APPENDIX C-2
Erosion and Sediment Control Plan for Virginia

PROJECT SPECIFIC STANDARDS AND SPECIFICATIONS FOR VIRGINIA

Submitted by:

Mountain Valley Pipeline, LLC
555 Southpointe Blvd, Suite 200 Canonsburg, PA 15317

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APPENDICES

ACRONYMS AND DEFINITIONS

ATWS	Additional Temporary Workspace
BSRF	Belted Silt Retention Fence
BMP	Best Management Practices
Commonwealth	Commonwealth of Virginia
EI	Environmental Inspector
E&ISC	Exotic and Invasive Species Control
ESC	Erosion and Sedimentation Control
FERC	Federal Energy Regulatory Commission
HDD	Horizontal Directional Drilling
LDA	Land-Disturbing Activity
LEI	Lead Environmental Inspector
LOD	Limits of Disturbance
MVP	Mountain Valley Pipeline, LLC
Project	Mountain Valley Pipeline Project
MS4	Municipal Separate Storm Sewer System
NWP12	Nationwide 12 Permit
PLAN	FERC Upland Erosion Revegetation and Maintenance Plan
PROCEDURES	FERC Wetland and Waterbody Construction and Mitigation Procedures
RLD	Responsible Land Disturber
ROW	Right-of-Way
SPCC	Spill Prevention, Containment and Countermeasure
SWM	Stormwater Management
SWMA	Stormwater Management Act
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
USFS	US Forest Service
USFWS	US Fish and Wildlife Service
VADEQ	Virginia Department of Environmental Quality
VDOT	Virginia Department of Transportation
VESCH	Virginia Erosion and Sediment Control Handbook
VESCP	Virginia Erosion and Sediment Control Program
VRRM	Virginia Runoff Reduction Method

VSMP	Virginia Stormwater Management Program
WLA	Wasteload Allocation

1.0 INTRODUCTION

Mountain Valley Pipeline, LLC (MVP), a joint venture of EQT Midstream Partners, LP, a subsidiary of NextEra Energy, Inc., WGL Holdings, Inc., Vega Energy Partners, Ltd., Con Edison Gas Midstream, LLC, and RGC Midstream, LLC, plans to construct the Mountain Valley Pipeline, an approximately 303-mile, 42-inch diameter natural gas pipeline, to provide timely, cost-effective access to the growing demand for natural gas for use by local distribution companies, industrial users and power generation in the Mid-Atlantic and southeastern markets, as well as potential markets in the Appalachian region. The Project will extend from the existing Equitrans, L.P. transmission system near Mobley in Wetzel County, West Virginia, to Transcontinental Gas Pipe Line Company, LLC's Zone 5 compressor station 165 in Pittsylvania County, Virginia. In Virginia, the pipeline construction activities will be located in Craig, Franklin, Giles, Montgomery, Pittsylvania, and Roanoke counties. Additionally, approximately 60 miles of access roads (AR) in Virginia are anticipated for use in the overall Project. This includes both existing roads and construction of new roads as necessary.

MVP is requesting approval to complete the Mountain Valley Pipeline project (Project) within the Commonwealth of Virginia (Commonwealth) in accordance with these Project Specific Standards and Specifications (Standards and Specifications) prepared at the request of the Virginia Department of Environmental Quality (VADEQ). The Project in the Commonwealth will consist of approximately 106 miles of 42-inch diameter pipeline to be constructed with four separate construction spreads during the course of the Project. Construction is scheduled to begin in late 2017 and continue throughout 2018. Final restoration activities are anticipated to extend into 2019 as needed.

The Project's limits of disturbance (LOD) will typically consist of a 125-foot-wide construction corridor for the majority of the Project. At waterbody and wetland crossings, MVP will typically reduce to a 75-foot-wide construction corridor unless otherwise noted. Additional temporary workspace (ATWS) will be required in certain areas, including adjacent to road, wetland, and waterbody crossings, and areas for material and equipment staging and topsoil segregation. Additional construction components will include temporary contractor yards and pipe storage yards.

MVP proposes to construct, operate, and maintain the Project's natural gas pipeline, appurtenances, and auxiliary facilities in the Commonwealth. The Project facilities will include but not be limited to conventional buried pipelines, valves, meter sites, interconnects, pigging facilities, cathodic protection groundbeds, access roads, etc. MVP will obtain any required federal, state and local permits or approvals prior to the start of land disturbing activities.

Unless otherwise noted in the Project's site-specific erosion and sediment control (ESC) and stormwater management (SWM) plans submitted to VADEQ for review and approval, these Standards and Specifications meet the all applicable requirements of the following:

- Virginia Erosion and Sediment Control Program (VESCP) Regulations (9VAC25-840);
- Virginia ESC and SWM Certification Regulations (9VAC25-850);
- Virginia Stormwater Management Act (SWMA) (Va. Code § 62.1-44.15:24 et seq.);
- Virginia Erosion and Sediment Control Law (Va. Code § 62.1-44.15:51 to 66);
- Virginia Stormwater Management Program (VSMP) Regulation (9VAC25-870);
- Federal Energy Regulatory Commission (FERC) Upland Erosion Revegetation and Maintenance Plan (PLAN); and
- FERC Wetland and Waterbody Construction and Mitigation Procedures (PROCEDURES).

MVP and its construction contractors will implement these Standards and Specifications for all regulated land disturbance activities associated with the Project in the Commonwealth. Figures illustrating the ESC devices to be implemented in these Standards and Specifications are included in Appendix A – STD & SPEC. Figures from the Virginia Erosion and Sedimentation Control Handbook (VESCH), 3rd Ed., 1992 are referenced by their original plate numbers.

2.0 GENERAL REQUIREMENTS

These Standards and Specifications have been prepared for use by MVP and its contractors to identify the means and methods for controlling erosion of surface soils, and to reduce the runoff of sediment to the greatest extent reasonably achievable during and post construction of the approximately 106-mile pipeline project and ancillary facilities.

Unless specifically stated, the BMPs and specifications from the VESCH, along with accompanying technical documents and guidance, have been adopted and included for use.

The Minimum Standards and Specifications (STD & SPECS) from the VESCH typically employed for the construction of natural gas facilities are referenced by number throughout these Standards and Specifications. FERC requirements are also referenced by section. Additional ESC measures in Chapter 3 of VESCH may be implemented if site specific conditions warrant.

Additional ESC BMPs are included in Appendix B – MVP Typical Construction Details. These BMPs will be implemented during Project construction and restoration activities. The MVP Typical Construction Details have been developed by MVP using typical details from similar projects designed, permitted and constructed in the Appalachian region. Should any non-VESCH control measures fail to effectively control soil erosion, sediment deposition, and non-agricultural runoff, then VESCH control measures shall be utilized.

Plan Development, Review, Submittal, Inspection, Implementation, and Reporting

- The plans will be developed under the supervision of a professional engineer licensed to practice engineering in the Commonwealth of Virginia. The plans will adhere to Virginia ESC Regulations (9VAC25-840-40) and Virginia ESC and SWM Certification Regulations (9VAC25-850-50) STD & SPECs as well as the FERC PLAN and PROCEDURES.
- MVP will submit variance requests as part of the ESC plan submission to DEQ in accordance with 9VAC25-840-50.
- The plans will be reviewed prior to submission to VADEQ by an individual(s) who has completed the VADEQ certification process for “Plan Reviewer for Erosion and Sediment Control” and “Plan Reviewer for Stormwater Management”. Any deficiencies identified by the Plan Reviewer(s) will be addressed and followed by further review by the Plan Reviewer(s). This process will continue until the Plan Reviewer(s) is satisfied that the plans meet the standards described in this document.
- Prior to submission of the plans to VADEQ, MVP and the Plan Reviewer(s) will conduct a completeness review to verify each submission is complete.
- Once the plans have been deemed satisfactory and complete by the Plan Reviewer(s), an individual(s) who has completed the “Program Administrator for Erosion and Sedimentation Control” and “Program Administrator for Stormwater Management” requirements will submit all necessary documentation to the VADEQ for review and approval. The Program Administrator(s) will act as the point of contact throughout the Project.
- Following completion of the technical review of the plans by VADEQ and determination the submission meets the requirement of these Standards and Specifications, VADEQ will issue an

approval letter as well as record stamp the approved plan documents. A copy of the approved plan will be maintained in a Project mailbox established for each construction spread. All redline changes will be maintained on this official copy of the plan drawings and presented to the VADEQ inspector during routine inspections.

