o. Many factors may dictate the selection of peak outflow discharge. The most common is to limit downstream discharges to a desired level, such as predevelopment discharge. Another factor may be that the outflow device has already been selected.
2. Estimate q_i by procedures in chapters 4 or 5. Do not use peak discharges developed by other procedure. When using the Tabular Hydrograph method to estimate q_i for a subarea, only use peak discharge associated with T_t =0.

Figure 6-1 Approximate detention basin routing for rainfall types I, IA, II, and III

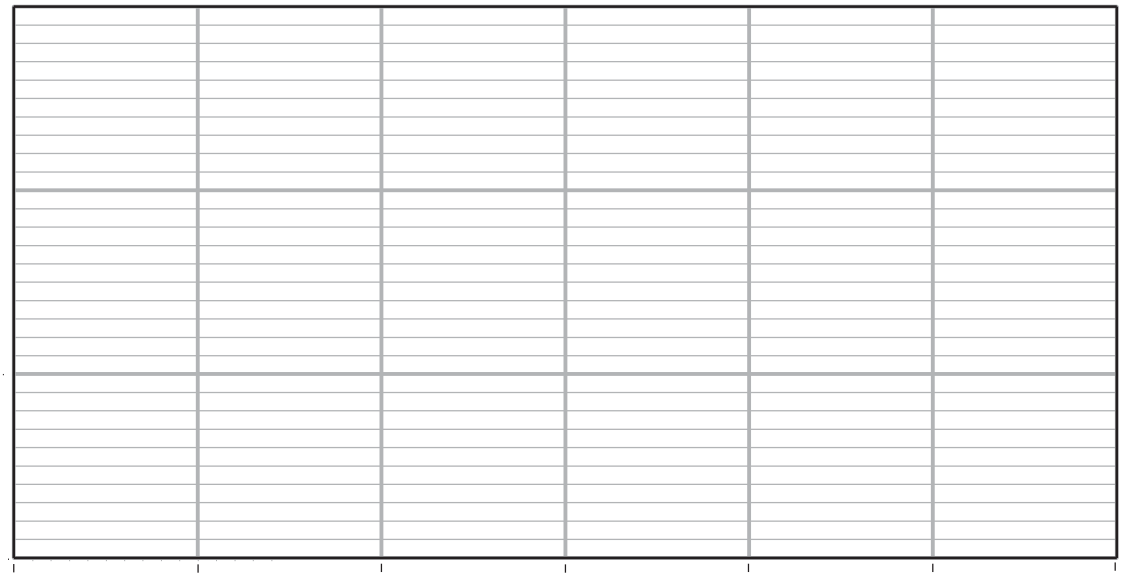


Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

☐ Elevation or ☐ stage



Detention basin storage (acre feet)

1. Data:

Drainage area ..... A_m =_____ mi^2

Rainfall distribution type (I, IA, II, III) =_____

	1st Stage	2nd Stage
2. Frequency ..... yr		
3. Peak inflow discharge q_i ..... ft^3/s (from worksheet 4 or 5b)		
4. Peak outflow discharge q_u ..... ft^3/s [1]		
5. Compute $\frac{q_o}{q_i}$		

6. $\frac{V_s}{V_r}$ ..... (Use $\frac{q_o}{q_i}$ with figure 6-1)

7. Runoff, Q ..... in (From worksheet 2)

8. Runoff volume V_r..... ac ft ($V_r = QA_m$ 53.33)

9. Storage volume, V_s ..... ac-ft ($V_s = V_r$ ($\frac{V_s}{V_r}$))

10. Maximum storage E_{max} (from plot)

[1] 2nd stage q_o includes 1st stage q_o .

Attachment A4.10: Flow Diffuser Construction in High Groundwater Table

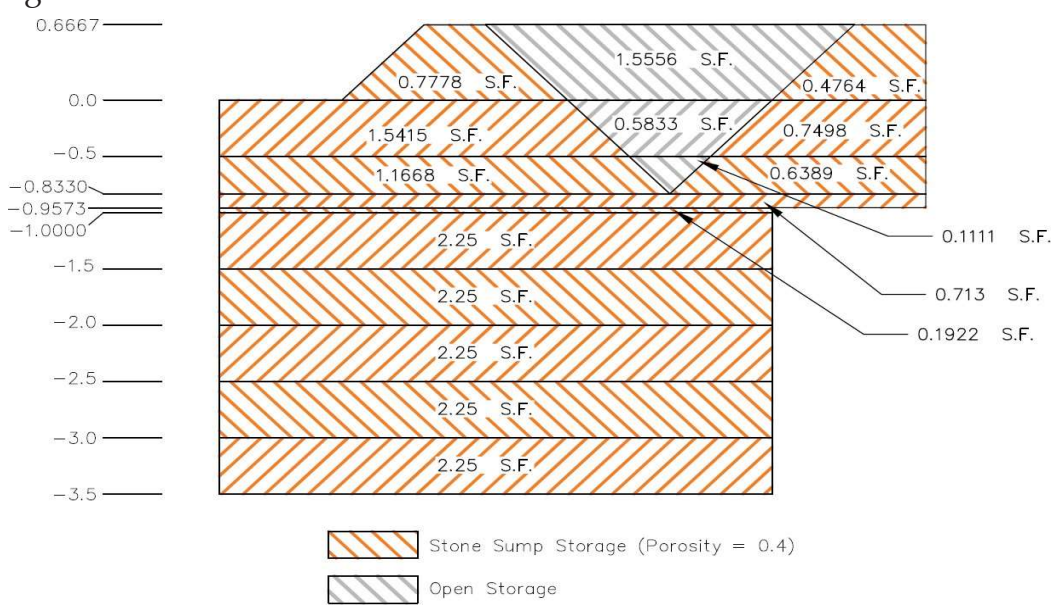
The Standard Sump Depth as defined per the Flow Diffuser detail (3.5 feet) will need to be adjusted by the contractor in the field in the event that High Groundwater Table (HGWT) conditions are encountered. In these circumstances the contractor shall determine the Effective Sump Depth based on the HGWT influence, and then will increase the sizing of the flow diffuser to be installed by multiplying the Flow Diffuser Length Per Plan by the appropriate Flow Diffuser Length Multiplier in accordance with the table below.

Table A4.10: Flow Diffuser Length Multipliers in Areas of HGWT

Effective Sump Depth (FT)	3.5	3.0	2.5	2.0	1.5	1.0	0.5
Storage Volume per Linear Foot based on Influence of HGWT (CF)	9.38	8.48	7.58	6.68	5.78	4.88	4.80
Flow Diffuser Length Multiplier to Accommodate HGWT	**1.00**	**1.11**	**1.25**	**1.42**	**1.64**	**1.95**	**1.98**

These Length Multipliers were developed by estimating the effective volumes on a per linear foot basis and correlating the volume associated with the reduced sump depths to that of the typical Flow Diffuser detail. All volumes were conservatively estimated based on the flow diffuser cross section with the less steep entry slope. The table shows the reduced volumes however, with the increase in length the overall required storage volume will be provided. The figure below depicts the effective storage area, both void space and open storage, for the respective relative elevations depicted. For purposes of this analysis, a porosity of 0.4 was utilized for all void space estimations and volumes depicted in the table above are shown capped at a maximum relative elevation of 0.6667 feet, which corresponds to the crest of the flow diffuser weir.

Figure A4.10: Flow Diffuser Volumetric Estimation



Attachment 5 – Standards and Specifications for Flow Diffusers

A5.1: H.R.C Research Series Report No. 10 – Analysis of Flow Through Porous Media as Applied to Gabion Dams Regarding the Storage and Release of Storm Water Runoff, NAHB/NRC Designated Housing Research Center at Penn State, August 1992

A5.2: Maine Level Spreader – Section 8.3, Maine Stormwater Best Management Practices Manual, September 2010

A5.1: H.R.C Research Series Report No. 10 – Analysis of Flow Through Porous Media as Applied to Gabion Dams Regarding the Storage and Release of Storm Water Runoff, NAHB/NRC Designated Housing Research Center at Penn State, August 1992

H.R.C. Research Series

NAHB/NRC Designated Housing Research Center at Penn State

Report No. 10

ANALYSIS OF FLOW THROUGH POROUS MEDIA AS APPLIED TO GABION DAMS REGARDING THE STORAGE AND RELEASE OF STORM WATER RUNOFF

by

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August 1992

Chapter 1

INTRODUCTION

The scope of this research effort is focused on flow through large-size porous media. This media is actually angular limestone rock, typically used in gabion dam structures . A gabion is basically a "basket of rocks." Typical applications of gabions include use in the construction of dikes and dams, underwater scour prevention around bridge piers, and as erosion stabilizers along river banks and coastlines. Within the past few years, innovative engineers have experimented with gabion dams as they relate to storm water management. The idea is to use these structures to detain and release storm water runoff. The concept is to design the gabion dam in such a way that the flow through the structure will meet the specified target release rates, typically predevelopment runoff rates.

The major concern with the use of gabions as outlet control structures is that their design is based upon practical experience and so nd engineering judgement. The hydraulic flow-through properties of gabions have never been evaluated in a laboratory setting. This research effort attempts to (I) evaluate the flow through large-size porous media, (2) develop a gabion design equation(s), (3) route a design storm through a detention basin and gabion structure to validate the equation, and (4) formulate recommendations and conclusions.

Chapter .2

PRELBDNARY INFORMATION

2.1 Backp:ound Information

The term "gabion" can be traced back to the times of the Roman Empire. Derived from the Latin word for **cage,** a gabion is actually a hollow basket frame, constructed of metal strapping or wire mesh and fi.lled with earth or stone. Originally gabions were used as barricades or ramparts designed to protect soldiers or as defensive fortifications.

Gabions have evolved to become an integral part of the water resources and hydraulic engineering fields. Figure 2.1 illustrates various gabion configurations. Gabion mattresses are used for scour prevention, for coastline protection, and for lining channels, as shown in Figures 2.2 through 2.4.

Recently gabions have been used in the control of storm water runoff. Their intended purpose was to retain the runoff and then release it at pre-specified rates. Gabion dams have several advantages over traditional dikes and outlet structures used in storm water management that make them a viable alternative approach: their base width is much smaller, they are virtually maintenance free, and some would say that they are aesthetically more pleasing.

Figures 2.5 and 2.6 show some gabion structures designed by Mr. Charles Weir , P.E., of Weir Associates, Inc., to control storm water flows. Mr. Weir used sound engineering principles, practices, and judgement in the design of these dams. The structures shown in these figures are located in Ambler, Pennsylvania, just nonh of Philadelphia, have been in place for over 15 years and seem to be functioning as intended. Figure 2.5 depicts the use of gabions in the control of residential storm water runoff. The structure is approximately 24 feet long, 3 feet wide, and a maximum of 3 feet in height. Figure 2.6 is a much larger dam measuring approximately 250 feet long, 9 feet wide at the base, and a maximum of 11 feet in height. This structure is particularly well adapted for this wooded site . Only three large-size trees had to be removed during *its* construction. A traditional earthen dam with 4: I side slopes and a 10 foot width at crest elevation would have a base width of about 100 feet. This would necessitate the removal of dozens of trees, not to mention the cost of construction and fill material requirements.

One of the major drawbacks to the use of gabions is that the hydraulic flow-through characteristics of their large-size porous media have apparently never been tested in the laboratory. Further investigation was necessary. The authors visited Maccaferri Gabions Inc. in Williamsport, Maryland, the nation's largest producer and supplier of gabions. It was discoveredthat a great deal of research has been done on gabion structures; however, it has focused ooly on their hydraulic properties as related to soil stabilization in channels and on slopes. No documented research work has been performed on their flow-through characteristics. At this point it became evident that some laboratory flow tests and analyses were needed. The authors decided to conduct some preliminary flow tests on porous media. The Hydraulics Laboratory of the Department of Civil and Environmental Engineering at The Pennsylvania State University was selected as the test site.

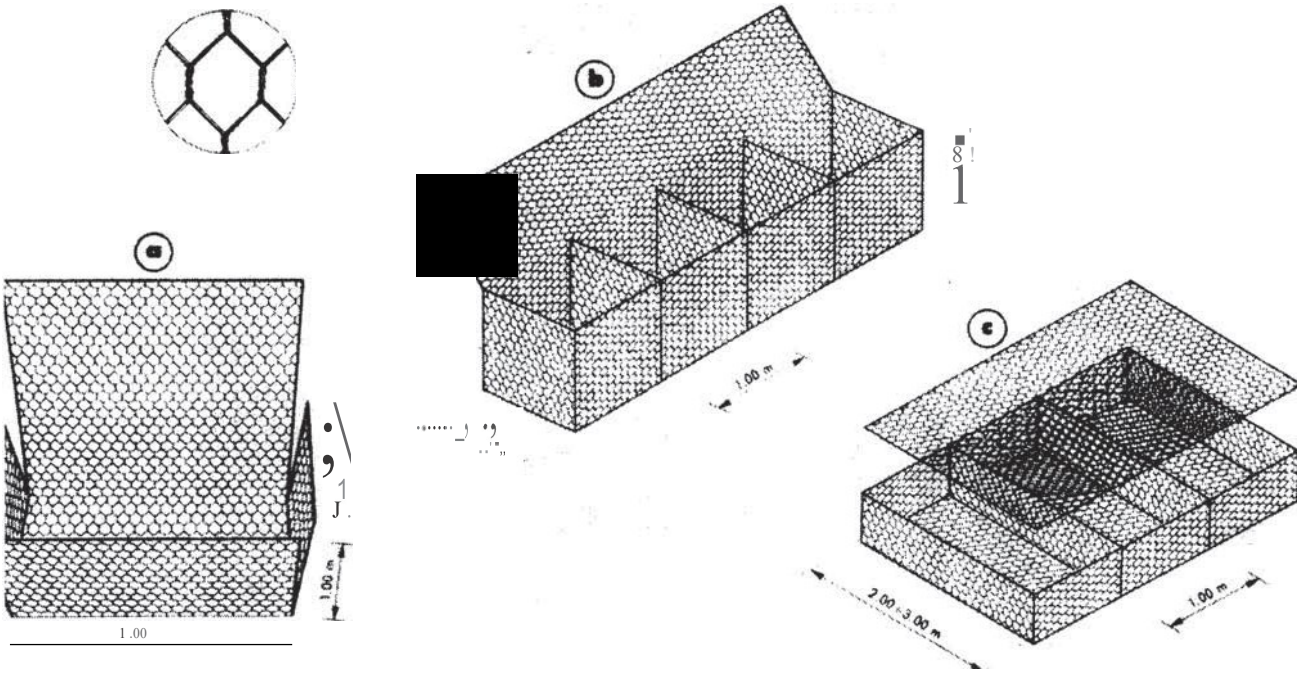


Figure 2.1. Examples of a Gabion: (a) without a diaphragm, (b) with a diaphragm, (c) with multiple cells. Courtesy of Maccaferri Gabion Inc.

Figure 2.2. Gabions Used to Protect Bridge **Piers** from Scour.
Courtesy of Maccaferri Gabion Inc.

Figure 2.3. Gabion Protected Coastline.
Courtesy of Maccaferric Gabion Inc.

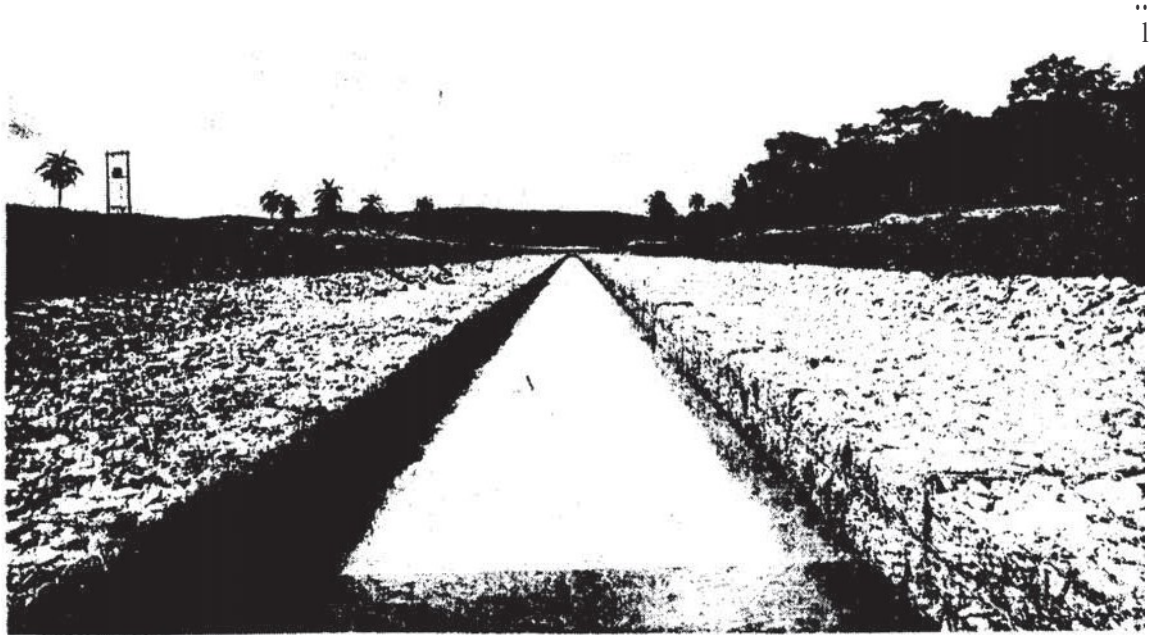


Figure 2.4. Gabion Lined Channel.
Courtesy of Maccaferric Gabion Inc.

Figure 2.5. Oabions Used in a Residential Development.

Figure 2.6. Large-Siz.e Oabion Dam in a Wooded Ar-ea.

2.2 Laboratory Set Up: Phase I

The existing hydraulic flumes in the lab proved inadequate for the gabion research effon. The flumes were constructed of plexiglass , which would become severely scratched when in contact with the rock media, and were also too narrow. A minimum flume width of two feet was required to effectively negate the effects of side wall flow which could bypass the media. Therefore, a flume had to be constructed. Plywood was the material of choice since it was readily available at a minimum cost. An 8 foot long flume with a cross section of 24" x 22" was constructed from the plywood sheets. All joints were sealed with silicone compound. Figure 2.7 illustrates the partially constructed gabion flume.

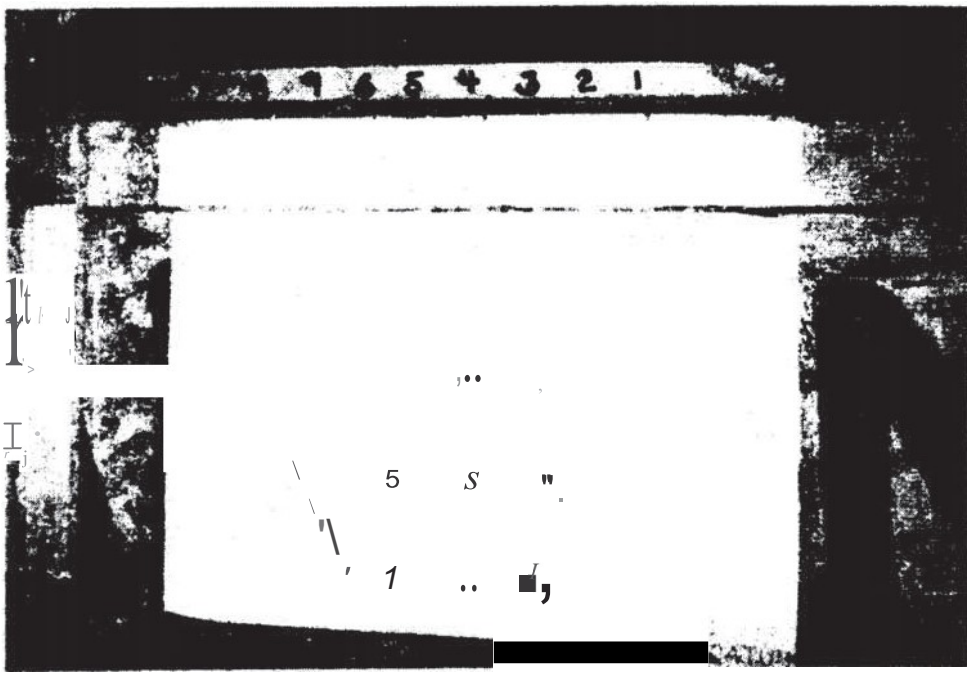
One-half inch wire mesh was selected for the gabion basket framework. The basket width represents the flow path length. Widths of one foot and two feet were selected for these preliminary tests. The baskets were positioned in the flume approximately four feet from the PVC inflow piping to reduce turbulent effects. The flume was then raised into position above a weighing tank .so that the outflow from the flume discharged directly into the tank and an accurate measure of the flow could be obtained. Two large piezometers were installed on the flume. one upstream and one downstream of the baskets, to read the upstream and downstream head. Nine smaller piezometer tubes were installed at the basket structure to provide a profile of the water surface. Water was then run through the flume to check for leaks and so that the weighing tank could be calibrated and checked for accuracy. Figure 2.8 shows the fully constructed flume, while Figure 2.9 is a close-up of the piezometer nest.

The angular limestone rock was obtained from a local quarry. Three different roclc sizes were collected: 3-5" stone, 1-2" stone, and 3/4" stone. Approximately fuur cubic feet of each size was collected and transported to the laboratory. Samples of the three rock sizes are shown in Figure 2.10. Additionally, thousands of golf balls were borrowed from the Penn State Golf Course for use in this study. since some data concerning spherical media might prove useful.

With all the apparatus and material in place and in proper workjng order in the laboratory, flow tests could begin.

Figure 2. 7 . **Partially** Constructed Gabion Flume.

Figure, 2 8 . Finished Gabion Flume.



Figure, 2 9. Piez omete r Nest.

Figure 2. 10. Various Rock Sizes Used as Porous Media (from left to right •- large stone, medium stone, small stone).

Chapter 6

SUMMARY AND CONCLUSIONS

6.1. Summazy

A series of laboratory flow tests was conducted on angular limestone rock. The purpose of these ts was to determine if a rock-filled gabioo dam could be used in stonn water management facilities to store and properly release stonn water runoff at the predevelopment "target" rates.

The results of the gradation and flow-through tests were applied to the Forchheimer [5,6] relationship for flow through large-size **media.** The equation was modified to fit the observed data. A single design equation was developed, which is a function of rock diameter, flow path length, ponding depth, and width. The equation is

$$Q = \frac{Ji3\_ri\_w}{(\quad + 2.S + L^2]^{112}}$$

where

Q == total flow through the gabioo dam (cfs)
h = ponding depth in the basin (ft)
W = total length of the gabion dam (ft)
L = horizontal flow path length (or width of the gabion dam) {ft)
D - avera,e rock diameter (ft)

The design equation was checked against the observed values, and then used in a routing sequence in a sample detention basin. The design and routing results yielded reasonable values using a gabion dam to store and release storm water runoff.

6.2 Conclusions

The results of this study indicate that properly sized and configured gabion dams can store significant amounts of storm water runoff **and release** it at or below the predevelopment "target" discharge rates. However, several key questions remain:

1. How are gabion dams constructed, and is it a very labor-intensive effort?

2. Where are these types of structures applicable, and what advantages do they offer?

3. Do they eventually clog up with leaves, grit, and debris?

4. Will review boards and municipal engineers accept these types of structures as a viable alternative to more traditional methods?

5. How do gabion dams respond in the field to actual storm evenrs?

Question I:

The construction of a gabion is not a terribly labor-intensive effort; however, a reasonable amount of care should be taken to preserve the integrity of the structure. The rock should be placed in the baskets in layers and then moved (or kicked) into place to minimize void space and to prevent future settlement. Cross-tie wires should be installed to prevent "bulging" of the baskets. Rock may be flat-faced against all sides of the baskets for aesthetic purposes. Adjacent baskets should be wired together to prevent possible future movement. Considering that, on average. elatively few gabion baskets will be required in the construction of the dam, the labor effort is minimal.

Question 2:

A gabion dam can be used almost anywhere; however, they are most applicable on heavily wooded sites, or on sites where excess fill is not available for the construction of traditional dikes. In some instances they may prove to be the most cost-effective means of constructing an outlet structure. They also dissipate the energy of the flow and can discharge the collected runoff as shallow overland flow, as opposed to concentrated swale or pipe flow. A gabion darn inherently constitutes its own spiJlway. Some may argue that these structures are actually more appealing and tend to blend into a residential setting much better than traditional structures, such as a concrete riser box or a perforated corrugated steel pipe riser in a detention basin.

Question 3:

Some clogging of gabion baskets may occur, especially if using smaller-sized rock media. Leaves and other organic material decompose quickly and are washed through along with fine grit and sand during the next substantial storm. Gabion dams are actually a self-cleansing structure. However, if clogging is of major concern, additional freeboard could be added to the height of the structure. The gabion dams designed by C. Weir (Ambler, PA) have been in operation for over 15 years in a variety of settings and show no apparent clogging of the void spaces. In fact, they seem to be functioning as intended.

Question 4:

Most municipal storm water management ordinances have a section which addresses alternative measures of control and release of runoff. While the term "gabion darn" may not be written out, the phrase " . . . or other alternative designs are permitted as determined by the MunicipaJ Engineer." The Model Storm Water Mana,ement Ordinance for Municipalities in the Centre Re&ion of Pennsylvania does have a provision for the use of rock-fLlled gabions . In other regions, the design engineer and/or project owner may have to "sell" this concept to the review boards and municipal engineers. The findings of this report and any other information the HRC at Penn State can provide may be used as credible evidence during negotiations.

Question 5:

There is no documented research available on the storage and release of storm water runoff from gabion darns in actual field conditions, aJthough existing structures appear to be doing their intended job. A logical extension to this study would involve the design, construction, monitoring, and evaluation of gabion dams in field conditions during actual storm events to determine their effectiveness.

Section 8.3
LEVEL SPREADER

September 2 010

A level spreader is a vegetated or mechanical structure used to disperse or "spread" concentrated flow thinly over a receiving area. Level spreaders reduce erosion and movement of sediment and also assist to filter sediment, soluble pollutants, and sediment-attached pollutants. They are generally used where concentrated flows are discharged to the ground and serve to convert the concentrated flow to sheet flow to prevent erosion of the downstream receiving area. They are generally used to disperse flows over a relatively flat receiving area such as a buffer or swale to ensure uniform distribution of flow and minimize the channelization of water. Level spreaders are not designed to remove pollutants from stormwater; however, some suspended sediment and associated phosphorus, nitrogen, metals and hydrocarbons will settle out of the runoff by settlement filtration, infiltration, absorption, decomposition and volatilization.

8.3.1 Site Suitability Criteria

1. Drainage area: The maximum drainage area to the spreader may not exceed 0.10 acre per foot length of level spreader lip if the level spreader is not discharging directly to a buffer and is only used to dissipate flow volume and velocity. The drainage area served by the spreader discharging directly cannot be more than half the size of the receiving buffer area.

2. Slope: The maximum slope of the receiving area below a level spreader should be no more than 30%. If the slope is greater than 30%, the discharge will need to be brought by a conduit and velocity dissipator to an area that is suitable.

IMPORTANT

This section discusses the design of a level spreader to convert concentrated flow to sheet flow to prevent erosion of downstream receiving areas and to lengthen time of concentration to reduce peak flows. The use of level spreaders with buffers for water quality purposes must follow the design criteria in Chapter 5 Buffers.

8.3.2 Design and Construction Criteria

These standards are not applicable for level spreaders discharging runoff to buffers used to meet the Department's General BMP Standards. Requirements for these level spreaders can be found in Chapter 5 for buffers.

1. Discharge to a Level Spreader: The peak stormwater flow rate to a level spreader due to runoff from a 10-year, 24-hour storm must be less than 0.25

cubic feet per second (0.25 cfs) per foot length of level spreader lip.

2. Length of Level Spreader: The level spreader length may not be more than 25 feet unless approved by the department.

3. Sitting of Level Spreader: The level spreader must be sited so that flow from the level spreader will remain in sheet flow until entering a natural or man-made receiving channel.

4. Capacity: The capacity of each level spreader shall be based on the allowable velocity of the receiving soil. The flow area upstream of the level spreader shall be sufficient to ensure low approach velocities to the level "lip". The minimum flow area shall be equal to the flow area of the delivery channel.

5. Buffer: Each level spreader shall have a vegetated receiving area with the capacity to pass the flow without erosion. The receiving area shall be stable prior to the construction of the level spreader. The receiving area shall have topography regular enough to prevent undue flow concentration before entering a stable watercourse but it shall have a slope that is less than 30%. If the receiving area is not presently stable, then the receiving area shall be stabilized prior to construction of the level spreader. This will limit construction to the growing season.

6. Berm: The berm of the level lip should consist of crushed rock with a three-quarter to three inches in diameter size gradation that will allow flows to slowly seep through the berm, a minimum of 18 inch high and 3 feet wide. The berm should have a 6 to 12 inch deep header channel with a 3-foot bottom width to trap sediments and reduce lateral flow velocities behind the berm. The bottom and back of the spreader channel should be lined with erosion control matting.

7. Installation: A level spreader must be installed correctly with 0% grade on the spreader base and lip to ensure a uniform distribution of flow; otherwise the structure may fail and become a source of erosion.

8. Upstream Velocity: The flow area upstream of the level spreader shall be controlled to ensure low approach velocities to the level "lip." The minimum flow area of level spreader shall be equal to the flow area of the delivery channel. The base and lip shall be installed at a 0% grade (level).

9. Receiving Area: Level spreaders shall blend smoothly into the downstream receiving area without any sharp drops or irregularities to avoid channelization, turbulence and hydraulic jumps. The receiving area below the level spreader shall be protected from harm during construction. Sodding and/or netting in combination with vegetative measures shall stabilize disturbed areas. The receiving area shall not be used by the level spreader until stabilization has been accomplished. A temporary diversion may be necessary in this case.

10. Undisturbed Soils: Level spreaders shall be constructed on undisturbed soil where possible.

11. Entrance Drainage Channel Design: The entrance channel to the

level spreader is constructed across the slope and consists of a combination of stone and existing natural vegetation used to disperse, filter and lower the runoff velocity into the level spreader. The entrance channel shall blend smoothly into the downstream receiving area without any sharp drops or irregularities, so to avoid turbulence and hydraulic jumps.

a. *Shape:* The entrance channel is typically trapezoidal in cross section, but may be parabolic as long as the soil bed design width is equivalent to the design bottom width for a trapezoidal section and is no more than 2 feet deep. Trenches shall be constructed along the existing contour and shall be 15-20 feet long and at least 7 feet wide across the top.

b. *Bottom Width:* Bottom width for a trapezoidal cross section of the entrance channel should be a minimum of two feet.

c. *Side Slopes:* Side slopes of the entrance channel shall be 2:1 or flatter to provide pretreatment of runoff entering the level spreader.

d. *Longitudinal Slope:* The longitudinal slope of the entrance channel should be 1% grade or less in order to avoid excessive velocity and deep water at the downstream end when ponding. If topography dictates a steeper net channel slope, the swale can be broken into relatively flat sections by check dams placed at no closer than 50 feet intervals.

e. Depth and Capacity: The swale should be designed to safely convey the 2 year storm with design velocities less than 4.0 to 5.0 feet per second. The swale should have sufficient total depth to convey the 10-year storm with 6 inches of freeboard.

8.3.3 Maintenance

Long term maintenance of the level spreader is essential to ensure its continued effectiveness. The following provisions should be followed. In the first year the level spreader should be inspected semi annually and following major storm events for any signs of channelization and should be immediately repaired. After the first year, annual inspection should be sufficient. Vegetated level spreaders may require periodic mowing. Spreaders constructed of wood, asphalt, stone or concrete curbing also require periodic inspection to check for damage and to be repaired as needed.

1. Inspections: At least once a year, the level spreader pool should be inspected for sand accumulation and debris that may reduce its capacity.

2. Maintenance Access: Level spreaders should be sited to provide easy access for removal of accumulated sediment and rehabilitation of the berm.

3. Sediment Removal: Sediment build-up within the swale should be removed when it has accumulated to approximately 25% of design volume or channel capacity. Dispose of the sediments appropriately.

4. Debris: As needed remove debris such as leaf litter, branches and tree growth from the spreader.

5. Mowing: Vegetated spreaders may require mowing.

6. Snow Storage: Do not store snow removed from the street and parking lot within the area of the level spreader.

7. Level Spreader Replacement: The reconstruction of the level spreader may be necessary when sheet flow from the spreader becomes channeled into the buffer.

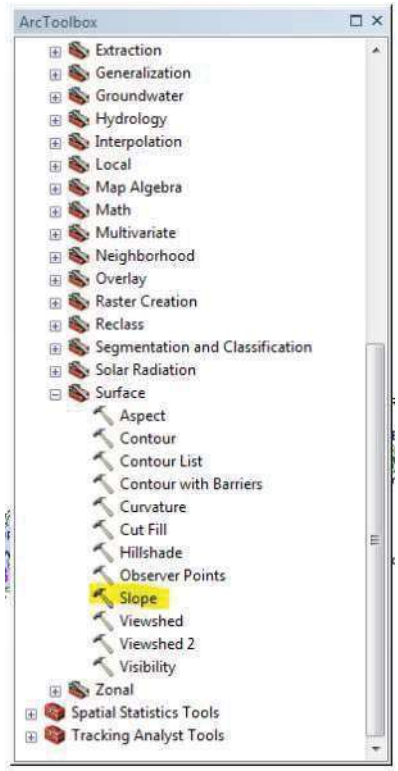
Attachment 6 – Procedure: Calculating Average Basin Slope

Procedure: Calculating Average Basin Slope

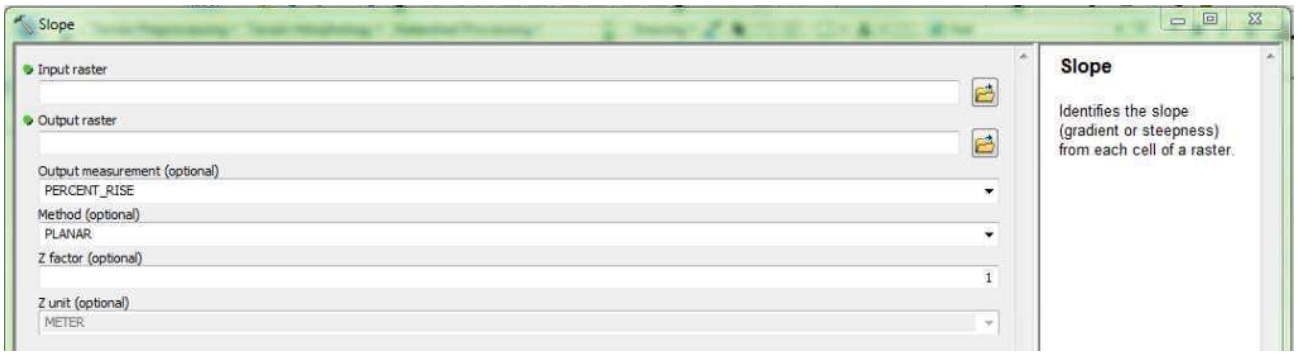
Necessary data: Slope raster (or DEM if slope raster is not available), drainage area polygons.

If slope raster is not available, begin from step 1. If slope raster is available, Skip to step 4.

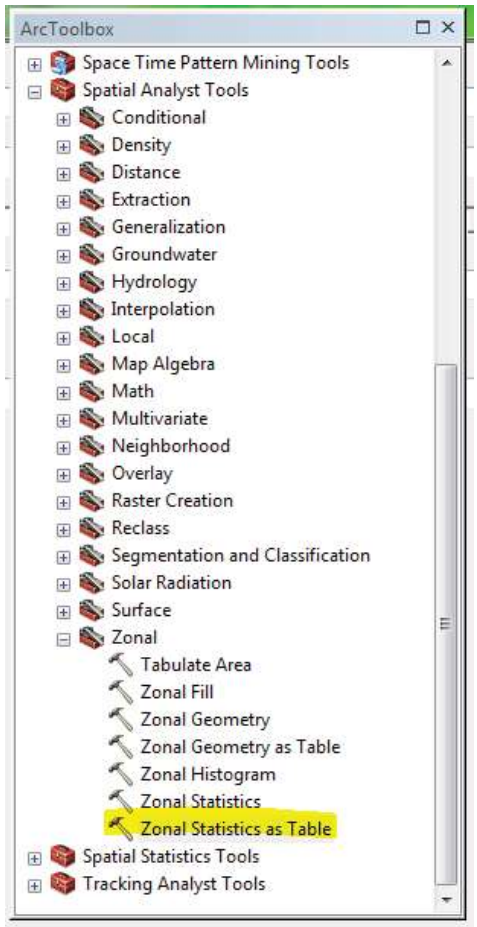
1. Generate slope raster: Add DEM to Map document
2. Select Slope (spatial analyst) tool from Arc Toolbox:



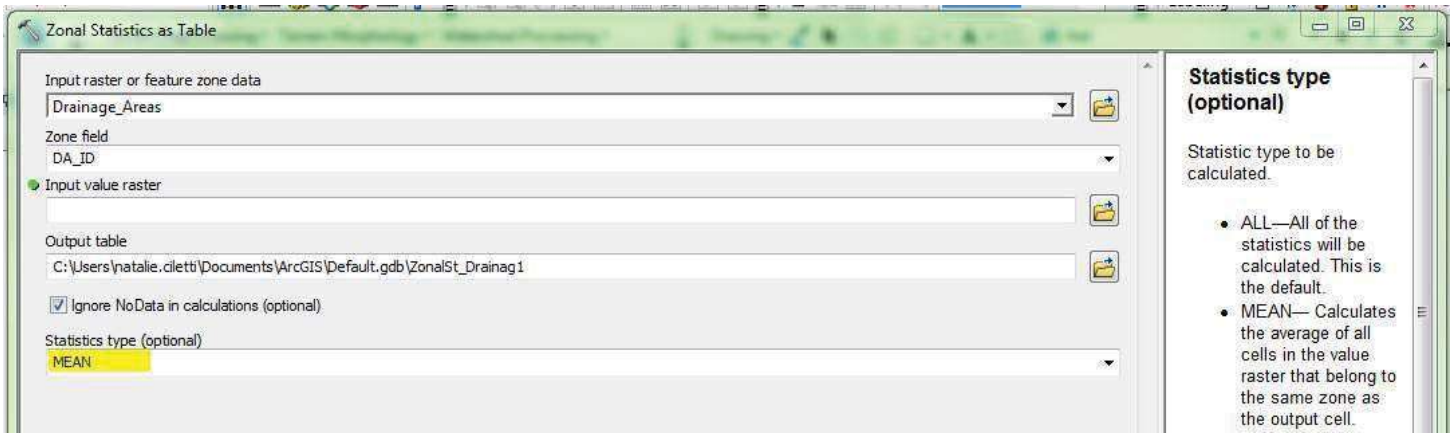
3. Enter the following parameter into the Slope dialog box below
    a. DEM into "Input raster"
    b. select the location for your output slope raster
    c. "Output measurement" = Percent rise
    d. Method = PLANAR,
    e. Z factor =1



4. Add average slope raster dataset to Map document (the average slope raster will automatically add to map if previously completed steps (1-3)
5. Add finalized drainage areas to map document (make sure they all have unique IDs)
6. ***Note Zonal statistics as Table will return the mean slope for the largest extent of overlapping polygons. In order to run on smaller sub drainage areas, select or query drainage polygons to just those smaller DA.
7. Open processing tool Zonal Statistics as Table:



8. Enter the following parameters into the Zonal statistics as Table dialog box below:
   a. "The Input raster or feature zone data" = Drainage Areas;
   b. Zone field" = DA_ID (all DA_IDs must be unique for calculation to work properly)
   c. Enter Slope Raster into "Input raster"; select the location for your output table.
   d. Statistic type = MEAN



9. If needed, repeat #6-8 for any areas with overlapping drainage for the smaller drainage areas.
10. Export/Copy the table(s) to excel spread sheet and save for engineering. They will need a drainage ID and mean slope for each drainage area.

If overlapping drainage areas are problematic, a tool for zonal statistics for overlapping polygons should be utilized, which may be found at:

https://www.arcgis.com/home/item.html?id=b859b33c616a47d2b99b5e133942db02

WHITE PAPER WBET ADDENDUM

CERTIFICATION

The Water Bar End Treatment Sizing (WBET) and Details was developed by Wetland Studies and Solutions, Inc. and AECOM. Wetland Studies and Solutions, Inc. has given permission for AECOM to use the work and seal in an email dated April 27, 2018.

WATER BAR END TREATMENT SIZING (WBET) AND DETAILS

10/18/2018

Background

This narrative is a companion narrative to the approved white paper developed by the Atlantic Coast Pipeline (ACP) Project Team entitled *"Virginia ACP Stormwater Quantity Compliance Methodology"*, dated February 16, 2018 (*ACP Methodology*). The ACP Methodology provides detailed site-specific end treatment computations and analyses that demonstrate how sheetflow below the proposed water bars can be achieved for each of the approximate 6,500 permanent water bars. While use of the site-specific methodology was approved by DEQ, the site-specific design requires that every design be reviewed in detail. As a result, a companion approach was requested for use in small watersheds with low runoff rates that would provide for end treatments that would streamline DEQ review for compliance and still ensure sheetflow is produced.

The proposed Water Bar End Treatment (WBET) methodology described in this narrative provides one conservatively sized end treatment length based primarily on the contributing drainage area. This approach incudes a set of conditions to be examined to determine whether the specified end treatment length will be sufficient, or if a site-specific analysis will be required. It was tested in three separate spreads (4, 6, and 11) that were deemed by DEQ and the Project Team to be representative of the terrain the pipeline will traverse, including sections in the Valley and Ridge/Blue Ridge, Piedmont, and Coastal Plain physiographic provinces.

Site specific analyses were developed for each province. Appendix A contains a listing of the map numbers from the project drainage plans depicting the location of each of the water bars assessed in this analysis. Based on the assessment of the water bars in each of the noted areas, site-specific end treatments will still be required in certain situations, primarily in the Coastal Plain. The following narrative describes the methodology for assessing the adequacy of the WBET methodology as well as a methodology description for site-specific end treatments.

Water Quantity: Concentrated Flow

Pre-construction non-agricultural and forested areas resulting in concentrated flow will satisfy Virginia Water Quantity channel and flood protection requirements (9VAC25-870-66.B.3.a and 9VAC25-870-66.C.2.b, respectively). Both channel and flood protection requirements compare runoff volumes and peak flows from pre- to post-construction condition. These values are based on curve numbers associated with land use. The ACP project will always result in lower post-development curve numbers in pre-construction non-agricultural areas with no impervious cover.

Channel protection requirements can be satisfied using the Energy Balance Method per 9VAC25-870-66.B.3.a. The Energy Balance Method is intended for post-development runoff to mimic forested conditions, and states the following:

> […] Under no condition shall $Q_{Developed}$ be required to be less than that calculated in the equation $(Q_{Forest} * RV_{Forest})/RV_{Developed}$; where:
>
> $Q_{Developed}$ = The allowable peak flow rate of runoff from the developed site.
> $RV_{Developed}$ = The volume of runoff from the site in the developed condition.
> Q_{Forest} = The peak flow rate of runoff from the site in a forested condition.
> RV_{Forest} = The volume of runoff from the site in a forested condition;

Flood protection requirements can be satisfied using 9VAC25-870-66.C.2.b.