- A VADEQ-Certified Responsible Land Disturber (RLD), holding a valid RLD Certification, shall be named for each construction spread established for the Project in the Commonwealth. MVP will require, at minimum, one Environmental Inspector per construction spread to obtain/maintain a valid RLD Certification throughout the Project construction and restoration activities.
- Notification

  The following information is required to be included in the e-notification (LinearProjects@deq.gov) two weeks prior to initiating a regulated land-disturbing activity (LDA):

  - Project name or Project number;
  - Project location (including nearest intersection, latitude and longitude, access point);
  - On-site project manager name and contact information;
  - Responsible Land Disturber (RLD) name and contact information;
  - Project description;
  - Acreage of disturbance for Project;
  - Project start and finish date; and
  - Any variances/exceptions/waivers associated with this Project.

  The Project's Pre-Construction kickoff meeting date, time and location will be provided in the e-notification. During the Project's Pre-Construction kickoff meeting, MVP staff will present the Project's Worker Environmental Awareness Program (WEAP) training. FERC requires that all visitors, agency representatives, contractors and company staff attend the Project specific WEAP training prior to entering the Project work limits. WEAP training will be conducted throughout the Project to facilitate staff additions and visitors as needed.

  Copies of the Project permit authorizations will be maintained at each construction spread job trailer/yard in a dedicated Project permit mailbox. Location of the mailbox will be identified during the Project's Pre-Construction kickoff meeting held for each construction spread.

- Inspection Staff Requirements.

  - The Project will have one Lead Environmental Inspector (LEI) and at least one Environmental Inspector (EI) per construction spread. Inspection staff requirements will be determined by MVP based on the construction activities being undertaken and accessibility to the active areas while providing appropriate coverage to maintain environmental compliance. The LEI and EI will be required to be knowledgeable of environmental permit compliance requirements, be experienced in ESC and SWM BMP installation, operation and maintenance requirements, Project permit conditions and experienced with the FERC's Plan and Procedures. The LEI/EI will review the implementation of this Standards and Specifications and any applicable environmental permits, resolve apparent conflicts between permits and this Standards and Specifications, and coordinate with the Construction Supervisor about additional measures which may be needed to address erosion and sedimentation. The LEI will also keep a daily log of activity documenting Project activities related to environmental permit compliance and corrective measures implemented, site visitors (i.e. non-project staff), waterbody and wetland crossing log and ESC installation and maintenance activities.

- The Project will have at least one VADEQ-Certified ESC and SWM Inspector per construction spread. These inspectors may be the same LEI and EI described above or a VADEQ-Certified ESC and SWM Inspector from a third party contractor. MVP may enter into agreements or contracts with soil and water conservation districts, adjacent localities, or other public or private entities to carry out or assist with these responsibilities.
- The Project will also have a FERC third party inspector as required. This inspector will have peer status with all other activity inspectors and shall have the authority to stop activities that violate the environmental conditions of the FERC certificate or other authorizations and order corrective action once approval has been granted by the MVP Project Manager.
- The Environmental inspection staff's responsibilities include:
    - Ensuring compliance with the requirements of these Standards and Specification Document;
    - Ensuring compliance with all other federal and state permitting conditions relating to environmental compliance related to ESC, SWM, NWP12 and 401WQC;
    - Ensuring compliance with the FERC's PLAN and PROCEDURES, the environmental conditions of the FERC's Project specific CERTIFICATE, the environmental mitigation measures proposed by MVP in the application submitted to FERC, and other environmental permits and approvals issued to MVP;
    - Verifying that the limits of authorized construction work areas and locations of access roads are properly marked before clearing activities commence;
    - Verifying the location of drainage and irrigation systems;
    - Identifying stabilization needs in all areas;
    - Locating dewatering structures and slope breakers to ensure they will not direct runoff into waterbodies or wetlands, known cultural resource sites or or other environmentally sensitive areas;
    - Verifying that trench dewatering activities do not result in the deposition of sand, silt, and/or sediment near the point of discharge into a wetland or waterbody. If such deposition is discovered, the dewatering activity shall be stopped and the design of the discharge shall be changed to prevent reoccurrence;
    - Testing subsoil and topsoil in agricultural and residential areas as necessary to measure compaction and determine the need for corrective action;
    - Advising the Chief Inspector when conditions (such as wet weather) make it advisable to restrict construction activities;
    - Ensuring restoration of contours and topsoil;
    - Approving imported soils for use in agricultural and residential areas;
    - Ensuring that temporary erosion controls are properly installed, inspected and maintained;
    - Conducting inspections of temporary ESC controls and SWM BMPs on at the least following frequencies:
        - In non-TMDL watersheds:
            - At least once every five business days; or
            - At least once every 10 business days and no later than 48 hours following a measurable storm event (or on the next business day

if the storm event occurs when there are more than 48 hours between business days).

  - In TMDL watersheds (see Sec. 4.5 below):
    - At least once every four business days; or
    - At least once every five business days and no later than 48 hours following a measurable storm event (or on the next business day if the storm event occurs when there are more than 48 hours between business days).
- Ensuring compliance with any more stringent plan requirements during construction activities within the Total Maximum Daily Loads (TMDL) watersheds of impaired waters located in Montgomery, Roanoke and Franklin Counties.
- Ensuring the repair of all ineffective temporary ESC measures within 24 hours of identification, or as soon as conditions allow if compliance with this time frame would result in greater environmental impacts;
- Keeping records of compliance with the environmental conditions, and the mitigation measures required by Federal or state environmental permits during active construction and restoration; and
- Establishing a program to monitor the success of restoration. Implementation of this program may be transferred to the company's operating section upon completion of construction and restoration activities.

- MVP will provide weekly e-reporting, via email to the VADEQ linear projects inbox LinearProjects@deq.gov which will then be directed to the appropriate VADEQ representatives and/or applicable regional office. Inspection reports will be submitted based on MVP's construction spread break basis and identified as such. MVP intends to utilize four (4) construction spreads for Project construction activities in the Commonwealth. Weekly reports will be submitted the week following the inspections and will include the weekly inspection report per spread as well as the post-rainfall event inspections that occur during the reporting week. The reports shall include the following:
  - Inspection reports;
  - Pictures;
  - Complaint logs and complaint responses; and
  - Other compliance documents.
- Additional project specific requirements for these Standards and Specifications include:
  - Project records, including approved ESC and SWM plans shall be kept for three (3) years after state permit termination or Project completion;
  - ESC site inspection and SWM facility inspection records shall be documented and retained for at least five (5) years from the date of inspection. 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 MVP, or as requested by the State Water Control Board or VADEQ;
  - Construction record drawings shall be maintained in perpetuity.
- The operator shall make all site documents, including all amendments, modifications, updates, and the Stormwater Pollution Prevention Plan (SWPPP) available upon request by the VADEQ or the operator of a municipal separate storm sewer system (MS4) receiving discharges from the construction activity, if any. This information must be posted electronically for public review.

- The SWPPP shall identify individuals or positions with delegated authority to sign inspection reports or modify the SWPPP.
- For Total Maximum Daily Load (TMDL) watersheds:
    - The impaired water(s), approved TMDL(s), and pollutant(s) of concern, when applicable, shall be identified in the SWPPP;
    - Permanent or temporary soil stabilization shall be applied to disturbed areas within seven (calendar) days of inactivity;
    - Nutrients shall be applied in accordance with manufacturer's recommendations or an approved nutrient management plan and shall not be applied during precipitation events; and;
    - The applicable SWPPP inspection requirements shall be amended as follows:
        - Inspections shall 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 48 hours following any runoff producing 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.
- For revisions to the approved ESC Plans
    - Minor field-approved revisions that do not increase the LOD or that will increase the effectiveness of ESC and SWM BMPs will be "redlined" on a set of plans that will remain on site for the duration of the Project to allow MVP and VADEQ to ensure compliance with the approved plan and applicable regulatory requirements.
        - MVP will maintain a log documenting all red-line changes per construction spread. The log will be presented to the VADEQ Inspector during project inspections for signoff. Minor redline revisions include (but are not limited to) the following:
            - Adjustment of BMP orientation to ensure proper function and protection of the adjacent resources;
            - Implementation of additional measures to meet changing site conditions or to address areas of potential concern;
            - Adjusting the location of the pipeline centerline within the permitted LOD;
            - Adjusting/lengthening the Temporary Stone Construction Entrance to address weather conditions; and
            - Additional reduction of LOD where necessary.
    - Major revisions that exit the permitted LOD will be submitted to VADEQ for review and approval prior to implementation of the change. Major revisions include (but are not limited to) the following:
        - Reroutes;
        - Proposed access road additions; and
        - Proposed additional temporary workspace (ATWS) areas.
- The revision log documenting redline changes as well as the redline markup of ESC/SWM drawings will be located in each construction spread permit mailbox.

In an emergency, MVP will respond as needed to prevent harm to persons or property, and will contact (via phone and email) the appropriate agencies as soon as practicable under the circumstances. MVP will immediately implement stabilization and containment measures upon identification of the hazard and develop corrective measures in coordination with the appropriate agencies (including VADEQ). Conducting LDAs in response to a public emergency where the related work requires immediate authorization to avoid imminent endangerment to human health or the environment is not considered a regulated LDA. In such situations, VADEQ shall be advised of the disturbance within seven (7) days of commencing the land-disturbing activity, and compliance with the administrative requirements of subsection A of § 62.1-44.15:34, which is required within 30 days of commencing the LDA.

MVP developed a Project specific Spill Prevention, Containment, and Countermeasure (SPCC) Plan that meets the requirements of the Commonwealth and federal agencies. A copy of the SPCC plan will be maintained onsite for implementation during Project activities.

2.1 GENERAL DESCRIPTION OF CONSTRUCTION ACTIVITIES

Pipeline or facility construction activities include all activities associated with the Project from the initial planning stages to the final restoration and maintenance of the right-of-way (ROW). Daily activities will be planned and managed in advance to provide sufficient resources and manpower for the work effort to be accomplished in a timely manner.

Cross-country pipeline construction typically proceeds in an assembly line fashion, with multiple stages of construction occurring simultaneously at different locations to minimize the time needed to complete the project. The stages of construction 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 ESC 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 or mulch, as directed by the Environmental Inspector) will be applied within seven (7) days (unless otherwise noted) to that area.

Specific areas of the Project (e.g. wetland/water body crossings, residential areas, road or railroad crossings, etc.) requiring specialized construction measures (e.g. boring or directional drilling) will be treated as separate construction entities. Environmental sensitive areas such as stream and wetland areas, ponds, water supply areas (springs, wells, public water intakes), karst features, threatened and endangered species areas, cultural significant areas (cemeteries, historical or archaeological resources) or areas identified by landowners as being of concern may require additional ESC Procedures, as described in Section 3.0 Temporary Erosion Controls and outlined in the Project's ESC plan drawings. Specialized construction techniques often combine several construction stages into one. This reduces the duration earth disturbing activities occur in a specific area and in many cases, reduces the LOD required for implementation of the Project in these specific areas. Segments constructed separately will later be tied into the main pipeline, creating additional small disturbances after these segments have been restored. Final testing (see Section 2.6.1 Hydrostatic Testing) of the facility will be completed after tie-ins are completed.

2.1.1 Site Specific VADEQ Oversight

In addition to the VADEQ-Certification process outlined in Section 2.0 of these Standards and Specifications, VADEQ oversight includes the following:

- All plans will be submitted to the VADEQ for review and approval.
- As authorized by law, the State Water Control Board and VADEQ may enforce approved specifications and charge fees equal to the lower of (i) $1,000 or (ii) an amount sufficient to cover the costs associated with standard and specification review and approval, project inspections, and compliance.
- Costs associated with the VADEQ review process will include third party plan review.

- VADEQ will perform pre-scheduled as well as random site inspections for the project. Random site inspection or inspections in response to a complaint may be conducted without prior notification to MVP, its contractors and/or inspection staff. Inspections are intended to ensure compliance with the SWMA, the ESC Law and regulations adopted thereunder. The VADEQ may take enforcement actions if areas of non-compliance are identified during the routine inspection or in response to a complaint report.

2.1.2 Construction Work Areas

Construction work areas include all facilities, access roads, staging areas, temporary pipe yards, contractor yards, and the construction ROW. To the extent possible, previously disturbed areas will be used for construction to minimize new impacts. Landowner agreement and appropriate permits will be obtained prior to the use of any area for Project construction activities. These ESC specifications apply to all construction work areas utilized by MVP.

The construction ROW typically will include the 50-foot permanent pipeline ROW and an additional 75-foot temporary ROW for the length of the Project. The Project's LOD will consist of a 125-foot-wide construction corridor for the majority of the Project. At waterbody and wetland crossings, MVP will typically reduce to a 75-foot-wide construction corridor unless otherwise noted. Temporary workspace is typically reduced at waterbody and wetland crossings to the extent feasible. ATWS may be required at specific locations to accommodate road and utility crossings, waterbody and wetland crossings and in steep slope areas, etc. Variations may occur based on the type of facility under construction, landowner conditions, permit conditions, or topographic conditions.

The construction ROW may be widened (subject to compliance with all applicable survey and mitigation requirements, landowner agreements and all other necessary approvals) in areas such as steep slopes and topsoil conservation areas to ensure safe construction and for storage of excess spoil.

After construction is completed, all work areas will be restored with a perennial vegetative cover, unless specifically directed otherwise by the landowner or permit conditions. Following permanent stabilization, temporary work areas will be returned to pre-construction land uses.

2.1.3 Construction Line List and Permits

MVP will provide the contractor with a Construction Line List that describes special requirements (e.g., timber salvage, topsoil segregation, restoration measures, and fencing requirements) requested by landowners. The contractor will comply with these special requirements so long as they do not conflict with the requirements of these Standards and Specifications or any other federal or state permit requirements.

Since MVP is a FERC regulated project, landowner contact information is considered privileged and confidential and is not available for public review including under Freedom of Information Act requests. As a result, parcel identification numbers are provided on the site-specific ESC and SWM plan drawings. Information regarding landowners will be maintained by each construction spread EI as well as in the Project job trailer located at each construction spread yard. This information will be available to the VADEQ during site inspections and as needed throughout the Project construction and restoration activities.

Per Minimum Standard (MS)14 of Virginia ESC Law and Regulations, MVP will obtain all applicable federal, state and local permits pertaining to working in wetlands or crossing live watercourses. In the event permit requirements are more stringent than the requirements of these Standards and Specification, the more restrictive requirements will be implemented.

It will be the construction contractor's responsibility to obtain permits that may be required for specialized activities such as burning, blasting, and transportation activities associated with the Project. This responsibility shall be a condition of each contractor's contract.