The ACP project is assuming a worst-case scenario in which localized flooding currently occurs during the 10-year 24-hour storm event. Therefore, the post-development peak flow rate for the 10-year 24-hour storm event must be "less than the predevelopment peak flow rate".

Because the post-construction ROW always results in a CN less than or equal to that of woods, and time of concentration will never decrease due to possible retention behind the water bar end treatments, peak flows will never exceed those of forested conditions. Therefore, the Energy Balance Method requirements are automatically satisfied, and channel protection requirements are met. Additionally, based on CN reduction from pre- to post-construction conditions, 10-year 24-hour storm volumes will also always be reduced, thereby satisfying flood protection requirements.

Methodology

Required end treatment sizes were computed for each water bar in the test areas (n = 529) to assess and develop the protocols for when site-specific analyses would be required. The specific representative water bars were selected by DEQ and AECOM and provided for analysis. The methodology is described below.

Flow Rate Computation

To calculate the required length of the end treatments, the flow rate to each water bar resulting from the 10-yr storm was necessary. This flow rate information has been computed for each water bar using the *ACP Methodology*.

Weir Flow Computation

To compute the required length of the water bar end treatment, the weir equation was solved for length using the flow rates developed by the *ACP Methodology*. This process was performed using a spreadsheet for each of the 529 water bars in the test areas by modeling the level sections as a broad crested (rectangular) weir:

$$Q = C_w L H^{3/2}$$

Where:

Q = *10-yr flow rate, cfs*

Velocity Computation

To assess the velocity of the sheet flow downslope of the end treatment, Manning's equation was used:

$$V = (1.49/n)\ R^{2/3}\ S^{1/2}$$

Where:

V = *Overland Velocity, ft/s*

n = *Manning's Coefficient:*

This parameter was assumed to be 0.24 for sheet flow in "dense grasses" (TR-55, Table 3-1. Areas below the end treatments will be seeded with native grasses and woody species as per the Restoration and Rehabilitation Plan (Rev 6, prepared in October 2017), so the "dense grasses" n value was deemed to be the most appropriate vs the "short prairie grass" (n = 0.15) or "Bermuda grass" (n = 0.41) alternatives).

R = *Hydraulic Radius, ft:*

This term is defined as the cross-sectional flow area divided by the wetted perimeter. However, for shallow, wide flow this can be assumed to be equal to the flow depth. In this case this is set to the specified flow depth of 0.10 ft, per the following example (for an assumed 10 ft end treatment):

$$\begin{aligned} R &= A / WP \\ &= (0.1\ ft * 10\ ft) / (0.1\ ft + 10\ ft + 0.1\ ft) \\ &= 1.0\ ft^2 / 10.2\ ft \\ &= 0.098\ ft \end{aligned}$$

Use depth = 0.10 ft

S = *Overland Slope, ft/ft:*

This parameter was developed by and obtained from the approved *ACP Methodology*.

Results

The above methodology was employed to determine the required end treatment length for each of the 529 water bars in the test areas. A summary of the analysis for each spread (top 25 sorted by end treatment length) is provided in Tables 1-3, below (full results for each spread in the test areas are presented in Appendix B).

Table 1 – Selections from Spread 4 (Valley and Ridge/Blue Ridge)

Waterbar	*Drainage Area (ac)*	*Q_{10} (cfs)*	*CN*	*T_c (min)*	*Slope (ft/ft)*	*End Treatment Length (ft)*	*Velocity (fps)*
P 128.046	0.60	2.36	80	5	0.02	22	0.19
P 123.043	0.74	2.10	73	5	0.11	20	0.44
P 125.070	2.40	1.78	53	5	0.28	17	0.71
P 123.045	0.62	1.76	73	5	0.15	17	0.52
P 123.041	0.50	1.55	75	5	0.03	15	0.23
P 132.069	0.59	1.39	68	5	0.62	13	1.05
P 131.020	0.42	1.30	74	5	0.34	12	0.78
P 131.022	0.55	1.29	68	5	0.33	12	0.77
P 131.018	0.36	1.16	75	5	0.29	11	0.72
P 129.012	1.41	1.15	53	5	0.15	11	0.52
P 132.059	0.47	1.11	68	5	0.1	11	0.42
P 129.002	0.29	1.06	78	5	0.11	10	0.44
P 126.044	0.46	0.98	67	5	0.23	9	0.64
P 129.023	1.58	0.96	51	5	0.1	9	0.42
P 126.055	0.42	0.85	66	5	0.27	8	0.69
P 131.008	0.27	0.80	73	5	0.37	8	0.81
P 126.008	1.01	0.75	53	5	0.42	7	0.87
P 131.004	0.23	0.65	72	5	0.26	6	0.68
P 134.014	0.21	0.62	73	5	0.31	6	0.74
P 133.041	0.20	0.62	74	5	0.15	6	0.52
P 132.057	0.28	0.60	66	5	0.13	6	0.48
P 128.041	0.22	0.57	70	5	0.07	5	0.35
P 123.069	0.19	0.54	73	5	0.19	5	0.58
P 126.057	0.24	0.51	67	5	0.36	5	0.80
P 134.027	0.17	0.50	73	5	0.13	5	0.48

Table 2 – Selections from Spread 6 (Piedmont)

Waterbar	Drainage Area (ac)	Q_{10} (cfs)	CN	T_c (min)	Slope (ft/ft)	End Treatment Length (ft)	Velocity (fps)
P 229.032	0.86	3.05	69	5	0.19	29	0.58
P 229.024	0.77	2.63	68	5	0.14	25	0.50
P 231.015	0.93	2.18	60	5	0.34	21	0.78
P 229.009	0.65	2.12	67	5	0.12	20	0.46
P 280.027	0.48	1.66	71	5	0.12	16	0.46
P 229.021	0.46	1.58	68	5	0.04	15	0.27
P 228.020	1.11	1.55	53	6	0.31	15	0.74
P 229.010	0.46	1.45	66	5	0.07	14	0.35
P 229.018	0.42	1.30	66	5	0.15	12	0.52
P 280.033	0.46	1.28	66	5	0.09	12	0.40
P 229.015	0.41	1.28	66	5	0.07	12	0.35
P 281.008	0.54	1.15	61	5	0.02	11	0.19
P 229.012	0.34	1.11	67	5	0.15	11	0.52
P 230.032	0.29	0.98	68	5	0.05	9	0.30
P 228.032	0.43	0.97	59	5	0.18	9	0.57
P 228.014	0.63	0.96	53	5	0.18	9	0.57
P 230.021	0.48	0.95	57	5	0.26	9	0.68
P 280.053	0.53	0.92	57	5	0.07	9	0.35
P 228.004	0.19	0.91	77	5	0.03	9	0.23
P 281.039	0.22	0.90	75	5	0.07	9	0.35
P 228.035	0.34	0.80	60	5	0.45	8	0.90
P 228.047	0.26	0.77	65	5	0.24	7	0.66
P 230.033	0.25	0.77	66	5	0.31	7	0.74
P 231.002	0.25	0.77	66	5	0.31	7	0.74
P 228.005	0.17	0.68	72	5	0.03	6	0.23

Table 3 – Selections from Spread 11 (Coastal Plain)

Waterbar	Drainage Area (ac)	$Q_{10\,(cfs)}$	CN	T_c (min)	Slope (ft/ft)	End Treatment Length (ft)	Velocity (fps)
P 050.033	2.37	9.87	89	18	0.01	94	0.14
P 052.003	1.66	9.16	80	6	0.01	87	0.15
P 083.026	0.73	5.94	94	5	0.12	56	0.46
P 052.006	1.11	5.57	76	5	0.03	53	0.22
P 083.012	0.88	5.33	86	7	0.12	51	0.46
P 079.002	3.93	5.26	61	30	0.03	50	0.24
P 079.036	1.15	4.76	81	15	0.01	45	0.13
P 083.027	0.52	4.21	94	5	0.16	40	0.54
P 083.001	0.47	4.01	96	5	0.01	38	0.13
P 083.024	0.57	4.00	88	5	0.10	38	0.42
P 052.005	0.69	3.71	78	5	0.03	35	0.23
P 079.032	0.69	3.47	78	7	0.06	33	0.32
P 079.024	1.36	2.31	58	13	0.03	22	0.22
P 083.023	0.29	2.00	87	5	0.08	19	0.38
P 080.002	0.33	1.99	81	5	0.01	19	0.13
P 077.001	0.39	1.95	77	6	0.01	18	0.13
P 080.001	0.32	1.91	81	5	0.01	18	0.15
P 082.041	0.31	1.90	82	5	0.01	18	0.12
P 079.010	1.50	1.85	48	5	0.03	18	0.22
P 081.001	0.18	1.61	97	5	0.01	15	0.13
P 079.027	1.53	1.51	46	5	0.01	14	0.16
P 079.026	0.70	1.41	61	13	0.18	13	0.57
P 079.001	0.28	1.34	75	6	0.02	13	0.19
P 079.025	0.23	1.31	80	5	0.04	12	0.27
P 035.038	0.25	1.23	77	5	0.01	12	0.13

From the analysis of the 529 water bars in the test areas, the proposed 20-ft end treatment will provide a conservative length that will ensure sheetflow is achieved for a vast majority of the assessed water bars:

Spread 4: 357 out of 359 (99%)
Spread 6: 82 out of 86 (95%)
Spread 11: 73 out of 86 (85%)

Overland Velocities

Overland velocities below the end treatments will remain well below erosive levels, which was assumed to be equal to 2.25 fps for a sandy loam, earthen lining under critical conditions (VESCH, Table 5-22 – lowest velocity). Note that the downslope areas will be vegetated and thus will be able to withstand an even higher velocity. To reiterate, even assuming an earthen lining, expected velocities are well below erosive levels. See Appendix B for a complete listing of the computed velocities for each of the test areas

Protocol for Site Specific Analyses

Based on the analysis of each test area (Appendix B and excerpts in Tables 1-3), the proposed end treatment length of 20 feet will not be sufficient in every case. This is particularly true in the coastal plain where the slope is very flat. Because the pipeline runs through several physiographic provinces with vastly different terrain, developing a separate protocol for determining when site specific analyses appeared necessary.

From inspection of the water bar analyses, the following protocols for when site specific analyses will be required for sections of the pipeline traveling through each physiographic province is provided below:

Spread 4 (Valley and Ridge/Blue Ridge)

D.A. > 0.5 ac and CN > 73

Spread 6 (Piedmont)

D.A. > 0.5 ac

Spread 11 (Coastal Plain)

D.A. > 0.4 ac

Applying these protocols for each of the test areas captures the end treatment lengths that exceed 20 feet. Tables 4-6 (sorted by drainage area) depict these results (highlighted rows require site specific analyses.

For all other conditions, the standard water bar end treatment length of 20 feet can be employed, constructed in the manner depicted in Exhibit C. However, when the pipeline ROW is following a ridgeline – thus producing runoff to both sides – the end treatment length will be adjusted to 10 feet on both sides of the ROW.

The values shown in Table 4 are based on parameters from the project that were valid at time of analysis and should be considered as a representation of the project based on that period or snapshot in time.

Table 4 – Spread 4 (Valley and Ridge/Blue Ridge) Site Specific Analyses (shaded)

Waterbar	*Drainage Area (ac)*	*Q_{10} (cfs)*	*CN*	*T_c (min)*	*Slope (ft/ft)*	*End Treatment Length (ft)*	*Velocity (fps)*
P 125.070	2.40	1.78	53	5	0.28	17	0.71
P 127.090	1.86	0.17	40	5	0.38	2	0.82
P 129.023	1.58	0.96	51	5	0.1	9	0.42
P 130.003	1.55	0.17	41	7	0.45	2	0.90
P 129.074	1.50	0.28	44	6	0.21	3	0.61
P 129.012	1.41	1.15	53	5	0.15	11	0.52
P 130.040	1.39	0.28	44	5	0.44	3	0.89
P 127.092	1.22	0.11	40	5	0.24	1	0.66
P 130.053	1.08	0.16	43	7	0.08	2	0.38
P 127.098	1.07	0.10	40	5	0.26	1	0.68
P 126.008	1.01	0.75	53	5	0.42	7	0.87
P 129.056	1.01	0.10	40	5	0.29	1	0.72
P 127.088	0.98	0.09	40	5	0.29	1	0.72
P 127.067	0.93	0.08	40	5	0.19	1	0.58
P 130.042	0.83	0.09	40	5	0.28	1	0.71
P 127.094	0.77	0.07	40	5	0.34	1	0.78
P 130.009	0.74	0.26	48	5	0.27	2	0.69
P 123.043	0.74	2.10	73	5	0.11	20	0.44
P 127.119	0.74	0.07	40	5	0.31	1	0.74
P 130.048	0.71	0.07	40	5	0.19	1	0.58
P 131.002	0.71	0.07	40	6	0.14	1	0.50
P 130.038	0.68	0.09	41	5	0.31	1	0.74
P 130.030	0.65	0.23	48	5	0.36	2	0.80
P 129.076	0.65	0.07	40	5	0.25	1	0.67
P 123.045	0.62	1.76	73	5	0.15	17	0.52
P 128.046	0.60	2.36	80	5	0.02	22	0.19
P 132.069	0.59	1.39	68	5	0.62	13	1.05
P 127.078	0.58	0.05	40	5	0.13	0	0.48
P 131.022	0.55	1.29	68	5	0.33	12	0.77
P 127.069	0.55	0.05	40	5	0.25	0	0.67
P 130.044	0.55	0.06	40	5	0.27	1	0.69
P 126.047	0.53	0.44	54	5	0.28	4	0.71
P 130.050	0.52	0.05	40	5	0.17	1	0.55
P 129.060	0.51	0.05	40	5	0.35	1	0.79
P 123.041	0.50	1.55	75	5	0.03	15	0.23
P 130.013	0.49	0.45	54	5	0.18	4	0.57
P 132.059	0.47	1.11	68	5	0.1	11	0.42

Table 5– Spread 6 (Piedmont) Site Specific Analyses (shaded)

Waterbar	Drainage Area (ac)	Q_{10} (cfs)	CN	T_c (min)	Slope (ft/ft)	End Treatment Length (ft)	Velocity (fps)
P 228.020	1.11	1.55	53	6	0.31	15	0.74
P 231.015	0.93	2.18	60	5	0.34	21	0.78
P 229.032	0.86	3.05	69	5	0.19	29	0.58
P 229.024	0.77	2.63	68	5	0.14	25	0.50
P 229.009	0.65	2.12	67	5	0.12	20	0.46
P 228.014	0.63	0.96	53	5	0.18	9	0.57
P 281.008	0.54	1.15	61	5	0.02	11	0.19
P 280.053	0.53	0.92	57	5	0.07	9	0.35
P 280.027	0.48	1.66	71	5	0.12	16	0.46
P 230.021	0.48	0.95	57	5	0.26	9	0.68
P 229.021	0.46	1.58	68	5	0.04	15	0.27
P 229.010	0.46	1.45	66	5	0.07	14	0.35
P 280.033	0.46	1.28	66	5	0.09	12	0.40
P 228.032	0.43	0.97	59	5	0.18	9	0.57
P 229.018	0.42	1.30	66	5	0.15	12	0.52
P 229.015	0.41	1.28	66	5	0.07	12	0.35
P 229.012	0.34	1.11	67	5	0.15	11	0.52
P 228.035	0.34	0.80	60	5	0.45	8	0.90
P 230.012	0.34	0.32	48	5	0.12	3	0.46
P 230.022	0.31	0.52	54	5	0.18	5	0.57
P 230.011	0.30	0.29	48	5	0.15	3	0.52
P 230.032	0.29	0.98	68	5	0.05	9	0.30
P 281.017	0.27	0.25	50	5	0.08	2	0.38
P 228.047	0.26	0.77	65	5	0.24	7	0.66
P 230.018	0.26	0.52	57	5	0.19	5	0.58

Table 6– Spread 11 (Coastal Plain) Site Specific Analyses (shaded)

Waterbar	Drainage Area (ac)	Q_{10} (cfs)	CN	T_c (min)	Slope (ft/ft)	End Treatment Length (ft)	Velocity (fps)
P 079.002	3.93	5.26	61	30	0.03	50	0.24
P 050.033	2.37	9.87	89	18	0.01	94	0.14
P 051.003	2.17	0.84	87	16	0.02	8	0.16
P 079.017A	2.16	0.77	40	5	0.03	7	0.25
P 052.003	1.66	9.16	80	6	0.01	87	0.15
P 079.027	1.53	1.51	46	5	0.01	14	0.16
P 079.010	1.50	1.85	48	5	0.03	18	0.22
P 079.024	1.36	2.31	58	13	0.03	22	0.22
P 079.011	1.17	0.42	40	5	0.01	4	0.11
P 079.036	1.15	4.76	81	15	0.01	45	0.13
P 052.006	1.11	5.57	76	5	0.03	53	0.22
P 079.003	1.05	0.83	52	27	0.02	8	0.17
P 083.012	0.88	5.33	86	7	0.12	51	0.46
P 051.032	0.78	0.02	77	14	0.03	0.2	0.24
P 083.026	0.73	5.94	94	5	0.12	56	0.46
P 079.026	0.70	1.41	61	13	0.18	13	0.57
P 052.005	0.69	3.71	78	5	0.03	35	0.23
P 079.032	0.69	3.47	78	7	0.06	33	0.32
P 083.024	0.57	4.00	88	5	0.10	38	0.42
P 083.027	0.52	4.21	94	5	0.16	40	0.54
P 079.016	0.48	0.17	40	5	0.01	2	0.13
P 083.001	0.47	4.01	96	5	0.01	38	0.13
P 052.008	0.40	0.95	58	5	0.02	9	0.20
P 077.001	0.39	1.95	77	6	0.01	18	0.13
P 035.023	0.35	0.29	49	11	0.01	3	0.15

From Tables 4-6, it is evident that the protocols in some instances require site-specific analyses for end treatment lengths that are less than 20 feet.

Design Basis

As described in this analysis, this proposed methodologies provide for end treatment lengths that are extremely conservative. A summary of how this is achieved is provided below:

1) In these test areas, 90% of the end treatment lengths are < 10 ft in length, yet the specified end treatment length is 20 ft. This is in addition to the conservative nature of the hydrologic calculations employed in the approved ACP Methodology.

2) The methodology will only be applied for the specified set of circumstances (for each physiographic province) detailed in this narrative. For water bars that require site specific analyses, non-erosive velocities will be achieved in one of two primary ways. Either additional water bars will be added to reduce the contributing drainage area (thereby reducing the flow rate and required end treatment length), or detailed, site-specific designs may be used.

3) The sheetflow velocities below the end treatments were assessed in this test watershed (10-yr storm) and compared to allowable velocities for bare earth – also a conservative approach. Even with this assumption, velocities will remain well below erosive levels (Appendix B).

4) The results provided by the proposed design methodology appear conservative, and the process provides the requested implementation of a repeatable design process that may facilitate review and remains consistent with VA stormwater protection requirements for protecting the environment.

Adaptive Management

As outlined in the Annual Standards & Specifications, inspections will be performed by DEQ-certified ACP inspectors to ensure any areas of erosion or concentrated outfall flows are quickly identified and promptly corrected. If field conditions warrant, the field inspectors can identify incorrect water bar end treatment for the engineer to redesign and submit to VADEQ for approval for modifications.

Index to Appendices

Appendix A – List of Drainage Figures for Assessed Water Bars
Appendix B – Complete Analyses of All Assessed Water Bars
Appendix C – End Treatment Details

Appendix A

Spread	*Drainage Map #*
4 [1]	1 of 20
	2 of 20
	3 of 20
	4 of 20
	9 of 20
	10 of 20
	11of 20
	12 of 20
	13 of 20
	14 of 20
	15 of 20
6	2 of 45
	3 of 45
	43 of 45
11	18 of 66
	33 of 66
	56 of 66
	57 of 66
	58 of 66
	60 of 66

[1] Drainage Maps developed by AECOM and included in project plan set entitled "Spread _, Appendix C: Drainage Features".

Appendix B

Spread 4 - Valley and Ridge/Blue Ridge

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 128.046	0.60	2.36	80	5	0.02	22	0.19
P 123.043	0.74	2.10	73	5	0.11	20	0.44
P 125.070	2.40	1.78	53	5	0.28	17	0.71
P 123.045	0.62	1.76	73	5	0.15	17	0.52
P 123.041	0.50	1.55	75	5	0.03	15	0.23
P 132.069	0.59	1.39	68	5	0.62	13	1.05
P 131.020	0.42	1.30	74	5	0.34	12	0.78
P 131.022	0.55	1.29	68	5	0.33	12	0.77
P 131.018	0.36	1.16	75	5	0.29	11	0.72
P 129.012	1.41	1.15	53	5	0.15	11	0.52
P 132.059	0.47	1.11	68	5	0.1	11	0.42
P 129.002	0.29	1.06	78	5	0.11	10	0.44
P 126.044	0.46	0.98	67	5	0.23	9	0.64
P 129.023	1.58	0.96	51	5	0.1	9	0.42
P 126.055	0.42	0.85	66	5	0.27	8	0.69
P 131.008	0.27	0.80	73	5	0.37	8	0.81
P 126.008	1.01	0.75	53	5	0.42	7	0.87
P 131.004	0.23	0.65	72	5	0.26	6	0.68
P 134.014	0.21	0.62	73	5	0.31	6	0.74
P 133.041	0.20	0.62	74	5	0.15	6	0.52
P 132.057	0.28	0.60	66	5	0.13	6	0.48
P 128.041	0.22	0.57	70	5	0.07	5	0.35
P 123.069	0.19	0.54	73	5	0.19	5	0.58
P 126.057	0.24	0.51	67	5	0.36	5	0.80
P 134.027	0.17	0.50	73	5	0.13	5	0.48
P 133.049	0.16	0.49	74	5	0.21	5	0.61
P 132.062	0.16	0.47	73	5	0.08	5	0.38
P 128.048	0.19	0.45	68	5	0.13	4	0.48
P 130.013	0.49	0.45	54	5	0.18	4	0.57
P 126.047	0.53	0.44	54	5	0.28	4	0.71
P 132.066	0.18	0.44	69	5	0.21	4	0.61
P 123.051	0.15	0.43	73	5	0.26	4	0.68
P 131.009	0.20	0.43	66	5	0.33	4	0.77
P 126.045	0.12	0.42	78	5	0.29	4	0.72
P 131.024	0.26	0.42	61	5	0.35	4	0.79
P 134.053	0.14	0.41	73	5	0.49	4	0.94
P 132.055	0.18	0.40	67	5	0.06	4	0.33
P 123.047	0.14	0.40	73	5	0.38	4	0.82
P 123.063	0.14	0.40	73	5	0.49	4	0.94
P 131.006	0.13	0.39	73	5	0.34	4	0.78
P 123.068	0.13	0.37	73	5	0.23	4	0.64
P 132.051	0.18	0.36	65	5	0.48	3	0.93
P 132.050	0.18	0.36	65	5	0.23	3	0.64
P 132.049	0.30	0.36	57	5	0.26	3	0.68
P 133.027	0.12	0.36	73	5	0.42	3	0.87
P 134.006	0.12	0.36	73	5	0.37	3	0.81
P 134.042	0.12	0.36	73	5	0.37	3	0.81
P 125.072	0.37	0.34	55	5	0.34	3	0.78
P 126.049	0.28	0.34	58	5	0.29	3	0.72
P 123.059	0.12	0.34	73	5	0.25	3	0.67
P 134.030	0.11	0.33	73	5	0.32	3	0.76
P 134.068	0.11	0.33	73	5	0.17	3	0.55
P 134.074	0.11	0.33	73	5	0.28	3	0.71
P 135.001	0.11	0.33	73	5	0.3	3	0.73
P 131.026	0.35	0.32	54	5	0.59	3	1.03

Spread 4 - Valley and Ridge/Blue Ridge

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 134.010	0.10	0.31	74	5	0.3	3	0.73
P 131.014	0.10	0.30	73	5	0.41	3	0.86
P 133.025	0.10	0.30	73	5	0.5	3	0.95
P 133.052	0.10	0.30	73	5	0.56	3	1.00
P 134.039	0.10	0.30	73	5	0.33	3	0.77
P 134.065	0.10	0.30	73	5	0.18	3	0.57
P 134.071	0.10	0.30	73	5	0.24	3	0.66
P 135.006	0.10	0.30	73	5	0.74	3	1.15
P 128.071	0.09	0.29	75	5	0.11	3	0.44
P 123.066	0.10	0.28	73	5	0.19	3	0.58
P 129.074	1.50	0.28	44	6	0.21	3	0.61
P 130.040	1.39	0.28	44	5	0.44	3	0.89
P 125.068	0.14	0.27	65	5	0.48	3	0.93
P 133.051	0.09	0.27	73	5	0.41	3	0.86
P 134.018	0.09	0.27	73	5	0.31	3	0.74
P 130.009	0.74	0.26	48	5	0.27	2	0.69
P 126.053	0.22	0.25	57	5	0.17	2	0.55
P 128.069	0.27	0.25	54	5	0.06	2	0.33
P 133.035	0.08	0.24	73	5	0.71	2	1.13
P 124.001	0.10	0.24	69	5	0.46	2	0.91
P 128.064	0.32	0.23	52	5	0.24	2	0.66
P 123.055	0.08	0.23	73	5	0.59	2	1.03
P 130.030	0.65	0.23	48	5	0.36	2	0.80
P 132.061	0.11	0.22	65	5	0.08	2	0.38
P 133.023	0.07	0.21	73	5	0.49	2	0.94
P 134.025	0.07	0.21	73	5	0.33	2	0.77
P 134.045	0.07	0.21	73	5	0.38	2	0.82
P 134.063	0.07	0.21	73	5	0.23	2	0.64
P 132.072	0.09	0.20	67	5	0.04	2	0.27
P 133.021	0.18	0.20	56	5	0.4	2	0.85
P 123.049	0.07	0.20	73	5	0.35	2	0.79
P 125.055	0.10	0.19	65	5	0.46	2	0.91
P 125.059	0.10	0.19	65	5	0.47	2	0.92
P 125.067	0.10	0.19	65	5	0.47	2	0.92
P 126.059	0.10	0.19	65	5	0.43	2	0.88
P 126.002	0.33	0.19	51	5	0.36	2	0.80
P 135.004	0.08	0.18	67	5	0.71	2	1.13
P 134.036	0.06	0.18	73	5	0.26	2	0.68
P 134.048	0.06	0.18	73	5	0.24	2	0.66
P 134.055	0.06	0.18	73	5	0.65	2	1.08
P 134.062	0.06	0.18	73	5	0.41	2	0.86
P 135.008	0.06	0.18	73	5	0.46	2	0.91
P 125.063	0.09	0.17	65	5	0.48	2	0.93
P 126.061	0.09	0.17	65	5	0.35	2	0.79
P 129.014	0.24	0.17	52	5	0.17	2	0.55
P 130.011	0.27	0.17	51	5	0.24	2	0.66
P 127.090	1.86	0.17	40	5	0.38	2	0.82
P 130.003	1.55	0.17	41	7	0.45	2	0.90
P 128.017	0.36	0.17	50	5	0.27	2	0.69
P 130.053	1.08	0.16	43	7	0.08	2	0.38
P 128.056	0.20	0.16	53	5	0.08	2	0.38
P 135.002	0.09	0.15	62	5	0.38	1	0.82
P 126.063	0.08	0.15	65	5	0.29	1	0.72
P 128.054	0.09	0.14	61	5	0.13	1	0.48
P 129.016	0.19	0.14	52	5	0.24	1	0.66
P 134.002	0.18	0.13	52	5	0.72	1	1.13

Spread 4 - Valley and Ridge/Blue Ridge

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 130.055	0.24	0.13	50	5	0.11	1	0.44
P 126.067	0.07	0.12	63	5	0.72	1	1.13
P 129.019	0.19	0.12	51	5	0.18	1	0.57
P 133.029	0.04	0.12	73	5	0.29	1	0.72
P 133.031	0.04	0.12	73	5	0.74	1	1.15
P 130.016	0.14	0.11	53	5	0.09	1	0.40
P 128.052	0.07	0.11	61	5	0.17	1	0.55
P 133.008	0.08	0.11	59	5	0.08	1	0.38
P 127.092	1.22	0.11	40	5	0.24	1	0.66
P 129.056	1.01	0.10	40	5	0.29	1	0.72
P 128.036	0.08	0.10	58	5	0.43	1	0.88
P 129.021	0.18	0.10	50	5	0.23	1	0.64
P 127.098	1.07	0.10	40	5	0.26	1	0.68
P 126.065	0.05	0.10	65	5	0.3	1	0.73
P 126.071	0.14	0.09	52	5	0.56	1	1.00
P 134.060	0.03	0.09	73	5	0.32	1	0.76
P 127.088	0.98	0.09	40	5	0.29	1	0.72
P 130.042	0.83	0.09	40	5	0.28	1	0.71
P 130.038	0.68	0.09	41	5	0.31	1	0.74
P 128.050	0.16	0.09	50	5	0.2	1	0.60
P 126.004	0.31	0.08	47	5	0.44	1	0.89
P 127.067	0.93	0.08	40	5	0.19	1	0.58
P 132.003	0.22	0.08	48	5	0.43	1	0.88
P 132.008	0.14	0.08	50	5	0.28	1	0.71
P 132.013	0.14	0.08	50	5	0.15	1	0.52
P 126.069	0.10	0.07	53	5	0.8	1	1.20
P 128.025	0.17	0.07	49	5	0.23	1	0.64
P 130.048	0.71	0.07	40	5	0.19	1	0.58
P 128.063	0.21	0.07	48	5	0.27	1	0.69
P 131.043	0.21	0.07	48	5	0.25	1	0.67
P 133.005	0.02	0.07	77	5	0.03	1	0.23
P 133.007	0.02	0.07	77	5	0.08	1	0.38
P 132.036	0.13	0.07	50	5	0.26	1	0.68
P 132.038	0.13	0.07	50	5	0.35	1	0.79
P 129.028	0.20	0.07	48	5	0.15	1	0.52
P 127.094	0.77	0.07	40	5	0.34	1	0.78
P 129.076	0.65	0.07	40	5	0.25	1	0.67
P 126.021	0.09	0.07	53	5	0.03	1	0.23
P 127.119	0.74	0.07	40	5	0.31	1	0.74
P 131.002	0.71	0.07	40	6	0.14	1	0.50
P 131.028	0.19	0.07	48	5	0.34	1	0.78
P 131.037	0.19	0.07	48	5	0.21	1	0.61
P 128.039	0.09	0.06	52	5	0.12	1	0.46
P 126.012	0.34	0.06	44	5	0.33	1	0.77
P 128.023	0.18	0.06	48	5	0.21	1	0.61
P 128.035	0.18	0.06	48	5	0.21	1	0.61
P 129.025	0.18	0.06	48	5	0.18	1	0.57
P 128.018	0.13	0.06	50	5	0.28	1	0.71
P 132.070	0.02	0.06	73	5	0.09	1	0.40
P 132.071	0.02	0.06	73	5	0.05	1	0.30
P 131.045	0.17	0.06	48	5	0.32	1	0.76
P 131.049	0.17	0.06	48	5	0.23	1	0.64
P 130.044	0.55	0.06	40	5	0.27	1	0.69
P 126.070	0.10	0.06	51	5	0.69	1	1.11
P 132.040	0.13	0.06	49	5	0.38	1	0.82
P 130.050	0.52	0.05	40	5	0.17	1	0.55

Spread 4 - Valley and Ridge/Blue Ridge

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 129.060	0.51	0.05	40	5	0.35	1	0.79
P 127.078	0.58	0.05	40	5	0.13	0	0.48
P 130.062	0.15	0.05	48	5	0.18	0	0.57
P 131.030	0.15	0.05	48	5	0.22	0	0.63
P 131.039	0.15	0.05	48	5	0.06	0	0.33
P 126.068	0.07	0.05	53	5	0.84	0	1.23
P 126.077	0.17	0.05	48	5	0.86	0	1.24
P 127.069	0.55	0.05	40	5	0.25	0	0.67
P 128.029	0.14	0.05	48	5	0.27	0	0.69
P 128.031	0.14	0.05	48	5	0.33	0	0.77
P 132.044	0.14	0.05	48	5	0.4	0	0.85
P 132.045	0.14	0.05	48	5	0.34	0	0.78
P 132.032	0.09	0.05	50	5	0.08	0	0.38
P 128.015	0.17	0.05	47	5	0.32	0	0.76
P 130.072	0.44	0.05	40	5	0.19	0	0.58
P 130.034	0.44	0.05	40	5	0.51	0	0.96
P 130.032	0.36	0.05	41	5	0.41	0	0.86
P 131.047	0.13	0.05	48	5	0.27	0	0.69
P 132.001	0.13	0.05	48	5	0.32	0	0.76
P 132.043	0.13	0.05	48	5	0.36	0	0.80
P 126.073	0.14	0.04	48	5	0.9	0	1.27
P 131.041	0.12	0.04	48	5	0.28	0	0.71
P 132.020	0.12	0.04	48	5	0.37	0	0.81
P 132.024	0.12	0.04	48	5	0.29	0	0.72
P 127.086	0.46	0.04	40	5	0.25	0	0.67
P 133.020	0.27	0.04	42	5	0.26	0	0.68
P 128.003	0.45	0.04	40	5	0.31	0	0.74
P 132.005	0.09	0.04	49	5	0.24	0	0.66
P 133.010	0.11	0.04	48	5	0.09	0	0.40
P 130.046	0.36	0.04	40	5	0.15	0	0.52
P 126.051	0.12	0.04	48	5	0.19	0	0.58
P 130.007	0.20	0.04	43	5	0.28	0	0.71
P 126.038	0.19	0.04	44	5	0.28	0	0.71
P 129.044	0.10	0.03	48	5	0.21	0	0.61
P 129.046	0.10	0.03	48	5	0.42	0	0.87
P 132.046	0.10	0.03	48	5	0.31	0	0.74
P 127.113	0.38	0.03	40	5	0.29	0	0.72
P 127.100	0.37	0.03	40	5	0.4	0	0.85
P 127.015	0.36	0.03	40	5	0.27	0	0.69
P 127.039	0.35	0.03	40	5	0.41	0	0.86
P 126.102	0.35	0.03	40	5	0.69	0	1.11
P 127.019	0.35	0.03	40	5	0.42	0	0.87
P 127.102	0.35	0.03	40	5	0.21	0	0.61
P 128.033	0.05	0.03	51	5	0.32	0	0.76
P 131.034	0.09	0.03	48	5	0.17	0	0.55
P 127.023	0.34	0.03	40	5	0.38	0	0.82
P 126.081	0.10	0.03	48	5	0.85	0	1.23
P 130.068	0.29	0.03	40	5	0.15	0	0.52
P 130.064	0.11	0.03	46	5	0.35	0	0.79
P 124.018	0.32	0.03	40	5	0.47	0	0.92
P 127.084	0.31	0.03	40	5	0.28	0	0.71
P 128.067	0.08	0.03	48	5	0.05	0	0.30
P 127.035	0.30	0.03	40	5	0.33	0	0.77
P 127.096	0.30	0.03	40	5	0.19	0	0.58
P 125.013	0.29	0.03	40	5	0.34	0	0.78
P 125.007	0.28	0.03	40	5	0.27	0	0.69

Spread 4 - Valley and Ridge/Blue Ridge

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 127.031	0.28	0.03	40	5	0.43	0	0.88
P 126.106	0.28	0.03	40	5	0.69	0	1.11
P 126.089	0.08	0.02	48	5	0.72	0	1.13
P 125.005	0.27	0.02	40	5	0.31	0	0.74
P 129.052	0.23	0.02	40	5	0.41	0	0.86
P 133.016	0.10	0.02	45	5	0.11	0	0.44
P 126.098	0.25	0.02	40	5	0.53	0	0.97
P 127.027	0.25	0.02	40	5	0.39	0	0.84
P 130.005	0.21	0.02	40	5	0.35	0	0.79
P 129.054	0.21	0.02	40	5	0.23	0	0.64
P 124.046	0.24	0.02	40	5	0.51	0	0.96
P 132.034	0.04	0.02	50	5	0.2	0	0.60
P 128.027	0.06	0.02	48	5	0.16	0	0.53
P 130.001	0.20	0.02	40	5	0.31	0	0.74
P 125.016	0.23	0.02	40	5	0.28	0	0.71
P 130.026	0.19	0.02	40	5	0.47	0	0.92
P 125.001	0.21	0.02	40	5	0.51	0	0.96
P 127.051	0.21	0.02	40	5	0.42	0	0.87
P 126.091	0.14	0.02	42	5	0.6	0	1.04
P 128.013	0.10	0.02	44	5	0.47	0	0.92
P 129.032	0.09	0.02	44	5	0.14	0	0.50
P 126.085	0.06	0.02	48	5	0.79	0	1.19
P 128.021	0.06	0.02	48	5	0.11	0	0.44
P 124.048	0.20	0.02	40	5	0.76	0	1.17
P 133.054	0.10	0.02	43	5	0.58	0	1.02
P 129.008	0.17	0.02	40	5	0.33	0	0.77
P 130.066	0.17	0.02	40	5	0.07	0	0.35
P 128.061	0.05	0.02	48	5	0.25	0	0.67
P 132.015	0.05	0.02	48	5	0.2	0	0.60
P 132.017	0.05	0.02	48	5	0.18	0	0.57
P 124.016	0.19	0.02	40	5	0.36	0	0.80
P 130.070	0.16	0.02	40	5	0.12	0	0.46
P 126.095	0.18	0.02	40	5	0.7	0	1.12
P 127.007	0.18	0.02	40	5	0.39	0	0.84
P 125.023	0.18	0.02	40	5	0.41	0	0.86
P 126.110	0.18	0.02	40	5	0.61	0	1.04
P 127.047	0.18	0.02	40	5	0.49	0	0.94
P 127.109	0.18	0.02	40	5	0.23	0	0.64
P 124.010	0.17	0.02	40	5	0.46	0	0.91
P 126.093	0.17	0.02	40	5	0.72	0	1.13
P 126.118	0.17	0.02	40	5	0.68	0	1.10
P 126.130	0.17	0.02	40	5	0.34	0	0.78
P 127.075	0.17	0.02	40	5	0.21	0	0.61
P 124.044	0.17	0.02	40	5	0.42	0	0.87
P 126.042	0.05	0.02	48	5	0.19	0	0.58
P 129.062	0.14	0.01	40	5	0.32	0	0.76
P 129.042	0.04	0.01	48	5	0.25	0	0.67
P 135.003	0.04	0.01	48	5	0.41	0	0.86
P 127.071	0.15	0.01	40	5	0.36	0	0.80
P 129.072	0.13	0.01	40	5	0.22	0	0.63
P 130.036	0.13	0.01	40	5	0.47	0	0.92
P 124.040	0.14	0.01	40	5	0.22	0	0.63
P 125.019	0.14	0.01	40	5	0.49	0	0.94
P 125.021	0.14	0.01	40	5	0.36	0	0.80
P 127.107	0.14	0.01	40	5	0.16	0	0.53
P 127.115	0.14	0.01	40	5	0.3	0	0.73

Spread 4 - Valley and Ridge/Blue Ridge

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 128.009	0.14	0.01	40	5	0.26	0	0.68
P 129.004	0.12	0.01	40	5	0.34	0	0.78
P 126.087	0.04	0.01	48	5	0.68	0	1.10
P 124.014	0.13	0.01	40	5	0.63	0	1.06
P 125.051	0.13	0.01	40	5	0.51	0	0.96
P 127.043	0.13	0.01	40	5	0.38	0	0.82
P 127.073	0.13	0.01	40	5	0.28	0	0.71
P 133.019	0.11	0.01	40	5	0.03	0	0.23
P 129.066	0.11	0.01	40	5	0.35	0	0.79
P 129.068	0.11	0.01	40	5	0.27	0	0.69
P 124.002	0.12	0.01	40	5	0.37	0	0.81
P 124.006	0.12	0.01	40	5	0.1	0	0.42
P 124.042	0.12	0.01	40	5	0.67	0	1.09
P 126.126	0.12	0.01	40	5	0.44	0	0.89
P 127.011	0.12	0.01	40	5	0.17	0	0.55
P 127.061	0.12	0.01	40	5	0.37	0	0.81
P 127.063	0.12	0.01	40	5	0.31	0	0.74
P 131.035	0.03	0.01	48	5	0.16	0	0.53
P 130.018	0.08	0.01	41	5	0.5	0	0.95
P 124.008	0.11	0.01	40	5	0.41	0	0.86
P 124.024	0.11	0.01	40	5	0.36	0	0.80
P 124.030	0.11	0.01	40	5	0.44	0	0.89
P 125.035	0.11	0.01	40	5	0.62	0	1.05
P 126.036	0.11	0.01	40	5	0.31	0	0.74
P 126.122	0.11	0.01	40	5	0.59	0	1.03
P 126.132	0.11	0.01	40	5	0.34	0	0.78
P 128.007	0.11	0.01	40	5	0.16	0	0.53
P 129.010	0.09	0.01	40	5	0.29	0	0.72
P 129.064	0.09	0.01	40	5	0.28	0	0.71
P 130.022	0.09	0.01	40	5	0.44	0	0.89
P 129.048	0.06	0.01	42	5	0.22	0	0.63
P 124.022	0.10	0.01	40	5	0.59	0	1.03
P 125.025	0.10	0.01	40	5	0.5	0	0.95
P 125.039	0.10	0.01	40	5	0.62	0	1.05
P 126.026	0.10	0.01	40	5	0.22	0	0.63
P 126.032	0.10	0.01	40	5	0.26	0	0.68
P 127.065	0.10	0.01	40	5	0.29	0	0.72
P 127.082	0.10	0.01	40	5	0.43	0	0.88
P 127.117	0.10	0.01	40	5	0.34	0	0.78
P 128.011	0.10	0.01	40	5	0.31	0	0.74
P 129.009	0.08	0.01	40	5	0.5	0	0.95
P 129.070	0.08	0.01	40	5	0.18	0	0.57
P 124.034	0.09	0.01	40	5	0.19	0	0.58
P 124.038	0.09	0.01	40	5	0.25	0	0.67
P 125.031	0.09	0.01	40	5	0.53	0	0.97
P 125.043	0.09	0.01	40	5	0.65	0	1.08
P 126.031	0.09	0.01	40	5	0.22	0	0.63
P 126.114	0.09	0.01	40	5	0.73	0	1.14
P 127.003	0.09	0.01	40	5	0.36	0	0.80
P 127.111	0.09	0.01	40	5	0.28	0	0.71
P 129.058	0.07	0.01	40	5	0.35	0	0.79
P 133.018	0.07	0.01	40	5	0.26	0	0.68
P 134.001	0.07	0.01	40	5	0.28	0	0.71
P 124.012	0.08	0.01	40	5	0.86	0	1.24
P 124.032	0.08	0.01	40	5	0.4	0	0.85
P 126.030	0.08	0.01	40	5	0.31	0	0.74