Per MS-14, all applicable federal, state and local regulations pertaining to working in or crossing live watercourses shall be met. These may include, for example, the following:

- United States Army Corps of Engineers Nationwide Permit 12
- Virginia Marine Resources Commission Submerged Lands Agreement
- VADEQ 401 Water Quality Certification

2.2 SURVEY AND PLANNING

To the extent practicable, construction work areas will be selected in advance and included in all surveys, landowner negotiations, and permitting. Any new work areas selected by the contractor must receive appropriate review, permitting and applicable agency approval prior to their use. In the event additional workspace (including access roads, expanded temporary ROW, ATWS, etc.) is needed for Project use, MVP will submit additional information to VADEQ for review and approval prior to initiating Project use of these areas. The limits of the approved work areas, boundaries of environmentally sensitive areas and the location of the facilities will be marked in the field and verified prior to the start of mechanized activities.

2.3 MOWING AND CLEARING

The initial mechanized stage of construction involves the clearing of brush, trees, and vegetation from the ROW. Vegetation will be cut off at ground level, and un-merchantable timber (e.g., brush, stumps, slash and tree tops) will be disposed of by chipping and blowing chips off LOD in upland areas (landowner approval required), windrowing, or by burning (if allowed). Burning will only be conducted if appropriate permit approvals are received and activity is authorized by MVP. Merchantable timber will be cut and stacked along the outboard edge of the construction LOD in upland areas as directed by the landowner ROW agreements and approved by MVP Construction Supervisor. If burning is not allowed, residual materials available from clearing and grubbing of the site may be used as temporary ESC in accordance with STD & SPEC 3.06 Brush Barrier (see Appendix A - STD & SPEC). Materials used in this BMP will be small limbs, brush, branches (under 6" diameter), soil, native rock or wood chips to create a barrier. Tree tops and brush may be chipped and spread (blown) uniformly onto undisturbed forest land adjacent to the disturbed ROW if allowed per landowner agreement. Alternately, if wood chips generated from land clearing activities are scattered along the edge of the ROW, the chips will be spread a maximum of 1 ton/acre and an additional application of 11 pounds of nitrogen per ton of wood chips will be made to affected areas.

Clearing of vegetation in wetlands will be limited to trees and shrubs, which will be cut flush with the surface of the ground and removed from the wetland. Stump removal, topsoil segregation, and excavation will be limited to the area immediately over the trench line within the permanent easement per NWP12 Regional Condition 3.b.iii, FERC PROCEDURES and Project's FERC Certificate conditions. Trees located within 15 feet of the pipeline with roots that could compromise the integrity of the pipeline coating may be selectively cut and removed from the permanent ROW. Limited stump removal and grading may be conducted within the permanent easement in wetlands to ensure a safe working environment.

Where requested by the affected landowners, trees of special concern (i.e. located within or immediately adjacent to construction LOD) will be protected by fencing and armoring in accordance with STD & SPEC 3.38 Tree Protection and Preservation as necessary. Trees and shrubs that are not required to be cleared to facilitate construction activities will not be unnecessarily damaged during construction (Plates 3.38-1, -2, -7, -8, -9).

2.3.1 Fence Crossings

Where it is necessary to remove existing fences in the ROW, adequate temporary fences and gates will be installed around the construction area, if required by the landowner. Temporary fences or gates will be provided with suitable fasteners and will be kept closed, except when necessary to be opened for construction purposes. Existing fences will be replaced in kind or as agreed upon with the landowner upon completion of work.

2.4 GRUBBING AND GRADING

The grading operation involves grubbing of stumps, stockpiling topsoil where applicable, and leveling the construction ROW to create a safe operating area for equipment, employees and vehicles. Topsoil and subsoil disturbed during grading operations will be stored separately and will not be mixed with foreign material (e.g., stumps and slash). The disposal methods described in Section 2.3 Mowing and Clearing for clearing debris also apply to stumps. Grading and grubbing will be conducted as a separate construction activity at waterbody and wetland crossings which will be treated as separate construction areas until the contractor is prepared to complete all other construction activities at that site in the shortest practicable time.

Clearing of vegetation in wetlands will be limited to trees and shrubs, which will be cut flush with the surface of the ground and removed from the wetland. Stump removal, topsoil segregation, and excavation will be limited to the area immediately over the trench line within the permanent easement per NWP12 Regional Condition 3.b.iii, FERC PROCEDURES and Project's FERC Certificate conditions (see Appendix B MVP-53). Trees located within 15 feet of the pipeline with roots that could compromise the integrity of the pipeline coating may be selectively cut and removed from the permanent ROW. Limited stump removal and grading may be conducted within the permanent easement in wetlands to ensure a safe working environment.

ESC measures will be installed as a first step in any LDA and will be made functional before upslope land disturbance takes place.

Specifications for temporary ESC measures are discussed below in Section 3.0 Temporary Erosion Control.

2.4.1 Topsoil Conservation (MVP-ES46)

Topsoil will be segregated in all areas of the Project including pastureland, upland forested areas, residential areas, meadowlands, wetlands without standing water or saturated soil, areas requested by the landowner, or where directed by the EI. The topsoil will be stored separately from trench subsoil and replaced on top of the subgrade during final grading. Topsoil will be stored along the edge of the temporary LOD, maintaining a minimum 10-foot setback from waterbody and wetland boundaries. In non-saturated/non-standing water wetland areas, the top 12 inches of wetland soil will be segregated from the trench line during trenching activities to be used during restoration.

In agricultural lands and upland forested areas, topsoil will be stripped from either the full LOD (using additional temporary ROW to store the topsoil in this case) or from the trench line and subsoil storage area. During construction, topsoil storage piles shall be stabilized or protected with sediment trapping measures.

At least 12 inches of topsoil (where available) will be segregated in deep soils. Where soils are shallow, every effort will be made to segregate the entire topsoil layer. In residential areas, topsoil replacement (i.e., importation of topsoil) is an acceptable alternative to topsoil segregation. Topsoil may not be used to fill sandbags or to pad the pipe.

2.4.2 Drain Tiles

The following Procedures apply to locations where existing drain tiles are encountered:

1. Mark drain tile locations identified prior to and during construction.
2. Inspect all drainage tile systems exposed within the area of disturbance to check for damage.
3. Repair drain tiles damaged during construction activities to their original condition. Drain tile repair will be limited to the area damaged within the construction LOD. Do not use filter covered drain tiles without agreement of the local soil conservation authorities and the landowner. The construction contractor, overseen by the EI or construction inspector, will be responsible 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).

2.4.3 Irrigation

Water flow will be maintained in crop irrigation systems, unless shutoff is coordinated with affected parties.

2.4.4 Access Roads

MVP will utilize both existing roads and newly constructed roads to facilitate implementation of the Project. Typical road widths will be 25-feet but may require temporary widening to facilitate use by large equipment and pipe delivery trucks. Existing roads will be maintained with minor grading and gravel dressing (as needed) to maintain the road surface. Temporary ESC BMPs will be installed in accordance with the Project ESC plan. For existing roads that require waterbody crossing culverts to be replaced due to condition or temporary widening for Project use, MVP will permit the culvert replacement as a permanent impact under the Nationwide Permit 12 application.

Following installation of the Project, existing roads that required temporary widening will be returned to pre-existing contours and conditions. Any drainage culverts damaged will be repaired as needed and returned to pre-existing conditions. Areas of temporary widening will have the temporary road surface reclaimed and the disturbed areas revegetated. The road surface will be returned to the pre-existing width and a top coat of gravel applied (where necessary). Once disturbed areas are permanently stabilized with vegetation or other measures (i.e. gravel, where applicable), temporary ESC BMPs will be removed and properly disposed of at an approved waste disposal site. In the event a landowner requests the temporary widening or other improvements to remain in-place post-construction, additional SWM design and permitting activities will be required.

Newly constructed temporary access roads will be installed in accordance with the Project's ESC permit terms and conditions. Following completion of the Project, temporary access roads will be returned to pre-existing contours and stabilized with permanent vegetation. Temporary ESC BMPs will be maintained on temporary access roads throughout the Project until the disturbed area is restored and permanently stabilized with vegetation. Once the area has been permanently stabilized, the temporary ESC BMPs will be removed and properly disposed. Existing dirt roads, logging roads, and two-track or vegetated agricultural roads will be returned to their pre-construction conditions. No new roads will be constructed unless prior approval has been received from the appropriate agencies (including VADEQ and FERC).

New access roads that are required for permanent operation of the Project will be installed in accordance with the Project's ESC plan terms and conditions. Permanent roads will be installed for construction use and will remain in-place for operation of the facilities. Permanent stormwater controls (as needed) will be designed in accordance with the terms and conditions outlined under Section 4.0 Stormwater Management Requirements of these Standards and Specifications and approved by VADEQ.

2.5 TRENCHING

Trenching consists of excavating the trench for the pipeline, and is typically accomplished with an excavator or a rotary wheel-ditching machine. In areas where soft rock or hard pans are present, a tractor-mounted ripper or excavator mounted hammer can be used to break and loosen consolidated material. Loosened material will then be removed with an excavator. The ditch will be excavated to a minimum practicable width for excavation stability; additional width will be excavated to meet safety standards when work will occur within the excavation such as at tie-ins, bore pits, valve settings, etc. In areas where mechanized means of rock removal is unsuccessful, blasting may be used as needed. MVP prepared a General Blasting Plan (Appendix J) for use during Project activities. MVP will require the Construction Contractor to prepare a site-specific blasting plan to be prepared and approved by MVP prior to implementation. The Contractor will have to obtain all necessary blasting permits prior to implementation of any blasting activities.

2.5.1 Trench Breakers

Temporary trench breakers will be installed in the open trench during trenching, just upslope of every interceptor diversion (at a minimum), to reduce the velocity of storm water flow along the trench and decrease erosive velocity. Trench breakers are not employed in trenchless construction such as conventional boring or horizontal directional drilling, or in non-linear excavations (such as work within a station yard). Temporary trench breakers are typically made of sandbags but may consist of native materials except topsoil. Topsoil shall not be used for trench breakers. Trench breakers will be inspected prior to final back filling of the trench.

MAXIMUM RECOMMENDED SPACING AND MATERIALS FOR

PERMANENT TRENCH BREAKERS

Trench Slope	Distance (feet)	Plug Material
0-5%	See Note 1	Concrete Filled Sacks
5-15%	500	Sandbags or Concrete Filled Sacks
15-25%	300	Sandbags or Concrete Filled Sacks
25-35%	200	Sandbags or Concrete Filled Sacks
35-100%	100	Sandbags or Concrete Filled Sacks
>100%	50	Concrete Filled Sacks (Wetted)

NOTE 1: Trench Breakers are required at all waterbody crossings regardless of trench slope. Otherwise, not required at slopes <5%.

Following pipe installation, the temporary trench breakers are replaced with permanent trench breakers to inhibit piping and subsurface erosion in the trench. Materials appropriate for use as permanent trench breakers include sandbags and concrete filled sacks. On steep slope areas, the MVP Construction Supervisor may require that permanent trench breakers be made with wetted cement bags or mortared stone. Permanent trench breakers must be installed at stream banks, at the edge of wetlands, and in road and railroad embankments to minimize the chance of subsidence. Permanent trench breaker installations at waterbody and wetland crossings must be constructed with impervious materials to prevent the trench line from serving as a conduit to convey groundwater away from the resource.

2.6 PIPE ASSEMBLY

Most pipe assembly activities do not require any additional ESC measures; however, all ESC measures will be maintained in good working order where pipe assembly is being conducted.

2.6.1 Hydrostatic Testing

A pipeline must be pressure tested after backfilling and before placing it into operation in order to establish the Maximum Allowable Operating Pressure (MAOP). Pressure testing may also be conducted on a pipe segment prior to lowering-in as directed by the Construction Supervisor. Pressure testing, or hydrostatic testing as it is called when the test is conducted with water, is often conducted while clean-up activities are on-going. The test manifold locations may be restored out of sequence with the rest of the ROW. If portions of the restored ROW must be disturbed again in order to complete pressure testing, ESC measures will be implemented as applied during the rest of construction and as described in these Standards and Specifications.

Hydrostatic test water will be released to upland areas through an energy dissipating dewatering device in accordance with STD & SPEC 3.26 Dewatering Structure (Appendix A) and Typical Construction Detail MVP-ES2 Pumped Water Filter Bag (Appendix B). The dewatering structures will be sized to accommodate the rate and volume of release. These activities will be monitored and regulated to prevent erosion and over pumping of the dewatering structures. Releases will be stopped when necessary to perform maintenance of the dewatering structures and ensure they remain in good working order. No hydrostatic test releases will occur directly to waterbodies, wetlands or other identified environmentally sensitive areas.

Because MVP does not intend to release any hydrostatic test water to waterbodies, the Project does not require coverage under a Virginia Pollutant Discharge Elimination System (VPDES) permit. Nevertheless, as an additional BMP, all upland releases of hydrostatic test water will be conducted in accordance with the sampling, monitoring, and effluent limit conditions (pH of 6.0-9.0, no more than 15.0 mg/l petroleum hydrocarbons and 0.011 total residual chlorine) of the General VPDES Permit for Discharges from Petroleum Contaminated Sites, Groundwater Remediation, and Hydrostatic Tests, VAG83, 9 VAC 25-120-80, applicable to discharges of hydrostatic test water.

2.6.2 Trench Dewatering

The trench will be cleared of debris and dewatered prior to lowering in pipe or equipment. Water from dewatering operations will be filtered through an approved filter bag that will comply with manufacturer's recommendations for inspection and maintenance, passed through a VADEQ standard dewatering structure, and discharged in a manner that does not result in accelerated erosion or adversely affect off-site property. Trench dewatering will be conducted through a filter bag (Appendix B –MVP-ES2) and placed within a dewatering structure (Appendix A – STD & SPEC 3.26-3). Pumped Water Filter Bags should be replaced as often as necessary to maintain function and prevent a failure of the filter bag. Pumps used in the dewatering activity will be placed in a secondary containment to prevent spills of fuel or oil to the ground surface in accordance with the SPCC Plan. Dewatering structures will be constructed in a well vegetated stabilized area away from waterbodies and wetlands and sized according to the intended use. Discharge will be monitored and controlled to prevent erosion and sedimentation from occurring to adjacent areas as well as to prevent over pumping of the dewatering structure. The discharge will be directed away from any waterbody, wetland or other environmentally sensitive areas. The discharge point will be monitored during the activity to ensure that the discharge is thoroughly filtered and no erosion or sedimentation occurs at the discharge point.

2.7 BACKFILLING

Backfilling follows pipe installation and generally consists of replacing the material excavated from the trench. In areas where topsoil has been segregated, the subsoil will be replaced first, and the topsoil will be replaced during final grading. Backfilled trench material will be compacted to stabilize the trench.

As specified above, permanent trench breakers will be installed in accordance with the specifications identified under Section 2.5.1 Trench Breakers to prevent the backfill from sliding or washing on sloping ground.

2.8 FINAL GRADING

Final grading will be completed no later than 20 calendar days after backfilling (10 calendar days in residential areas), soil and weather conditions permitting. These durations may be extended in locations where it is necessary to maintain a travel lane for access to other portions of the Project.

The ROW will be cleared of construction debris, re-graded to pre-construction contours, and topsoil will be replaced. ROW diversions will be installed in accordance with Section 3.5 Temporary Slope Breakers/Temporary Right-of-Way Diversion. All temporary ESC barriers will remain in place until replaced by permanent ESC measures or when a ground cover that is uniform, mature enough to survive, and will inhibit erosion is achieved. In rotated and permanent cropland and pastures, residential areas, and other areas as stipulated by the Construction Supervisor, excess rock greater than four (4) inches in diameter will be removed from at least the top 12 inches of soil to the extent practicable. After final grade is achieved, the size, density, and distribution of rock on the construction work area should be similar to adjacent areas not disturbed by construction. The landowner may approve other rock size provisions in writing.