Spread 4 - Valley and Ridge/Blue Ridge

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 127.055	0.08	0.01	40	5	0.27	0	0.69
P 127.059	0.08	0.01	40	5	0.3	0	0.73
P 128.001	0.08	0.01	40	5	0.3	0	0.73
P 131.032	0.02	0.01	48	5	0.37	0	0.81
P 124.020	0.07	0.01	40	5	0.43	0	0.88
P 124.028	0.07	0.01	40	5	0.19	0	0.58
P 124.036	0.07	0.01	40	5	0.45	0	0.90
P 125.047	0.07	0.01	40	5	0.32	0	0.76
P 126.034	0.07	0.01	40	5	0.32	0	0.76
P 124.026	0.06	0.01	40	5	0.25	0	0.67
P 126.017	0.06	0.01	40	5	0.06	0	0.33
P 126.022	0.06	0.01	40	5	0.06	0	0.33
P 129.011	0.05	0.01	40	5	0.22	0	0.63
P 129.050	0.05	0.01	40	5	0.28	0	0.71
P 126.134	0.05	0.00	40	5	0.11	0	0.44
P 128.005	0.05	0.00	40	5	0.21	0	0.61
P 133.017	0.04	0.00	40	5	0.13	0	0.48
P 124.058	0.04	0.00	40	5	0.52	0	0.96
P 126.016	0.04	0.00	40	5	0.21	0	0.61
P 133.004	0.01	0.00	48	5	0.21	0	0.61
P 129.006	0.03	0.00	40	5	0.21	0	0.61
P 124.056	0.03	0.00	40	5	0.73	0	1.14
P 125.027	0.01	0.00	40	5	0.47	0	0.92
P 127.001	0.01	0.00	40	5	0.18	0	0.57

Spread 6 - Piedmont

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 228.020	1.11	1.55	53	6	0.31	15	0.74
P 231.015	0.93	2.18	60	5	0.34	21	0.78
P 229.032	0.86	3.05	69	5	0.19	29	0.58
P 229.024	0.77	2.63	68	5	0.14	25	0.50
P 229.009	0.65	2.12	67	5	0.12	20	0.46
P 228.014	0.63	0.96	53	5	0.18	9	0.57
P 281.008	0.54	1.15	61	5	0.02	11	0.19
P 280.053	0.53	0.92	57	5	0.07	9	0.35
P 280.027	0.48	1.66	71	5	0.12	16	0.46
P 230.021	0.48	0.95	57	5	0.26	9	0.68
P 229.021	0.46	1.58	68	5	0.04	15	0.27
P 229.010	0.46	1.45	66	5	0.07	14	0.35
P 280.033	0.46	1.28	66	5	0.09	12	0.40
P 228.032	0.43	0.97	59	5	0.18	9	0.57
P 229.018	0.42	1.30	66	5	0.15	12	0.52
P 229.015	0.41	1.28	66	5	0.07	12	0.35
P 229.012	0.34	1.11	67	5	0.15	11	0.52
P 228.035	0.34	0.80	60	5	0.45	8	0.90
P 230.012	0.34	0.32	48	5	0.12	3	0.46
P 230.022	0.31	0.52	54	5	0.18	5	0.57
P 230.011	0.30	0.29	48	5	0.15	3	0.52
P 230.032	0.29	0.98	68	5	0.05	9	0.30
P 281.017	0.27	0.25	50	5	0.08	2	0.38
P 228.047	0.26	0.77	65	5	0.24	7	0.66
P 230.018	0.26	0.52	57	5	0.19	5	0.58
P 281.015	0.26	0.27	51	5	0.08	3	0.38
P 230.033	0.25	0.77	66	5	0.31	7	0.74
P 231.002	0.25	0.77	66	5	0.31	7	0.74
P 228.013	0.24	0.59	61	5	0.21	6	0.61
P 281.001A	0.24	0.58	63	5	0.07	6	0.35
P 228.017	0.24	0.33	52	5	0.2	3	0.60
P 281.038	0.24	0.20	49	5	0.15	2	0.52
P 280.046	0.23	0.31	54	5	0.15	3	0.52
P 280.048	0.23	0.26	52	5	0.04	2	0.27
P 281.039	0.22	0.90	75	5	0.07	9	0.35
P 281.035	0.22	0.19	49	5	0.17	2	0.55
P 230.028	0.21	0.64	65	5	0.11	6	0.44
P 230.020	0.21	0.59	64	5	0.16	6	0.53
P 228.026	0.21	0.19	48	5	0.1	2	0.42
P 229.006	0.20	0.61	66	5	0.18	6	0.57
P 228.004	0.19	0.91	77	5	0.03	9	0.23
P 228.038	0.19	0.56	65	5	0.16	5	0.53
P 280.052	0.19	0.18	50	5	0.14	2	0.50
P 280.043	0.18	0.60	70	5	0.12	6	0.46
P 228.044	0.18	0.53	65	5	0.32	5	0.76
P 228.005	0.17	0.68	72	5	0.03	6	0.23
P 231.006	0.17	0.49	65	5	0.12	5	0.46
P 231.009	0.17	0.16	48	5	0.08	2	0.38
P 281.032	0.16	0.16	50	5	0.11	2	0.44
P 230.036	0.15	0.50	68	5	0.35	5	0.79
P 231.003	0.15	0.50	68	5	0.35	5	0.79
P 229.034	0.15	0.49	67	5	0.21	5	0.61
P 230.001	0.15	0.49	67	5	0.21	5	0.61
P 280.042	0.15	0.42	66	5	0.08	4	0.38

Spread 6 - Piedmont

Waterbar	*Drainage Area (ac)*	*Q_{10} (c/s)*	*CN*	*T_c (min)*	*Slope (/t//t)*	*End Treatment Length (/t)*	*Velocity (/ps)*
P 281.014	0.15	0.33	61	5	0.06	3	0.33
P 228.010	0.15	0.28	56	5	0.58	3	1.02
P 230.007	0.15	0.14	48	5	0.12	1	0.46
P 281.036	0.15	0.13	49	5	0.18	1	0.57
P 229.029	0.14	0.44	67	5	0.12	4	0.46
P 280.051	0.14	0.11	48	5	0.08	1	0.38
P 228.036	0.13	0.39	65	5	0.37	4	0.81
P 280.028	0.13	0.28	61	5	0.06	3	0.33
P 281.007	0.13	0.11	49	5	0.01	1	0.13
P 281.016	0.13	0.11	49	5	0.07	1	0.35
P 229.027	0.12	0.35	65	5	0.17	3	0.55
P 229.003	0.11	0.32	65	5	0.26	3	0.68
P 228.009	0.11	0.11	48	5	0.39	1	0.84
P 280.055	0.10	0.37	73	5	0.12	4	0.46
P 228.011	0.10	0.29	65	5	0.55	3	0.99
P 280.032	0.10	0.28	65	5	0.12	3	0.46
P 228.029	0.10	0.27	62	5	0.07	3	0.35
P 280.056	0.10	0.05	46	5	0.31	0	0.74
P 281.042	0.09	0.35	75	5	0.22	3	0.63
P 228.041	0.09	0.27	65	5	0.25	3	0.67
P 228.024	0.09	0.09	48	5	0.09	1	0.40
P 281.001	0.09	0.07	48	5	0.08	1	0.38
P 228.006	0.08	0.31	72	5	0.64	3	1.07
P 281.013	0.08	0.15	59	5	0.03	1	0.23
P 228.007	0.07	0.31	74	5	0.42	3	0.87
P 230.002	0.07	0.20	65	5	0.15	2	0.52
P 230.004	0.07	0.20	65	5	0.12	2	0.46
P 281.004	0.07	0.06	49	5	0.03	1	0.23
P 280.057	0.07	0.05	48	5	0.17	0	0.55
P 280.038	0.06	0.16	65	5	0.08	2	0.38
P 230.031	0.05	0.19	73	5	0.23	2	0.64
P 281.029	0.04	0.03	48	5	0.08	0	0.38

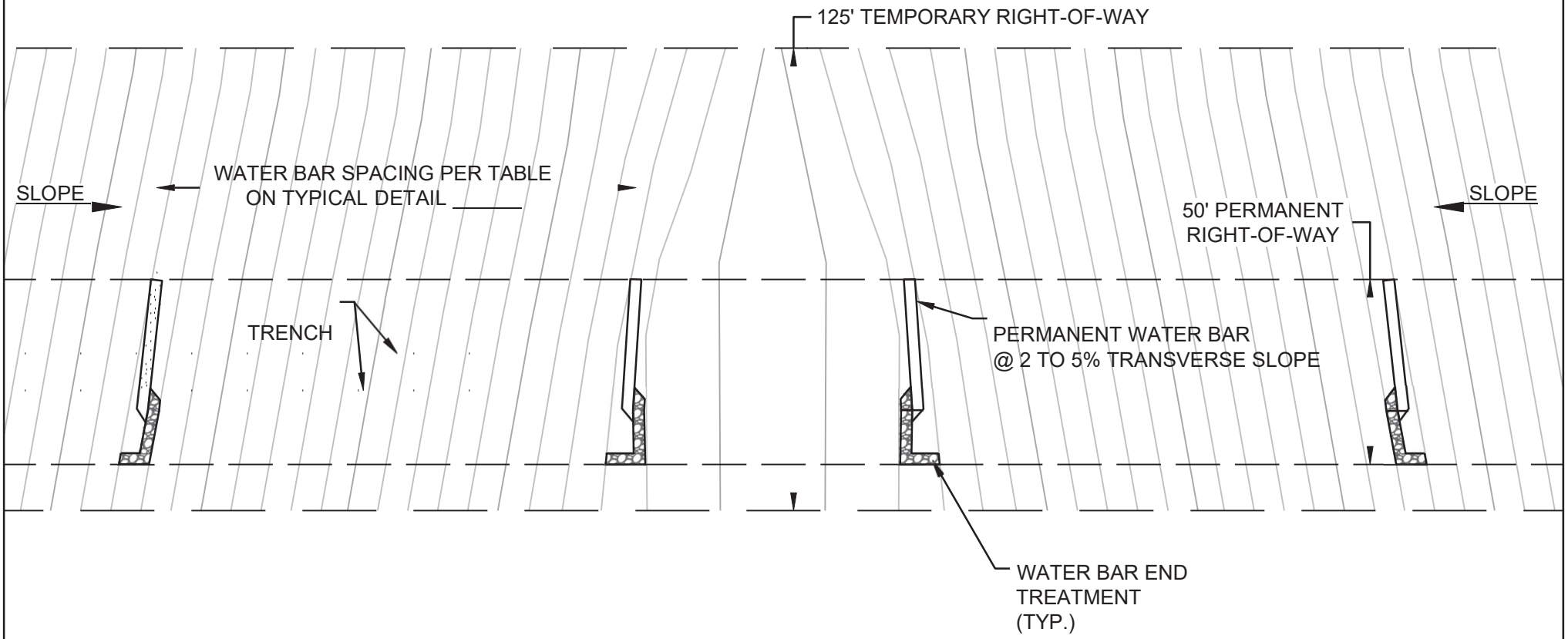
Spread 11 - Coastal Plain

Waterbar	*Drainage Area (ac)*	*Q_{10} (cfs)*	*CN*	*T_c (min)*	*Slope (ft/ft)*	*End Treatment Length (ft)*	*Velocity (fps)*
P 050.033	2.37	9.87	89	18	0.01	94	0.14
P 052.003	1.66	9.16	80	6	0.01	87	0.15
P 083.026	0.73	5.94	94	5	0.12	56	0.46
P 052.006	1.11	5.57	76	5	0.03	53	0.22
P 083.012	0.88	5.33	86	7	0.12	51	0.46
P 079.002	3.93	5.26	61	30	0.03	50	0.24
P 079.036	1.15	4.76	81	15	0.01	45	0.13
P 083.027	0.52	4.21	94	5	0.16	40	0.54
P 083.001	0.47	4.01	96	5	0.01	38	0.13
P 083.024	0.57	4.00	88	5	0.10	38	0.42
P 052.005	0.69	3.71	78	5	0.03	35	0.23
P 079.032	0.69	3.47	78	7	0.06	33	0.32
P 079.024	1.36	2.31	58	13	0.03	22	0.22
P 083.023	0.29	2.00	87	5	0.08	19	0.38
P 080.002	0.33	1.99	81	5	0.01	19	0.13
P 077.001	0.39	1.95	77	6	0.01	18	0.13
P 080.001	0.32	1.91	81	5	0.01	18	0.15
P 082.041	0.31	1.90	82	5	0.01	18	0.12
P 079.010	1.50	1.85	48	5	0.03	18	0.22
P 081.001	0.18	1.61	97	5	0.01	15	0.13
P 079.027	1.53	1.51	46	5	0.01	14	0.16
P 079.026	0.70	1.41	61	13	0.18	13	0.57
P 079.001	0.28	1.34	75	6	0.02	13	0.19
P 079.025	0.23	1.31	80	5	0.04	12	0.27
P 035.038	0.25	1.23	77	5	0.01	12	0.13
P 080.003	0.25	1.13	73	6	0.037	11	0.26
P 077.005	0.18	0.96	77	5	0.010	9	0.13
P 035.035	0.23	0.96	75	7	0.005	9	0.09
P 052.008	0.40	0.95	58	5	0.02	9	0.20
P 077.006	0.18	0.94	77	5	0.010	9	0.13
P 036.014	0.29	0.84	64	6	0.016	8	0.17
P 051.003	2.17	0.84	87	16	0.02	8	0.16
P 083.011	0.14	0.84	81	5	0.010	8	0.13
P 080.009	0.14	0.84	80	5	0.010	8	0.13
P 078.013	0.16	0.83	77	5	0.010	8	0.13
P 051.004	0.14	0.83	85	7	0.041	8	0.27
P 079.003	1.05	0.83	52	27	0.02	8	0.17
P 080.008	0.18	0.83	73	5	0.010	8	0.13
P 079.017A	2.16	0.77	40	5	0.03	7	0.25
P 080.012	0.13	0.76	79	5	0.010	7	0.13
P 083.004	0.13	0.72	80	5	0.010	7	0.13
P 083.002	0.11	0.61	80	5	0.043	6	0.28
P 035.036	0.12	0.60	76	5	0.005	6	0.09
P 083.009	0.10	0.55	80	5	0.010	5	0.13
P 035.018	0.12	0.55	75	5	0.005	5	0.09
P 083.010	0.10	0.53	79	5	0.231	5	0.64
P 035.008	0.22	0.52	59	5	0.036	5	0.25
P 080.018	0.09	0.51	79	5	0.010	5	0.13
P 077.002	0.09	0.49	77	5	0.033	5	0.24
P 080.016	0.08	0.48	80	5	0.010	5	0.13
P 077.003	0.07	0.48	85	5	0.198	5	0.60
P 079.035	0.08	0.46	80	5	0.040	4	0.27
P 035.032	0.09	0.45	77	5	0.005	4	0.09

Spread 11 - Coastal Plain

Waterbar	*Drainage Area (ac)*	*Q_{10} (cfs)*	*CN*	*T_c (min)*	*Slope (ft/ft)*	*End Treatment Length (ft)*	*Velocity (fps)*
P 079.011	1.17	0.42	40	5	0.01	4	0.11
P 035.031	0.09	0.42	73	5	0.024	4	0.21
P 080.013	0.07	0.40	78	5	0.010	4	0.13
P 051.006	0.13	0.36	85	5	0.005	3	0.09
P 082.042	0.06	0.33	77	5	0.025	3	0.21
P 051.007	0.06	0.31	85	5	0.04	3	0.27
P 035.023	0.35	0.29	49	11	0.01	3	0.15
P 080.015	0.05	0.29	80	5	0.010	3	0.13
P 079.031	0.13	0.28	56	5	0.020	3	0.19
P 035.037	0.05	0.26	77	5	0.005	2	0.09
P 036.007	0.06	0.22	69	5	0.022	2	0.20
P 035.030	0.05	0.21	73	5	0.005	2	0.09
P 036.006	0.08	0.20	61	5	0.022	2	0.20
P 079.016	0.48	0.17	40	5	0.01	2	0.13
P 052.002	0.03	0.17	85	5	0.026	2	0.22
P 077.004	0.02	0.16	88	5	0.141	1	0.50
P 083.003	0.03	0.13	73	5	0.010	1	0.13
P 036.001	0.12	0.13	48	5	0.039	1	0.26
P 035.020	0.11	0.12	48	5	0.085	1	0.39
P 036.009	0.20	0.06	40	5	0.033	1	0.24
P 035.019	0.05	0.06	50	7	0.005	1	0.09
P 079.017	0.15	0.05	40	5	0.034	0	0.25
P 035.027	0.04	0.05	48	5	0.055	0	0.31
P 035.021	0.01	0.04	67	5	0.005	0	0.09
P 035.029	0.03	0.04	48	5	0.067	0	0.35
P 035.022	0.01	0.03	67	5	0.005	0	0.09
P 051.013	0.11	0.03	63	7	0.013	0	0.15
P 051.014	0.03	0.03	47	5	0.01	0	0.13
P 036.008	0.03	0.03	47	5	0.022	0	0.20
P 079.029	0.07	0.03	40	5	0.066	0	0.34
P 035.028	0.02	0.02	48	5	0.005	0	0.09
P 051.032	0.78	0.02	77	14	0.03	0.2	0.24
P 051.033	0.05	0.02	40	5	0.033	0	0.24

Appendix C

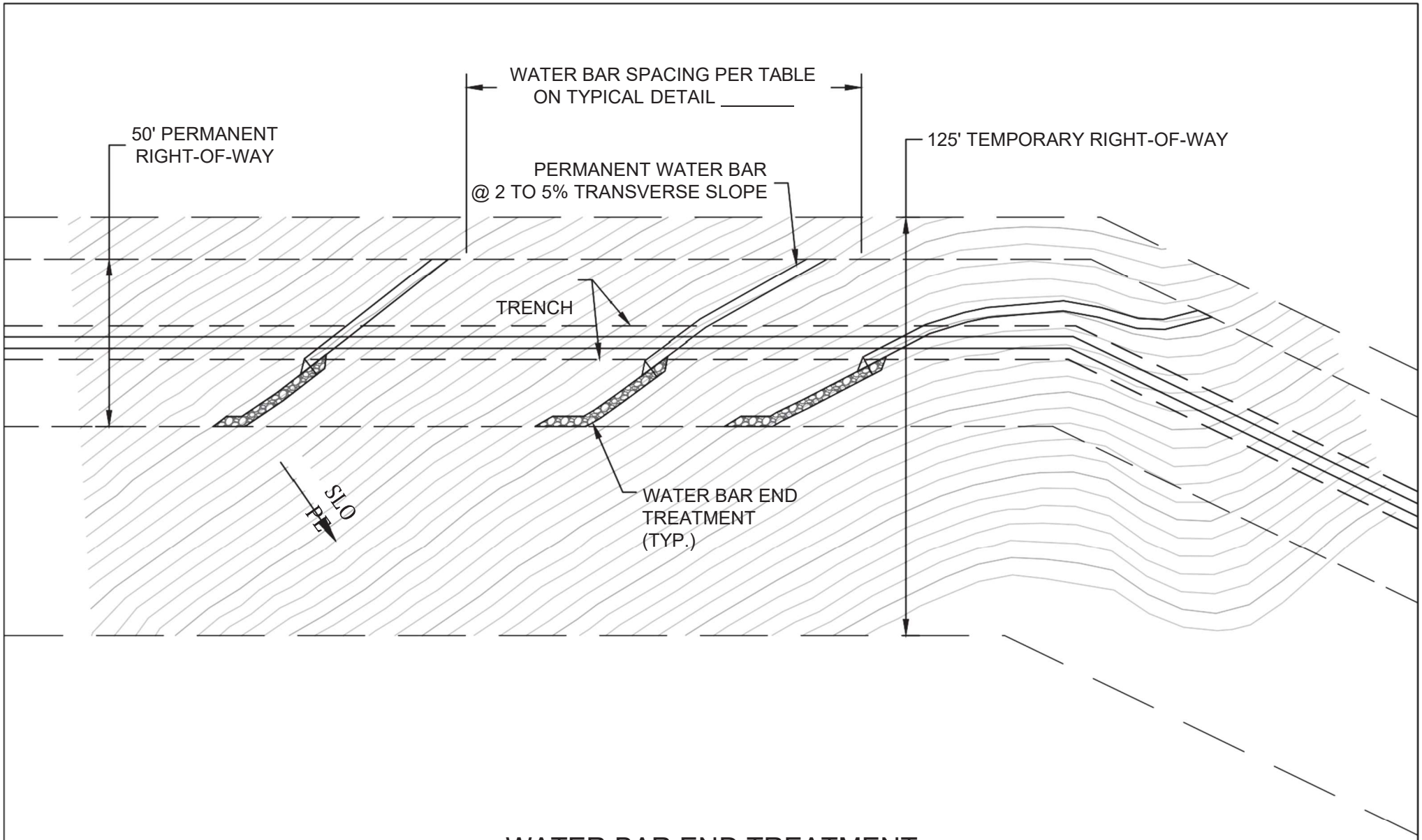


WATER BAR END TREATMENT
PERPENDICULAR TO SLOPE EXAMPLE

NOT TO SCALE

DATE: 4/18/18

SHEET 1 OF 5



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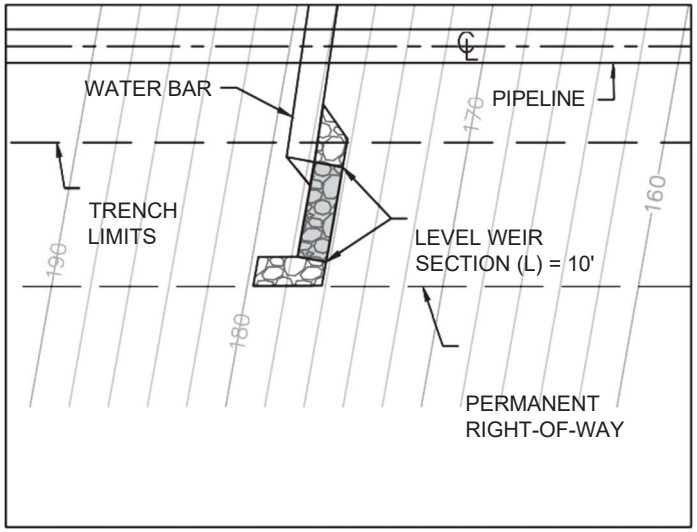

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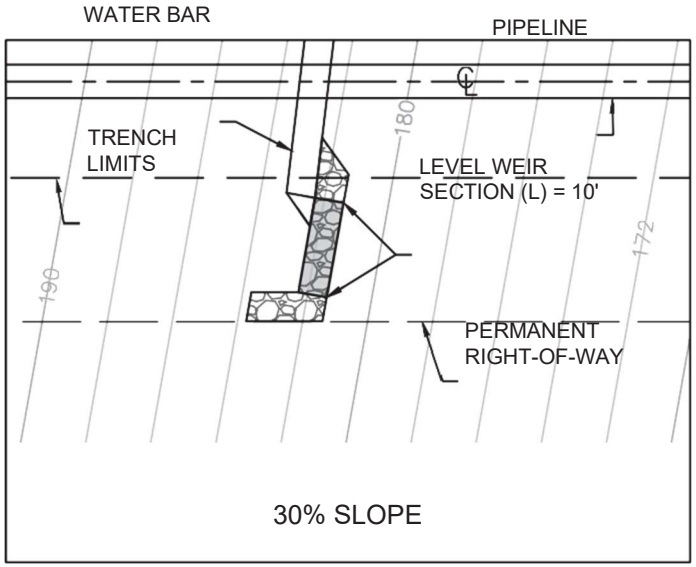

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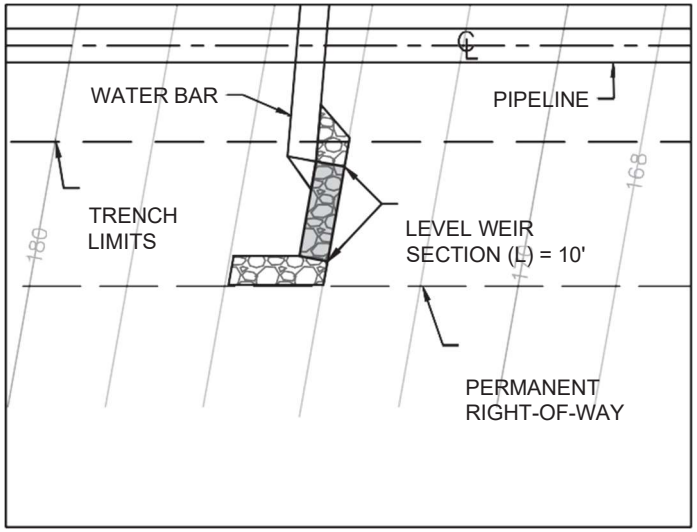

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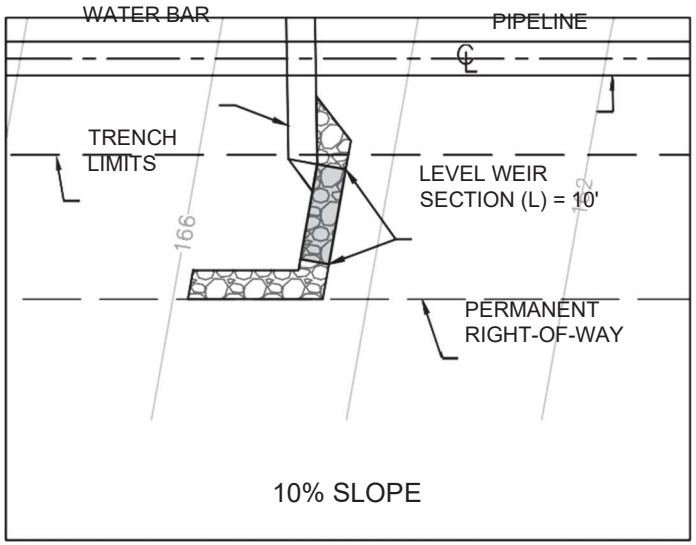

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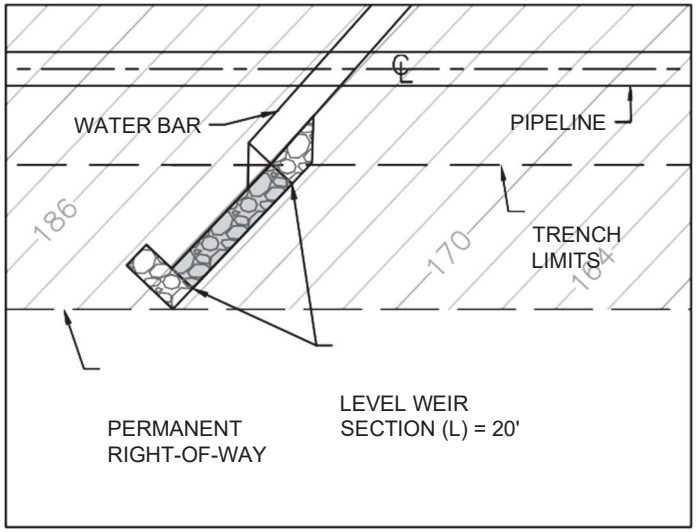
DETAILED EXAMPLES - PERPENDICULAR TO

SLOPE CONDITION

NOT TO SCALE

DATE: 4/18/18



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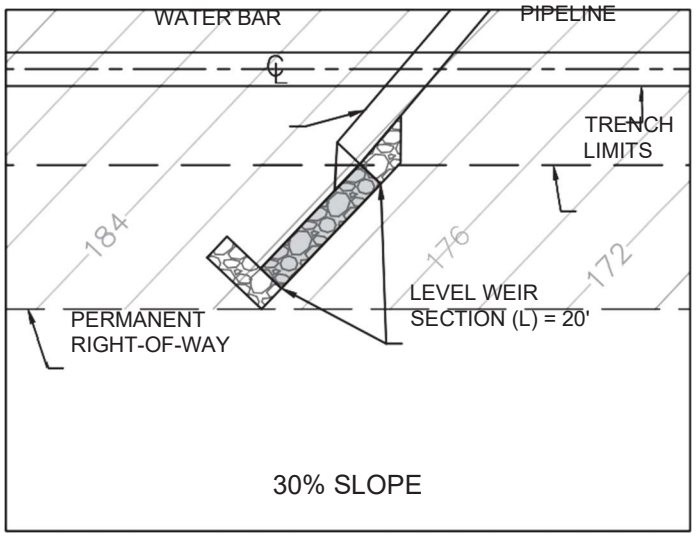

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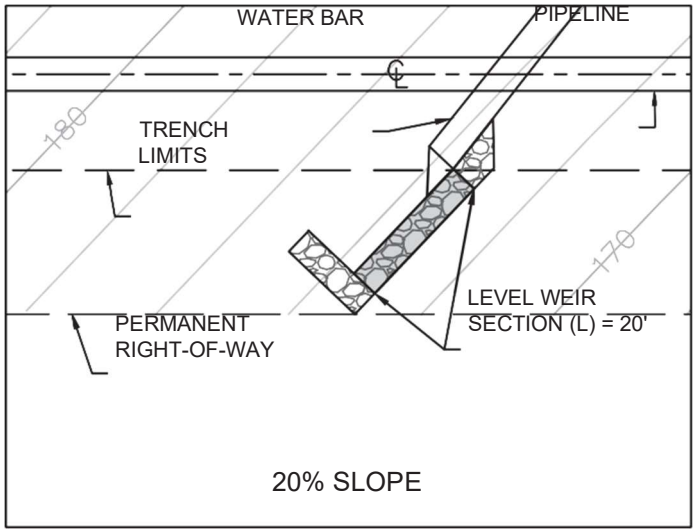

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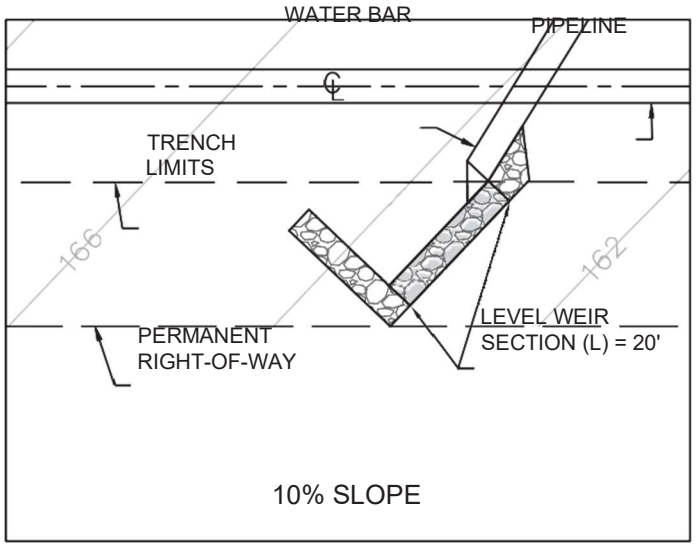

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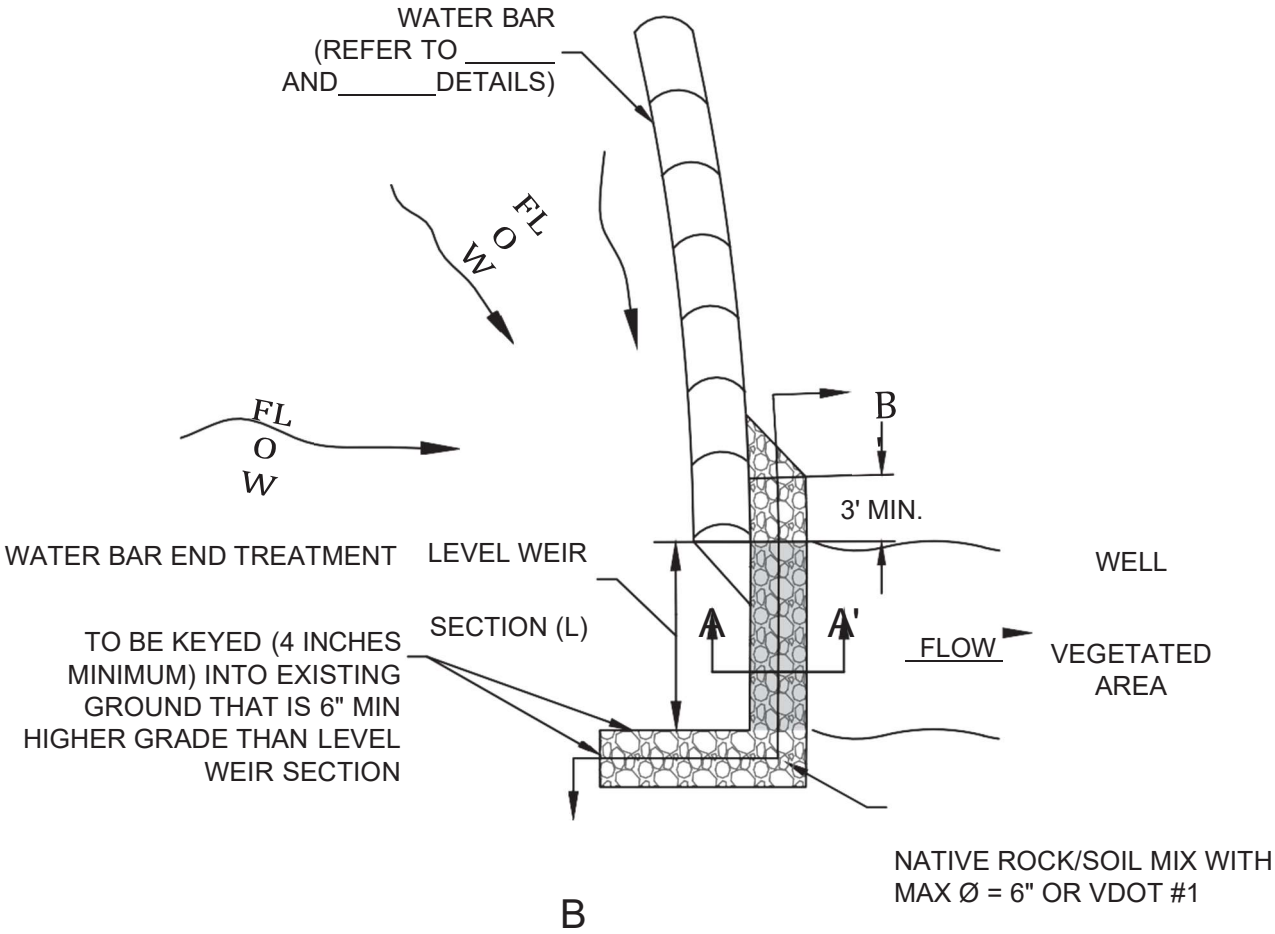
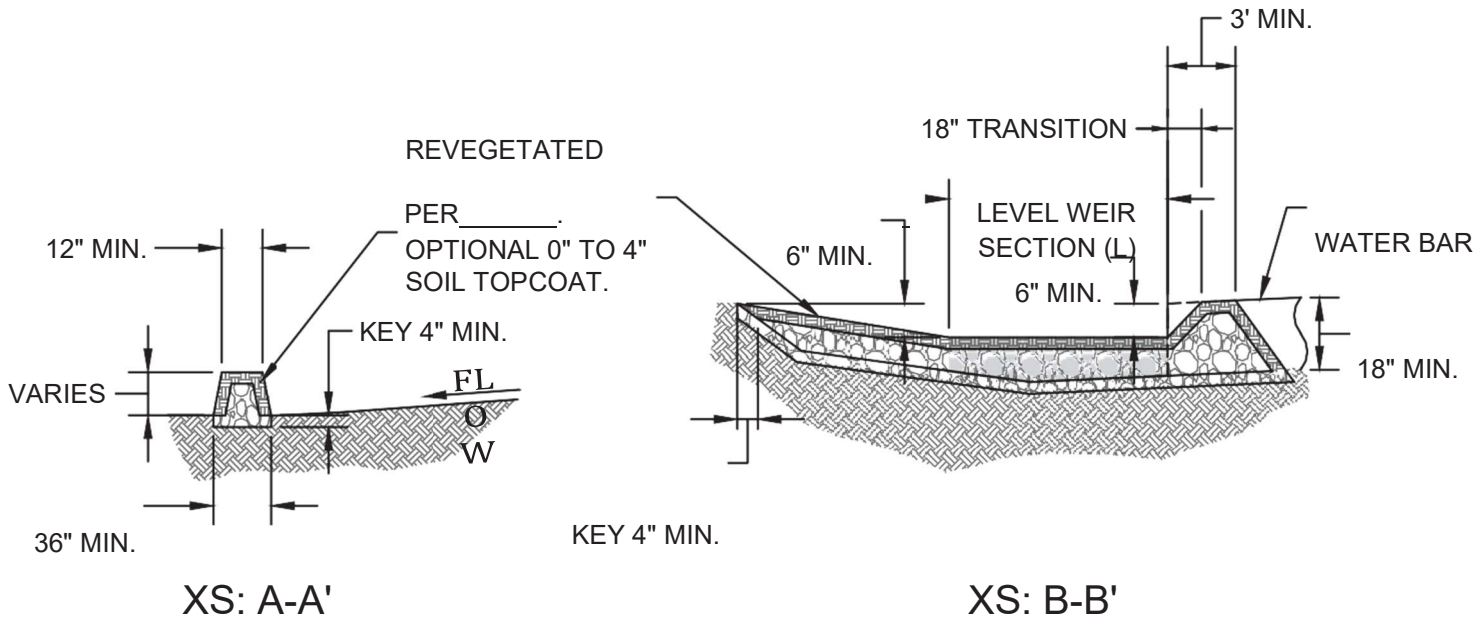
DETAILED EXAMPLES -

CROSS SLOPE CONDITION

NOT TO SCALE

DATE: 4/18/18





WATER BAR
END TREATMENT DETAIL

TO SCALE

DATE: 4/18/18

ATLANTIC COAST PIPELINE WHITE PAPER WATER QUALITY ADDENDUM

12 September 2018

The ACP Water quality compliance is complies with applicable DEQ requirements and was completed based on best professional engineering judgement.

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1.0 INTRODUCTION

The *Virginia Atlantic Coast Pipeline (ACP) Stormwater Quantity Compliance Methodology* (the White Paper), approved by Virginia Department of Environmental Quality (DEQ) on 16 February 2018 describes the stormwater management compliance strategy specifically for quantity control for the ACP project. This White Paper also serves as documentation and explanatory information for the DEQ Water Program's Office of Stormwater Management to demonstrate the compliance approach for the Virginia Stormwater Management Program (VSMP) Part IIB Technical Criteria, specifically with 9VAC25-870-66 for water quantity.

The purpose of the water quality section of this memorandum is to supplement the approved White Paper methodology for the permanent pipeline right-of way (ROW) and permanent access road ROW to demonstrate compliance with Virginia's water quality criteria set forth in 9VAC25-870-63 et seq., authorized by the Virginia Stormwater Management Act (VSMA).

In addition to these criteria, Section 3.4.4 of the 2017 Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management for Construction and Maintenance of Gas Transmission Facility projects in Virginia for the Dominion Energy Transmission, Inc. (DETI) notes that:

> *"The Department of Environmental Quality, in some instances, exercises discretionary authority on certain large projects to apply more stringent additional criteria than those normally applied under these Standards and Specifications. The Atlantic Coast Pipeline project is an example of one of these large projects…"*

As described in Section 1 of the White Paper, the Virginia portion of the ACP consists of an approximated 300-mile linear pipeline and eight (8) miles of associated permanent access roads (Figure 1). The pipeline corridor consists of a proposed 50-foot wide permanent ROW, located within a temporary 125-foot wide temporary ROW, as well as a 10-foot wide permanent ground bed ROW connected to the pipe. Temporary pipeline ROWs and temporary access roads associated with the ACP are discussed in the White Paper (5.0 COMPLIANCE STRATEGIES); permanent access roads will consist of a 30-foot wide permanent ROW and are discussed along with the permanent pipeline ROW in further detail in Section 3.1 below.

This water quality supplemental memorandum defines a stepwise process for evaluation, calculation, and documentation of water quality compliance of permanent pipeline ROW and permanent access roads projects with the Virginia Stormwater Management Program (VSMP), the DETI standards, and additional ACP Special Conditions. Special Conditions for the ACP project described Section 2.3 will be adhered to, in addition to the standard criteria outlined in this document.

2.0 COMPLIANCE FRAMEWORK

2.1 Virginia Stormwater Management Program

In Virginia, the DEQ is responsible for the administration, implementation and enforcement of the VSMA and to delineate the procedures and requirements to be followed in connection with state permits issued by the board pursuant to the Clean Water Act (CWA) and permits issued by a VSMP authority (9VAC25-870-20). For Federal or State projects within Virginia, such as the ACP, the DEQ serves as the VSMP authority for the General VPDES Permit for Discharges of Stormwater from Construction Activities (Construction General Permit [GP]). The Federal Energy Regulatory Commission (FERC) does not exert jurisdiction pertaining to water quality in Virginia.

The term "construction activity" is defined in 9VAC25-870-10 as "…any clearing, grading or excavation associated with large construction activity or associated with small construction activity." The Construction GP provides coverage for land-disturbing activity (LDA) regulated under the VSMA (§ 62.1-44.15:34) that is equal to or greater than one (1) acre (outside of a Chesapeake Bay Preservation Area); or equal to or greater than 2,500 square feet within a Chesapeake Bay Preservation Area. The GP Permit covers point source discharges of stormwater from construction activities to surface waters of the Commonwealth, including discharges through municipal or non-municipal separate storm sewer systems.