In areas where establishing pre-construction contours and conditions are not feasible (i.e. mainline valve locations, meter sites, new access road locations, Transco Interconnect, etc.), MVP will address these areas in the site-specific ESC and SWM plans submitted to VADEQ for review and approval. In the event additional areas are identified (i.e. temporary access roads, etc.), MVP will contact VADEQ to discuss changes via permit modification etc.

2.8.1 Temporary Stabilization

When acceptable final grade cannot be achieved (e.g., during winter or early spring construction), when permanent seeding (see Section 2.9.2 – Permanent Seeding) cannot be applied due to adverse soil and weather conditions, or any time a denuded area will remain idle for more than 14 calendar days, temporary seeding (STD & SPEC 3.31) will be applied to the rough graded area in accordance with Table 3.31-B in Appendix A. ESC measures will be monitored and maintained until conditions improve and final cleanup can be completed in the next recommended planting window.

2.8.2 Permanent Slope Breakers (Right-of-Way Diversions/Waterbars)

Permanent slope breakers are intended to reduce runoff velocity and divert water off the construction ROW. Permanent slope breakers will be constructed in accordance with Typical Construction Detail MVP-17 and MVP-18 (Appendix B). Permanent slope breakers will be constructed and maintained in all areas, except cultivated areas and lawns, using the maximum spacing recommendations in the following table.

RECOMMENDED MAXIMUM SPACING FOR

PERMANENT SLOPE BREAKERS

Pipeline Grade	Distance (feet)
<2%	-[1,2]
2-5%	400
6-15%	200
16-30%	100
>31%	50[3]

[1] Permanent Slope Breakers will be installed as needed based on field conditions.
[2] Permanent Slope Breakers will be installed 25 feet from each waterbody boundary regardless of slope conditions.
[3] Slopes greater than 65% may require site specific stabilization measures based on field conditions as approved by MVP Design Engineering and MVP Environmental Inspector.

Permanent slope breakers will be constructed with a 2-percent out slope to divert surface flow to a well vegetated stabile area. In the absence of a well vegetated stable area, appropriate energy-dissipating devices will be constructed off the construction ROW (Appendix B MVP-ES42). Slope breakers may extend beyond the edge of the construction ROW up to four (4) feet to direct water off the disturbed area and into a stabilized area and are subject to compliance with all applicable survey requirements.

2.8.3 Soil Compaction Mitigation

During preparation of the LOD and trench excavation, topsoil will be segregated and stockpiled separately from excavated subsoil. During backfill and final grading, topsoil and subsoil will be returned to their original profile. MVP will disc areas disturbed during construction activities to facilitate revegetation of the ROW. This will include discing subsoil to a depth of 4-6" prior to returning topsoil to the ROW. Topsoil will then be disced prior to seed and mulch application. Severely compacted areas may require additional de-compaction activities to be employed on an as needed basis using a plow or other deep tillage implement.

Following discing, seed and mulch will be applied to the prepared seedbed. In lieu of anchoring mulch to the topsoil using tracked equipment, MVP would utilize an agricultural crimper to minimize potential for excessive compaction to occur. As an alternative option in agricultural areas, arrangements can be made with the landowner to plant and plow under a "green manure" crop, such as alfalfa, to decrease soil bulk density and improve soil structure. If subsequent construction and cleanup activities result in further compaction, additional tilling may be required.

Restored soils will tested for compaction throughout the Project as necessary in areas disturbed by construction activities. Compaction testing locations will be determined by the MVP LEI/EI during restoration activities. Tests will be conducted on the same soil type under similar moisture conditions in undisturbed areas immediately adjacent to the Project site to identify approximate pre-construction conditions. A cone penetrometer or other appropriate devices will be used to conduct tests as necessary.

2.9 RESTORATION

Restoration includes permanent soil stabilization measures, both vegetative and non-vegetative (e.g., rip rap or gabions). A permanent vegetative cover will be established on all disturbed areas of the ROW not otherwise permanently stabilized. Restoration will promptly follow final grading to take advantage of soil scarification resulting from grading, and will be completed within seven (7) calendar days of final grading, weather and soil conditions permitting.

2.9.1 Cleanup

Final cleanup of an area (including final grading and installation of permanent ESC structures) will be completed within 20 calendar days after backfilling the trench in that area (10 calendar days in residential areas). These durations may be extended in locations where it is necessary to maintain a travel lane for access to other portions of the Project. If this schedule cannot be met, all temporary ESC measures shall be removed within 30 calendar days after final site stabilization or after the temporary measures are no longer needed. In no case will final cleanup be delayed beyond the end of the next recommended seeding season.

Excess rock, including blast rock may be used to backfill the trench to the top of the existing bedrock profile.

Excess rock will be removed from at least the top 12 inches of soil to the extent practicable in all rotated and permanent cropland, hayfields, pastures, residential areas, and other areas at the landowner's request. The size, density, and distribution of rock on the construction work area should be similar to adjacent areas not disturbed by construction. Diligent efforts will be made to remove stones greater than four (4) inches if the off ROW areas do not contain stones greater than (4) inches. The landowner may approve other rock size provisions in writing.

Construction debris will be removed from the ROW and grade the ROW to leave the soil in the proper condition for planting.

2.9.2 Permanent Seeding (MVP-ES11)

The goals of permanent seeding are to establish a dense, self-propagating, low maintenance ground cover that will minimize erosion and sedimentation while providing wildlife habitat benefits. To achieve these many goals requires attention to detail in selecting the seed mix and preparing the seedbed.

MVP will request a variance in regard to STD & SPEC 3.32 (Permanent Seeding) with each ESC and SWM plan submission to VADEQ for review and approval. MVP is partnering with the Wildlife Habitat Council (WHC), a nonprofit organization dedicated to assisting corporations, conservation organizations, and individuals with restoration and enhancement of wildlife habitat. The WHC is working with MVP on their commitment toward restoration of the Project ROW and establishment of perennial vegetation using native seed mixes created in collaboration with local seed supplier, Ernst Conservation Seeds, Inc. State-specific seed mixes recommended for MVP are summarized in Appendix B MVP-ES11.1 through 11.7. These seed mixes incorporate recommendations received from the US Fish and Wildlife Service (USFWS), US Forest Service, VA Department of Conservation and Recreation, Wildlife Habitat Council and MVP's threatened and endangered species consultant will be applied along the Project's ROW except where landowners request a specific seed mix and on state or federal land where agencies request specific seed mixes. In areas where a specific mitigation seed mix is not required, MVP will implement STD & SPEC 3.32 Table 3.32-C (Site Specific Seeding Mixtures for Appalachian/Mountain Area).

For the Project's crossing of US Forest Service (National Forest) Lands, MVP will utilize seed mixes specified in their document SUGGESTED SEED MIXES FOR PIPELINE RIGHTS-OF-WAYS AND ASSOCIATED DISTURBANCES ON THE MONONGAHELA AND GEORGE WASHINGTON-JEFFERSON NATIONAL FORESTS (November 2016) provided in Appendix C. Seed mixes for the National Forest Lands are also provided under Appendix B - MVP-ES12.1 through 12.3.

The low-maintenance seed mix appropriate for the region of the state where the Project is located (see Appendix A – STD & SPEC: Table 3.32-C) will be the default unless otherwise specified in the applicable permit conditions, mitigation specifications or landowner agreements. Certified seed will be used whenever possible, and will be applied to the ROW within 12 months of the testing date. Legume seed will be treated with an inoculant specific to the species. Slopes steeper than 33% will be seeded immediately after final grading, weather permitting. All disturbed soils will be seeded within seven (7) working days of final grading, weather and soil conditions permitting.