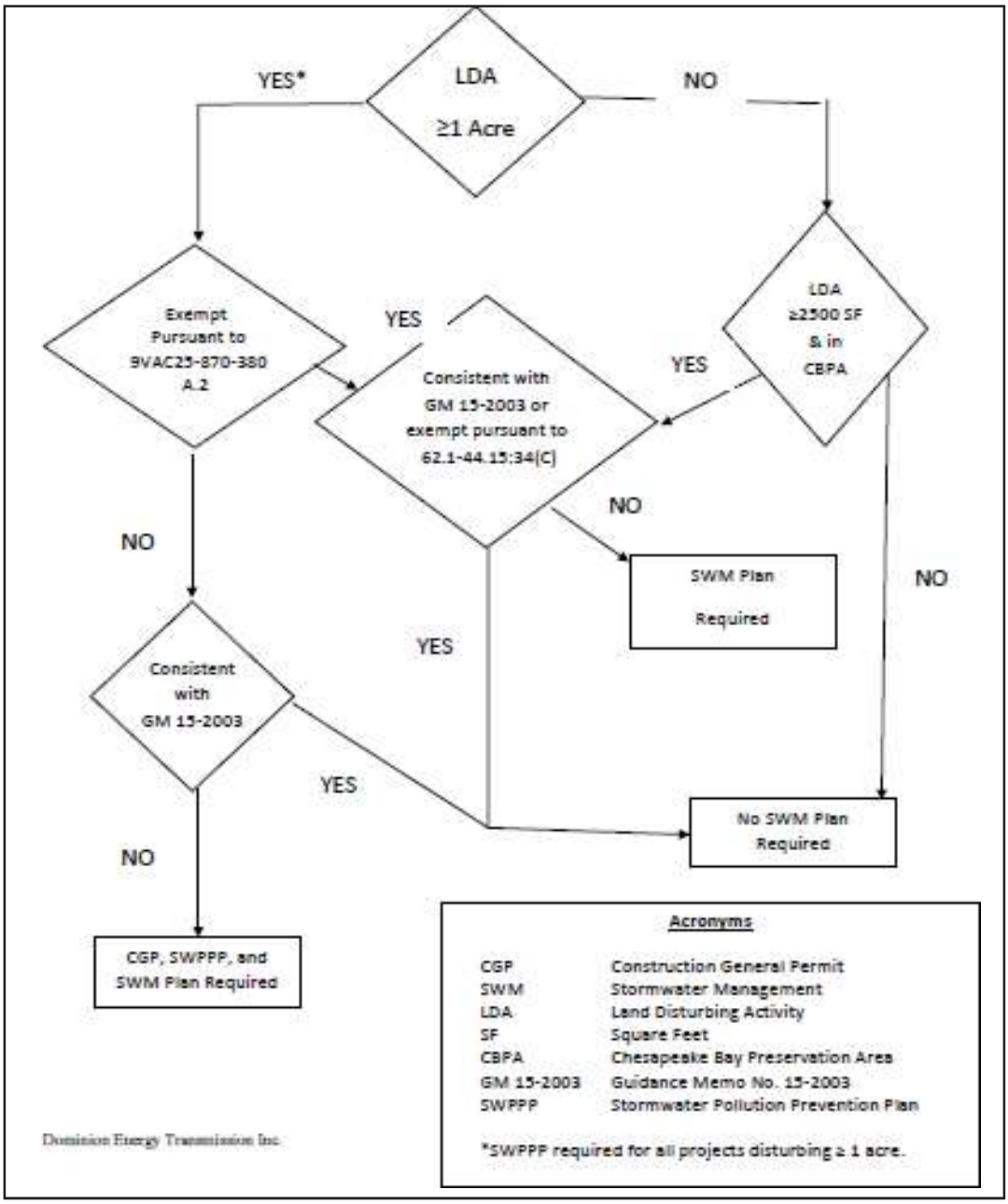
The DEQ VSMP Part IIB states that the total phosphorous (TP) load shall not exceed 0.41-pound per acre per year (lb/ac-yr) for new development activities. The Land Cover Guidance for the Virginia Runoff Reduction Method (VRRM) specifies that areas (including utility ROWs left in a natural vegetated state) under certain operational conditions shall be considered "forested/open space" for stormwater quality compliance.

2.2 DETI Standards and Specifications

The *2017 Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management for Construction and Maintenance of Gas Transmission Facility projects in Virginia* for Dominion Energy Transmission, Inc. (DETI) Standards and Specifications, approved 5 July 2017, addresses stormwater management and an ESC. It establishes general specifications for the control of erosion and sedimentation and stormwater runoff management as a result of LDAs performed during the construction, operation and maintenance of natural gas pipelines that are not exempt from the Construction GP.

The 2017 DETI Annual Standards and Specifications apply to applicable natural gas transmission facility projects pursuant to § 62.1-44.15:55 of the Code of Virginia. DETI projects not exempted from ESC or stormwater management requirements shall comply with the requirements of the local or state authority in the locality in which the project is located.

2017 DETI Standards and Specifications Construction General Permit and Stormwater Management Plan Process:



If a SWM plan is required (e.g., due to significant changes to predevelopment runoff characteristics or other requirements which require a Construction GP or post-construction SWM), DETI must develop and implement a SWM plan consistent with the applicable requirements as defined in 9VAC25-870 and 9VAC25-880. The VRRM Spreadsheet is a tool for regulated entities to use to document general water quality planning and consistency with the technical requirements.

There are no significant changes to predevelopment land-use in the pipeline ROW. Consistent

with the Annual Standards and Specifications for DETI, and long-standing DEQ policy for utility easements traversing existing agricultural land uses, these existing agricultural areas will not receive permanent treatment to address post-construction stormwater requirements if they are restored to the pre-construction agricultural land use. Specifically, the annual standards state(Appendix B, Section 2.2.3), "For portions of pipeline easements which traverse prior developed lands (e.g. under turf-intensive uses such as ballfields, or under existing parking lots or road segments), DETI does not expect to provide improvements to existing runoff conditions if predevelopment conditions are restored. DEQ has clarified that it is not their expectation that permanent best management practices be installed on restored right-of-way." As such, agricultural lands that are temporarily disturbed during construction and restored to their pre-construction land use are omitted from the VRRM workbooks.

While this document alone does not serve as a SWM plan, it lays out the methodology for compliance with the VSMP requirements in addition to other stormwater deliverables (including the White Paper and SWPPP).

2.3 Special Conditions

The special conditions for the ACP (which exceed the requirements of 9VAC25-870-65, DEQ Memo 15-2003, and DETI Standards and Specifications) will be adhered to, in addition to the minimum criteria outlined in this document.

Per the request received from DEQ by letter dated 16 May 2016 for the ACP Project, DETI has agreed to incorporate more stringent, or "special," conditions into the planning and implementation phases of ESC and Stormwater Management for ACP, including the following seven (7) items:

1. In addition to DETI's internal review process, individual project-specific plans will be submitted to DEQ for review and approval.

2. Given the nature of critical infrastructure, the project-specific ESC and Stormwater Management plans and DEQ approval will be made available to DEQ as agreed upon in a memorandum to be negotiated between DETI and DEQ.

3. Inspection reports conducted by DETI as well as complaint logs and complaint responses will be submitted to DEQ.

4. DETI will provide payment to DEQ of reasonable costs incurred by DEQ to hire additional technical expertise to assist in plan, review, and compliance activities for the ACP project.

Additional special conditions were incorporated based on communications with the Virginia DEQ on 20 April 2018:

5. DEQ has requested that generally, each access road within a hydrologic unit code (HUC), be one project except for considerations via soil segregation on the pipeline ROW. Projects can also be redefined to include the ROW when the pipeline ROW has soil segregation practices implemented. Over 150 linear miles of ACP permanent access roads were changed to temporary access roads; therefore, DEQ agreed that redefining access road projects could be considered on a case-by-case basis.

6. DEQ stated that ACP is not to exclude impervious area returned to pre-construction impervious condition from the VRRM calculations.
7. DEQ stated that if ACP implements low-impact road design for permanent access roads, that a 3-foot permeable grass strip in the middle of the 2-track access road design may be considered to be managed turf instead of impervious cover.

3.0 WATER QUALITY COMPLIANCE METHODOLOGY

Compliance with Virginia water quality regulations and additional special criteria required by the DEQ specifically for ACP is evaluated by utilizing the VRRM Spreadsheets.

Consistent with Guidance Memo No. 16-2001 - Updated Virginia Runoff Reduction Method Compliance Spreadsheets - Version 3.0 (GM 16-2001), the ACP compliance can be described in three steps. First, environmental site design (ESD) was implemented to avoid and minimize land disturbance. Second, ACP's total phosphorous load per year reduction (TP load reduction) is computed for unavoidable land disturbance through assessment of pre-construction and post-construction land use using the VRRM (Version 3.0) compliance spreadsheets. Third, pollutant removal best management practices (BMPs) and/or off-site compliance through nutrient credit purchase is applied through site-specific assessments.

3.1 Environmental Site Design to Avoid and Minimize Land Disturbance

The goal of ESD is to minimize impervious cover and mass grading, and maximize retention of forest cover, natural areas and undisturbed soils (especially those most conducive to landscape-scale infiltration). To the extent practicable, ESD is implemented on the ACP Construction Work Areas, including all access roads, temporary pipe yards and contractor yards, and the construction ROW will use previously disturbed areas for construction to minimize new impacts. As part of the ACP ESD, over 150 miles of proposed permanent access roads were modified to become temporary access roads. Only roads required to access facilities with mandatory maintenance remained permanent (approximately eight miles). The temporary pipeline ROW and temporary access road ROW will be restored to pre-construction conditions per the 2017 DETI Standards and Specifications and were therefore excluded from the VRRM calculations.

3.1.2 Revegetation

The forestry and vegetative management practices employed by DETI within the permanent pipeline ROW comply with the GM16-2001 definition for forest/open space:

- Portions of residential lots undisturbed during construction
- Portions of roadway ROWs that, following construction, will be used as filter strips, grass channels, or stormwater treatment areas (must include soil restoration or placement of engineered soil mix as per the design specifications)
- Community open space areas and utility ROWs that will not be mowed routinely, but left in a natural vegetated state, including areas that will be bush hogged no more than four (4) times per year
- Surface area of stormwater BMPs that are not wet ponds, have some type of vegetative cover, and that do not replace an otherwise impervious surface. BMPs in this category

include bioretention ponds, dry swales, grass channels, and extended detention ponds that are not mowed routinely

- Stormwater wetlands, soil amended areas that are vegetated, and infiltration practices that have a vegetated cover
- Other areas of existing forest and/or open space that will be protected during construction and that will remain undisturbed (including wetlands)
- Where the ROW consisted of forest/open space conditions prior to the construction activity will remain in a forested or open space condition under post-developed conditions

A seed source of select temporary and permanent scrub/shrub species[1] will be included in the permanent stabilization. As such, DETI shall ensure that the permanent seed mix be adjusted within the permanent ROW to incorporate a minimum percentage of early successional scrub/shrub species to establish a seed source for development consistent with the seeding and planting plan for the adjacent restoration of the temporary ROW. The purpose of the introduction of these scrub/shrub species seed mixtures is to accelerate the recolonization of scrub/shrub species that are expected to occur naturally within the regions the pipeline ROW traverses. Accordingly, a selection of woody vegetation seed mixtures is proposed for each of the physiographic regions, mountain ranges, piedmont regions, and coastal plains crossed by the pipeline ROW in Virginia.

3.1.2 Soil Segregation

For selected areas of the ROW, topsoil may be segregated in areas of the linear project including pastureland, upland forested areas, residential areas, meadowlands, wetlands without standing water or saturated soil, and areas requested by the landowner or directed by the DEQ. All topsoil will be removed as a separate layer from the area to be disturbed and be stockpiled when it is impractical to redistribute such materials promptly on regraded areas. Nutrients and soil amendments will be applied at a specified rate to the initially redistributed material when needed to help establish vegetative cover. Soil testing must be conducted prior to the application of any fertilizer, soil amendment, or lime application. In the case of subsoil segregation, the division may require that the B horizon, C horizon, or underlying strata be removed and segregated, stockpiled, and redistributed as subsoil as is necessary to comply with the revegetation requirements (4VAC25-130-817).

Soil segregation may be implemented on an as-needed basis to satisfy ACP Special Condition 5.

3.2 Total Phosphorus Load Reduction Calculation

Consistent with ACP Special Condition 5, each access road segment and/or pipeline ROW segment within one 12-digit HUC is considered an individual project, also known as a “site” using the VRRM. The definition of “site” for purposes of water quality calculations will be defined by the permanent ROW. The TP load reduction required for each project is determined by evaluating the change from pre-construction conditions to the proposed post-construction conditions. All projects regardless of size for ACP (even those under one acre) are subject to compliance with TP load reductions. Appling TP load reduction requirements to all projects

[1] Scrub/shrub: Scrub-shrub habitats are characterized by low, multistemmed woody vegetation in young or stunted stages of growth. Such habitats commonly result of mature woodlands being disturbed by wind, fire, flooding or commercial activities such as timber harvesting, farming, or maintenance of the ROW (USDA-NRCS).

regardless of its size ensures compliance with 9VAC25-870-10, and is implemented across all projects for the ACP for ease of regulatory conditional review.

3.2.1 Pre-construction Condition Determination

The baseline land cover data is obtained from the Virginia Geographic Information Network (VGIN) Land Cover Product in raster and vector data formats from the Virginia Land Cover Map Service. The VGIN land use data was developed based on the *Virginia Base Mapping Program* 2011-2014 4-band orthophotography. The VGIN land use data were obtained in 2016 and the spatial resolution of the data is 1-meter. Existing VGIN Land Use/Land Cover Type were based on Appendix A from the 2016 VITA Land Use Methodology.

The VGIN land cover classes were converted to VRRM Pre-Development Land Use/Cover consistent with the Land Cover Guidance for VRRM Compliance Spreadsheets, *Virginia Runoff Reduction Method Compliance Spreadsheet User's Guide & Documentation* dated April 2016 to provide improved land coverage data (**Table 1**). This evaluation utilized the categories of the VGIN Land Cover Product in order to assign the VRRM land cover categories (Forest/Open Space, Managed Turf, or Impervious Cover) to each land cover classification (see **Table 1**). For permanent access roads, the VGIN land classifications are supplemented with georeferenced, field-based observations to assign the VRRM land cover categories (**Table 2**).

Table 1. VGIN land use land cover classification incorporated into VRRM Land Cover categories for pre-construction land-use.

Existing VGIN Land Use/Land Cover Type	VRRM Pre-Development Land Use/Cover
Water	N/A[1]
Turf Grass	Managed Turf
Pasture, Cropland, or Harvested/Disturbed	Managed Turf if within AR
Pasture[2], Cropland[2], or Harvested/Disturbed[2]	N/A if within pipeline ROW
Impervious (Local Datasets), Impervious (Extracted), Barren, Paved	Impervious
Forest, Tree, Scrub-shrub, NWI/Other	Forest/Open Space

[1]VGIN LULC areas identified as Water were excluded from VRRM land cover types and calculations.
[2]Pre-construction agricultural areas are returned to their original pre-development condition consistent with 9VAC25-870-300.

Table 2. Field observation incorporation into VRRM Land Cover categories for pre-construction land-use.

Field-based, Georeferenced Observations	VRRM Pre-Development Land Cover
Gravel	Impervious Cover
Greenfield	Managed Turf
Paved	Impervious Cover
Dirt (compacted)	Impervious Cover
Two-Track	Impervious Cover
Other (Sand)	Open Space

Field-based, Georeferenced Observations	VRRM Pre-Development Land Cover
Other (River Cobble)	N/A (Water, Removed)
Other (Concrete)	Impervious Cover

The Hydrologic Soil Group (HSG) classification is obtained from the Soil Survey Geographic Database (SSURGO)[3] which is publically available from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The HSG "D" is assigned in cases where the HSG is listed as "A/D," "B/D," or "C/D". GIS sourced data used for water quantity and erosion and sediment control plansheets are the same as used for water quality. There is an option on the electronic VRRM map sheets to adjust layers to be shown or hidden for selective viewing.

3.2.2 Post Construction Conditions

The following proposed post-construction conditions were used to evaluate TP load using the VRRM (Version 3.0) compliance spreadsheets (**Table 3**):

- A 50-foot wide maintained permanent ROW along the pipeline consisting of scrub-shrub land-cover with the exception of managed turf and existing impervious cover. Land use that makes up Managed Turf is excluded from stormwater compliance per FERC's Upland Erosion Control, Revegetation, and Maintenance Plan (May 2013) and pre-construction impervious cover is to be returned to pre-construction conditions following construction consistent with the 2017 DETI specifications.
- Generally perpendicular to the 50-foot wide permanent ROW, a10-foot wide permanent ground bed ROW will be maintained as a ground bed for the installation and maintenance of a buried, sacrificial anode that will be connected to the pipe. The permanent ground bed ROW is treated the same as the ROW for post-construction conditions and included in the ROW VRRM (Version 3) Workbook.
- For permanent access roads, a 30-foot wide permanent right-of-way ROW will be maintained for permanent access roads, consisting of a 16-foot wide impervious surface (asphalt and/or gravel) abutted by managed turf for the remaining 30-foot width.

In accordance with the approved 2017 DETI Standards and Specifications, access roads will be categorized in one (1) of four (4) categories based on the extent of improvements required to prepare the road for use in support of the project:

1. Existing road with no improvements proposed – includes those existing roads that are in a condition such that no improvements are needed to prepare the road for use in support of the project (e.g., asphalt and or/ gravel surfaced roads). These roads are not included in the VRRM calculations.

2. Existing road with minor improvements proposed – includes those existing roads that contain both a compacted earth or gravel surface and a current road configuration(e.g.,

[3] Natural Resources Conservation Service, USDA. 2017 February. https://websoilsurvey.nrcs.usda.gov

width, grade, etc.) adequate for use to support the project. Roads in this category may receive supplemental gravel and/or asphalt to improve the surface condition; however, the footprint of the road shall not be expanded (i.e., no additional impervious surface is proposed). These roads are not included in the VRRM calculations.

3. Existing road with major improvements proposed – includes those existing roads that will receive an expanded footprint (i.e., post-construction impervious surface exceeds pre-construction impervious surface after widening road) in order to prepare the road for use to support the project. These roads are included in the VRRM calculations.

4. New road – includes roads not located within the limits of an existing road. These roads are included in the VRRM calculations.

In addition to the permanent pipeline ROW, only permanent access roads within existing roads with major improvements proposed and new road categories (Condition #3 and #4) were analyzed for water quality via VRRM calculations.

Table 3. Post-development classification for permanent pipeline ROW, permanent access roads, and appurtenant structures for use of DEQ's VRRM spreadsheets.

Pre-Development Land Cover	**Post-Construction Condition**	
	Description of Proposed Condition	**VRRM Land Use/Cover**
Forested/Open Space	Pipeline ROW	Forest/Open Space
Forested/Open Space	Access Road (16' road)	Impervious
Forested/Open Space	Access Road (shoulder)	Managed Turf
Forested/Open Space	Appurtenant Structures	Impervious
Managed Turf	Pipeline ROW	Managed Turf
Pasture[1], Cropland[1], or Harvested/Disturbed[1]	Pipeline ROW	Pasture[1], Cropland[1], or Harvested/Disturbed[1], respectively
Managed Turf (Pasture, Cropland, or Harvested/Disturbed)	Access Road (16' Road)	Impervious
Managed Turf (Pasture, Cropland, or Harvested/Disturbed Access Road)	Access Road (shoulder)	Managed Turf
Managed Turf	Access Road (16' road)	Impervious
Managed Turf	Access Road (shoulder)	Managed Turf
Managed Turf	Appurtenant Structures	Impervious
Impervious	Pipeline ROW	Impervious[2]
Impervious	Access Road (16' road)	Impervious[2]
Impervious	Access Road (shoulder)	Impervious[2]
Impervious	Appurtenant Structures	Impervious

[1]Pre-construction agricultural areas are returned to their original pre-development condition consistent with 9VAC25-870-300
[2]Impervious land cover to be returned to pre-construction condition per 2017 DETI Standards and Specifications.

3.2.3 Re-Development and New Development Areas

Each access road segment and/or ROW segment within the same HUC-12 watershed, herein referred to as a "project," was classified as either "re-development" or "new development" for the purpose of utilizing the VRRM spreadsheets. The VRRM spreadsheets calculate the TP load reduction requirement specific to each project within the spread, but varies based on whether the project is considered to be new development or re-development.

Re-development areas are defined as "lands that have been previously utilized for residential, commercial, industrial, institutional, recreation, transportation or utility facilities or structures, and that will have the impervious areas associated with those uses altered during a land-disturbing activity" (9VAC25-870-10). Re-development areas are evaluated using the DEQ "VRRM Re-Development Compliance Spreadsheet - Version 3.0" and new development areas are evaluated using the DEQ "VRRM New Development Compliance Spreadsheet - Version 3.0".

Consequently, the remaining areas are located on undeveloped lands and are evaluated using the DEQ "VRRM New Development Compliance Spreadsheet - Version 3.0".

This classification of re-development or new development projects is determined on a case-by-case basis for each project using professional engineering judgement, utilizing the VGIN land cover, aerial imagery, hydrologic soil group (HSG) classification, and proposed conditions.

3.3 Off-Site Compliance and Best Management Practices

3.3.1 Off-site Compliance

For projects equal to or less than five (5) acres of land disturbing activity, if there are no locality restrictions, such as sediment or nutrient total maximum daily load (TMDL) restrictions within the project watershed area, nutrient credits can be purchased in the same or adjacent 4th Order (8 digit) HUC as that of the project (9VAC25-870-69). If an adjacent 4th Order (8 digit) HUC is used, it must be in the same basin/tributary as the project. If there are no local TMDL restrictions, and where no Nutrient Credit Banks are located within the project's 4th Order (8 digit) HUC or adjacent 4th Order (8 digit) HUC, nutrient credits may be purchased from any Bank located within the same basin/tributary as the project. Net TP load calculated shall not exceed the threshold of 0.41 lbs/ac-yr for proposed conditions (9VAC25-870-63). In instances where existing impervious areas such as access roads are to be improved during this linear project, the post-development TP load shall reduce to 20% below the predevelopment TP load.

If there are relevant TMDL restrictions, credit purchse will be coordinated with DEQ to ensure that credits are purchased from a bank in the same or adjacent 4th Order (8 digit) HUC For projects exceeding five (5) acres of land-disturbing activity and have a nutrient credit limitation, on-site water quality BMPs shall be implemented unless pre-construction coordination with DEQ has been initiated for BMPs differing from those listed in 9VAC25-870-65 Subsection B. SWPPP will be updated to include the BMP clearinghouse design if any permanent access roads

require on-site nutrient reduction methods.

3.3.2 Best Management Practices

In order to satisfy the water quality standards, phosphorus load reductions can be enhanced by incorporating BMPs on site. BMPs such as grass channels[4] or dry swales[5] in accordance with the Virginia Stormwater BMP Clearinghouse standards and specifications can be used to reduce phosphorus loading in the Access Road ROWs. Due to the linear nature of the Access Road ROW, the drainage ditches adjacent to the access roads can be converted to one (1) of these BMPs where appropriate.

Grass channel nutrient load removal efficiencies are shown in **Table 4**. The TP load reduction resulting from this BMP implementation shall be calculated using the VRRM spreadsheets for each location. Grass channels must meet the minimum criteria outlined in **Table 5** to qualify for the indicated level of runoff reduction.

Table 4. Summary of Stormwater Functions Provided by Grass Channels[1]

Stormwater Function	HSG Soils A and B		HSG Soils C and D	
	No CA [2]	With CA	No CA	With CA
Annual Runoff Volume Reduction (RR)	20%	NA [3]	10%	30%
Total Phosphorus (TP) EMC Reduction[4] by BMP Treatment Process	15%		15%	
Total Phosphorus (TP) Mass Load Removal	32%		24% (no CA) to 41% (with CA)	
Total Nitrogen (TN) EMC Reduction[4] by BMP Treatment Process	20%		20%	
Total Nitrogen (TN) Mass Load Removal	36%		28% (no CA) to 44% (with CA)	
Channel & Flood Protection	**Partial.** Designers can use the RRM spreadsheet to adjust curve number for each design storm for the contributing drainage area, based on annual runoff reduction achieved. Also, the Tc for the grass swale flow path should reflect the slope and appropriate roughness for the intended vegetative cover.			

[1] CWP and CSN (2008) and CWP (2007).
[2] CA= Compost Amended Soils, see Stormwater Design Specification No. 4.
[3] Compost amendments are generally not applicable for A and B soils, although it may be advisable to incorporate them on mass-graded and/or excavated soils to maintain runoff reduction rates. In these cases, the 30% runoff reduction rate may be claimed, regardless of the pre-construction HSG.
[4] Change in event mean concentration (EMC) through the practice. Actual nutrient mass load removed is the product of the pollutant removal rate and the runoff volume reduction rate (see Table 1 in the *Introduction to the New Virginia Stormwater Design Specifications*).

[4] VA DEQ Stormwater Design Specification No. 3. Version 1.9, March 1, 2011. http://www.vwrrc.vt.edu/swc/documents/2013/DEQ%20BMP%20Spec%20No%203_GRASS%20CHANNELS_Final%20Draft_v1-9_03012011.pdf
[5] VA DEQ Stormwater Design Specification No. 10. Version 1.9, March 1, 2011. http://www.vwrrc.vt.edu/swc/documents/2013/DEQ%20BMP%20Spec%20No%2010_DRY%20SWALE_Final%20Draft_v1-9_03012011.pdf

Table 5. Grass Channel Design Guidance

Design Criteria
The bottom width of the channel should be between 4 to 8 feet wide.
The channel side-slopes should be 3H:1V or flatter.
The maximum total contributing drainage area to any individual grass channel is 5 acres.
The longitudinal slope of the channel should be no greater than 4%. (Check dams may be used to reduce the effective slope in order to meet the limiting velocity requirements.)
The maximum flow velocity of the channel must be less than 1 foot per second during a 1-inch storm event.
The dimensions of the channel should ensure that flow velocity is non-erosive during the 2-year and 10-year design storm events and the 10-year design flow is contained within the channel (minimum of 6 inches of freeboard).

Dry swales are soil filtering systems that temporary store and then filter the desired treatment volume. Unlike grass channels, dry swales have two (2) levels of design that differ in nutrient removal efficiencies (see **Table 6**). The TP load reduction resulting from this BMP implementation shall also be calculated with the VRRM spreadsheets for each location. Dry swales must meet either Level 1 or Level 2 minimum criteria outlined in **Table 7** to qualify for the associated level of runoff reduction.

Table 6. Summary of Stormwater Functions Provided by Dry Swale

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	40%	60%
Total Phosphorus (TP) EMC Reduction[1] by BMP Treatment Process	20%	40%
Total Phosphorus (TP) Mass Load Removal	52%	76%
Total Nitrogen (TN) EMC Reduction[1] by BMP Treatment Process	25%	35%
Total Nitrogen (TN) Mass Load Removal	55%	74%
Channel Protection	Use the RRM Design Spreadsheet to calculate the Cover Number (CN) Adjustment ***OR*** Design for extra storage (optional; as needed) on the surface, in the engineered soil matrix, and in the stone/underdrain layer to accommodate a larger storm, and use NRCS TR-55 Runoff Equations [2] to compute the CN Adjustment.	
Flood Mitigation	Partial. Reduced Curve Numbers and Time of Concentration	

[1] Change in the event mean concentration (EMC) through the practice. The actual nutrient mass load removed is the product of the removal rate and the runoff reduction rate (see Table 1 in the *Introduction to the New Virginia Stormwater Design Specifications*).
[2] NRCS TR-55 Runoff Equations 2-1 thru 2-5 and Figure 2-1 can be used to compute a curve number adjustment for larger storm events, based on the retention storage provided by the practice(s).

Sources: CWP and CSN (2008), CWP, 2007

Table 7. Dry Swale Design Criteria

Level 1 Design (RR:40; TP:20; TN:25)	Level 2 Design (RR:60; TP:40; TN: 35)
Sizing (Sec. 5.1): Surface Area (sq. ft.) = (T_v– the volume reduced by an upstream BMP) / Storage depth [1]	Sizing (Sec. 5.1): Surface Area sq. ft.) = {(1.1)(T_v) – the volume reduced by an upstream BMP } / Storage Depth [1]
Effective swale slope ≤ 2%	Effective swale slope ≤ 1%
Media Depth: minimum = 18 inches; Recommended maximum = 36 inches	Media Depth minimum = 24 inches Recommended maximum = 36 inches
Sub-soil testing (**Section 6.2**): not needed if an underdrain is used; min. infiltration rate must be > 1/2 inch/hour to remove the underdrain requirement;	Sub-soil testing (**Section 6.2**): one per 200 linear feet of filter surface; min. infiltration rate must be > 1/2 inch/hour to remove the underdrain requirement
Underdrain (**Section 6.7**): Schedule 40 PVC with clean-outs	Underdrain and Underground Storage Layer (**Section 6.7**): Schedule 40 PVC with clean outs, and a minimum 12-inch stone sump below the invert; ***OR*** none if the soil infiltration requirements are met (see **Section 6.2**)
Media (**Section 6.6**): supplied by the vendor; tested for an acceptable phosphorus index: P-Index between 10 and 30; ***OR*** Between 7 and 23 mg/kg of P in the soil media [2]	
Inflow: sheet or concentrated flow with appropriate pre-treatment	
Pre-Treatment (**Section 6.4**): a pretreatment cell, grass filter strip, gravel diaphragm, gravel flow spreader, or another approved (manufactured) pre-treatment structure.	
On-line design	Off-line design or multiple treatment cells
Turf cover	Turf cover, with trees and shrubs
All Designs: acceptable media mix tested for phosphorus index (see **Section 6.6**)	
1 The storage depth is the sum of the Void Ratio (V_r) of the soil media and gravel layers multiplied by their respective depths, plus the surface ponding depth (Refer to **Section 6.1**) 2 Refer to Stormwater Design Specification No. 9: Bioretention for soil specifications	

4.0 RESULTS

The computation of the TP load reduction requirement is documented for each spread and contains the following information:

- Type of ROW (permanent pipeline ROW, and access road ROW) and associated development type (new development or re-development);
- TP load reduction requirement;
- Pre-development and post-development land cover referenced by VGIN class, VRRM land cover category, and HSG classification (A, B, C, or D);
- DEQ VRRM New Development Compliance Worksheets; and
- DEQ VRRM Re-Development Compliance Worksheets.

4.1 Right-of-Way

As discussed in the 2017 DETI Standards and Specifications for pipeline ROWs, there are no expected improvements to existing runoff conditions if pre-development conditions are restored.

Under normal operating conditions, the post construction permanent ROW will be considered "Forest/Open Space" land cover for VRRM water quality calculations per *Section 4.3 Stormwater Quality Calculations* of the *Project Specific Standards and Specifications for Virginia* (PSS&S). As such, the ROW phosphorus loading will always be less than the 0.41 pounds per acre per year maximum for new development, as shown in **Table 8**.

Table 8. TP Load per acre based on VRRM Land Cover and HSG (lb TP/ac/yr)[1]

Soil Type	A	B	C	D	Totals
Forest/Open Space	0.00	2.92	0.00	0.73	3.65
Managed Turf	0.00	0.00	0.00	0.00	0.00
Impervious Cover	0.00	0.00	0.00	0.00	0.00

[1] Based on the following default values:

- Annual rainfall for the state of Virginia = 43 inches
- Target Rainfall Event = 1-inch
- TP Event Mean Concentration (EMC) = 0

4.2 Access Roads

Areas with new impervious cover in the post-construction permanent condition will satisfy the Virginia water quality requirements through a combination the following options:

1. Phosphorus load reduction requirements will be met via offsite compliance options;[6]
2. Phosphorus load reduction requirements will be met via onsite BMPs and/or incorporation of low-impact design, such as installing a 3-foot managed turf swatch in the middle of the access roads as part of a low-impact design (Appendix 2); and
3. The pre-construction non-agricultural areas will result in low phosphorus loading (TP load less than 0.41 lbs/ac-yr), which will offset higher loading from new impervious cover, resulting in a balance or load reduction for each project.

It is anticipated that the offsite compliance options for phosphorous load reduction requirements will be addressed through the purchase of perpetual nutrient credits and/or offset options pending the approval from the VSMP authority.

4.3 Sensitive Water Resources

In addition to the previously approved ACP sensitive resource plans (e.g., Supplemental Karst Evaluation Plan), watersheds with proposed ACP permanent access road were evaluated for the presence of sensitive resources, specifically Virginia exceptional state waters as well as sediment and nutrient TMDLs. HUC 20700050702 and 20802010202 have Nutrient TMDLs and HUC 30102050604 is identified as having an exceptional state water (Lake Drummond).

5.0 ACP COMPLIANCE SUMMARY

Under the required Annual Standards and Specifications Program, utilities are not required to submit site specific ESC and SWM plans to DEQ for approval. However, as an additional measure to ensure protection of state waters, DEQ has required the ACP and MVP projects to submit their site specific ESC and SWM plans to DEQ for review and approval. This document, combined with the SWPPP and additional White Paper addenda meet and in some instances exceed the Virginia Stormwater Protection requirements.

[6] 9VAC25-870-69

6.0 REFERENCES

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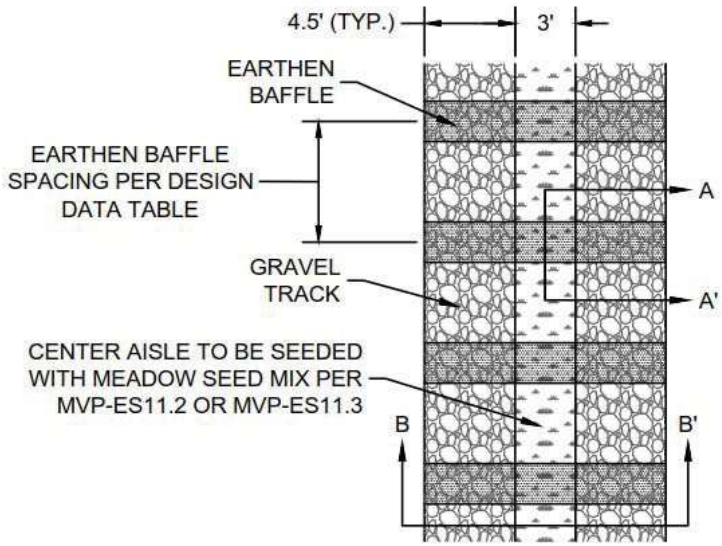
Watershed Boundary Dataset (WBD). Coordinated effort between the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), the United States Geological Survey (USGS), and the Environmental Protection Agency (EPA). Available online at https://nhd.usgs.gov/wbd.html. Accessed January 2017.

APPENDIX 1 TYPICAL DETAILS

LOW-IMPACT ACCESS ROAD DETAIL



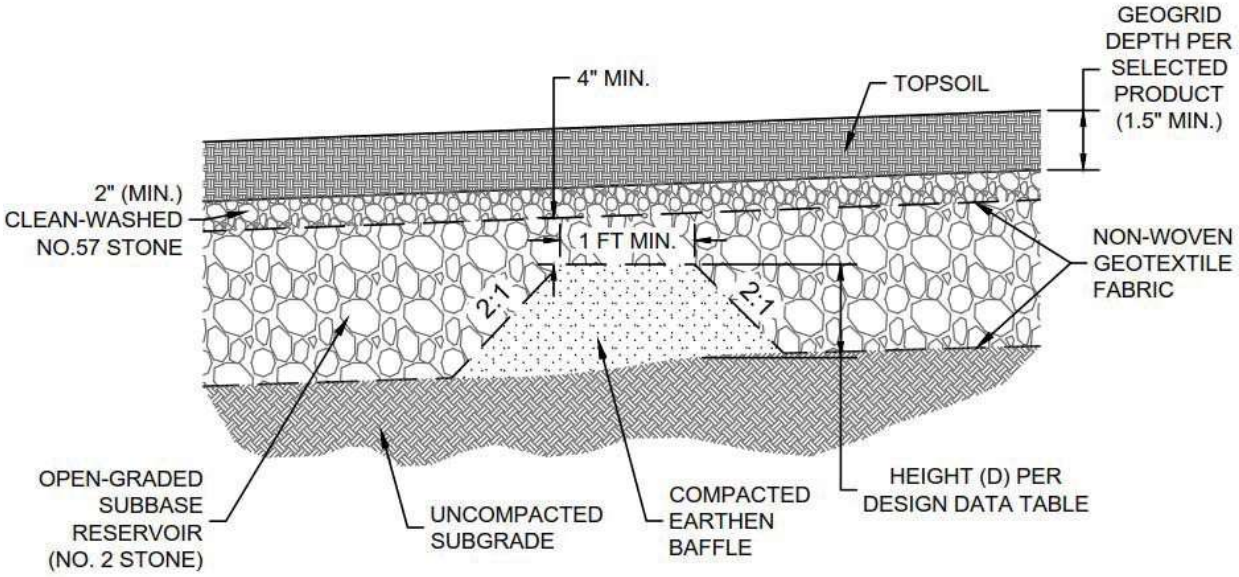
PLAN VIEW
NOT TO SCALE

DESIGN DATA*					
Site	Road Length (ft)	Road Slope (ft/ft)	# of Baffles	Baffle Spacing (ft)	Baffle Height (ft)
MVP-MLV-AR-23	125	0.25	6	20	2
MVP-MLV-AR-24	400	0.085	3	133	1

*Refer to Stormwater Management Narrative for baffle design equations.

NOTES:

1. INSTALLATION OF GEOGRID SHALL BEGIN AT 5-FEET FROM THE EDGE OF PUBLIC / VDOT ROADS TO ACCOMMODATE ANY CULVERTS AND TURNING OF TIRES.
2. GEOGRID SHALL NOT BE INSTALLED IN THE MAIN LINE VALVE PAD AREAS.
3. GEOGRID SHALL BE SUREGREEN PP40 OR APPROVED EQUIVALENT.



XS: A-A'
NOT TO SCALE

LULC FIELD CHANGE CLARIFICATION

September 12, 2018

Land Use Land Cover and Field Change Clarification

1) Land uses identified in Appendix D: Pre-Development Land Cover and Appendix E: Post-Development Land Cover currently under review by the DEQ for the Atlantic Coast Pipeline project are based on the Virginia Land Cover Data Product that is published by the DEQ and Virginia Geographic Information Network (VGIN). This data, published in 2016, is based on aerial imagery captured between 2013 and 2015 under the Virginia Base Mapping Program and is classified based on revised Anderson classifications with a spatial resolution of one meter. This version of the data to be used for all mapping and calculations, which will not include any additional digitization (manual or automated) or update to the data products. The current data is based on DEQ and VGIN publicly available data that is substantially equivalent to the current regulations and to revise the land cover for calculations will create minimal corresponding benefit.

2) By agreement with DEQ, revisions may include additional or modified control measures identified in the field during construction and after coordination with the DEQ for significant field changes or deviations from the approved plans unless more protective or emergency situations arise. Minor, field-approved changes will be documented on the construction alignment sheets, site plans, and/or inspection reports.

APPENDIX H

Approved Deviations

Deviations from technical guidance documents that have been approved by DEQ for alterations to existing practices or additional practices should be catalogued with these annual standards and be incorporated into future revisions to the Standards and Specifications, if applicable. Both the deviation request and the approval letter should be inserted in this appendix upon approval.

Deviation Request Log

Request Date	Std &Spec.	Approval Date	Summary	Approved (Y/N)

APPENDIX I

Slope Stability Policy and Procedure for Pipeline Design, Construction and Right of Way Maintenance

NOTE: *In instances where the VESCH criteria and the Slope Stability Policy differ, the more stringent of the two criteria shall apply.*

Slope Stability Policy and Procedure for Pipeline Design, Construction and Right of Way Maintenance

Dominion Transmission, Inc.

Engineering Services Reference Manual

Revised 12/1/2016

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ACRONYM LIST

BMP – Best management practice
CLSM – Controlled low strength material
DCNR – (Pennsylvania) Department of Conservation and Natural Resources
DTI – Dominion Transmission, Inc.
DTM – Digital terrain model
E&S – Erosion and Sediment
E&SC – Erosion and sediment control
ECC – Environmental Compliance Coordinator
EI – Environmental Inspector
EIES – Energy Infrastructure Environmental Services
FERC – Federal Energy Regulatory Commission
GIS – Geographic information system
GPS – Global positioning system
HDD – Horizontal Directional Drill
LiDAR – Light Detection and Ranging
LMS – Learning management system
LOD – Limit of disturbance
MD - Maryland
MSE – Mechanically stabilized earth
NOT – Notice of Termination
NRCS – National Cooperative Soil Survey
NRI – Natural Resource Inventory
OEPA – Ohio Environmental Protection Agency
OGRIP – Ohio Geographically Referenced Information Program
PAMAP – Pennsylvania Map
ROW – Right of way
RSS – Reinforced Soil Slope
SWPPP – Stormwater Pollution Prevention Plan
TWS – Temporary work space
USDA – United States Department of Agriculture
USGS – United States Geological Survey

VESCP – Virginia Erosion and Sediment Control Program
WSS – Web Soil Survey
WV – West Virginia
WVDEP – West Virginia Department of Environmental Protection
WVDOH – West Virginia Department of Highways
WVGES – West Virginia Geological and Economic Survey

Slope Stability Policy and Procedure for Pipeline Design, Construction and Right of Way Maintenance

POLICY:

The following slope stability procedure must be utilized as part of the development and execution of any Dominion Transmission, Inc. (DTI) pipeline project. The possibility of slope failures including landslides, will be considered during the routing, design, construction, restoration and post-construction phases of a pipeline project to avoid, reduce, or mitigate the incidence of slope failures on DTI pipeline projects. Specifically, DTI personnel and contractors engaged in pipeline projects must be trained to understand this policy and conform to the following procedure.

PROCEDURE:

1.0 Applicability

This policy and procedure will become effective on September 30, 2016. The applicability table shown below provides the details of which sections of the procedure are applicable for new pipeline projects, active pipeline projects and pipeline replacement projects.

Table 1: Applicability Sections for New Pipeline Projects, Pipeline Replacement Projects, and Existing ROW.

Applicable Sections	New pipeline projects that begin permitting after 9/30/2016	Pipeline Replacement Projects in Existing ROW	Slope Failures on Existing ROW
2.0 Introduction	X	X	
2.1 Slope Failure Susceptibility	X	X	
2.2 Types of Slope Failures	X	X	
2.3 Slope Failure Causes	X	X	
3.0 Pipeline Route Selection	X		
3.1 Preliminary Route Selection	X		
3.2 Desktop Study	X		
3.2.1 Existing Landslide Maps and Data	X		
3.2.2 Define Slopes of Greater than 30 Degrees	X	X	
3.2.3 USDA Natural Resources Conservation Service Soil Surveys	X	X	
3.2.4 Light Detection and Ranging (LiDAR)	X		

Table 1: Applicability Sections for New Pipeline Projects, Pipeline Replacement Projects, and Existing ROW, Continued.

Applicable Sections	New pipeline projects that begin permitting after 9/30/2016	Pipeline Replacement Projects in Existing ROW	Slope Failures on Existing ROW
3.2.5 Mine Study	X		
3.2.6 Desktop Study Mapping	X		
3.3 Field Reconnaissance	X	X	
3.4 Desktop Slope Failure Risk Assessment	X		
3.5 Selection of Preventative Measures for Identified High Risk Slope Failure Locations	X		
3.5.1 Selection of Preventative Measures for Pipeline Replacement Projects		X	
4.0 Pipeline Design and Engineering	X	X	
4.1 Excavation Minimization	X	X	X
4.2 Document Slope Failure Areas on Project Plans	X	X	
4.3 Temporary Work Space (TWS)	X	X	X
4.4 Include Additional Drainage	X	X	X
4.5 Engineered Details	X	X	X
4.6 Construction Stormwater Permit	X	X	
4.7 Stormwater Pollution Prevention Plan	X	X	
4.8 Documentation of Design Information	X		
5.0 Pipeline Preconstruction Planning	X	X	

Table 1: Applicability Sections for New Pipeline Projects, Pipeline Replacement Projects, and Existing ROW, Continued.

Applicable Sections	New pipeline projects that begin permitting after 9/30/2016	Pipeline Replacement Projects in Existing ROW	Slope Failures on Existing ROW
5.1 Slope Failure Training	X	X	X
5.1.1 Training	X	X	X
5.1.2 Environmental Permit Transition	X	X	X
5.2 Slope Failure Mitigation and Response Materials	X	X	
6.0 Addressing Slope failures during Construction	X	X	
6.1 Inspections	X	X	
6.2 Responding to Slope Failures	X	X	X
6.2.1 Evaluate Priority	X	X	X
6.2.2 Install Temporary BMPs	X	X	X
6.2.3 Gather Data	X	X	X
6.2.4 Select Slope Failure Repair Approach	X	X	X
6.2.5 Install Short Term Stabilizing Measures	X	X	X
6.2.6 Implement and Document Slope Failure Repair	X	X	X
6.2.7 Documentation of Repairs	X	X	X
7.0 Addressing Slope Failures after Construction	X	X	X
8.0 Slope Failures Caused by a Third Party	X	X	X

2.0 Introduction

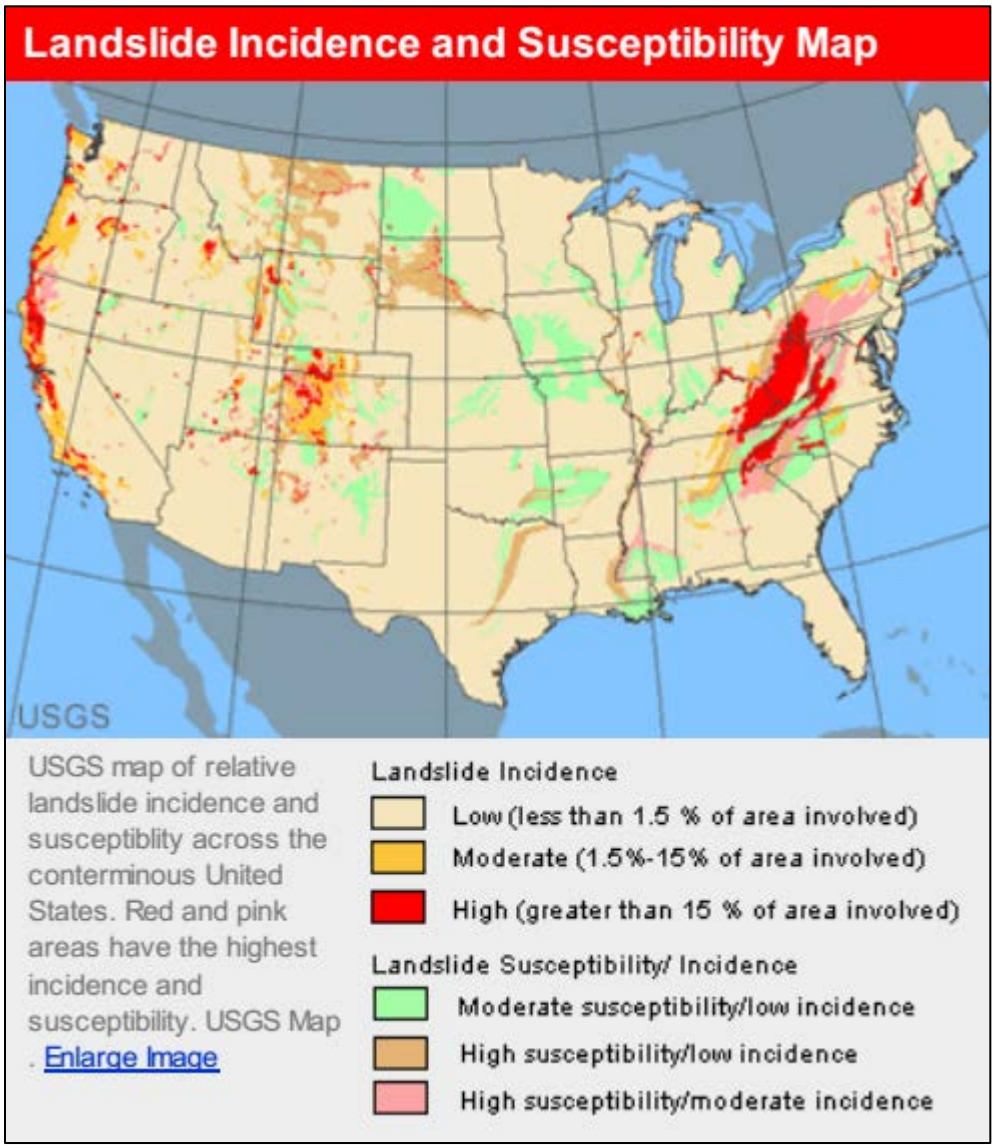
Slope failures, also referred to as landslides or slips on pipeline right-of-ways (ROW) can create adverse erosion control conditions, result in sediment deposits in adjacent waterways, cause landowner complaints, and/or damage the pipeline or other infrastructure. Additionally, slope failures can be costly to repair. Recognizing that the location of slope failures can be challenging to predict, the purpose of this procedure is to avoid and/or reduce the number and severity of slope failures that occur on new Dominion pipeline ROW, and planned expansion of existing Dominion ROW. Every pipeline project and slope failure is unique. Therefore, the specific requirements during project planning and implementation are dependent upon the site-specific conditions. The procedure provides the following:

- A method of identifying potential slope failures;
- Preventative measures;
- A method of protecting waterbodies from slope failure material runoff;
- Containment procedures for slope failure material;
- Remediation procedures; and,
- Training requirements.

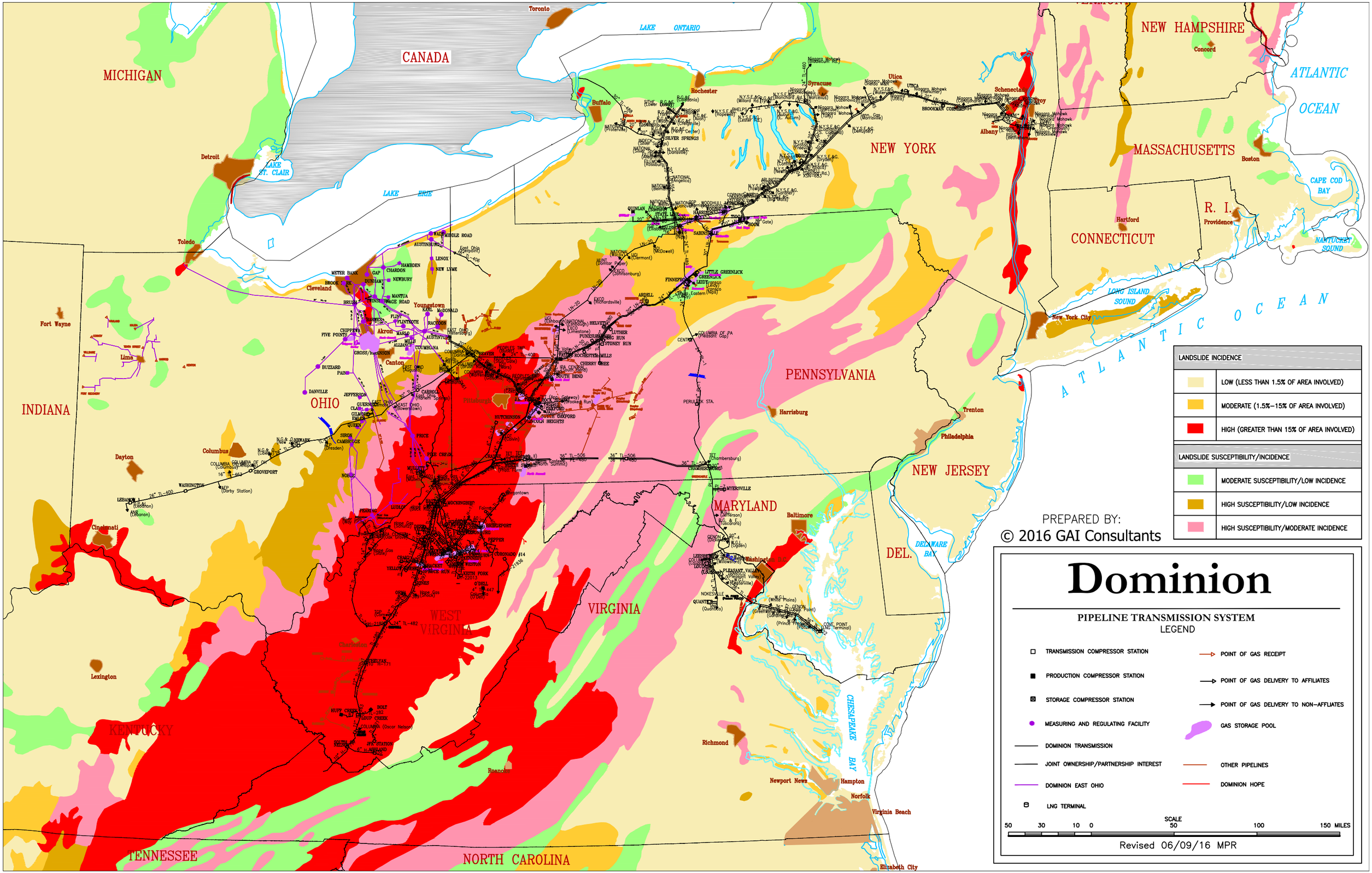
2.1 Slope Failure Susceptibility

Slope failures are plentiful and occur naturally in a large portion of the DTI operating area, and in particular the Appalachian Plateau and Valley and Ridge Provinces. Susceptibility is generally associated with cohesive soils (Silts and Clays) formed on steeper slopes that are triggered by precipitation, gravity and human activities. This region has some of the highest landslide or slope failure susceptibility in the United States, as indicated in Figure 1, which shows a USGS landslide map of the conterminous United States, and Figure 2, which shows a smaller scale map of DTI's operating area, with the locations having the highest risk of landslides shown in red.

Figure 1 – Landslide Susceptibility Map of the United States[1]



[1] USGS - Landslide Overview Map of the Conterminous United States


CANADA
MICHIGAN
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
R. I.
NEW JERSEY
DEL.
MARYLAND
VIRGINIA
WEST VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
LAKE ONTARIO
LAKE ERIE
LAKE ST. CLAIR
ATLANTIC OCEAN
CAPE COD BAY
NANTUCKET SOUND
LONG ISLAND SOUND
DELAWARE BAY
CHESAPEAKE BAY
Toronto
Buffalo
Rochester
Syracuse
Utica
Schenectady
Albany
Concord
Boston
Hartford
Providence
New York City
Detroit
Toledo
Fort Wayne
Lima
Cleveland
Akron
Canton
Youngstown
Pittsburgh
Columbus
Dayton
Cincinnati
Lexington
Harrisburg
Trenton
Philadelphia
Baltimore
Washington D.C.
Richmond
Newport News
Hampton
Norfolk
Virginia Beach
Elizabeth City
Roanoke
Charleston
Morgantown
LANDSLIDE INCIDENCE
LOW (LESS THAN 1.5% OF AREA INVOLVED)
MODERATE (1.5%–15% OF AREA INVOLVED)
HIGH (GREATER THAN 15% OF AREA INVOLVED)
LANDSLIDE SUSCEPTIBILITY/INCIDENCE
MODERATE SUSCEPTIBILITY/LOW INCIDENCE
HIGH SUSCEPTIBILITY/LOW INCIDENCE
HIGH SUSCEPTIBILITY/MODERATE INCIDENCE
PREPARED BY:
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Dominion
PIPELINE TRANSMISSION SYSTEM
LEGEND
TRANSMISSION COMPRESSOR STATION
PRODUCTION COMPRESSOR STATION
STORAGE COMPRESSOR STATION
MEASURING AND REGULATING FACILITY
DOMINION TRANSMISSION
JOINT OWNERSHIP/PARTNERSHIP INTEREST
DOMINION EAST OHIO
LNG TERMINAL
POINT OF GAS RECEIPT
POINT OF GAS DELIVERY TO AFFILIATES
POINT OF GAS DELIVERY TO NON-AFFLIATES
GAS STORAGE POOL
OTHER PIPELINES
DOMINION HOPE
SCALE
50 30 10 0 50 100 150 MILES
Revised 06/09/16 MPR

Landslides are common in the mountainous terrain of Virginia due to the presence of steep slopes and highly fractured bedrock overlain by shallow soils. The greatest landslide hazards are present in western and southwestern Virginia. Areas of low-relief such as the Piedmont and Coastal Plain also have landslides but these are generally smaller and generated by human disturbance.

Landslides have occurred throughout the majority of Pennsylvania. However, most landslides occur in southwestern Pennsylvania in areas where shallow soils are developed on steep slopes that have clay-rich bedrock. Areas such as this include the Waynesburg Hills and Pittsburgh Low Plateau sections of the Appalachian Plateaus province.

Landslides are rare or nonexistent throughout much of Ohio due to a lack of steep slopes and/or lack of geologic units prone to failure. However, there are a few areas of Ohio that experience frequent landslides. Portions of eastern and southern Ohio are characterized by steep slopes and several hundred feet of local relief. Bedrock of Mississippian, Pennsylvanian, and Permian ages, thick colluvium, and thick lake silts and outwash formed in association with Pleistocene glaciers make these areas particularly prone to slope failures. Red mudstones lose strength when they become wet and are the most slide-prone rocks in eastern Ohio. The state has experienced slope failures in areas where thick colluvium has developed, such as in Hamilton and Clermont County and the Scioto River Valley. The north-eastern half of Ohio along the Lake Erie shoreline experiences continual erosion, preventing the natural achievement of slope stability.

New York is not categorized as a state with a serious landslide threat as most of the state's soil consists of dense glacial till comprised mostly of granular material that is not prone to landsliding. However, landslides have occurred across all of New York State, from the Adirondacks to Long Island where soft cohesive soils exist. The most common type of landslides that occur in New York are due to the combination of New York's physiography and glacial history with most landslides occurring along major rivers and lake valleys were there were previously glacial lakes. These lakes result in glacial lake deposits (silts and clays) and are generally associated with steeper slopes.

2.1.1 Appalachian Highlands Region

The geology of the Appalachian Highlands is a primary contributor to the high incidence of slope failures. The Appalachian Plateau Province in West Virginia and Pennsylvania occurs west of the Appalachian Front, and coincides with the highest incidence of slope failures. This region contains narrow valleys and

steep sided slopes with some deeper valleys. Overburden soils generally consist of colluvium overlying shallow bedrock. Colluvium is soil and debris (rock, tree material, etc.) that accumulate at the base of a slope or along the side slope by mass wasting or sheet erosion. It generally includes angular rock fragments, not sorted according to size, and could contain larger portions of bedrock. The sedimentary bedrock is mostly of the Permian-Pennsylvanian age that is relatively flat-lying and consists of cyclic sequence of sandstone, red beds, shale, limestone, and coal from the Dunkard and Monongahela Groups. Bedrock from the underlying Conemaugh Group is present in the deeper valleys. Because of the region's steep topography, abundant rainfall, low shear strength rocks, and soils with low residual strength, landslides have resulted in major infrastructure and property damage. In addition, large portions of West Virginia are extensively underlain by deep mining operations and strip mines that can also be associated with ground movements.

Southeast of the Appalachian Plateau, the flanks of the Appalachian Ridges and the Blue Ridge are covered by colluvium that is highly susceptible to sliding. Because the colluvium covers many types of bedrock, the map designations of landslide incidence and susceptibility cross formational boundaries. The designations do not correspond so closely in these areas to the units on the geologic map of the United States as they do in most areas west of the Mississippi. Most slope movements in the colluvium consist of slowly moving debris slides although many debris avalanches and debris flows can occur. Rainfall and the subsequent increase in groundwater conditions is a common trigger for landslides in this region, with the factors being the soil types and shape of the land surface, all of which relate to the underlying bedrock geology, and in many cases to slope modifications by human activity. Widespread occurrences of landslides coincide with major rainfall events, especially when the remnants of large storms track over the mountains.

In the Great Valley of Pennsylvania, Maryland, West Virginia and Virginia, east of the Appalachian Ridges, broad areas of Cambrian and Ordovician limestone contain pockets of thick residual clay that is moderately susceptible to sliding. This clay forms many small earth flows and slumps, especially along highway cuts.

2.1.2 Piedmont Region

East of the Appalachian Mountains, is the Piedmont Province of Maryland, Pennsylvania and Virginia. The province is a dissected rolling plain formed on residual soil from deeply weathered metamorphic rocks, and is bordered on the east by a dissected terraced plain on thick deposits of sand, gravel, and

clay. Most of the region is free of landslides, except in the Lower Cretaceous clays of Maryland and Virginia, where the incidence of slumps and earth flows is high.

2.1.3 Atlantic Coastal Plain Region

The low dissected Atlantic Coastal plain of Maryland and Virginia is generally free of slope instability due to the moderate terrain in the majority of the area. However, there are localized areas in eastern Maryland with relatively steep slopes that have a high incidence of slope failures. In addition, a majority of Southern Maryland is highly susceptible to slope failure where the Marlboro Clay is exposed. A poorly exposed outcropping of Marlboro Clay begins in Prince Georges County and continues southwest for approximately 20 miles reaching into Charles County. Slope failures are particularly numerous in the east-central and south-western portions of Prince Georges County. Also, in the valleys of Piscataway and Mattawoman Creeks, the clay is mostly buried beneath Holocene alluvium.

2.2 Types of Slope Failures

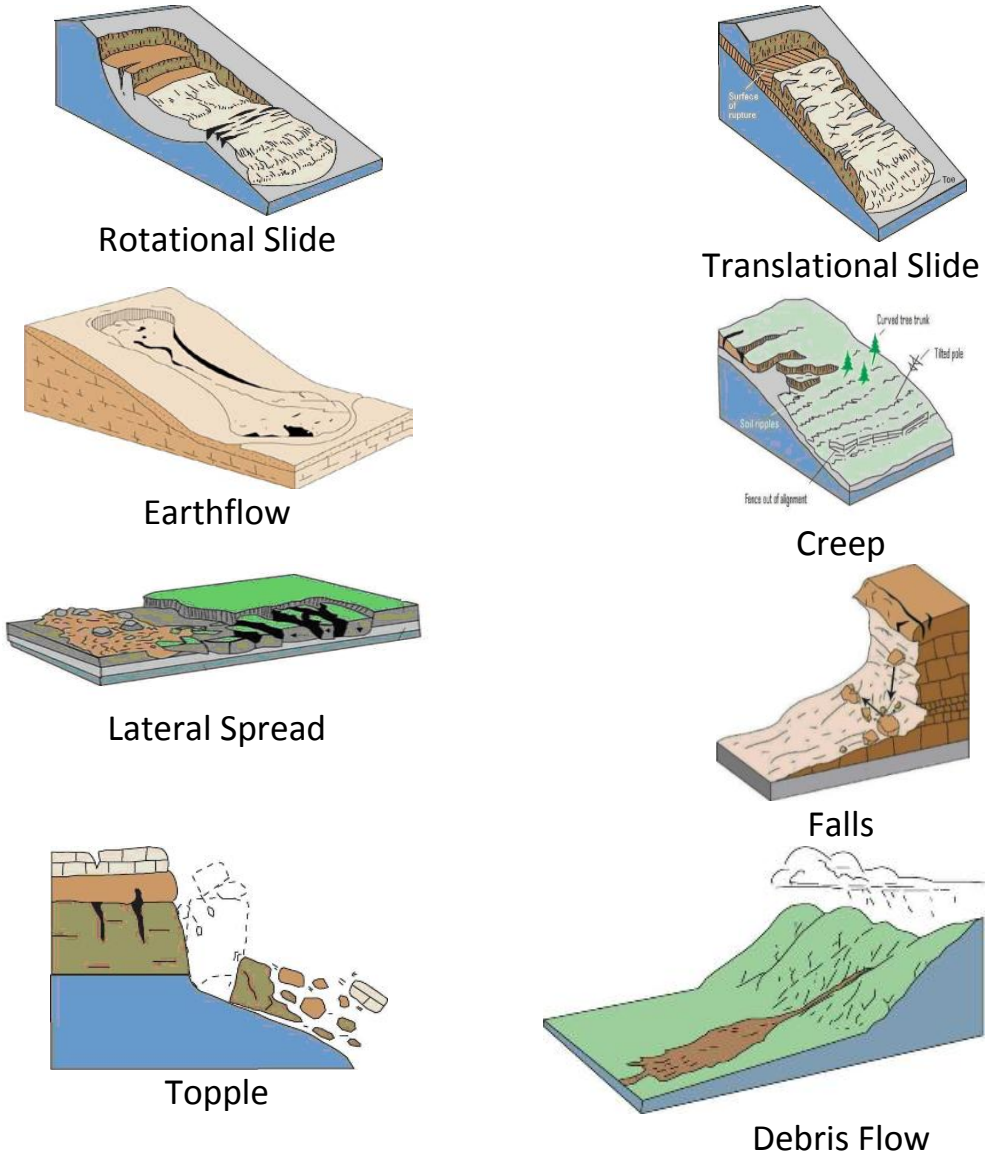
The term landslide or slip as it pertains to geologic reference can be defined as[2]: 1. the downward falling or sliding of a mass of soil, detritus, or rock, on or from a steep slope; 2. the mass itself. Other terms used to describe slips include landslides, land slips, land movements, slumps, slides, etc. The term “head scarp” refers to the tear in the ground surface located at the top of a slip. The term “toe bulge” refers to the mound of failed soil at the base of the slip.

The most common types of slips are described below[3], and a representation of some typical slips observed on pipeline ROW are presented in Figure 3.

[2] http://dictionary.reference.com/browse/landslide

[3] FEMA Landslide Loss Reduction: A Guide for State and Local Government Planning

Figure 3 – Types of Slope Failures



Source: USGS

- *Rotational Slides* – Movement of soil and debris downslope in a distinctive rotational motion. A "slump" is an example of a small rotational slide.
- *Translational Slide* – Down slope movement of soil and/or rock on a relatively planar surface and has little rotational movement or backward tilting. The mass commonly slides out on top of the original ground surface.
- *Earthflow* – Unchannelized flow of water, soil, rock, and vegetation that moves downslope.
- *Creep* – Imperceptibly slow, steady downward movement of a slope. Evidence of creep can be indicated by curved tree trunks, bent or tilted fences or retaining walls, and hummocky ground surface.
- *Lateral Spread* – Nearly horizontal movement of geologic materials; usually occurs on very gentle slopes.
- *Falls* – Abrupt movement of masses of soil or rock that becomes detached from steep slopes or cliffs. Movement generally occurs by free-fall, bouncing, and rolling. These movements are promoted by undercutting, differential weathering, excavation, or erosion.
- *Topple* – A block of rock that tilts or rotates forward on a pivot point and then separates from the main mass, falling to the slope below.
- *Debris Flow* – A moving mass of loose mud, sand, soil, rock, water and air that travels down a slope under the influence of gravity. To be considered a debris flow, the moving material must be loose and capable of "flow" and at least 50% of the material must be sand-size particles or larger.

2.3 Causes of Slope Failures

Slope Failures can be caused by nature, by man, or a combination of both. A listing of common contributing factors to slips is below.

Human Activities

- Removal of shallow bedrock on steep slopes and replacement with a weaker backfill material, such as soil fill;
- Removal of vegetation and trees;
- Changes in slope configuration, such as additional load placed on the top of the soil mass, or removal of material near the bottom of the soil mass (such as trenching for pipeline construction); and,
- Changes to the surface water or groundwater regime, such as the addition of water to a slope.

Natural Factors

- Weather;
- Erosion of toe support;
- Weathering of bedrock can produce weak, slope failure-prone materials;
- Earthquakes; and,
- Rapid lowering or rising of water level.

3.0 Pipeline Route Selection

Pipeline route selection is an important component of avoiding or minimizing the impacts of slope failures for new natural gas pipelines. The route selection process described in this document must be used for all DTI projects that include the construction of new natural gas pipelines or re-alignment of existing pipelines. DTI will avoid or mitigate the adverse effects of slope failures by following a route selection process that incorporates identification, avoidance, and/or mitigation. This process is an iterative process, and it includes preliminary route selection, desktop studies, field reconnaissance, landowner discussions and landowner considerations, temporary and permanent access road identification, and environmental factors as inputs to developing a final route. Multiple iterations of each step in the process may be necessary to develop a route that avoids or reduces the risk of slope failures.

3.1 Preliminary Route Selection

Preliminary routing includes establishing a preliminary route that serves as a starting point for the project team, and the final route will likely vary from this preliminary route. A preliminary route can be established using tools such as topographic maps, Google Earth™, available light detection and ranging (LiDAR) data, and other computer mapping software. Considerations during preliminary routing include slope failure-prone areas and construction techniques. Preliminary routing will avoid or minimize routing parallel to slopes, also known as “side hilling”, as this construction technique requires excessive excavation of material, increases the construction limits of disturbance, and results in a right-of-way that is difficult to restore and to stabilize. During preliminary route layout, care must be taken to traverse slopes perpendicular to topographic contours, and to avoid traversing slopes greater than 30 degrees (58 percent) to the maximum extent practicable. If traversing slopes of greater than 30 degrees (58 percent) cannot be avoided, it must be minimized, and these areas will be a focus of the desktop study and further evaluation during the field reconnaissance process discussed below in Section 3.3.

3.2 Desktop Study

The purpose of the desktop study is to further evaluate the preliminary route and make route adjustments prior to conducting the field reconnaissance. The DTI Project Team/field engineer, in consultation with DTI Engineering Management must decide at the beginning of a project the appropriate data to be considered during the desktop study. For small projects, the desktop study may only consist of a review of the route, and identification of steep slope areas that can be avoided. For longer projects, the desktop study should be more extensive and can include all of the items discussed below. The desktop study includes a review of existing data on slope failures and slope failure-prone areas, to allow the DTI Project Team/field engineer to make corresponding alterations in the route to avoid or minimize routing across existing slope failures and slope failure-prone areas, and to identify areas that must be crossed that will require additional review during field reconnaissance and project design.

The DTI Project Team/field engineer must define the study corridor at the beginning of the study to provide ample coverage for route alterations either during the desktop study or the field reconnaissance study. Because the potential for route adjustments is greater for longer pipelines, the desktop study corridor must be wider than for shorter pipelines. The minimum width of a study corridor during the desktop review phase is 1000 feet, but may be expanded if necessary based on the project specifics. Geographic information system (GIS) is the most efficient method to conduct the desktop study. A project-specific GIS database can be developed using various information sources including, but not limited to those listed below. Additional information in the GIS includes topography, residential and commercial structures, land use, geology, streams, wetlands, cultural resource sites, cultural features such as roads, railroads, public lands and cemeteries to be used during the desktop study to refine the pipeline route prior to beginning the field reconnaissance. Potential access roads must be identified during the desktop study for further evaluation during the field reconnaissance.

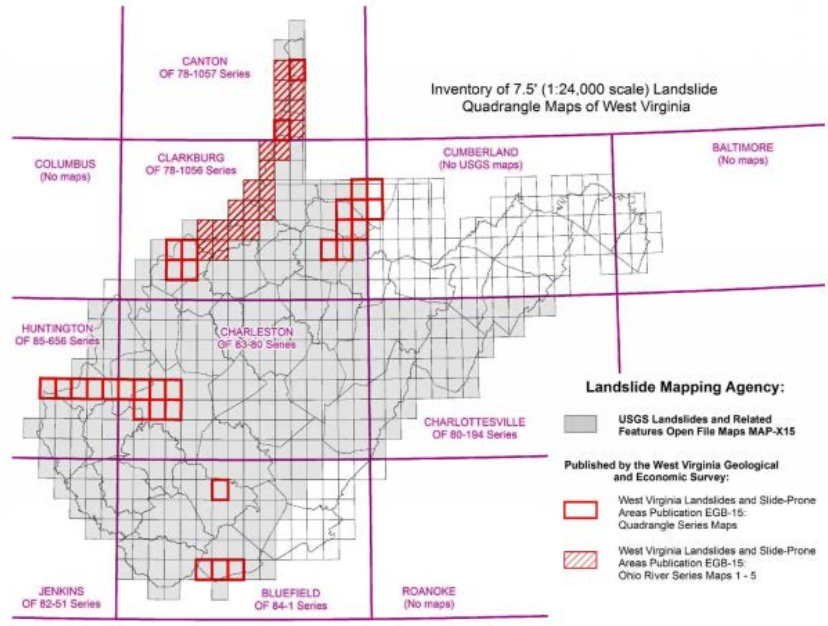
3.2.1 Existing Landslide Maps and Data

The United States Geological Survey (USGS) maintains publically available GIS data for a digital compilation of landslide overview mapping of the conterminous United States at http://pubs.usgs.gov/of/1997/ofr-97-0289/ . This dataset consists of polygons enclosing areas of landslide incidence and susceptibility for the conterminous United States. The purpose of this dataset is

to give the user a general indication of areas that may be susceptible to landslides, and is not suitable for local planning or site selection without further investigation on the ground.

For a portion of West Virginia, maps of old landslides and slide-prone areas were compiled in 1976 by the West Virginia Geological and Economic Survey (WVGES) in WVGES Publication EGB-15a, West Virginia Landslides and Slide-Prone Areas, P. Lessing, et. al, 1976. Landslides and slide-prone areas were mapped on USGS 7.5 minute quadrangles. Thirty-six 7.5 minute quadrangles are available as georeferenced images from the WV GIS Technical Center. The GIS data can be accessed here WVGISTC: GIS Data Clearinghouse, and areas covered by the data are shown in Figure 4 below. Non-georeferenced maps are available for the remaining USGS quadrangles shown in gray in Figure 4. These maps are available for download and can be georeferenced for projects that occur in areas where the georeferenced data are not directly available from the WV GIS Tech Center. State-specific information other than from USGS as discussed above are not available for Maryland, Ohio, New York, Pennsylvania or Virginia.

Figure 4 – Landslide Mapping in West Virginia



The maps must be used in the desktop study to identify areas of past slope failures, the slopes at the highest risk for slope failures, and the route adjusted to the extent practicable to avoid the highest hazard areas.

3.2.2 Define Slopes of Greater than 30 Degrees.

The desktop study must identify the degree of slope for the entire route. There are several methods to identify and define the degree of slope, either by direct measurement from topographic maps or using various computer programs. The DTI Project Team/field engineer will select an appropriate method based on the size of the project. The DTI Project Team/field engineer may select a slope angle that is shallower than 30 degrees on a project-specific bases.

3.2.3 USDA Natural Resources Conservation Service Soil Surveys

The United States Department of Agriculture (USDA) National Cooperative Soil Survey (NRCS) web-based Web Soil Survey (WSS) (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) provides georeferenced soil maps. The DTI Project Team/field engineer will review the soil survey information related to soil landscapes, soil formation, soil limitations for various land uses, and properties of the soils in the survey areas. In particular, information related to soil origin, slope steepness, drainage characteristics, typical soil profile with layer thickness, approximate depth to bedrock, and slope failure-prone soils can be obtained from the soil survey. Additionally, archived soil surveys are available for selected portions of West Virginia (http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=WV), and may provide additional interpretation of soil conditions, land use applications, and soil hazards.

The objective of soil surveys is to separate major landforms that have similar land use, and not to delineate exact boundaries of soil type. Therefore, soil surveys provide a broad overview of soil conditions but are not designed for site-specific evaluations.

3.2.4 Light Detection and Ranging (LiDAR)

LiDAR is a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. LiDAR is capable of producing high resolution mapping of the earth's surface including very subtle topographic features such as headscarps, lobate features, and hummocky topography indicative of past or active slope failures.

For projects that include construction of new pipelines, the DTI Project Team/field engineer may use publicly available LiDAR data in the desk top study. If publicly available LiDAR data is not available, the project specific LiDAR data may be obtained if the DTI Project Team/field engineer and Engineering Management decides it is necessary. LiDAR data is available for purchase from select vendors for portions of the DTI system. Where LiDAR data is unavailable for purchase, it may be deemed necessary to obtain project-specific LiDAR data by flying the route. The DTI Project Team/field engineer and Engineering Management must determine if the route should be flown to obtain LiDAR data. If the DTI Project Team/field engineer determines that project specific LiDAR is not necessary, that decision must be documented in the Desktop study documentation. Typical LiDAR coverage ranges from 1000 feet to 4000 feet in width.

LiDAR data is analyzed by developing a digital terrain model (DTM) that can be imported to various computer aided drafting software suites. The DTM can be imported into the project GIS during the desktop study and used to identify past slope failures, steep slopes and other terrain features useful in routing the pipeline.

Publically available LiDAR data are available to varying degrees for each state as shown below;

Maryland: LiDAR data and other mapping data are available from the Maryland iMAP program located at http://imap.maryland.gov/Pages/lidar-topography-server.aspx

New York: LiDAR is available for portions of New York from the New York State Elevation Data site (http://gis.ny.gov/elevation/).

Ohio: LiDAR data for Ohio are available through the Ohio Geographically Referenced Information Program at http://ogrip.oit.ohio.gov/)

Pennsylvania: LiDAR data for Pennsylvania are available at the PAMAP website athttp://www.pamap.dcnr.state.pa.us/

Virginia: LiDAR is available for portions of Virginia from the Virginia LiDAR Database at http://www.virginialidar.com/index-3.html#.V3Qtw032apo

West Virginia: As of July 2015, LiDAR data is available from the WV GIS Tech Center for all or portions of Berkley, Gilmer, Jackson, Jefferson, Morgan, Webster, and Wyoming counties of West Virginia.

3.2.5 Mine Study

A mining study should occur in areas of suspected resource mining. Underground and surface coal mining is extensive throughout West Virginia, southwestern Pennsylvania, western Virginia, and southeastern Ohio. A study of state agency data bases should be checked for potential impacts to the pipeline route. Depending on the type of mining, the impacts could range from ground subsidence or ground movement from uncontrolled backfilling of strip mines or auger mining to longwall mine panel subsidence. Publically available mine mapping from state agencies are shown below:

New York
Department of Environmental Conservation - Mining & Reclamation
http://www.dec.ny.gov/cfmx/extapps/MinedLand/search/mines/
Information on the mines can be found by location, permit information or mine identification

Ohio
Division of Geological Survey - Division of Mineral Resources
https://gis.ohiodnr.gov/MapViewer/?config=OhioMines
Information for the coal seam and mine names are given

Pennsylvania
Pennsylvania Mine Map Atlas - Pennsylvania State University
http://www.minemaps.psu.edu/
Information on the Mine Map and the coal seam and mine names are given

Virginia
Virginia Department of Mines, Minerals and Energy
https://www.dmme.virginia.gov/DM/DMMappingCenter.shtml
Maps and Resource Center for mapping with mining status and coal mine outlines

West Virginia
West Virginia Geological & Economic Survey
http://ims.wvgs.wvnet.edu/index.html
All Mining Map - Information on the seam and mine names are given

3.2.6 Desktop Study Mapping

At the conclusion of the desktop study, a map will be generated that shows a composite of the desktop study results identifying the areas of high risk for slope failures including; slopes greater than 30 degrees (58 percent), past slope failures, slope failure-prone areas based on USGS mapping and/or LiDAR data, surface or near-surface mine areas that could impact stability and areas where shallow bedrock exists.

The purpose of the mapping is to document and locate areas where further evaluation during the field reconnaissance is necessary. The information from the desktop study must be used in conjunction with other desktop data (streams, wetlands, residences, roads, cultural features, etc.) to revise the preliminary route to avoid as many high hazard areas as practicable. Slope failure-prone areas that cannot be avoided, must be identified for further evaluation during the field reconnaissance.

3.3 Field Reconnaissance

Field reconnaissance must be performed by individuals experienced in the identification and assessment of slope failures, other geohazards, and pipeline constructability to enhance the data obtained during the desktop study. This geohazard field reconnaissance can be performed in conjunction with identification of environmental features (i.e., streams, wetlands), but must include an emphasis on risk indicators for future slope failures. In particular, the following information are to be recorded with a hand-held GPS unit or other suitable mapping device, field notes, and photographs: existing slope failures, hummocky topography, head scarps, toe bulges, seeps and springs, tilted utility poles and fence posts, misaligned fences or guardrails, tilted trees, curved tree trunks, bedrock outcrops, sink holes, and mine spoil.

Based on the project conditions, the field reconnaissance can be limited to those areas identified during the desktop study as having increased risk of slope failures and potentially other impacts. The DTI Project Team/field engineer in consultation with DTI Engineering Management must determine if the field reconnaissance is to be performed on the entire pipeline alignment. The study corridor for field reconnaissance must be no less than the planned LOD, but may be up to 600 feet or greater in width.

3.4 Desktop Slope Failure Risk Assessment

Following data collection through the desktop study and field reconnaissance, a desktop slope failure risk assessment will be performed using the Desktop Slope Failure Risk Assessment Matrix included in Appendix A for new pipeline projects. For pipeline replacement projects, the DTI Project Team/field engineer will use the results of the field reconnaissance discussed in Section 3.3 to identify existing and previous slope failures and designate those areas as High Risk.

Using the guidance information included in Appendix A, each potential slope failure area identified in the desktop study and field reconnaissance will be assigned a numerical value for the following:

- Low, Moderate, or High probability of additional slope movement; and,
- Low, Moderate, or High probability of significant impact to pipeline, waterbodies, roadways, adjacent property, or other features.

Multiplying these two numerical values provides a risk score, as shown in the Slope Failure Risk Matrix in Figure 5 (included in Appendix A). The resulting risk score will be tabulated to prioritize the slope failures based on risk of future movement and degree of impact. This prioritization will allow for selection of 1) risks which can be avoided through a reroute or special construction design; 2) risks which are feasible to address as part of construction; 3) risks which cannot be avoided and will be handled as a future maintenance repair, if necessary.

Figure 5 – Desktop Slope Failure Risk Assessment Matrix

Probability of significant impact to pipeline, waterbodies, roadways, adjacent property, or other features	**Probability of additional slope movement**		
	High Probability (3)	**Moderate Probability (2)**	**Low Probability (1)**
High Probability (3)	High Risk (9)	High Risk (6)	Moderate Risk (3)
Moderate Probability (2)	High Risk (6)	Moderate Risk (4)	Low Risk (2)
Low Probability (1)	Moderate Risk (3)	Low Risk (2)	Low Risk (1)

3.5 Selection of Preventative Measures for Identified High Risk Slope Failure Locations

Following risk prioritization as outlined in Section 3.4 above, those areas along the preliminary route that have a risk score of "High" will be assigned a preventative measure. The DTI Project Team/field engineer and DTI Engineering Management must select preventative measures appropriate for each high risk location identified during the slope failure risk assessment. The DTI Project Team/field engineer also will determine if preventative measures are necessary for any of the moderate risk

locations. This determination can be based on landowner concerns, highly sensitive resources in the area (trout streams, freshwater mussel streams, residential areas, transportation corridors, other utilities or other considerations. Potential preventative measures are listed below:

- Reroute around the slope failure hazard.
- Adjust the pipeline route through the slope failure hazard to minimize the consequence if slope failure were to occur. For instance, if a cross slope cannot be avoided, route the pipeline on the upslope side of the ROW and/or bury the pipe within bedrock to minimize risk to the pipeline integrity if a slope failure were to occur.
- Define locations that require engineered details, such as specialized backfill. This will include areas with slopes steeper than 30 degrees (58 percent).
- Define locations to perform a preemptive repair of an existing slope failure through which the pipeline passes.
- Adjust Temporary Work Space (TWS) limits such that soil stockpiling is not permitted along ridgelines where known slope failures are present immediately downslope of the LOD.
- In rare cases, Horizontal Directional Drill (HDD) under the hazard. However, it is not expected that HDD will be a viable options in most cases due to site constraints, such as steep terrain, that make HDD infeasible. Additionally, the increased impacts resulting from larger ground disturbance associated with HDD may increase the risk of slope failures.
- Identify and provide sufficient permanent access roads to facilitate inspection and repair in high risk slope failure locations after restoration.

3.5.1 Selection of Preventive Measures for Pipeline Replacement Projects

A Desktop Slope Failure Risk Assessment is not required for pipeline replacement projects. Therefore, the selection of preventive measures for pipeline replacement projects must be done using information gathered during the field reconnaissance. Any existing slope failure will be considered a high risk, and the project team should select an appropriate preventative measure to address that slope failure. Potential preventative measures are listed below:

- Reroute around the slope failure hazard.
- Adjust the pipeline route through the slope failure hazard to minimize the consequence if slope failure were to occur. For instance, if a cross slope cannot be avoided, route the pipeline on the upslope side of the ROW and/or bury the pipe within bedrock to minimize risk to the pipeline integrity if a slope failure were to occur.

- Define locations that require engineered details, such as specialized backfill. This will include areas with slopes steeper than 30 degrees (58 percent).
- Define locations to perform a preemptive repair of an existing slope failure through which the pipeline passes.
- Adjust Temporary Work Space (TWS) limits such that soil stockpiling is not permitted along ridgelines where known slope failures are present immediately downslope of the LOD.
- In rare cases, Horizontal Directional Drill (HDD) under the hazard. However, it is not expected that HDD will be a viable options in most cases due to site constraints, such as steep terrain, that make HDD infeasible. Additionally, the increased impacts resulting from larger ground disturbance associated with HDD may increase the risk of slope failures.
- Identify and provide sufficient permanent access roads to facilitate inspection and repair in high risk slope failure locations after restoration.

4.0 Pipeline Design and Engineering

Slope failure-prone areas that were identified through the desktop study and field reconnaissance during the pipeline route selection phase must be properly engineered if avoidance is not an option. Additionally, preventative measures for high-risk slope failure areas were assigned to prioritize the work. Some of the selected preventative measures will be implemented during the engineering and design phase, as described in this section.

4.1 Excavation Minimization

Pipeline construction activities can result in conditions that can cause slope failures including removal of shallow bedrock on steep slopes and replacement with a weaker backfill material, removal of vegetation and trees, changes in slope configuration, and changes to the surface water or groundwater regime. Therefore, care must be taken to minimize excavation to that necessary to safely install the pipeline in areas prone to slope failures. The pipeline trench should be excavated to minimize the volume of material excavated and requiring subsequent restoration. The prepared pipe should be welded and or bent to match the trench profile rather than expanding the trench profile to accommodate the pipeline. Road crossings and bore pits are to be designed to minimize excavation through the use of shoring. Adequate extra work space is to be determined during project design, to prevent storing excavated material on steep slopes.

4.2 Document Slope Failure Areas on Project Plans

Slope failures and slope failure-prone areas must be included in the project plans. The following items must be included on the Stormwater Pollution Prevention Plans (SWPPP) and the Erosion and Sediment (E&S) control plans:

- Slope failure areas having high risk, as determined in Section 3.4 (not applicable for pipeline replacement projects);
- Existing slope failures; and,
- Slopes steeper than 30 degrees (58 percent).

The above items will be clearly identified on the plans using legend items, shading, or call outs such that the information is conveyed to the construction personnel and that awareness of the hazard is communicated.

4.3 Temporary Work Space (TWS)

As discussed in Section 3.5, TWS limits must be identified during the route selection phase so that soil stockpiling is not permitted along ridgelines in high risk areas, or where known slope failures are present immediately downslope of the LOD. Similarly, the limits of TWS must be adjusted to avoid placement over existing slope failures.