Seedbed preparation includes adding lime and fertilizer, and tilling or discing the top 4-6 inches of the soil, or soil roughening if tilling cannot be accomplished. When hydro seeding is to be used, the seedbed will be scarified to facilitate lodging and germination of the seed. Unless site-specific recommendations are received from the land owners or land management agencies, MVP will incorporate 4,000 lbs./acre of pulverized agricultural grade lime and 1,000 lbs./acre of 10-20-10 fertilizer into the soil. Soil pH modifier and fertilizer will be incorporated into the top two (2) inches of soil as soon as possible after application. Other fertilizer formulations, including slow-release sources of nitrogen (preferred from a water quality standpoint), may be used provided they can supply the same amounts and proportions of plant nutrients). PCB-free hydro seed will be used if available.

Seeding rates will be based on pure live seed and used within 12 months of seed testing. Seed will be uniformly applied using a broadcast seeder, drill, culti-packer seeder or hydroseeder. When dry seeding, the seeding depth should be ¼ to ½ inch. During hydroseeding, it is recommended to add 50% more seed to the tank if a machinery breakdown occurs. If the breakdown exceeds two (2) hours, a full rate of new seed may be necessary. Asphalt binders will not be used when hydroseeding near wetlands or water bodies. Twice the supplier's recommended rate of inoculant will be used on dry seeding, five times the recommended rate if hydroseeded.

The upland seed mix should not be applied within wetlands boundaries. Seeding and mulching in cultivated cropland will conform to the adjacent off ROW area unless otherwise requested by the landowner in writing.

Seeding of permanent vegetation will be performed within the recommended seeding dates in the VESCH. If seeding cannot be done within those dates, appropriate temporary erosion control measures will be used and seeding of permanent vegetation will be performed at the beginning of the next recommended seeding season. Permanent seed may be applied out of the recommended window in addition to temporary seeding; however, the contractor must be prepared to return during the next recommended seeding window to reseed any areas that did not develop adequate permanent cover. Lawns may be seeded on a schedule established with the landowner.

2.9.3 Mulching (MVP-ES45)

Following seed application, mulch will be applied to help the seed stay in place, to hide the seed from animals, and to retain soil moisture. Mulch can consist of straw, erosion control fabric, or some functional equivalent. Mulch will be free of noxious weeds. Hay shall not be used as mulch.

RECOMMENDED LOOSE MULCH AND MATERIALS AND APPLICATION RATES

Mulch Application	Rate (lbs./acre)	Notes
Straw	4000	Free from weeds and coarse matter. Must be anchored. Spread with mulch blower or by hand.
Fiber Mulch	1500	Do not use as mulch for winter cover or during hot, dry periods. Apply as slurry.

Mulch Application	Rate (lbs./acre)	Notes
Corn Stalks	8000-12,000	Cut or shredded in 4-6" lengths. Air-dried. Do not use in fine turf areas. Apply with mulch blower or by hand.
Wood Chips	8000-12,000	Free of coarse matter. Air-dried. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand. Apply additional 12 lbs. slow-release nitrogen/ton of wood chips.
Bark Chips or Shredded Bark	50-70 cu. Yds.	Free of coarse matter. Air-dried. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand.

Install erosion control fabric, such as jute thatching or bonded fiber blankets, at a minimum, on waterbody banks at the time of final bank re-contouring. Anchor the erosion control fabric with staples or other appropriate devices. Fiber matrix or polyacrylamide based erosion control products (Appendix B – MVP-ES40 and MVP-ES40-1) will be substituted for erosion control blanket in agricultural areas.

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 hay or its equivalent. If wood chips are used as mulch, do not use more than 6 tons/acre and add the equivalent of 12 lbs./acre available nitrogen per ton.

Application of liquid mulch binders and tackifiers may be used in place of mechanical crimping/anchoring. Heaviest application will occur on crest of ridges and steep slope areas (including spoil piles) to prevent mulch displacement. MVP will monitor mulch application and function throughout the Project duration. If MVP determines mulch coverage to be sparse due to wind or other factors, reapplication will be conducted as needed.

Ensure that mulch is anchored to minimize loss by wind and water. When anchoring by mechanical means, use a mulch-anchoring tool to properly crimp the mulch to a depth of 2 to 3 inches. When anchoring with liquid mulch binders, use rates recommended by the manufacturer. Do not use liquid mulch binders within 100 feet of wetlands or water bodies.

2.9.4 Soil Stabilization Blankets and Matting

Slopes in excess of 30%will be stabilized with steep slope soil stabilization blankets and matting techniques identified in Appendix A - STD & SPEC 3.36 Soil Stabilization Blankets and Matting. The blanket shall be nontoxic to vegetation and to the germination of seed and shall not be injurious to the unprotected skin of humans. The netting will be entwined with the mulching material/fiber to maximize strength and provide for ease of handling. It is recommended that the mulching material/fibers should interlock or entwine to form a dense layer, which not only resists raindrop impact, but also allow vegetation to penetrate the blanket. Blanket mulches will be started at the top of the slope and unrolled downhill, and adjacent blankets will be overlapped by a minimum of 2 inches. Wire staples 11-gauge or better and a minimum of 6 inches in length will be used to secure the blanket mulch in place in accordance with STD & SPEC 3.36 Soil and Stabilization Blankets & Matting.

In addition to STD & SPEC 3.36 Soil and Stabilization Blankets & Matting, MVP will utilize hydraulically applied soil stabilization blankets and matting (i.e. Earthguard, Flexterra or equivalent) as an alternate to the rolled ESC blanket material identified under STD & SPEC 3.36. Information regarding the hydraulically applied blankets is provided under Appendix B –MVP-ES-40 and MVP-ES40.1.

2.9.5 Mulch Before Seeding

Mulch before seeding if:

- Final cleanup, including final grading and installation of permanent erosion control measures, is not completed in an area within 7 calendar days (per MS-1) after the trench in that area is backfilled; or
- Construction or restoration activity is interrupted for extended periods, such as when seeding cannot be completed due to seeding period restrictions; if mulching before seeding, increase mulch application on all slopes within 100 feet of waterbodies and wetlands to a rate of 3 tons/acre.

2.9.6 Bare Root Sapling and Shrub Planting

Planting of bare-root saplings and shrubs will occur within select areas of the Project (Appendix B – MVP-ES11.8 and 11.9). The purpose of these plantings is to establish target native tree species comparable to the region, site characteristics (e.g., topography; soil characteristics; adjacent vegetation), and adjacent forest composition in order to encourage the timely reestablishment of habitat removed during Project construction. For small mammals and birds, adequate spacing of planted shrubs can form a large clump or thicket and provide excellent cover, refuge, or brood-rearing habitat often absent in open landscapes. Furthermore, planting a diverse array of native shrubs and saplings with varying blooming periods will provide reliable sources of pollen and nectar for pollinator species during spring, summer, and autumn.

All species planted will be native to the area, and the seed source or ecotype of the saplings and shrubs will be as local as possible with preference given to within-state, then mountainous regions of an adjacent state, followed by within the Appalachian Mountain range.

A variety of factors are considered when planting bare-root seedlings. Storage of seedlings is important to ensure viability and to limit loss of seedlings prior to planting. To the extent practicable, time between delivery of seedlings to the restoration site and planting is limited. In an effort to prevent desiccation and preserve moisture, seedlings are kept in original shipping container (e.g., sack; box) and stored in cool, moist, and shady locations that will not receive direct sunlight, and is sheltered from wind. Refrigerated storage is used when possible.

Immediately prior to planting, seedlings are inspected for damage that may result in seedling mortality. Seedlings are examined and discarded if the following are present: broken stems or main roots, mold or mildew, stems with missing bark, desiccated roots, or a root system less than five (5) inches long. Seedlings deemed suitable are planted using a spade, shovel, or planting bar between October 1 and April 30 following seeding application (i.e., woody plants, forbs, and graminoids).