4.4 Include Additional Drainage

The project plans and specifications must include provisions for additional subsurface drainage on slopes greater than 30 degrees (58 percent). Include callouts and details in the E&S plans for location and type of drainage.

4.5 Engineered Details

Project-specific engineered details and specifications must be developed for those slope failure-prone areas requiring engineered preventative measures, as identified in Section 3.5. These locations will likely include areas with slopes steeper than 30 degrees (58 percent), or locations requiring pre-emptive repair of an existing slope failure in the proposed pipeline corridor.

It is important to understand that there is no one particular type of repair approach that works for all slope failures. Selection of the most cost effective preventative measure generally requires the following steps:

1. Detailed subsurface exploration to determine the condition of existing materials, depth of failure surface, depth to bedrock or stable soils, and groundwater conditions.
2. Slope stability modeling of the existing slope and the proposed preventative measure(s). This is done to verify that the repair will provide sufficient improvement in the stability of the final slope. Surface topography, laboratory strength testing, and groundwater information are necessary to perform this type of analysis.
3. Perform an Alternatives Feasibility Study to assess suitability of possible preventative and/or repair measures. Associated construction costs of each alternative can be evaluated as well.

Given difficult site access and time constraints for most pipeline projects in this region, some of these steps may not be feasible. Absent this information, conservative assumptions can be made as to the soil strength parameters, and the depth and type of failure surface for design based on good engineering principles and best professional judgment.

In general, the following engineered design methods apply to slope failure prevention and correction, and are presented in general order of increasing cost. Selection of the most appropriate engineered prevention measure or combination thereof, is dependent on individual site conditions and constraints. The DTI Project Team/field engineer and Engineering Management must also consider input from landowners, permitting agencies, and the Federal Energy Regulatory Commission (FERC) as applicable to evaluate all the factors that influence the design and construction of engineered design methods. Example typicals are shown in Appendix B. These typicals are provided as potential examples, and must be tailored to meet the site-specific requirements for each slope failure location.

- Drainage Improvement:
  - Provide subsurface drainage at seep locations through granular fill and outlet pipes.
  - Incorporate drainage into trench breakers using granular fill.
  - Intercepting groundwater seeps and diverting off ROW.
- Buttressing slopes with Sakrete trench breakers.
- Change Slope Geometry:
  - Reduce the slope by cutting at the top, or incorporating a toe buttress.
  - On many overly steepened slopes the depth to bedrock is relatively shallow and slope failures often occur at the interface between the overburden soil and the bedrock. By removing the overburden soil and leaving the bedrock exposed, this could eliminate these types of slope failures. Continued erosion of the soft exposed bedrock should be anticipated.

  - Modifications to E&S BMPs may be required to manage stormwater runoff between the final ROW slope configuration and existing grades beyond the ROW. One alternative approach to manage stormwater is to direct runoff to a defined channel within the ROW to carry surface water downslope. The channel must be stabilized with rip rap or by other means and be directed to an appropriately-sized stabilized outlet.
- Bench and Regrade with Controlled Backfill:
  - A common slope failure repair approach for slopes up to 30 degrees (58 percent) includes removal of the failed soil mass and reconstruction of the slope by cutting level benches into competent soil or rock beneath the failure plane, installing subsurface drainage, and placing compacted soil or other material as backfill.
- Use Alternate Backfill:
  - Removal of the existing fill soil and replacement with rock fill, such as shot rock (WVDOH Item 704.8 or equivalent) can be beneficial in slope failure repair because it improves drainage, provides a higher friction strength, and generally weighs less than a compacted soil backfill. This method is effective on slopes as steep as 38 degrees (78 percent), but should not be expected to vegetate.
  - The potential use of controlled low strength material (CLSM), such as cementitious flowable fill, as backfill within the pipeline trench could be considered as a method to reduce the pipeline trench from collecting and transporting water. The challenge is placing this material incrementally up the slope and containing it long enough for the flowable fill to harden and gain strength. **Note: Dominion policy does not allow the use of CLSM containing fly ash as filler. Therefore a flowable fill using fine aggregates or sand must be used.**
- Chemical Stabilization of Backfill:
  - Chemical modifiers, such as cement and lime, have successfully been used to dry cohesive soils that are saturated beyond the optimum moisture content, and are often used to extend the construction season. When used at higher concentrations, these modified soils can exhibit increased strength properties that can benefit slope failure stabilization projects on slopes up to 30 degrees (58 percent) or greater.
- Geogrid Reinforced Slope:
  - For slopes steeper than 30 degrees (58 percent), construction of a reinforced soil slope (RSS) may be necessary to match existing grades. A RSS consists of benching into the existing slope, installing subsurface drains, and incorporating geogrid reinforcement into compacted backfill.

- Retaining Structures:
  - Numerous types of retaining structures can be effective for slope failure prevention and repair, and are often used in combination with the repair approaches discussed previously. However, structural approaches are generally expensive since they require specialized equipment for installation on remote sites with challenging access. From the standpoint of protecting the pipeline, the most economical solution in certain cases may be to install a retaining wall and then regrade the slope below. In some cases, the slope below the retaining structure may continue to move.
  - One structural approach includes installation of soil nails with surface mesh to anchor the surficial soils to the underlying competent soil or rock. The soil nail spacing and length are designed based on the soil/rock conditions and the depth of sliding. If desired, the surface mesh can be sized to permit vegetation growth through the mesh.
  - Another alternative is the proprietary Geopier SRT system, which utilizes patented plate pile steel reinforcing elements to stabilize slopes. This system is advertised for use on slope failures less than 15 feet in depth where the soil conditions consist of an upper zone of unstable soil over stable soil or soft rock, since the pile elements must penetrate below the sliding surface into stable material. If shallow bedrock is present, predrilling of each plate pile could be required.
  - Other structural retaining wall options include gabion baskets, modular blocks, geocells, H-pile and lagging, drilled shafts, tieback walls, sheet piles, and mechanically stabilized earth (MSE).

4.6 Construction Stormwater Permit

State agency construction stormwater permits and the Federal Energy Regulatory Commission (FERC) require that restoration of the ROW be performed to match preconstruction grade. These requirements sometimes can be problematic on slopes steeper than 30 degrees (58 percent) where pipeline construction activities remove the shallow bedrock and replace it with weaker soil fill. The soil fill has lower internal shear strength than the natural rock and is unstable on these steep slopes, thus increasing the risk of slope failures. To prevent this known slope failure root cause, slopes could be reconstructed to a shallower grade than the existing slope. If the final restored slope is 30 degrees (58 percent) or less, this approach would allow restoration of the ROW using fill materials comprised of natural soil and rock fragments without engineering design. If adjustments to the final grade are implemented, then the pipeline embedment must be increased sufficiently to maintain adequate cover depth. Additionally, modifications to stormwater Best Management Practices (BMPs) will be required since the ROW will likely be at lower elevation than the surrounding hillside, which could preclude

installation of waterbars to divert water off ROW. An option to manage this stormwater effort is to direct the runoff to a defined channel within the ROW to convey surface water downslope. Any change in topography may require an individual construction stormwater permit rather than the general permit, which could add significant time to the permitting timeline and require additional review by permitting agencies along with the potential for a public comment period. This approach would require landowner approval and FERC approval if on a FERC project.

4.7 Stormwater Pollution Prevention Plan (SWPPP)

The SWPPP must include a discussion of the methods implemented to avoid slope failures and a plan of action should slope failures occur. The below paragraph provides a template that can be modified with specific measures to be used on a project.

> *Potential erosion problem areas, including but not limited to areas with 30^0 slopes or greater, will be protected by silt fence and permanent slope breakers. Slope breakers will be placed a minimum of 75 feet apart in areas with greater than 25^0 slopes. Care has been taken to avoid areas of steep slopes as much as practical; however, areas which could not be avoided will be addressed with (INSERT ENGINEERING MEASURES, e.g. waterbars, Rolled Erosion Control Product). In the event that subsurface flow is encountered, an under drain will be utilized, as necessary, to divert water outside of the LOD. If encountered, seeps can be mitigated by using seep collectors placed downslope of areas showing seepage. Armored fill placed at the toe of the slope may be used in areas of steep slopes in addition to a perforated drain pipe to divert subsurface water away from the cut slope. If a slope failure occurs Dominion will (INSERT CONTAINMENT MEASURES, e.g. install super silt fence, gabion baskets, jersey barriers or other portable containment devices) to keep the slope failure from impacting areas outside the LOD or waters of the state. Steep slopes have been avoided to the maximum extent practicable. Steep slopes will be restored with erosion control blanket and Dominion will implement the slope failure prevention items mentioned above as needed.*

Maryland: Slopes equal to, or greater than, 15 percent are classified as “steep slopes” and must be shown on the NRI plan. The standard symbol for steep slopes must be used on the plan and included in the legend.

New York: The New York State Standards for Erosion and Sediment Control Manual requests site plans which delineate and avoid disturbing wetlands, stream corridors and, to the extent practicable, wood lots, steep slopes and other environmentally sensitive areas. The plans should also minimize impacts by

maintaining vegetative buffer strips between disturbed area and water resources. Additionally, an E&SC plan should be prepared for all land development and construction activity when uncontrolled erosion and sedimentation is anticipated and should, at a minimum, include sites on slopes that exceed 15%, sites in areas of severe erosion potential, sites within 100 feet and draining to wetland, sites within 100 feet draining to a watercourse, and/or sites with a high percentage of colloidal solids.

Ohio: Oil and gas pipeline construction activities are conditionally exempt from stormwater discharge permitting in Ohio. However, the Ohio Rainwater and Land Development Manual provides limited best practices for steep slopes. Additionally, the Ohio Environmental Protection Agency (OEPA) defines steep slopes as those that are 15 percent or greater.

Pennsylvania: According to the Erosion and Sediment Pollution Control Program Manual, critical areas should be covered with erosion control fabric. Critical areas are defined as part of a disturbed area which poses the greatest threat of sediment pollution to a receiving water. Any slope 3H:1V or steeper directly above a surface water is considered a steep slope and a critical area.

Virginia: According to the General VPDES Permit for Discharge of Stormwater from Construction Activities, a legible site plan must be submitted that identifies the limits of land disturbance including steep slopes and natural buffers around surface waters that will not be disturbed, as well as minimize(s) the disturbance of steep slopes is required as part of the permitting process.

West Virginia: WVDEP requires that the SWPPP include information on slide prone areas and the methods to be implemented to both avoid slope failures and a plan of action should slope failures occur.

4.8 Documentation of Design Information

The following documentation must be developed and filed in the DTI Engineering Documentum filing system.

- Desktop Study mapping and documentation of route adjustments to avoid slope failures and slope failure-prone areas;
- Slope failure Risk Assessment and identification of high risk areas; and
- Selected avoidance or mitigation method for each high risk slope failure location identified in the slope failure risk assessment

5.0 Pipeline Preconstruction Planning

5.1 Slope Failure Training

Training in this procedure consists of annual training on the ~~e~~ procedure, and project-specific review at the Environmental Permit Transition meeting.

5.1.1 Training

DTI personnel with responsibility for pipeline routing, construction, or operation must be trained in this procedure on an annual basis. The training may be completed by an online learning management system (LMS) module or may be conducted by Energy Infrastructure Environmental Services (EIES) personnel, or DTI Engineering Management. At a minimum, the following personnel will be trained;

- Engineering Directors and Managers;
- Design and construction engineers;
- Operations Directors, Managers and Supervisors;
- Construction supervisors; and
- Construction and operations Environmental Compliance Coordinators (ECC).

The training must include the following;

- types and causes of slope failures;
- routing avoidance and desktop methods;
- field reconnaissance;
- risk prioritization;
- pipeline design and engineering to prevent slope failures;
- addressing slope failures during construction;
- addressing slope failures post construction; and,
- reporting requirements.

5.1.2 Environmental Permit Transition

Prior to beginning construction, DTI and contractor personnel with responsibility for the pipeline construction must attend the Permit Transition with EIES. The EIES Permitting Lead will schedule the Permit Transition meeting to rollout the permits and clearances. The meeting will include a review of all environmental permits. At a minimum, the following personnel must attend the Environmental Permit Transition meeting;

- Permit Lead
- Project supervisor;
- Operations Supervisor/Manager (if available);
- ECC; and
- Environmental Inspector (EI) (if identified).

Recommended attendees at the Permit Transition meeting include the following;

- Construction engineer;
- Contractor supervisors, superintendents, and foreman - Policy can be reviewed with contractor at separate pre-construction meeting if cannot attend permit transition meeting;
- DTI inspectors; and

If the contractor cannot attend the environmental permit transition meeting, this policy will be reviewed with the contractor at a separate preconstruction meeting. The Environmental Permit Transition meeting will review the environmental permit conditions, training requirements, inspection requirements, and reference to this policy and procedure.

5.2 Slope Failure Mitigation and Response Materials

The DTI Construction Supervisor must identify during the preconstruction phase, the materials to be maintained onsite during construction to address a slope failure and to prevent slope failures from impacting waters of the state. These materials may include belted silt retention fence, super silt fence, jersey barriers, sakrete bags, gabion baskets, soil additives, drain pipe, stone, geotextile, or portable containment structures.

6.0 Addressing Slope Failures During Construction

6.1 Inspections

For projects with a construction stormwater permit or other E&S plan approved by a regulatory agency, inspection and maintenance of all E&S control structures shall be completed and documented. The ROW and E&S control devices will be inspected by the EI or person designated by the DTI Construction Supervisor. A record of weekly and storm event inspections will be maintained onsite for the duration of the project by the Project EI or Project Supervisor. Inspection forms will include the date(s) and names(s) of personnel making the inspection and results (including any major observations and corrective actions taken or needed). Any major observation and corrective action needed will be carried over to subsequent inspection reports until completely resolved. The inspection records must be maintained onsite during construction and retained by DTI Engineering for a minimum period of three (3) years after final stabilization. Completed inspection reports must be provided to the Construction ECC on a routine basis during construction, and the Construction ECC will conduct periodic site visits to review inspection records and to complete environmental self-assessments on select projects. Construction stormwater inspection requirements vary by state. The below table summarizes these requirements which are further detailed in the subsequent sections.

Table 2. Construction Stormwater Inspection Requirements by State.

State	Inspection Frequency	Rainfall Inspection	Inspection Records	Sign Posting
Maryland	Weekly	The following day after rainfall event resulting in runoff.	Inspection records maintained for three (3) years from the date that permit terminated.	NA
New York	< 5 acres – every 7 days > 5 acres disturbed at one time – at least 2 times every 7 calendar days separated by 2 full calendar days	NA	Inspection reports retained for 5 years following submittal of the NOT.	NA
Ohio	Every 7 calendar days	Within 24 hours of a 0.5” storm event that occurs within a 24 hour period.	Inspection reports retained for 3 years following the submittal of the NOT.	NA

Pennsylvania	Weekly	Within 24 hours after a measurable rainfall event	Inspection reports retained for 3 years from the date of the termination of coverage.	NA
Virginia	Every 5 business days or at least every 10 business days and →	Within 48 hours following any runoff producing measurable storm event.	Inspection report retained for 3 years from the expiration or termination of the permit.	Post copy of notice of coverage letter.
West Virginia	Every 7 calendar days for actively disturbed areas and Every 14 calendar days for restored areas	Within 24 hours after a storm event > 0.5" of rain in a 24 hour period.	Inspection reports retained for 2 years.	Sign posted within 24 hrs. of submitting NOI.

6.1.1 FERC Requirements

For FERC projects, inspections are required in accordance with the FERC Plan. FERC inspections are required on a daily basis in areas of active construction or equipment operation, on a weekly basis in areas with no construction or equipment operation, and within 24 hours of each 0.5 inch of rainfall. All grade surfaces, walls, dams and structures, vegetation, E&SC measures and other protective devices must be maintained in good and effective condition and promptly repaired or restored, even if damaged by a third party.

6.1.2 Maryland

The December 2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control can be found at the following site:

http://www.mde.state.md.us/programs/water/stormwatermanagementprogram/soilerosionandsedimentcontrol/pages/programs/waterprograms/sedimentandstormwater/erosionsedimentcontrol/esc_standards.aspx

According to the Maryland Soil Erosion and Sediment Control Manual SECTION A-3 SEDIMENT CONTROL PRINCIPLES, the owner is responsible for conducting routine inspections and required maintenance. At a minimum, the site and all controls should be inspected weekly and the next day after each rain event. However, the approval authority may require more frequent inspections, especially adjacent to sensitive areas or in impaired watersheds. A written inspection report is part of every inspection. In addition,

Maryland requires a "Responsible Person" to act as an inspector. The responsible personnel involved in the construction project shall have a Certificate of Training at a Maryland Department of the Environment (MDE) approved training program for the control of erosion and sediment prior to beginning the project. Additionally, the owner or developer shall certify right of entry for periodic on-site evaluation by the appropriate enforcement authority and/or MDE.

6.1.3 New York

The following excerpts are from *Part IV. Inspection and Maintenance Requirements of the New York, Department of Environmental Conservation, SPDES General Permit for Stormwater Discharges from Construction Activity*. A copy of the entire document and appendices can be found at the following location**:**

http://www.dec.ny.gov/docs/water_pdf/gp015002.pdf

A qualified inspector must conduct site inspections. The qualified inspector qualifications are a: - licensed Professional Engineer, Certified Professional in Erosion and Sediment Control (CPESC), Registered Landscape Architect, or someone working under the direct supervision of, and at the same company as, the licensed Professional Engineer or Registered Landscape Architect, provided they have received four (4) hours of Department endorsed training in proper erosion and sediment control principles from a Soil and Water Conservation District, or other Department endorsed entity.

The qualified inspector shall conduct site inspections where soil disturbance activities are on-going at least once every seven (7) calendar days. In areas where disturbance is greater than five (5) acres of soil at any one time or in sensitive areas, the inspector shall conduct at least two (2) site inspections every seven (7) calendar days. The two (2) inspections shall be separated by a minimum of two (2) full calendar days. During temporarily suspended work (e.g. winter shutdown) and when *temporary stabilization* measures have been applied to all disturbed areas, a site inspection should be completed at least once every thirty (30) calendar days.

6.1.4 Ohio

The following excerpt is from the *Ohio Environmental Protection Agency, General Permit Authorization for Stormwater Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System.* A copy of the entire document can be found at the following location**:**

http://www.epa.ohio.gov/Portals/35/permits/OHC000004_GP_Final.pdf

At a minimum, procedures in an SWPPP shall provide that all controls on the site are inspected at least once every seven calendar days and within 24 hours after any storm event greater than one-half inch of

rain per 24 hour period. The inspection frequency may be reduced to at least once every month if the entire site is temporarily stabilized or runoff is unlikely due to weather conditions. The permittee shall assign "qualified inspection personnel" to conduct these inspections to ensure that the control practices are functional and to evaluate whether the SWPPP is adequate and properly implemented.

6.1.5 Pennsylvania

The following excerpt is from the *March 2012 Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Pollution Control Program Manual.* A copy of the entire document can be found at the following location**:**

http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-88925/363-2134-008.pdf

PADEP requires a maintenance program that provides for the operation and maintenance of BMPs and the inspection of BMPs on a weekly basis and after each stormwater event, including the repair or replacement of BMPs to ensure effective and efficient operation. The program must provide the completion of a written report documenting each inspection and all BMP repair or replacement and maintenance activities.

Pennsylvania has no certification requirement for E&SC inspectors.

6.1.6 Virginia

The following excerpt is from the *Virginia Department of Environmental Quality, General VPDES Permit for Discharges of Stormwater from Construction Activity.* A copy of the entire document can be found at the following location**:**

http://www.deq.virginia.gov/Portals/0/DEQ/Water/Regulations/9VAC25-880-VPDESConstructionSWGPRegulation.pdf

Virginia requires Inspections to be conducted at a frequency of at least once every five business days and no later than 48 hours following a measurable storm event. In the event that a measurable storm event occurs when there are more than 48 hours between business days, the inspection shall be conducted on the next business day; and representative inspections used by utility line installation, pipeline construction, or other similar linear construction activities shall inspect all outfalls discharging to surface waters identified as impaired or for which a TMDL wasteload allocation has been established and approved prior to the term of this general permit.

Virginia requires a "Certified Inspector" to complete all E&SC inspections. Certified Inspector means an employee or agent of a VESCP authority who holds a certificate of competence from the Board in

the area of project inspection or is enrolled in the Board's training program for project inspection and successfully completes such program within one year after enrollment. The Virginia Regulation can be found at the following site:

http://register.dls.virginia.gov/details.aspx?id=3945

6.1.7 West Virginia

The following is summarized from *Section G. Other Requirements of the West Virginia Department of Environmental Protection, Division of Water and Waste Management, General Water Pollution Control Permit* for Stormwater Associated with Oil and Gas Related Construction Activities. A copy of the entire document can be found at the following location**:**

http://www.dep.wv.gov/WWE/Programs/stormwater/csw/Documents/OG%20stormwater%20GP%203_10_15.pdf

Inspections must be completed by individuals experienced and trained in E&S control inspections. Inspections must be completed and documented at least once every *seven (7) calendar days* for actively disturbed areas, *14 calendar days* for restored areas (restored areas includes pavement, buildings, stable waterways, a healthy, vigorous stand of perennial grass that uniformly covers at least 70 percent of the ground) and *within 24 hours* after any storm event greater than one-half (0.5) inch of rain per 24-hour period. The Project area will continue to follow the preceding schedule until a Notice of Termination (NOT) has been submitted and is approved by WVDEP. Slope failure repairs, soil conditioning, fertilization, reseeding, and mulching will be performed as required.

6.2 Responding to Slope Failures

In the event a slope failure is documented during an inspection, the following steps must be followed. Each step is discussed in detail in the following subsections and summarized in Table 2.

1. Contact the ECC immediately and they will notify EIES who will help evaluate the priority of the slope failure based on the document "Slope Failure Priority Guidance" in Appendix D. The ECC will complete any required reporting to regulatory agencies.
2. Install temporary BMPs to contain slope failure material and to prevent the slope failure from impacting waters of the state.
3. Gather data on slope failure and submit to Dominion Engineering and EIES.
4. Determine repair method and whether the repair is field-directed or engineering-directed.
5. Install short term field stabilizing measures, if applicable.
6. Implement and document slope failure repair.

Table 3. Slope failure Reporting and Repair Responsibility Matrix.

Responsible Party	Action	Time Frame
Construction Supervisor	Report Slope failures to the ECC upon discovery, who will work with EIES to evaluate slope failure using Slope Failure Priority Guidance (Appendix D)	Immediately upon discovery
Construction Supervisor	Install temporary BMPs to contain slope failure material/prevent slope failure from impacting waters of the state	As soon as practicable
ECC	Notify state environmental agency if required	Immediately
Construction Supervisor	Complete Slope Failure Information and Reporting Form (Appendix C)	Within 5 business days of discovery of slope failure
Engineering Team	Complete Slope Failure Repair Assessment Form (Appendix C) and determine if slope failure repair will be field-directed or engineering-directed.	Within 10 business days of receipt of Slope failure Evaluation Reporting Form
Engineering Team	Design repair of Engineering-directed repairs	As soon as practicable
Construction Supervisor	Install short term stabilizing measures for Priority 1 and 2 slope failures that will not be repaired within 60 days of discovery	As soon as practicable
Construction Supervisor	Implement slope failure repair	As soon as practicable
Construction Supervisor	Document slope failure repair	Upon completion of repair

6.2.1 Evaluate Priority

Upon observation of a slope failure, the ECC must be contacted to assist in the Slope Failure Priority determination using the Slope Failure Priority Guidance in Appendix D. The ECC will contact the appropriate entity for all Priority 1 and 2 Slope failures, as specified in Appendix D.

6.2.2 Install Temporary BMPs

DTI's Construction Supervisor or the EI must direct the contractor to install temporary BMPs for containment of slope failure material to protect waterbodies from slope failure material and runoff. Typical details for temporary containment measures, including silt fence, silt sock, super silt fence, and jersey barriers, are included in the SWPPP. Selection of the appropriate BMPs must be determined by the EI in consultation with the DTI Construction Supervisor so that runoff from the slope failure material is contained and waterbodies, if present, are protected. It is noted that temporary BMPs will not arrest future slope movements, and follow up actions to remediate the slope failure must be implemented as soon as practicable.

6.2.3 Gather Data

The Construction Supervisor will obtain site data of the slope failure by completing the Slope failure Information and Reporting Form provided in Appendix C, and will submit this information to DTI Engineering and EIES within five (5) business days of discovering the slope failure. The slope failure information and reporting form included in Appendix C may be used to document slope failure information. In particular, the following minimum information will be obtained and communicated:

- Name of observer;
- Date;
- Slope failure location, including latitude and longitude;
- Slope failure dimensions;
- Site photographs;
- Site sketch;
- Evidence of preexisting slope failures;
- Presence of surface water or groundwater;
- Estimate of slope steepness;
- Estimate of slope failure type (i.e., rotational, translational, earthflow, etc.); and
- Slope failure priority based on Slope Failure Priority Guidance (Appendix D).

6.2.4 Select Slope Failure Repair Approach

Within ten (10) business days of receiving the slope failure data form, DTI Engineering will evaluate whether the slope failure repair is to be field-directed or engineering-directed, and whether to engage a specialist in slope failure evaluation and repair (i.e., geotechnical engineer). The attached score sheet has been developed to assist in determining the appropriate direction of the repair and whether to engage a specialist. In general, field-directed repairs are to be limited to slope failures that are on slopes flatter than 30 degrees (58 percent), can be repaired by installation of drainage measures and earthwork, and have low consequence of future failure. Slope failures that occur on steep slopes, extend outside the ROW, pose increased consequence of future failure, or require construction techniques outside the pipeline contractor's typical construction methods are to be directed by DTI Engineering.

Selection of the most appropriate slope failure repair method is dependent on individual site conditions and constraints. Section 3.5 above provides a discussion on typical repair approaches.

- If the slope failure repair will be field-directed, then the EI and Construction Supervisor will determine the most appropriate repair approach. In general, this will involve installation of drainage, minor slope regrading, and replacement of the failed soil on benches.
- If the slope failure repair will be engineering-directed, then the Project Engineer will lead development of the slope failure repair plan.
- If a geotechnical engineer is engaged, then the Project Engineer will coordinate with the specialist to select and design the repair. This may require field exploration, stability modeling, alternatives feasibility study, and preparation of construction plans.

6.2.5 Install Short Term Stabilizing Measures

In addition to installation of temporary BMPs per Section 5.2, Priority 1 and 2 slope failures that will not be repaired within 60 days of discovery, and other slope failures that will not be repaired within 120 days of discovery will have short term stabilizing measures applied. The following is a list of possible short term stabilizing measures that can be considered:

- Remove soil at the top of the slope failure to unload the slope;
- Install a toe buttress using soil or rock fill, gabion baskets or similar devices;
- If possible, perform minor regrading of the slope with some level of compaction to smooth out the existing scarps and reduce the number of pockets in which water can collect;

- Direct drainage away from the slope failure through waterbars, diversion ditches, or temporary drains;
- Place plastic on the failed slope to protect the soils from rainfall and surface runoff; and
- Monitor the slope failure for signs of slope movement, especially after periods of heavy rain fall. If additional movement is detected or visible (i.e. cracks or scarps), notify Dominion Engineering for assistance.

Even with temporary measures, there is still a risk of additional slope movement. Therefore, long term slope failure repair measures must be implemented.

6.2.6 Implement Slope Failure Repair The slope failure repair must be completed in an efficient and timely manner, and implemented in accordance with the slope failure repair approach selected following this procedure.

6.2.7 Document Repair

The slope failure repair must be documented by the Construction Supervisor, and documentation stored in the DTI Engineering Documentum filing system. Documentation must include the following;

- Name of person completing documentation;
- Date repair was completed;
- Repair location, including latitude and longitude;
- As-built of repair showing locations of installed devices including, subsurface drainage devices, ditching, water bars, buttressing, etc.;
- Method of repair; and
- Photos of repair.

7.0 Addressing Slope Failures After Construction

In the event of a slope failure occurring after construction and prior to regulatory agency approval of a Notice of Termination (NOT) the stormwater permit, the DTI Project Team/field engineer must follow the procedures described in Section 6.0. DTI financial policies provide an out-of-cycle budget request mechanism to reopen a project budget with the proper justification to address slope failures that are a result of construction after the project budget has been closed. The out of cycle budget request can be used to address slope failures that occur in the time period between NOT submittal and regulatory agency approval of the NOT, and to ensure inspections continue until the NOT is approved.

In the event that a slope failure is discovered after approval of the NOT through routine pipeline patrols or other methods of inspection, DTI Operations must report the slope failure to the ECC who will assist EIES in the determination of the slope failure priority classification as a Priority 1 (immediate danger to environment or human health), Priority 2 (sediment laden run-off has entered a water body, Priority 3 (sediment has not reached water body, but appears imminent), or Priority 4 (poses little or no threat to the environment). In addition, DTI Operations must contact DTI Field Engineering for assistance to review the condition and develop a repair plan in accordance with this Policy and Procedure for Slope failure Avoidance, Identification, Prevention, and Remediation.

8.0 Slope Failures Caused by a Third Party

If it is determined that a slope failure is caused by the actions of a third party and not related to pipeline construction or activities by DTI, the DTI Engineering Team or Operations will contact the DTI Land, Lease, and ROW group to make notification to the third party of the slope failure.

APPENDIX A

Desktop Slope Failure Risk Assessment

Desktop Slope Failure Risk Assessment Matrix

Probability of significant impact to pipeline, waterbodies, roadways, adjacent property, or other features	Probability of additional slope movement		
	High Probability (3)	**Moderate Probability (2)**	**Low Probability (1)**
High Probability (3)	High Risk (9)	High Risk (6)	Moderate Risk (3)
Moderate Probability (2)	High Risk (6)	Moderate Risk (4)	Low Risk (2)
Low Probability (1)	Moderate Risk (3)	Low Risk (2)	Low Risk (1)

<u>Probability of additional slope movement</u>

- Low
  - Slope 22° (40%) or flatter
  - No bedrock outcrops visible
  - No evidence of previous slope movement (bent trees, fence posts, utility poles)
  - No mapped landslide is present
- Moderate
  - Slope 22° to 30° (40% to 58%)
  - Bedrock outcrops possible or limited to small portion of the slope
  - Possible evidence of previous slope movement (bent trees, fence posts, utility poles)
  - Mapped landslides present in the area, but not within the LOD
- High
  - Slope steeper than 30° (58%)
  - Bedrock outcrops prevalent or cover a sizeable portion of the slope
  - Evidence of previous slope movement (bent trees, fence posts, utility poles)
  - Mapped landslide is present within the LOD
  - Existing landslide is present based on field observations

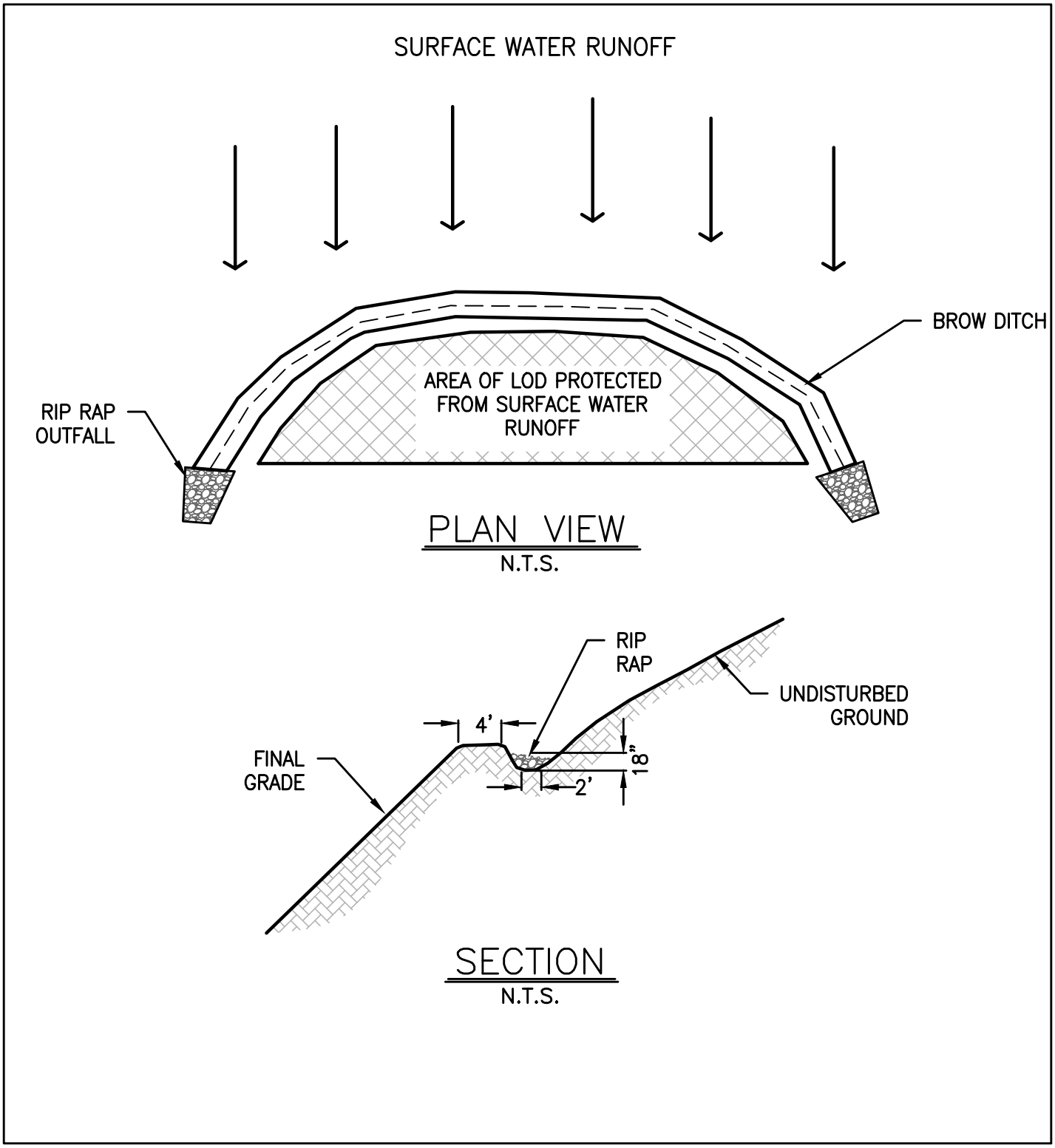
<u>Probability of significant impact to pipeline, waterbodies, roadways, adjacent property, or other features</u>

- Low
  - Pipeline traveling directly up and down the slope
  - Waterbodies or roadways are located 50 feet or more from toe of slope
- Moderate

    - Pipeline traveling directly up and down the slope and slope is 30° (58%) or steeper
    - Pipeline crossing the slope (sidehilling), but will likely be installed below top of bedrock surface
    - Waterbodies or roadways are located 20 to 50 feet or more from toe of slope
- High
    - Pipeline crossing the slope (sidehilling), but will not be installed below top of bedrock surface, or top of bedrock surface is unknown
    - Waterbodies or roadways are located less than 20 feet from toe of slope

APPENDIX B

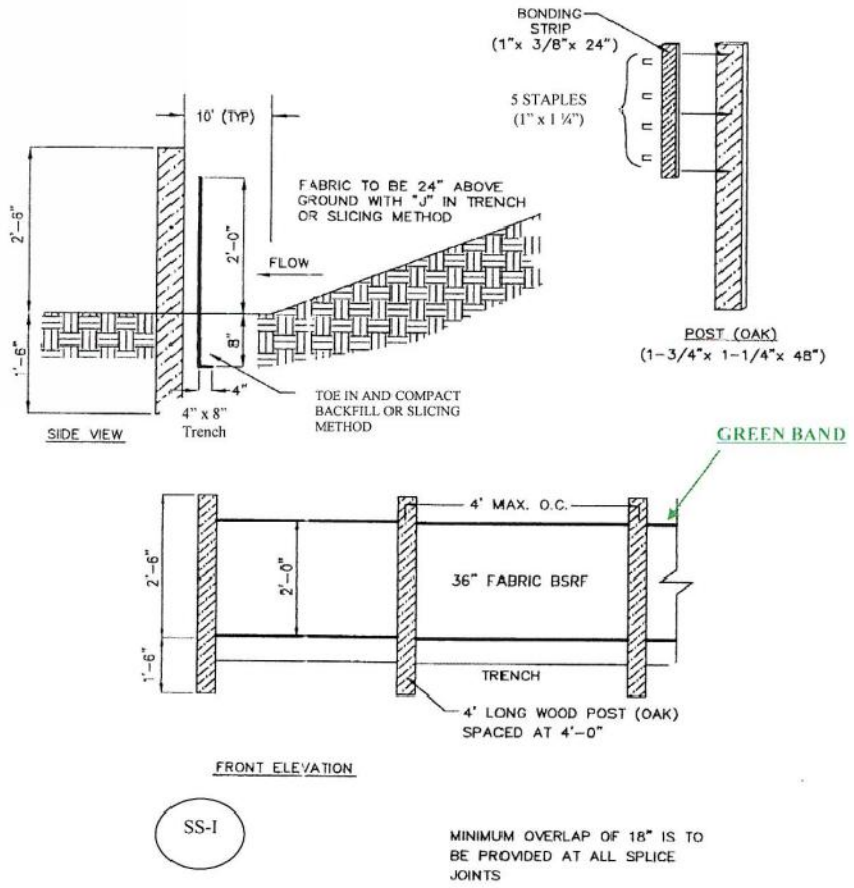
Select Typicals



BROW DITCH DETAIL

BELTED SILT RETENTION FENCE
INSTALLATION DETAIL
PRIORITY 1 – GREEN BAND

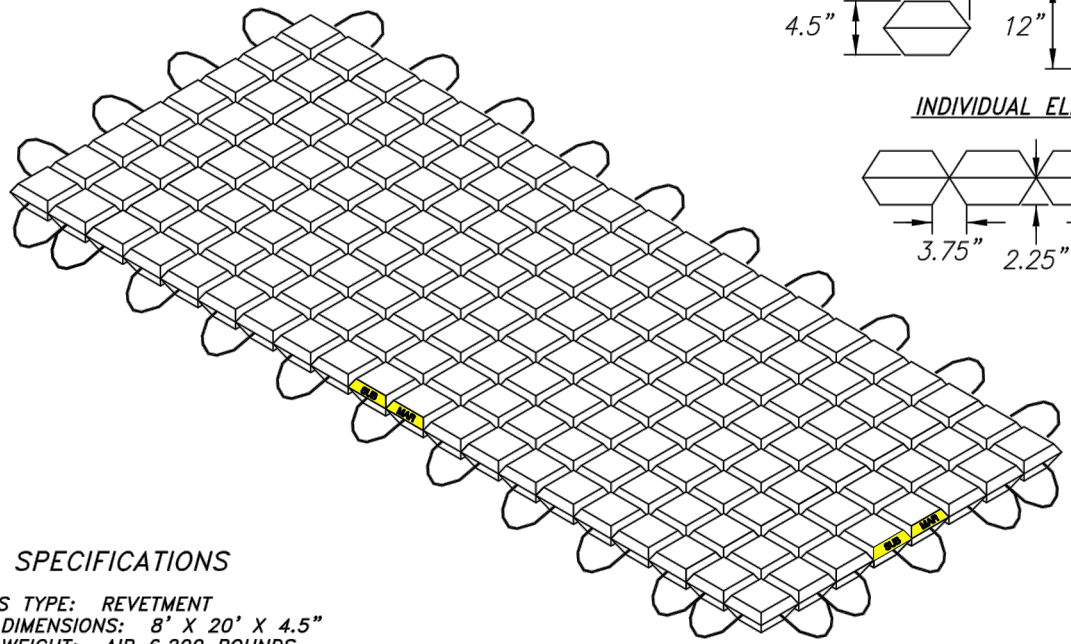
SILT-SAVER, INC.

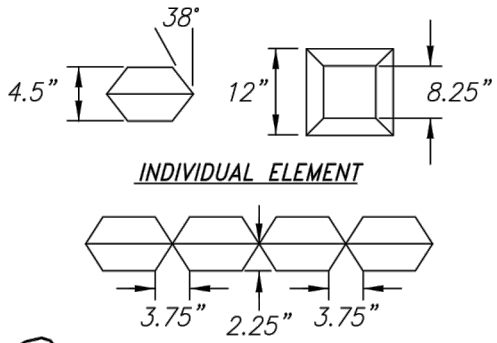


BELTED SILT RETENTION FENCE (BSRF)

SILT-SAVER, INC.
• 1094 CULPEPPER DRIVE • CONYERS, GA 30094 •
OFFICE 770-388-7818 • FAX 770-388-7640 • TOLL FREE 1-888-382-SILT (7458) • WEBSITE WWW.SILTSAVER.COM •

BELTED SILT RETENTION FENCE





SPECIFICATIONS

MATTRESS TYPE: REVETMENT
MATTRESS DIMENSIONS: 8' X 20' X 4.5"
MATTRESS WEIGHT: AIR 6,200 POUNDS
MATTRESS WEIGHT SUBMERGED: 3,600 POUNDS (APPROX.)
CONCRETE DENSITY: 145 LBS. PER CU. FT., 4,000 PSI
160 ELEMENTS: 5/8" ULTRA VIOLET STABILIZED COPOLYMER
EXTRUDED FIBER ROPE, MINIMUM TENSILE STRENGTH 9,500 POUNDS

805 Dunn Street
Houma, LA 70360
Ph. 985-868-0001
Fax 985-851-0108
Email: submar@submar.com
Website: www.submar.com

SUBMAR
Synergy with Nature

SUBMAR
STANDARD 8.00'x20.00'
MAT DETAIL

4.5" CONCRETE MATTRESS

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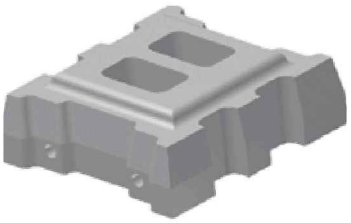
DATE:	CHECKED BY:	DRAWN BY:	SCALE:	CONTACT:	PHONE #:
01/03/13	DWD	KPF	N.T.S.		

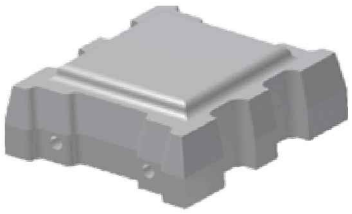
SUBMAR MATTRESS DETAIL

CONTECH®
ENGINEERED SOLUTIONS

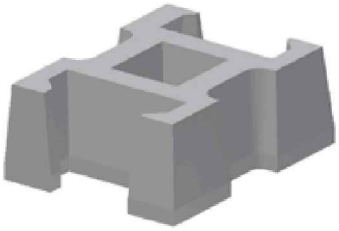
ARMORTEC® Product Details



ArmorFlex® - Open Cell

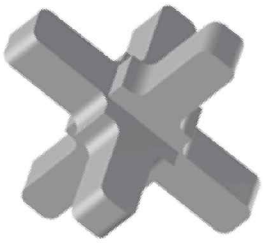


ArmorFlex® - Close Cell

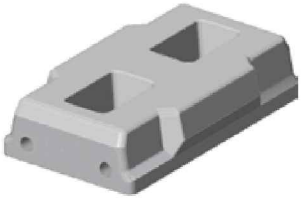


ArmorLoc®

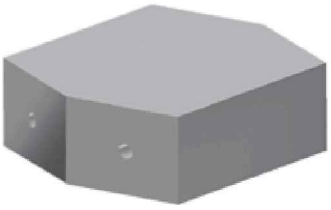
ArmorWedge®



A-Jacks®



ArmorStone®

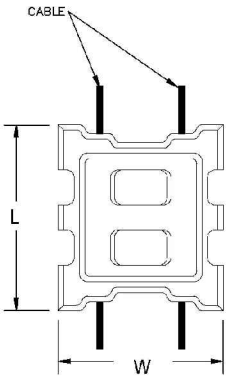


ArmorRoad®

MANUFACTURING SPECIFICATION
ASTM D6684-04

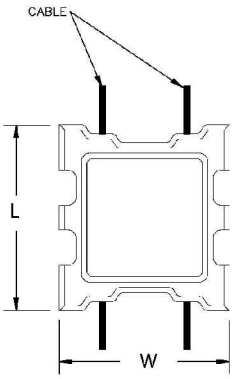
ARMORTEC®
Erosion Control Solutions

ArmorFlex® (not to scale)



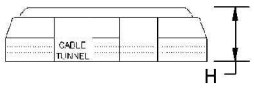
TOP VIEW

Open Cell Block

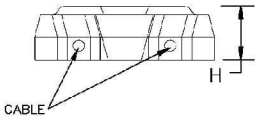


TOP VIEW

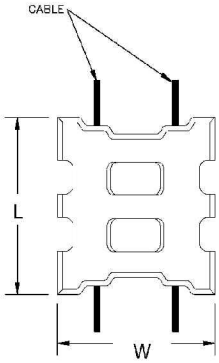
Close Cell Block



SIDE VIEW

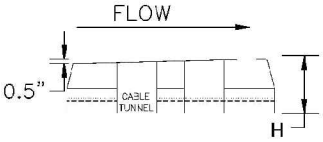


END VIEW

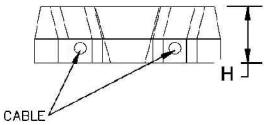


TOP VIEW

Tapered Series



SIDE VIEW



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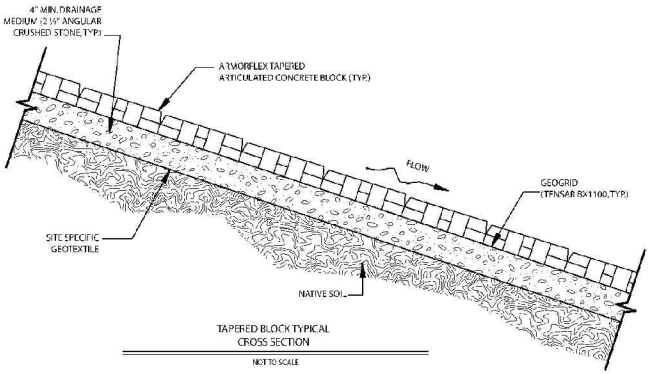
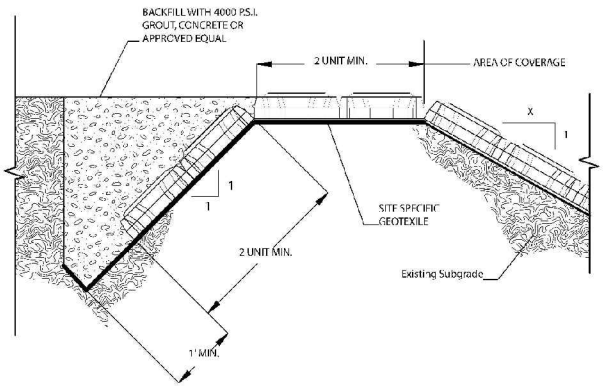


Tapered Series - Cross Section

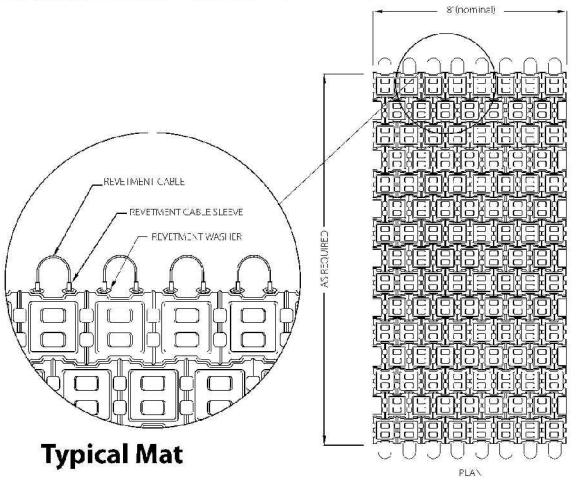


Top of Slope - Standard Detail

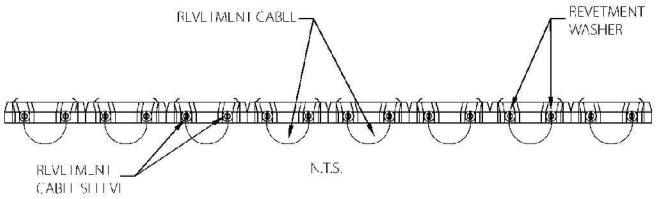
ArmorFlex Unit Specification

Concrete Block Class	Open/Closed Cell	Nominal Dimensions			Gross Area/ (sq. ft.)	Block Weight		Open Area %
		L	W	H		lbs	lbs/sq. ft.	
30s	Open	13.0	11.6	4.75	0.98	33-35	34-36	20
50s	Open	13.0	11.6	6.00	0.98	42-45	43-46	20
40	Open	17.4	15.5	4.75	1.77	59-64	33-36	20
50	Open	17.4	15.5	6.00	1.77	76-82	43-46	20
70	Open	17.4	15.5	8.50	1.77	108-117	61-66	20
40L	Open	17.4	23.6	4.75	2.58	97-105	38-41	20
70L	Open	17.4	23.6	8.50	2.58	174-188	68-73	20
45s	Closed	13.0	11.6	4.75	0.98	39-42	38-43	10
55s	Closed	13.0	11.6	6.00	0.98	50-54	49-55	10
45	Closed	17.4	15.5	4.75	1.77	71-77	40-43	10
55	Closed	17.4	15.5	6.00	1.77	91-98	52-56	10
85	Closed	17.4	15.5	8.50	1.77	136-146	77-83	10
45L	Closed	17.4	23.6	4.75	2.58	109-118	42-46	10
85L	Closed	17.4	23.6	8.50	2.58	207-223	80-87	10
High Velocity Application Block Classes								
40-T	Open	17.4	15.5	4.75	1.77	58-63	33-35	20
50-T	Open	17.4	15.5	6.00	1.77	75-81	43-46	20
70-T	Open	17.4	15.5	8.50	1.77	116-124	65-70	20

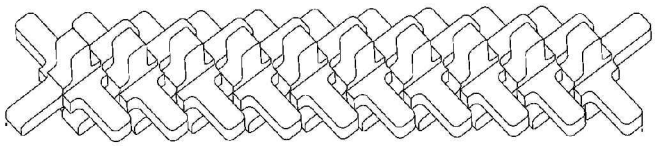
ArmorFlex® cont. (not to scale)



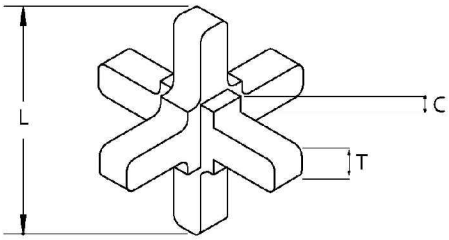
Typical Mat



A-Jacks® (not to scale)



A-Jacks Placement Profile

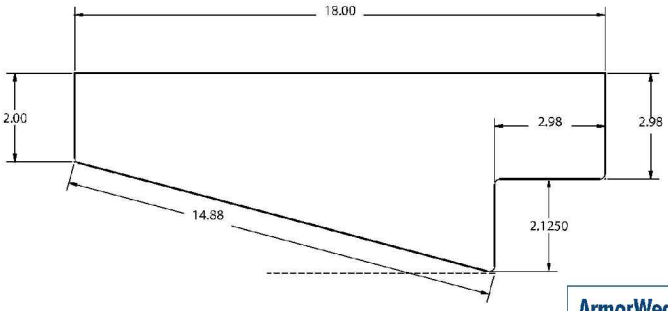


A-Jacks Unit

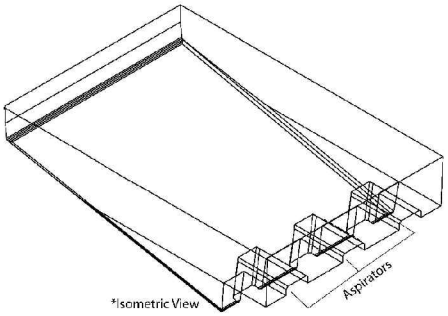
A-Jacks Unit Specification

A-JACKS	L(IN)	T(IN)/H(IN)	C(IN)	VOL(FT³)	WT (LBS)
AJ-24	24	4	1.84	0.56	78
AJ-48	48	7.36	3.68	4.49	629
AJ-72	72	11.04	5.52	15.14	2.120
AJ-96	96	14.72	7.396	35.87	5.022
AJ-120	120	18.40	9.20	70.69	9.699

ArmorWedge® (not to scale)



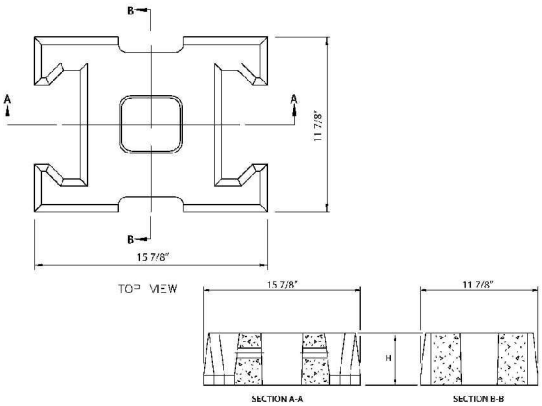
Side View - Typical Block



ArmorWedge Unit Specification

UNIT DIMENSION	UNIT WEIGHT (LBS/ FT³)	SYSTEM WEIGHT (LBS/ FT³)	UNIT COVERAGE (SF)	COMPRESSIVE STRENGTH (PSI)	MAXIMUM ABSORPTION (LBS/FT³)
12x18	130-140	54-59	1.1875	4000	12

ArmorLoc® (not to scale)

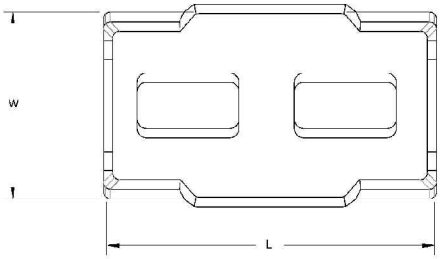


ArmorLoc Unit Specification

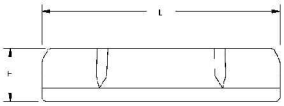
BLOCK	TECHNICAL DATA			DIMENSIONS AND WEIGHTS				
	Specific Weight lbs/ft³	Compressive Strength psi	Max Absorption, Avg. of 3 units 10 lbs/ft³	Thickness Inches (H)	Gross Area/ Grid ft²	Weights/ Grid lbs	Weights/ Area lbs/ft²	Open Area %
3510	130-140	4000 min	10	4	1.0	30-35	30-35	25
4511	130-140	4000 min	10	5.25	1.1	44-50	40-45	20
5011	130-140	4000 min	10	6	1.1	50-54	40-45	20

*Open-cell block shown. Closed-cell block also available.

ArmorStone® (not to sca e)



PLAN

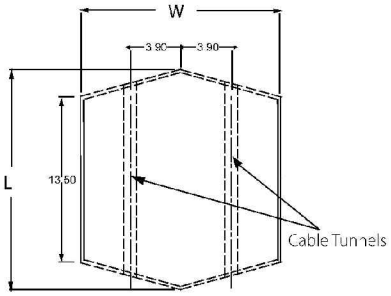


FRONT

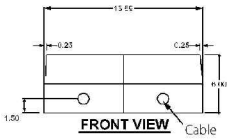
ArmorStone Unit Specification

CONCRETE BLOCK CLASS		NOMINAL DIMENSIONS (IN.)			UNIT COVERAGE (SF)	BLOCK		OPEN AREA %
		L	W	H		UNIT WEIGHT LBS.	SYSTEMS WEIGHTS LBS./SF	
AS 40	Open	18.00	10.00	4.50	1.25	50-54	40-44	25
AS 55	Closed	18.00	10.00	4.50	1.25	61-66	49-53	5

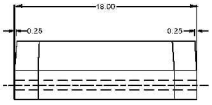
ArmorRoad® (not to scale)



TOP VIEW



FRONT VIEW



SIDE VIEW

ArmorRoad Unit Specification

BLOCK	TYPE	L	W	H	SF COVERAGE PER UNIT	WEIGHT LBS PER UNIT	SF PER TRUCK LOAD
Mat	Closed	18.00	15.60	6.00	1.74	105-109	750
Individual	Closed	18.00	15.60	6.00	1.74	100-104	750

ARMORTEC Minimum Physical Requirements per ASTM 06684-04

MIN. DENSITY (IN AIR) LBS/FT³		MIN. COMPRESSIVE STRENGTH PSI		MAX WATER ABSORPTION LBS/FT³	
Ave. of 3 Units	Individual Unit	Ave. of 3 Units	Individual Unit	Ave. of 3 Units	Individual Unit
130	125	4,000	3,500	9.1	11.7

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NDS
WE PUT WATER IN ITS PLACE

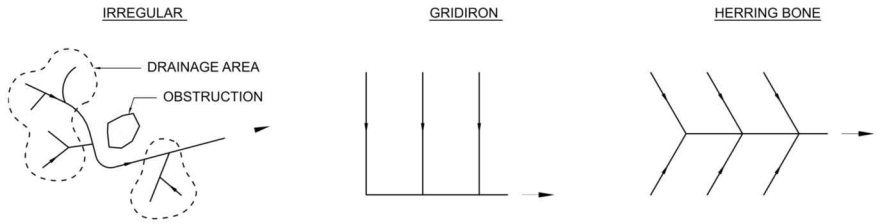
French Drains

Subsurface drainage systems have been in common use for centuries. They take many forms, but are all similar in design and function to the traditional French drain. French drains are excavated trenches filled with aggregate surrounding a slotted or perforated pipe that conveys excess surface and groundwater to a discharge point away from the drainage area. **EZ***flow* drainage products can be used as a substitution for conventional aggregate in French drain systems.

PLACEMENT

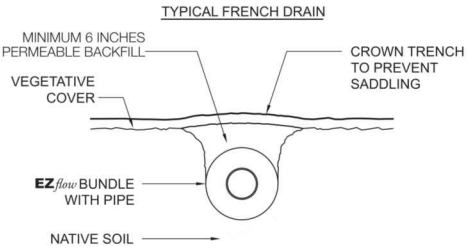
EZ*flow* drainage French drains should be laid out strategically to dewater irregular, poorly drained areas. A defined pattern such as a herring bone and gridiron should be used to drain complete areas including lawns, athletic fields, golf course greens and sand traps. These patterns include laterals that drain to collectors that discharge to an outfall. In general, laterals should not be longer than 50 feet and collectors no longer than 100 feet without increasing the pipe diameter downstream. In addition, the slope of each downgradient run should increase throughout the length of the system.

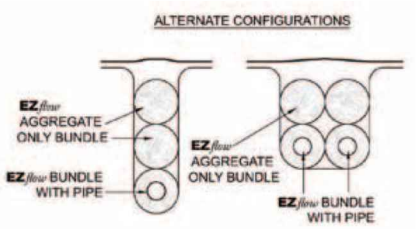
Trench depth and spacing will vary depending on soil texture of the area being drained. Trench depth can also be limited by outlet conditions in flatter areas. Lines may be spaced widely and deeply in sandy soils, and are generally placed shallower and closer together in clay soils.

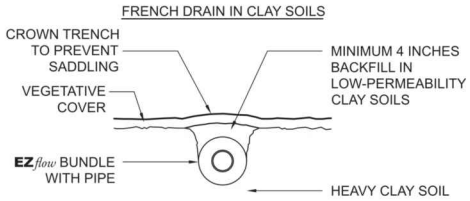


PRODUCT

The 7-inch **EZ***flow* drainage bundles with integrated 3-inch pipe are appropriate for small area residential subsurface drainage systems. 10-inch bundles with 4-inch pipe can be used to drain areas of up to two acres in poorly drained organic soils. In larger areas or if there is over 200 feet of pipe upstream, the 15-inch bundles with 6-inch pipe are recommended.





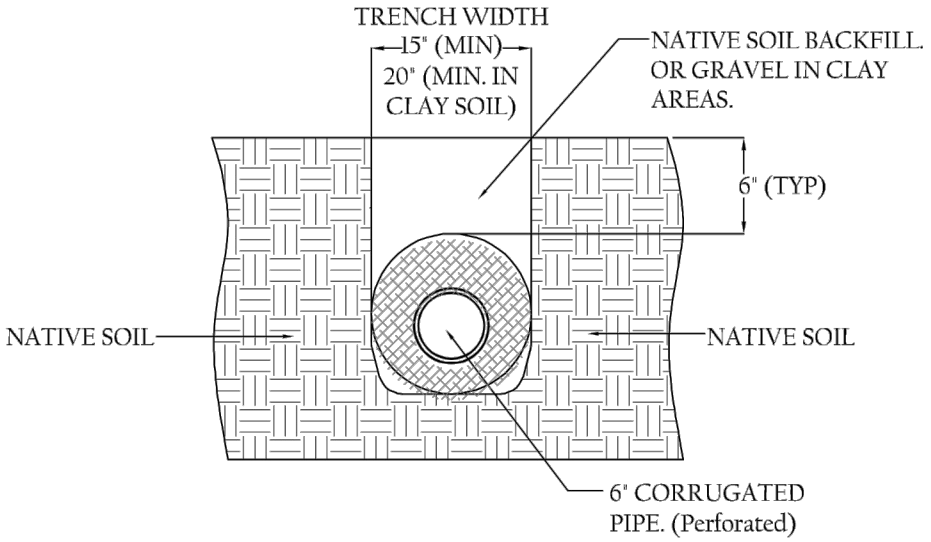


Minimum Recommended Depth of Cover*	
Condition	**Depth (in.)**
Residential area, commercial lawn mowers	6**
Athletic fields with consistent activity	8
Areas with occasional light vehicular traffic	12

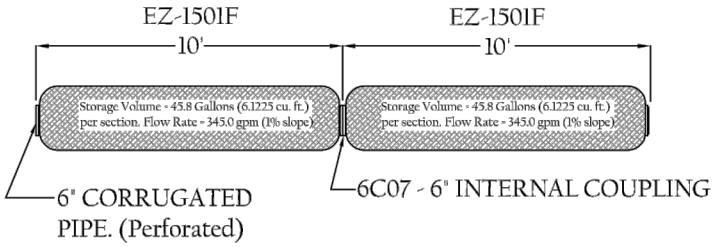
* It is recommended that **EZ***flow* drainage systems be installed a minimum of 6 inches below existing or planned subsurface irrigation lines.
** In low-permeability clay soils, trenches can be placed with a minimum 4 inches of permeable backfill.

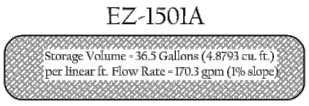
EZflow

TRENCH DRAIN DETAIL



SECTION





PLAN VIEW

ADDITIONAL COVER MAY BE REQUIRED BASED ON SITE CONDITIONS. 12" COVER REQUIRED TO OBTAIN AN H-10 LOAD RATING. CONSULT WITH A LOCAL ENGINEER FOR SITE SPECIFIC REQUIREMENTS.

EZflow™

AGGREGATE DRAINAGE SYSTEM

NDS

TECHNICAL SERVICES
1-888-825-4716
techservice@ndspro.com

N. T. S.

TRENCH DRAIN DETAIL

French Drain Installation Instructions

The steps below offer typical installation practices for French drains and will vary based on site conditions. These practices are also applicable to landscape plant bed drains and for wet areas on golf courses.

1. Identify the area to be drained and mark off lateral and collector lines before digging beginning trench excavation.

2. Start excavating the trench at the discharge point or where connections to downstream piping will be made. Trench width should be equal to the diameter of the bundle being used. Trench depth will reflect existing terrain, desired drainage line slope and length, height of bundles(s) and required cover thickness. Ensure proper slopes by using a transit or builder's level and grade the trench bottom evenly for proper flow.

3. Place the **EZ** *flow* drainage bundle with pipe end to end along the edge of the trench. Use an end cap at the system high point and fully insert the proper couplings at all bundle-to-bundle connections. Lay the connected bundles with pipe in trench, stacking aggregate-only bundles above these bundles as needed.

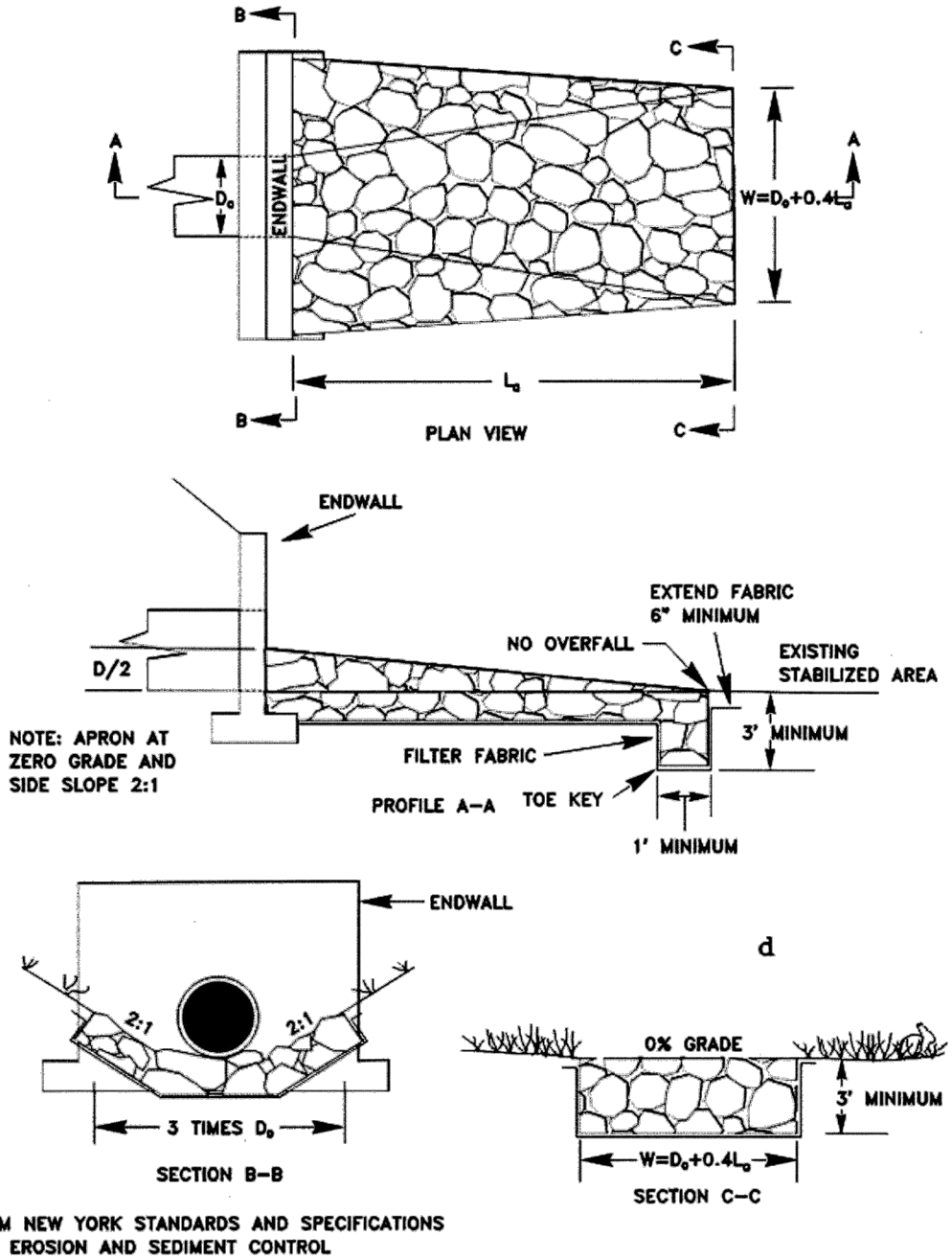
4. Place a minimum of 4-inches permeable backfill (see recommended depths of cover on page 6) over the bundles without compaction. Additional sand/backfill can be placed and compacted normally above the loose fill to prevent trench saddling. Cover trench with sod or topsoil and seed to finish installation.

TRENCH DRAIN DETAIL

FIGURE 3.17.3

OUTLET PROTECTION

DISCHARGE TO UNCONFINED SECTION
(MINIMUM TAILWATER)

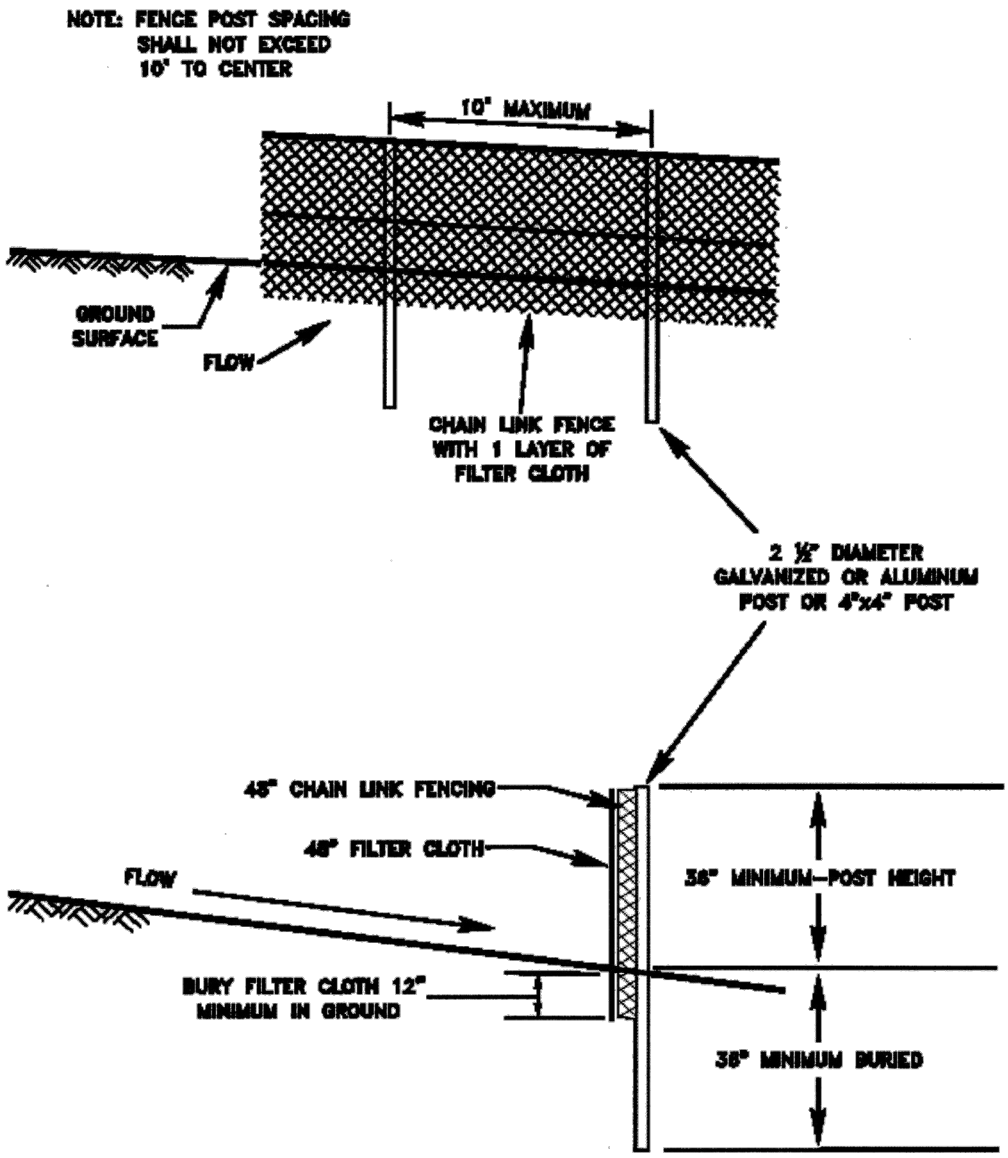


FROM NEW YORK STANDARDS AND SPECIFICATIONS
FOR EROSION AND SEDIMENT CONTROL

OUTLET PROTECTION DETAIL

FIGURE 3.28.1

SUPER SILT FENCE



SUPER SILT FENCE DETAIL

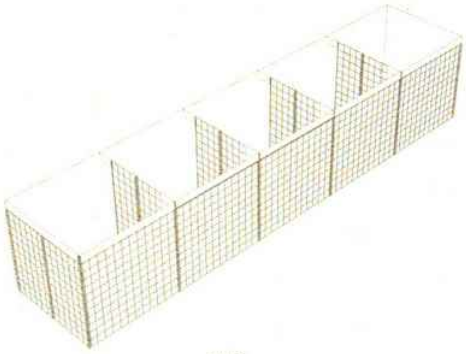
BARRICAGE™ FLOOD

SHIELD | FLOOD | EARTH | ROCK

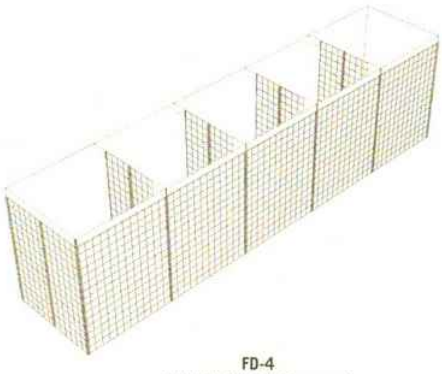
BarriCage™ geotextile-lined civil system for flood-defense applications. Interior grids free of geotextile fabric allow the fill to compact between cells. Easily fillable with dirt, sand, or gravel. Spiral corners join to other units with included connecting pins. Plastic ties are provided to secure geotextile lining and prevent fill from falling between system joints.

Connecting Pin

Plastic Tie



FD-3
H-3' W-3' L-15' (5 cages)



FD-4
H-4' W-3' L-15' (5 cages)

GENERAL SPECIFICATIONS:

Galvanized welded wire system to ASTM A 974-97 standards with geotextile lining. Lining is high-quality, nonwoven geotextile made of polypropylene fibers designed to form a high-strength fabric. Geotextile liner is available in tan color.

WELDED WIRE GRID CONTAINER	
Wire	
Wire Guage	8.5 American SWG, steel
Wire Diameter	0.155"/3.937mm
Wire Tensile Strength	80-110 ksi 550-760 kPa
Corrosion Protection	Zn-5Al-MM to ASTM A 856A/A 856M-03 minimum coating weight 0.8oz/Ft²/240g/m²
Grid	
Wire Spacing	3" x 3"
Tolerance on Line Wire Spacing	+/ - 1/8"
Cross Wire Straightness Across Test Panel	Limit of deviation 1/4" in 72"
Mesh Strength	70% of wire tensile strength
Panels	
Squareness	In 4' diagonals shall not vary by more than 5/8"
Flatness	In 6' not more than 2" from plane

GEOTEXTILE	STANDARD	VALUE
Mechanical Properties		
Grab Tensile Strength (Machine Direction)	ASTM D 4632	170lbs.
Grab Tensile Strength (Cross Direction)	ASTM D 4632	170lbs.
Grab Elongation (Machine Direction)	ASTM D 4632	50%
CBR Puncture	ASTM D 6241	450lbs.
Endurance Resistance		
Trapezoidal Tear (Machine Direction)	ASTM D 4533	70lbs.
Trapezoidal Tear (Cross Direction)	ASTM D 4533	70lbs.
UV Resistance (% retained after 500 hrs)	ASTM D 4355	90%
Hydraulic Properties		
Apparent Opening Size*	ASTM D 4751	70 US Std. Sieve
Permittivity*	ASTM D 4491	1.50sec⁻¹
Permeability*	ASTM D 4491	.38 cm/sec
Water Flow*	ASTM D 4491	110 gpm/ft²

*At time of manufacturing. Handling may change these properties.

a product of landmark EARTH SOLUTIONS, INC.

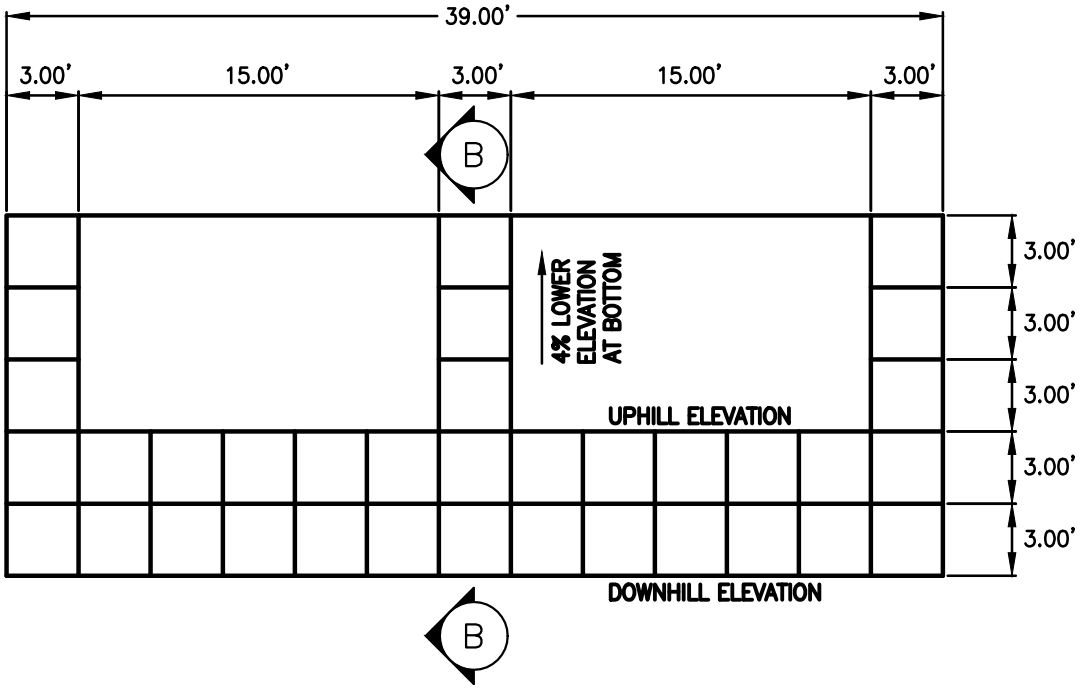
The given values were obtained through a series of testing performed by our suppliers and other outside testing facilities. The information included herein is subject to change at any time without notice from Landmark Earth Solutions™, Inc.

LandmarkEarthSolutions.com | (888) 574-6473 (#3)

BarriCage gabion system meets all ASTM A974 requirements and specifications. All trademarks owned by Landmark Earth Solutions, Inc.
©2012 Landmark Earth Solutions, Incorporated, a subsidiary of Leggett & Platt, Incorporated | 11087_1-12

barricage™

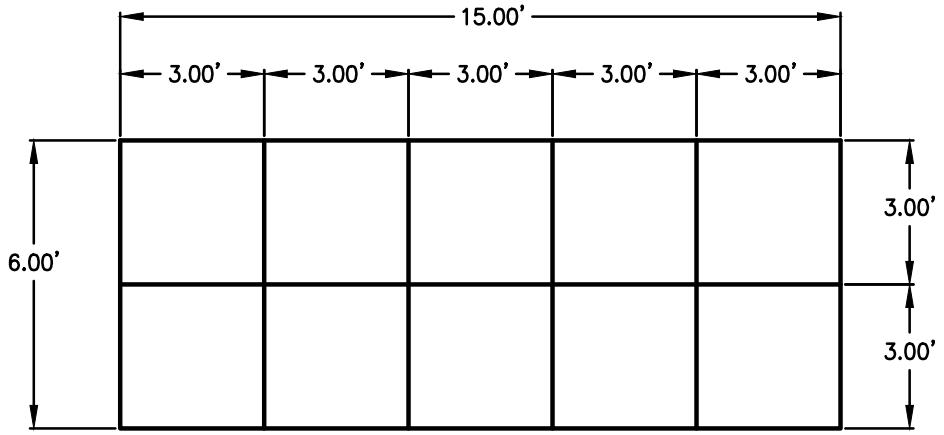
BARRICAGE CONTAINMENT DETAIL



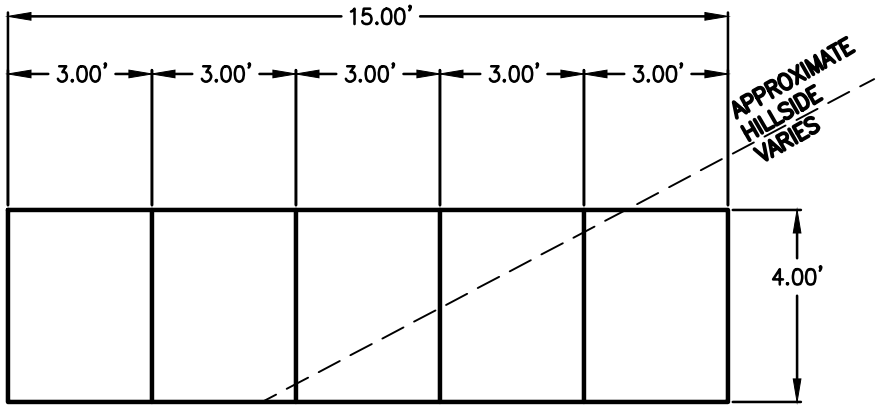
PLAN VIEW
N.T.S.

NOTE:
THIS PRODUCT FOR USE AS A TEMPORARY BUTTRESS
OR CONTAINMENT. NOT FOR PERMANENT USE.

BARRICAGE CONTAINMENT DETAIL



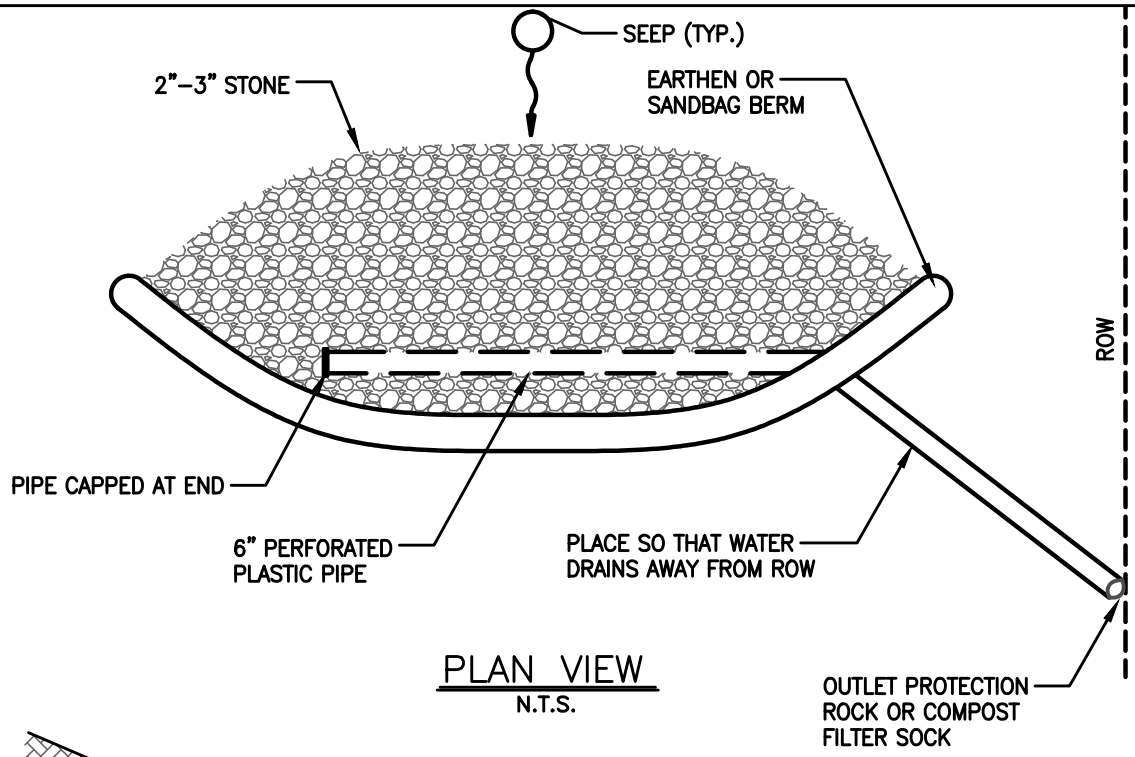
AERIAL VIEW
N.T.S.



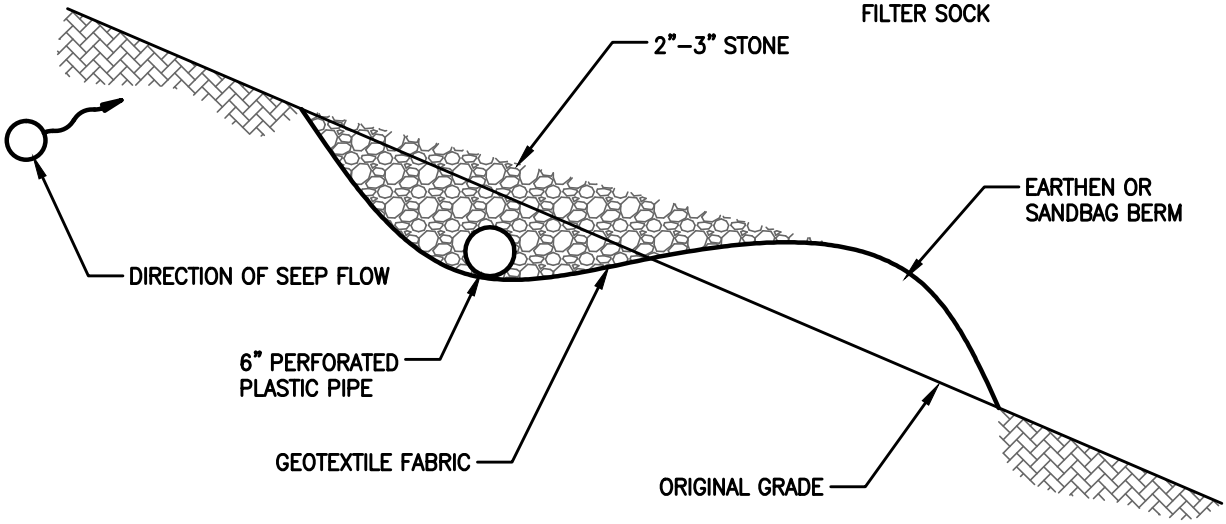
SECTION B
N.T.S.

NOTE:
THIS PRODUCT FOR USE AS A TEMPORARY BUTTRESS
OR CONTAINMENT. NOT FOR PERMANENT USE.

BARRICAGE CONTAINMENT DETAIL



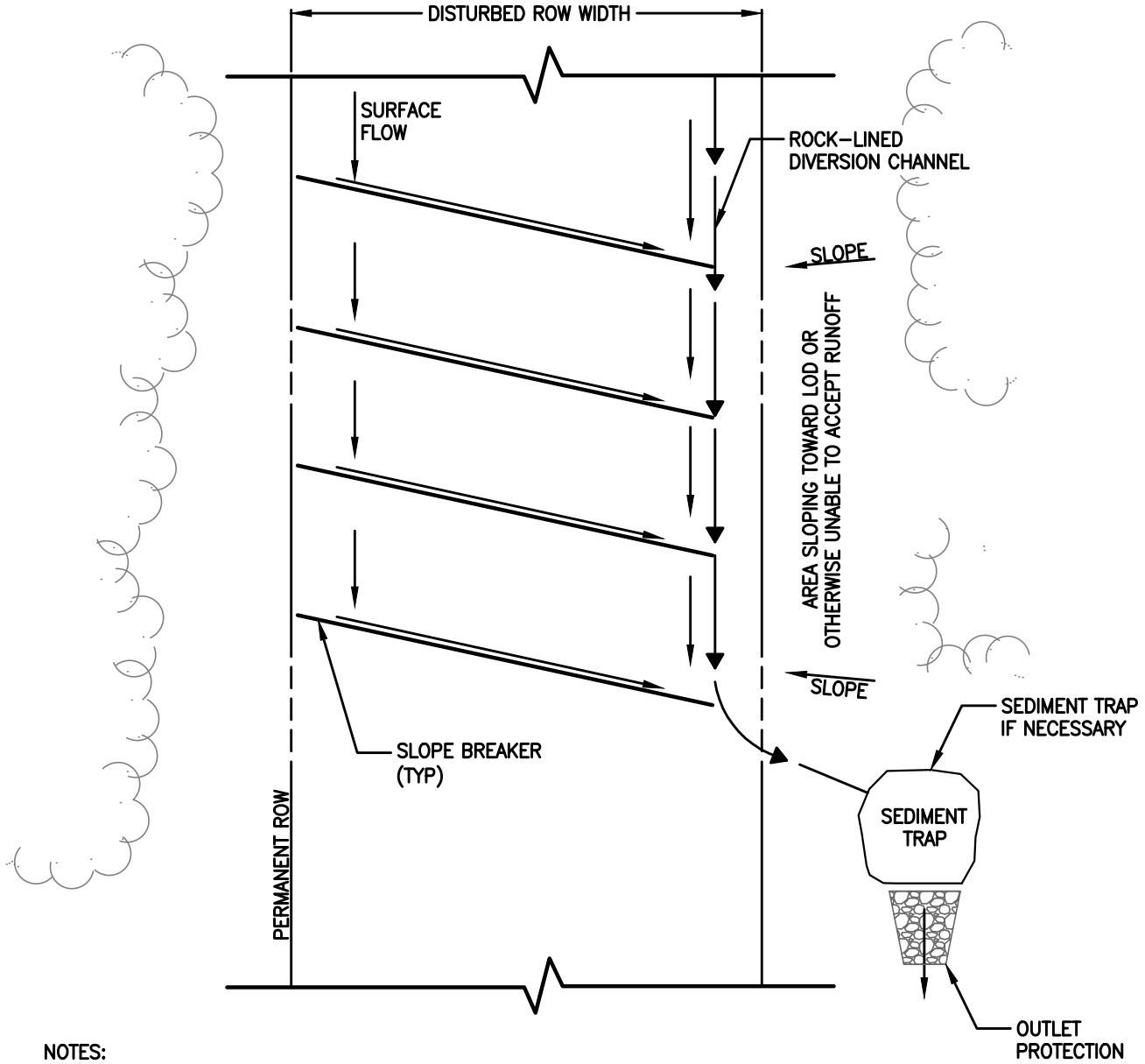
PLAN VIEW
N.T.S.



SECTION
N.T.S.

NOTE:
BERMS MAY BE CONSTRUCTED USING SANDBAGS TEMPORARILY DURING CONSTRUCTION. PERMANENT BERMS TO BE CONSTRUCTED USING COMPACTED EARTH.

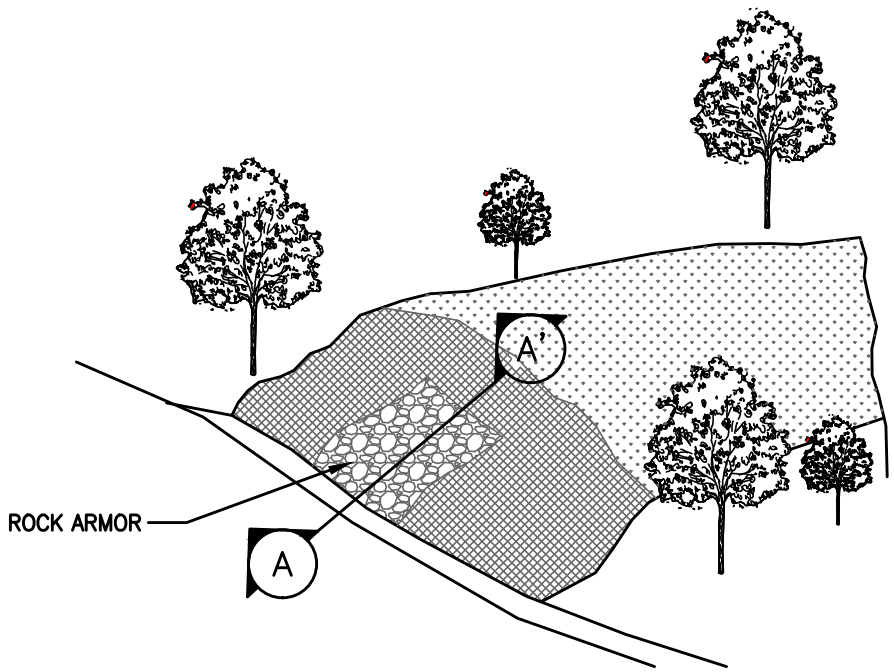
SEEP COLLECTOR DETAIL



NOTES:

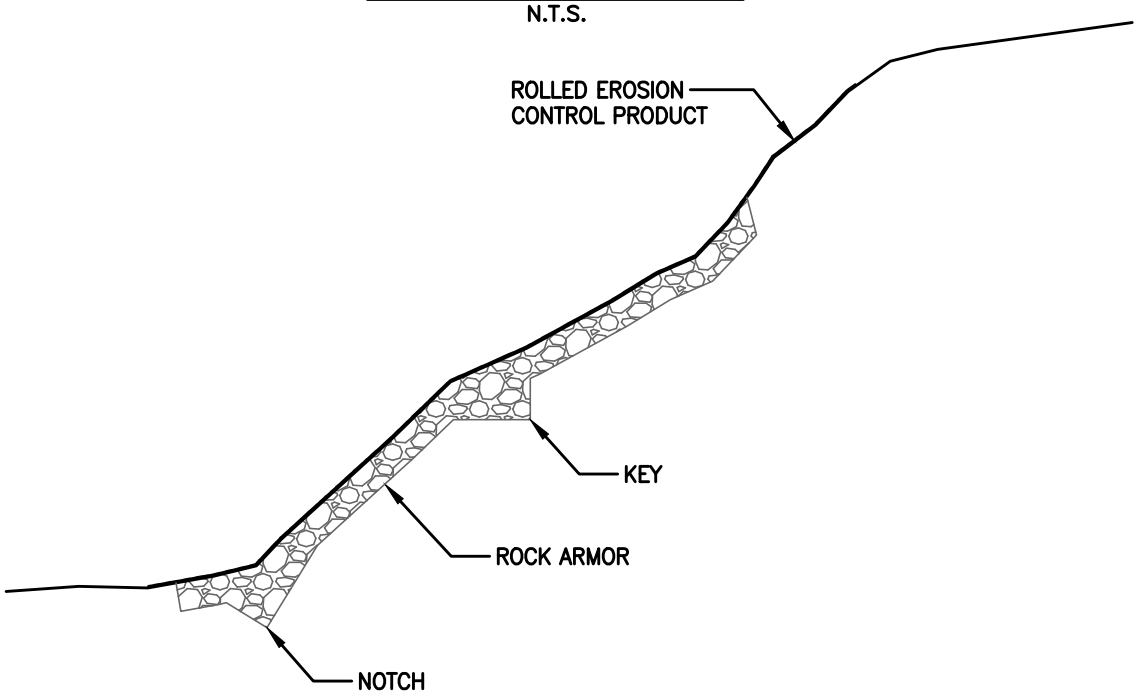
1. CHANNEL AND SLOPE BREAKER LAYOUT WILL NEED TO BE FIELD ADJUSTED TO CONFORM TO SITE CONDITIONS
2. CHANNEL MAY REQUIRE STONE CHECK DAMS, ROLLED EROSION CONTROL PRODUCTS AND OTHER SITE SPECIFIC EROSION AND SEDIMENT CONTROL MEASURES AS NECESSARY
3. SEDIMENT TRAP MAY BE REQUIRED WHERE SUFFICIENT VEGETATIVE COVER EXISTS DOWNSLOPE OF DIVERSION CHANNEL
4. SEDIMENT TRAP WILL REQUIRE SIZING BY AN ENGINEER

CROSS DRAIN DETAIL



PERSPECTIVE VIEW

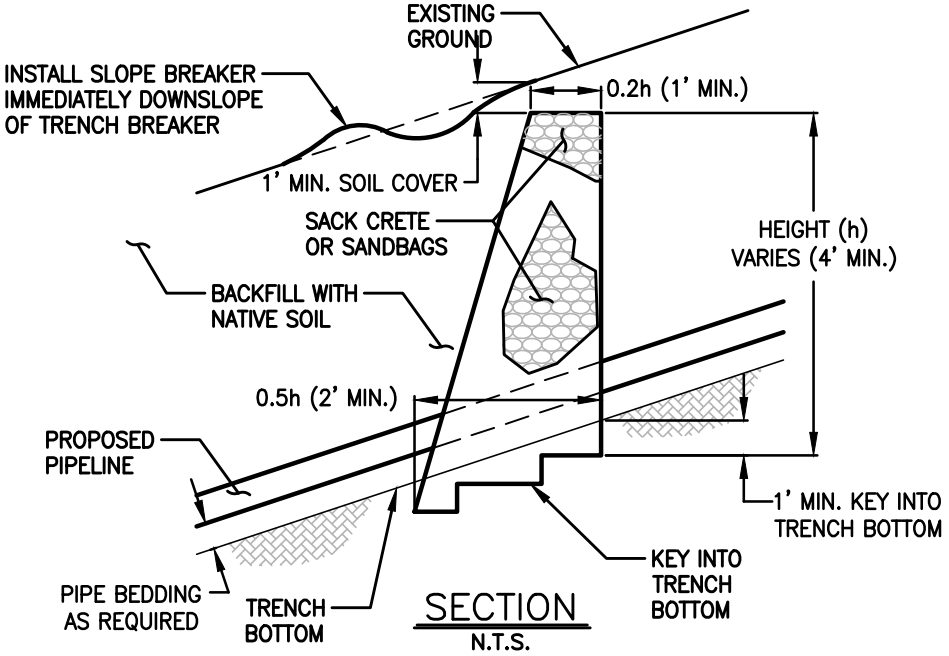
N.T.S.



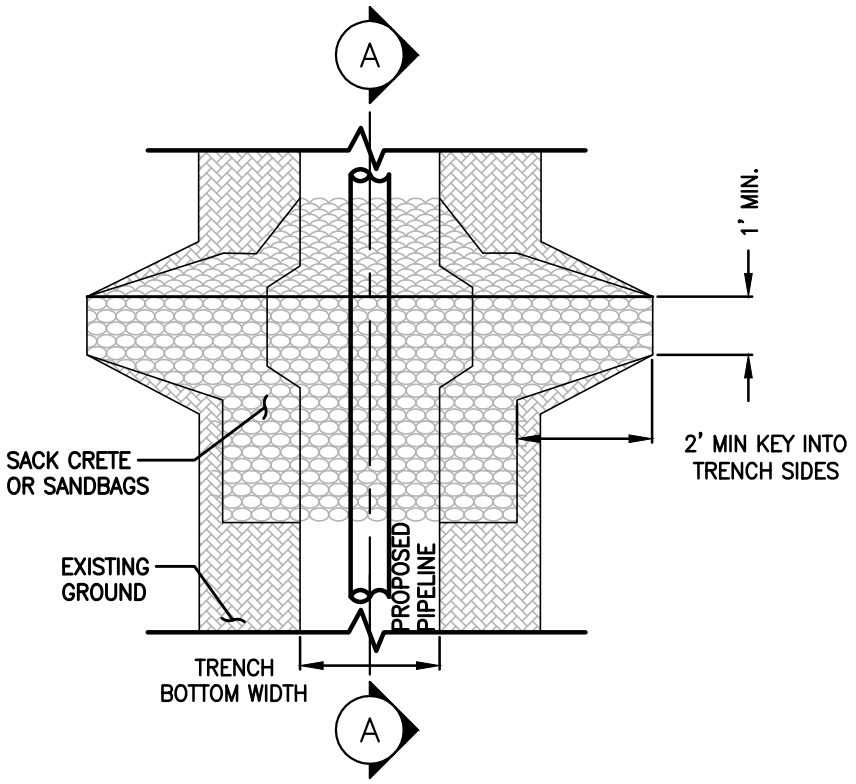
A–A' ROCK ARMOR ON STEEP SLOPE

N.T.S.

ROCK FILTER BLANKET DETAIL

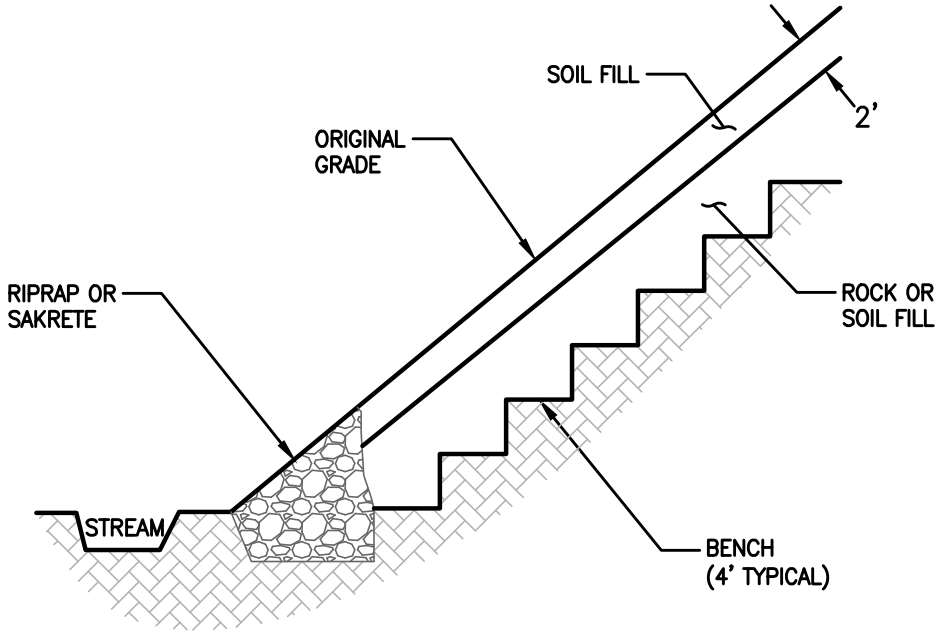


SECTION
N.T.S.

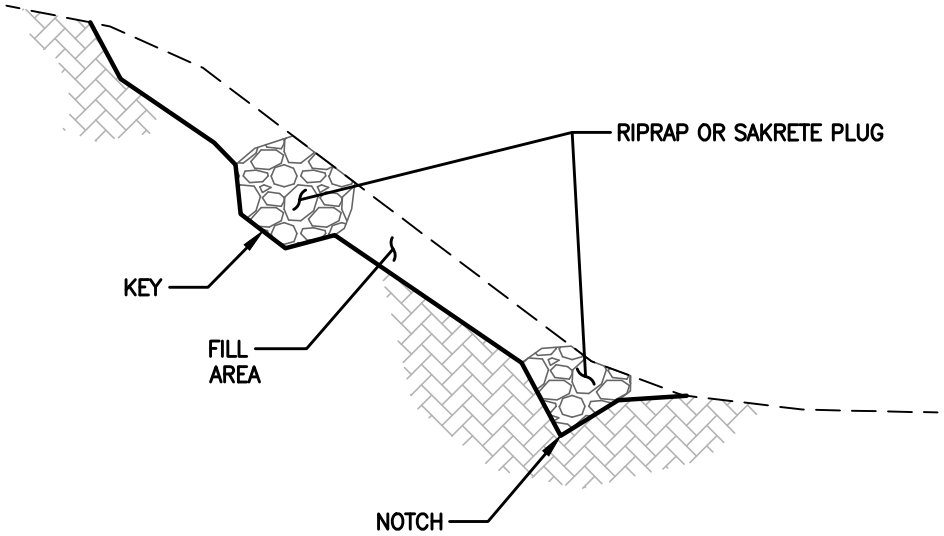


PLAN VIEW
N.T.S.

TRENCH PLUG AND WATERBAR DETAIL

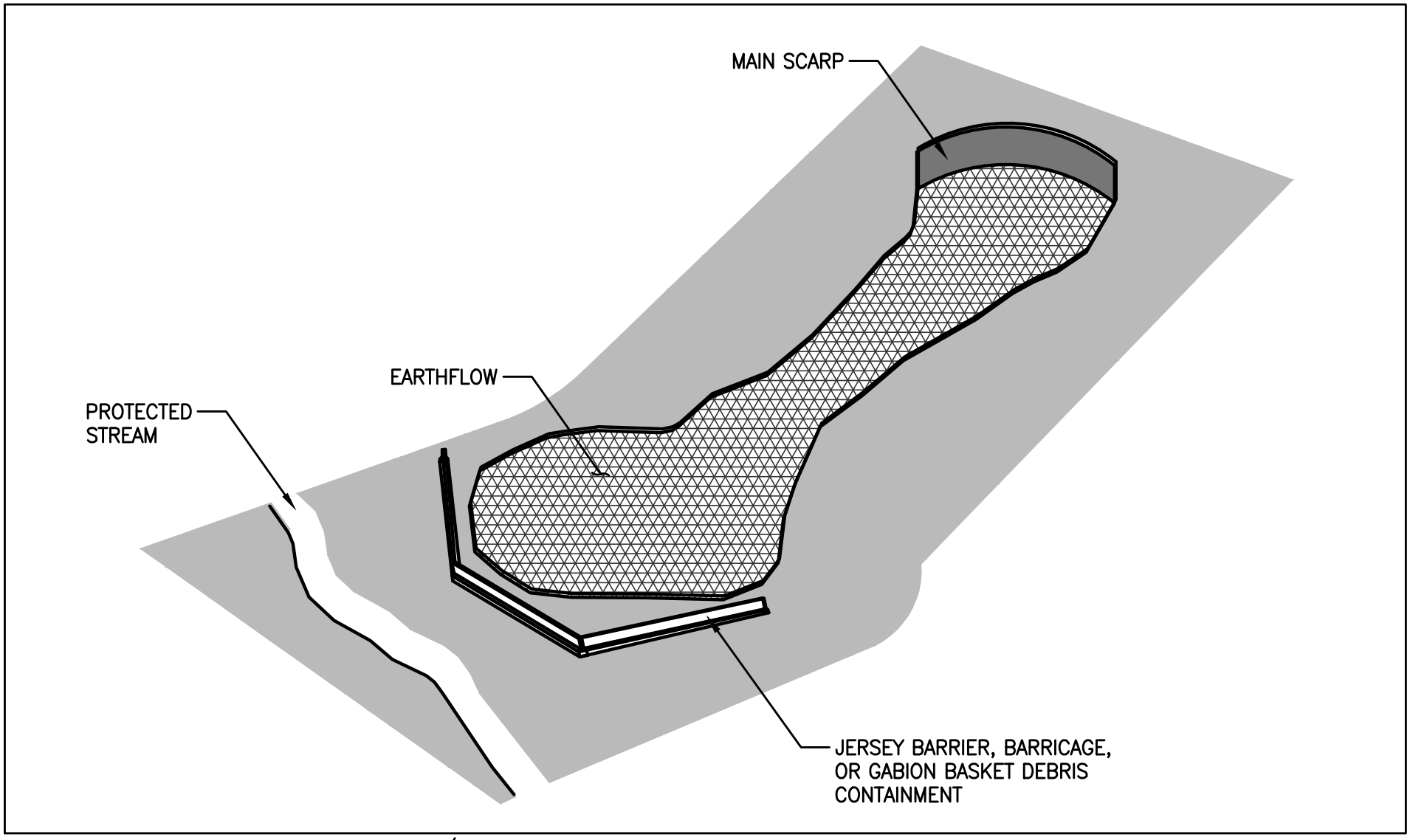


BENCH AND REGRADE TYPICAL
N.T.S.

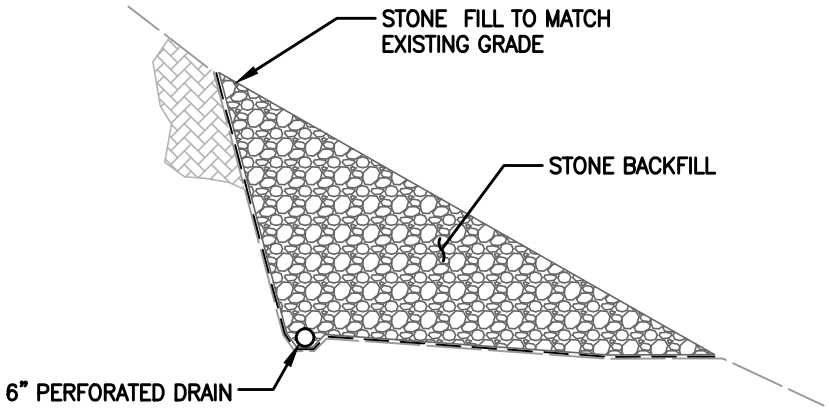


KEYING TYPICAL
N.T.S.

BENCH AND REGRADE WITH CONTROLLED BACKFILL DETAIL

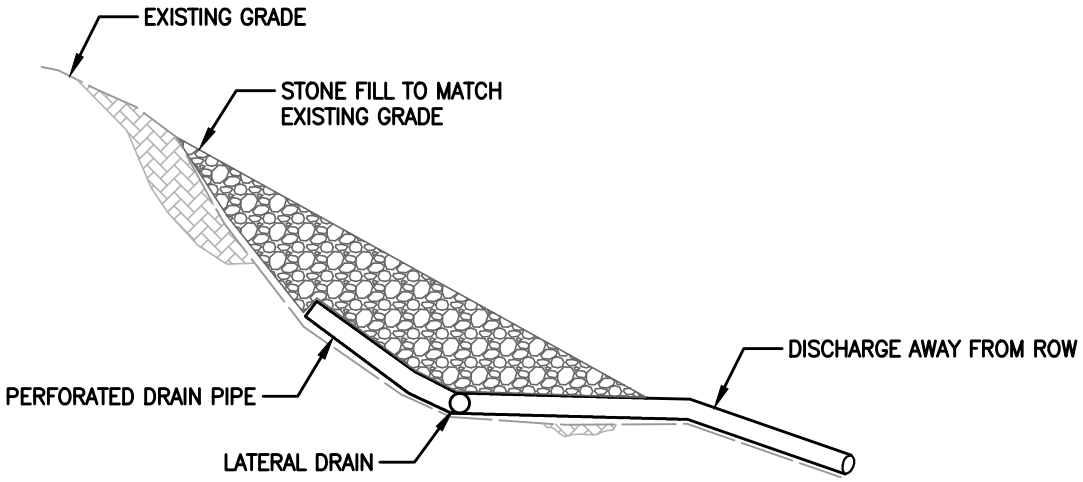


GABION BASKET/JERSEY BARRIER CONTAINMENT DETAIL



STONE WITH DRAIN TO RESTORE FAILING SLOPE

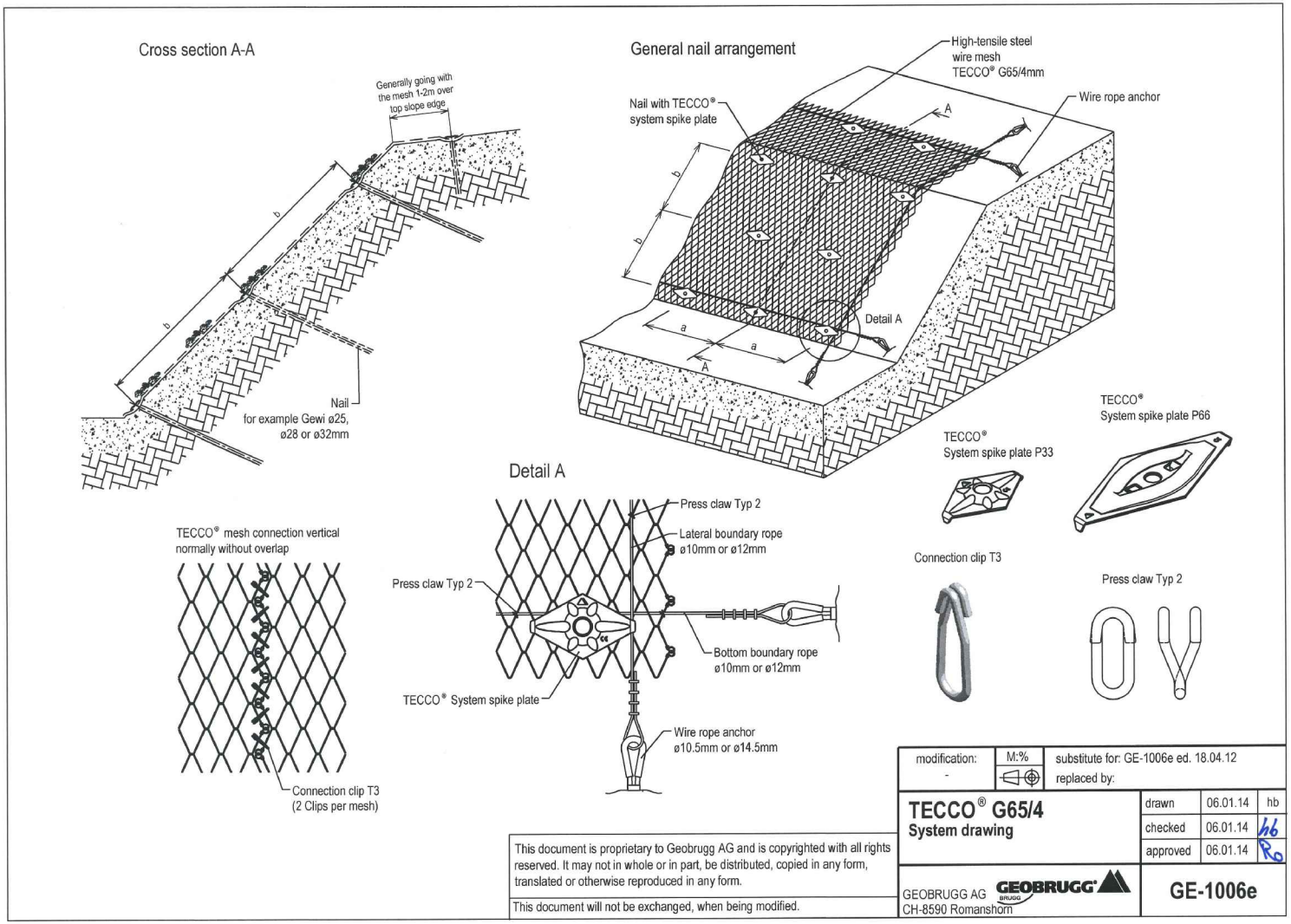
N.T.S.



SMALL SLIP REPAIR WITH LATERAL

N.T.S.

ROCK FILL ON SLOPES BETWEEN 30–38 DEGREES DETAIL



GEOBRUGG–TECCO SYSTEM – WIRE MESH STABILIZATION

APPENDIX C

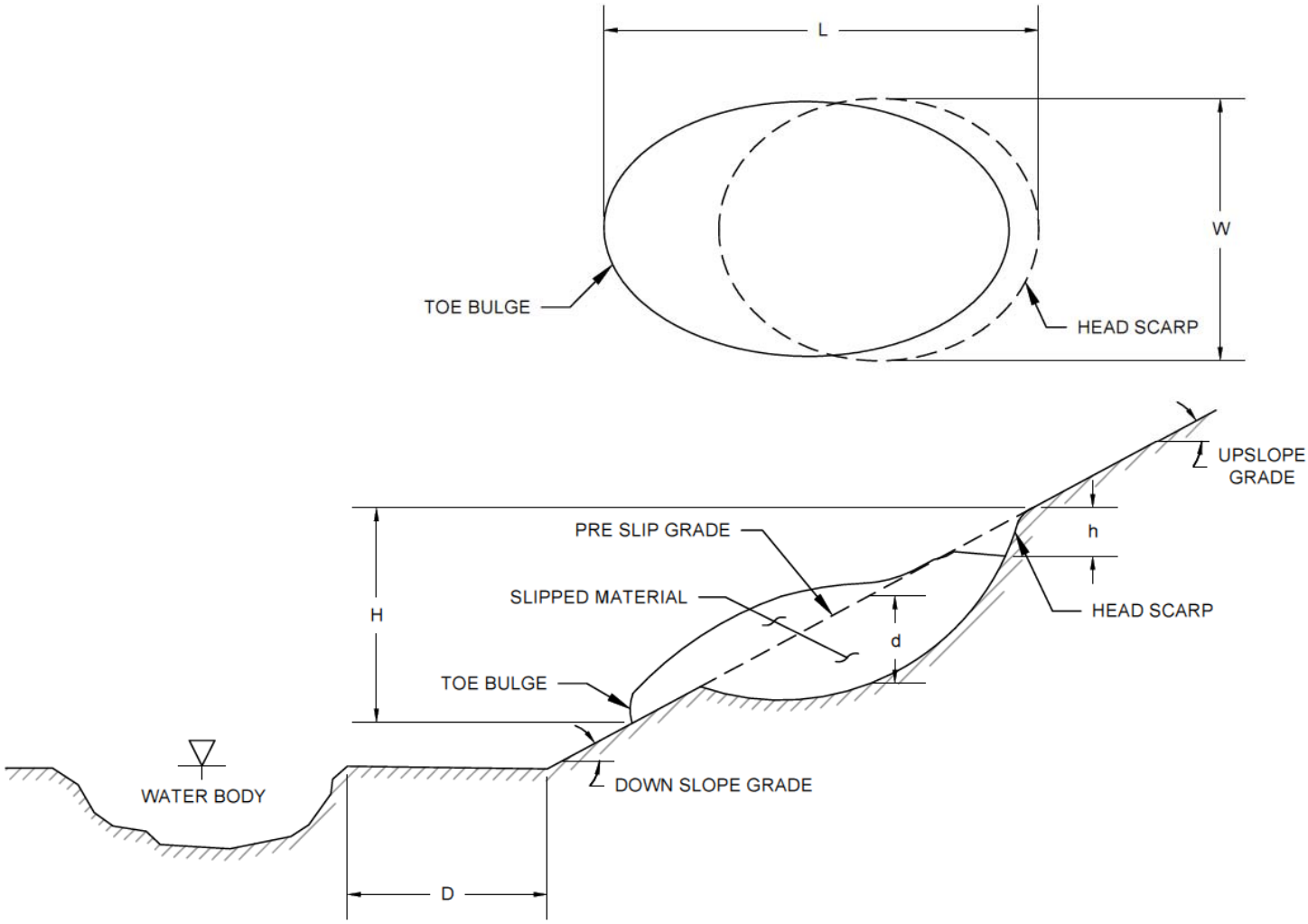
Forms

SLOPE FAILURE INFORMATION AND REPORTING FORM

Pipeline Name	
Slope Failure Station	GPS Coordinates Latitude _____ Longitude _____

Name of Observer	
Date	

Slope Failure Priority per Guidance in Appendix D Policy	○ 1 ○ 2 ○ 3 ○ 4



Slope Characteristics

General dimensions (Rough estimate) *See above sketch for dimension key	Length, ***L*** (ft): _____ Width, ***W*** (ft): _____ Head Scarp Height, ***H*** (ft):_____ Height of total slope failure area, ***h*** (ft):_____ Distance from base of slope to waterbody, ***D*** (ft)_____ Estimated maximum depth of failure surface, ***d*** (ft)_____
Slope Angle	At failure ____20° or flatter ____22° to 30° ____30° to 38° ____Steeper than 38°
	Upslope ____20° or flatter ____22° to 30° ____30° to 38° ____Steeper than 38°
	Downslope ____20° or flatter ____22° to 30° ____30° to 38° ____Steeper than 38°
Slope direction relative to pipeline	____ Pipeline is parallel to slope (up and down slope) ____ Some amount of cross slope ____ Pipeline is perpendicular to slope (cross slope, or sidehilling)
Slope type	____ Natural ____Cut ____ Fill ____ Cut and fill
Presence of surface water	____ Yes ____ No ____ Unknown Describe: _____
Presence of groundwater	____ Yes ____ No ____ Unknown Describe: _____
Rock outcrops	____ Yes ____ No ____ Possible Describe location:
Rock type	____ Shale ____ Mudstone /Claystone ____ Siltstone ____ Sandstone ____ Limestone ____ Coal ____ Interbedded ____ Others _____
Is there evidence of tree movement? **Look at trunks**	Perpendicular or leaning tree trunks is evidence of recent movement Describe: _____
	Tree trunk bending and going vertical is evidence of previous slide movement Describe: _____

Slope Failure Characteristics

Failure surface appearance	____ Circular ____ Hummocky ____ Terraced
Type of movement	____ Rotational slide ____ Translational block slide ____ Debris slide ____ Complex
Failure material(s)	____ Soil ____ Rock ____ Both Describe:
Head scarp	Describe:
Secondary scarps	Describe:
Evidence of toe bulge	____ Yes ____ No ____ Possible
Evidence of erosion	____ Head ____ Toe ____ Flank ____ Body ____ None
Is failure within pipeline ROW	____ Permanent ____ Temporary ____ Outside LOD
Current impact to adjacent structures or properties	____ Waterbody ____ Pipeline/Utilities ____ Roads ____ Railroad ____ Residential ____ Buildings ____ Bridge ____ None ____ Others_____ Distance from toe of slope (ft): _____
Potential impact to adjacent structures or properties	____Waterbody ____Pipeline/Utilities ____Roads ____Railroad ____ Residential ____ Buildings ____ Bridge ____ None ____ Others _____ Horizontal distance from toe of slope (ft): _____

Existing remediation	☐ Drainage ☐ Bio-stabilization ☐ Slope geometry correction ☐ Retaining structures ☐ Internal slope reinforcement ☐ Erosion control ☐ Chemical stabilization ☐ None ☐ Others _____ Describe:

Other

Site access	☐ Site is accessible by permanent road, or active temporary access road ☐ Site access requires traversing steep slopes or long distance along ROW
Contractor availability	☐ Pipeline contractor still on site ☐ Pipeline contractor no longer on site, but still responsible for ROW restoration ☐ Pipeline contractor not contractually obligated for ROW restoration ☐ Specialty contractor required for anticipated repair method

Comments	

Photo Log

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SLOPE FAILURE SKETCH

Plan View and Cross-Section

Pipeline Name	Slope Failure Station

SLOPE FAILURE REPAIR ASSESSMENT FORM

Use this form to evaluate whether repair of an existing slope failure will be field-directed or engineering-directed, and whether to engage a specialist in slope failure evaluation and repair (i.e., geotechnical engineer).

PIPELINE NAME: _____ **SLOPE FAILURE STATION:** _____ **DATE:** _____

FILLED OUT BY: _____ **PROJECT MANAGER:** _____

Criteria	Value	Selected Score
Slope Steepness		
Flatter than 20 degrees	1	
20 degrees to 30 degrees	5	
30 degrees to 38 degrees	10	
Steeper than 38 degrees	20	
Slope Direction Relative to Pipeline		
Pipeline is parallel to slope (i.e., up and down the slope)	1	
Some amount of cross slope	5	
Pipeline is perpendicular to slope (i.e., cross slope, or sidehilling)	10	
Evidence of Pre-existing Slope Failures		
None	1	
Mapped slope failures are present at the site, or pipeline plans indicate this location is a slope failure-prone hazard	5	
Tree trunks in the vicinity bend and go vertical	10	
Slope Failure Location		
Slope failure and material is fully within ROW	1	
Slope failure or material extends beyond ROW	10	
Consequence of Future Movement		
No Potential for Impact to pipeline, water bodies, roadways or private property	1	
Slope failure has potential to cause danger to human health and the environment (compromises other utilities, pipeline rupture, blocked public roadway(s), fish kill, release of pipeline fluids, sediment/debris in stream)	3	
Slope failure has caused an immediate danger to human health and the environment (compromises other utilities, pipeline rupture, blocked public roadway(s), fish kill, release of pipeline fluids, sediment/debris in stream)	5	
Site Access		
Site is accessible by permanent road or active temp. access road	1	
Site access requires traversing steep slopes or long distance along ROW	5	
Contractor Availability		
Pipeline contractor still on site	1	
Pipeline contractor no longer on site, but still responsible for ROW restoration	3	
Pipeline contractor not contractually obligated for ROW restoration	5	
Specialty contractor required for anticipated slope failure repair method	10	
	TOTAL	**0**

	Score
Field-directed repair	7-25
Engineering-directed repair	20-35
Engage third party specialist (i.e., geotechnical engineer)	30-70

APPENDIX D
Slope Failure Priority Guidance

Slope Failure Priority Guidance

- If you identify a slope failure on an *actively permitted construction project*, you must immediately notify the Environmental Compliance Coordinator (ECC). The ECC will coordinate with Energy Environmental Infrastructure Services (EIES) to determine the slope failure priority and the regulatory agency notification requirements. The ECC will notify the appropriate regulatory agencies as applicable.
- The ECC and EIES will work with you to identify the slope failure priority (see below).
- The ECC will provide immediate notification to the appropriate regulatory agency as required. **NOTE**: most regulatory agencies define immediate as "upon awareness and knowledge," and generally expects this to occur within 2 hours.
- If the ECC cannot be reached, contact the permitting lead in EIES. If neither the ECC nor the EIES permitting lead can be reached, please review the Slope Failure Priority Guidance below and prioritize the slope failure. For all priority 1 and 2 slope failures, immediate notification must be made to the appropriate regulatory agency. In most states this is the state emergency Spill Line, but not the National Response Center.

Slope Failure Priority Guidance

Priority 1 Slope Failure:

Definition: A slope failure which has caused an immediate danger to human health and/or the environment. This type of slope failure requires an emergency response.

Criteria: If any one of the following criteria exists, it is a Priority 1 slope failure.

- Compromises or threatens other utilities.
- Active and/or functional pipeline is broken or detached.
- A public roadway which may be used for emergency vehicles is blocked.
- A fish kill has been observed and/or reported in the general vicinity.
- Release of aqueous phase hydrocarbons (i.e. condensate). If aqueous phase hydrocarbons have been released to surface water additional notification to the National Response Center may be required.

Required Actions: Depending on the criteria met above, at least one or more of the following actions must be taken for a Priority 1 slope failure.

- Contact 811 or the appropriate one call for utilities.
- Notify the appropriate state Spill Line.
- Contact responsible party if not Dominion and potential to impact our right of way.
- Contact any other outside agencies for emergency purposes as necessary.

Priority 2 Slope Failure:

Definition: A slope failure or associated migration of sediment and/or debris, which has reached a waterway causing Conditions Not Allowable in state waters.

Criteria: If any one of the following criteria exists, it is a Priority 2 slope failure.

- Slope failure material or sediment laden runoff has entered water body.
- A pipeline is exposed but not broken.

Required Actions: At least one of the following actions must be taken for a Priority 2 slope failure.

- Contact 811 or the appropriate one call for utilities.
- Notify the appropriate state Spill Line.
- Contact responsible party if not Dominion and potential to impact our right of way.
- Contact any other outside agencies for emergency purposes as necessary.

Priority 3 Slope Failure:

Definition: A slope failure, slide or associated migration of sediment and/or debris that has not yet reached state waters.

Criteria: If any one of the following criteria exists, it is a Priority 3 slope failure.

- Impact to the water body is imminent.

Required Actions:

- Notify responsible party if not Dominion and potential to impact our right of way.

Priority 4 Slope Failure:

Definition: A slope failure that poses little or no environmental threat.

Criteria:

- No water body in the immediate area.
- Low/no probability of Conditions Not Allowable (Sediment in water body, E&S controls not maintained).
- Pipeline is not in danger of exposure, severing, detaching or rupture.

Required Action:

- Notify responsible party if not Dominion and potential to impact our right of way.

APPENDIX J

DEQ List of Potential Critical Areas

Appendix J - DEQ List of Potential Critical Areas

DEQ developed the following list of potential critical areas, derived from VESCH and other sources, to aid plan preparers in identifying potential critical areas on a project. These areas should be considered when preparing a plan and identifying critical areas. Extra attention should be directed to these areas if they have potentially serious problems or are sensitive to sediment impacts.

A. Steep Slopes:
- i. Ranges of slope gradient erodibility:
  1. 0-7% → Low erosion hazard
  2. 7-15% → Moderate erosion hazard
  3. ≥ 15% → High erosion hazard
- ii. Erosion hazard becomes greater as the slopes length increases. Erosion hazard will become critical if the slope exceeds:
  1. 0-7% ☐ 300 feet
  2. 7-15% ☐ 150 feet
  3. >15% ☐ 75 feet

B. Areas with high erodibility, high reactivity of soils, etc.
- i. 0.23 and lower → low erodibility
- ii. 0.23 to 0.36 → moderate erodibility
- iii. ≥ 0.36 → high erodibility
- iv. Soil pH

C. Areas that flow to environmentally sensitive areas (e.g. State waters including wetlands)

D. Areas that require Virginia Wetland Protection permits

E. Areas containing threatened or endangered species or their habitat, etc.

F. Sink holes, wet weather/underground springs, karst areas, etc.

G. Sensitive agricultural soils

H. Other Potential Critical areas –
- i. Fragipans
- ii. Lacustrine soils
- iii. Dense basal tills
- iv. Soils with seasonally high water table
- v. Soils with less than 5 feet of depth to bedrock
- vi. Subsurface drainage areas
- vii. Open ditches
- viii. Diversions
- ix. Diversion terraces
- x. Buried utility lines (for farmstead consumptive use)
- xi. Water sources (developed springs, wells, etc…)
- xii. Grassed waterways
- xiii. Water impoundment structures (dams and ponds)
- xiv. Unnamed water flows