Holes for seedlings will be dug deep enough to fit the entire bare root system without bending; typically between 8 and 10 inches. If roots are longer than the depth of the typical planting hole, roots shall be pruned. All pruning will take place in a manner to avoid desiccation (e.g., in shade). Following pruning, roots are moistened. Roots shall be treated with root dip absorbent polymers and mycorrhizal root dip inoculates in accordance with manufacturer's recommendations. One seedling will be placed in each hole with the roots inserted to the bottom and then lifted upward slightly so that the root collar is at or slightly below the finished grade. Each seedling is fertilized with a 5-gram tablet of controlled release fertilizer. When filling the planting hole, the seedling is maintained upright. The spade, planting bar, or shovel is inserted behind the planting hole and tilted back to close the bottom of the planting hole. The tool is then tilted forward to close the top of the hole. Soil is gently packed to fill any remaining voids.

2.9.7 After Restoration

Permanent vegetation will not be considered established until a ground cover is achieved that is uniform and mature enough to survive and inhibit erosion. In general, a stand of vegetation cannot be determined to be fully established until it has been maintained for one full growing season after planting. ESC BMPs will be inspected and maintained until a ground cover that is uniform, mature enough to survive, and will inhibit erosion is achieved and established. Sediment captured by the temporary ESC measures will be cleaned out when the deposited sediment meets 50% of the BMP capacity (height). Soils disturbed during ESC maintenance activities will be permanently seeded and mulched to prevent further erosion. All temporary ESC measures shall be removed within 30 calendar days after the site has been permanently stabilized and the temporary ESC measures are no longer needed, unless written authorization is received from the program authority. Following removal of the ESC measures, all areas disturbed during removal of the ESC measures will be seeded and mulched. MVP anticipates that one full growing season after restoration planting is complete and vegetation has established, construction will be complete and the ROW enters the maintenance cycle (see Section 6.0 - Maintenance of Permanent Right-of-Way).

2.9.8 Off-Road Vehicle Control

At the request of a land management agency, measures may be installed and maintained to control unauthorized vehicle access to the ROW. These measures may include:

- Signs;
- Fences with locking gates;
- Slash and timber barriers, pipe barriers, or a line of boulders across the ROW; and
- Conifers or other appropriate trees or shrubs across the ROW.

3.0 TEMPORARY EROSION CONTROLS

The temporary ESC measures detailed below are those most often used for pipeline construction. Additional detail about the measures described is available in the VESCH, and should be reviewed before implementing these measures. Other measures found in the VESCH may be applied or substituted with the concurrence of the LEI, EI and Construction Supervisor if site-specific conditions warrant. Any measures not included in the VESCH or this plan must receive written approval from the appropriate agencies prior to implementation. All temporary ESC devices will be functional before upslope land disturbance takes place. All ESC structures and systems will be maintained, inspected, and repaired as needed to insure continued performance of their intended function until replaced by permanent ESC devices or restoration is complete. All temporary devices will be removed within 30 days after site stabilization or after the temporary measures are no longer needed.

3.1 SAFETY FENCE (STD & SPEC 3.01)

Construction of temporary safety fencing will be installed as needed along the LOD during grading and excavation at public access points to warn pedestrians of possible hazards. This would include adjacent to public road crossings, trails, recreational areas, cemeteries, places of worship, etc... In addition, lights, signs and other warnings are required at road entrances and road crossings in accordance with Virginia Department of Transportation permits and regulations. For residences that are located within 50 feet of the construction work areas, MVP will install temporary construction safety fencing along the edge of the work area for a distance of 100 feet on either side of the residence in accordance with the site-specific residential construction plans prepared for the Project.

Construction safety fence will consist of plastic orange construction safety fence typically measuring four (4) feet in height anchored to six (6) foot long metal “T” or “U” posts. Installation will be implemented in accordance with Appendix A – STD & SPEC 3.01 Safety Fence.

Construction safety fencing may also be used to identify environmentally sensitive areas to be protected during construction or to highlight hazards along the right-of-way (e.g., a single-strand electric fence). Safety fencing may not be substituted for wire fencing in active pastures.

3.2 CONSTRUCTION ENTRANCE (STD & SPEC 3.02)

A construction entrance will be constructed at any point where construction equipment leaves the ROW and enters a paved public road or other paved surface. Typically, they are comprised of geotextile fabric overlain by 6 inches of coarse aggregate (VDOT #1) extending a minimum of 70 feet from the edge of the pavement. The construction entrance must function to remove mud from vehicles and equipment leaving the ROW. As mud accumulates on the entrance, clean stone must be added or the tire mats lifted and shaken to remove mud. Any mud that is carried onto the pavement must be thoroughly removed by the end of the day by shoveling or sweeping. The mud will be returned to the ROW. If the EI determines that the construction entrance is not adequately removing mud from vehicles and equipment leaving the ROW, the construction entrance will be extended in 70-foot increments until the matter is alleviated. Another option in place of the 70-foot extensions would be to install a wash rack (see Appendix A – STD & SPEC: Plate 3.02-1).

3.3 SEDIMENT BARRIERS (STD & SPEC 3.04, 3.05, 3.06 AND 3.27)

Sediment barriers such as silt fence or brush barrier will be used to temporarily intercept and detain small amounts of sediment from disturbed areas of limited extent and to decrease the velocity of sheet flows. Temporary sediment barriers will be installed at the base of slopes adjacent to road crossings until disturbed vegetation has been reestablished. Temporary sediment barriers will also be installed to prevent siltation into waterbodies or wetlands crossed by or near the construction work area where appropriate. Brush barriers may not be used within 50 feet of a wetland or waterbody. None of these devices is suitable for blocking flow in a stream channel but may be used to filter runoff in an interceptor diversion as well as along the edge of the work area. Sediment barriers will typically be installed along the contour with the ends turned upslope enough to prevent end runs. Sediment barriers will be inspected to identify damage incurred during construction and after each rainfall, and necessary repairs will be made immediately. Sediment barriers that are not functioning properly must be cleaned out and restored to good working condition or replaced.

Straw bales are intended mostly to filter sheet flow leaving the perimeter of a work area. In order to be effective, they must be installed a minimum of 4 inches below the ground surface to minimize undercutting, oriented so the bindings (strings or wires) go around the sides rather than over the top and bottom. Each bale must be staked with at least 2 stakes and firmly butted against the adjacent bale so that runoff passes through the straw rather than between the bales (see Appendix A – STD & SPEC: Plate 3.04-1).

Silt fence provides improved sediment filtration over straw bales, though it cannot be adapted for use in rocky areas. Silt fence may be applied to filter sheet flow from the perimeter of the work area, or to filter flow in minor swales that cross the work area. Silt fence must also be installed at least 4 inches below grade, and the flap along the lower edge turned upslope and buried in order to prevent undercutting. Silt fence should be used with extra-strength filter cloth and stakes spaced 6 feet apart. In areas of heavy sedimentation, silt fence may require additional support. In these areas, wire-backed silt fence (sometimes called super silt fence) may be used or existing silt fence may be backed with a line of staked bales (not necessarily dug in as they are providing structural support) on the downslope side (see Appendix A – STD & SPEC: Plates 3.05-1 and -2).

Priority One Belted Silt Retention (BSRF) fence may be utilized for additional ESC measures in areas where additional controls are warranted. BSRF is a patented product constructed of a 36-inch wide gray continuous filament polyester non-woven fabric, needle-punched to entangle the continuous filaments, and containing an internal scrim incorporated into the fabric for additional strength and durability. The system utilizes wood stakes and "J" shaped fabric configuration in the anchor trench (See Appendix B – MVP-ES9).

The compost filter sock is a tubular mesh sleeve filled with compost that is installed with stakes downslope at the perimeter of the disturbed area to filter run-off from the construction area. The compost filter sock is a linear, land-based treatment that removes stormwater pollutants through filtration of soluble pollutants and sediments and by deposition of suspended solids. The compost filter sock is typically available in 8-inch (200 mm), 12-inch (300 mm), 18-inch (450 mm), and 24-inch (600 mm) diameters (see Appendix B - MVP-ES3).

Brush barriers consist of small diameter (under 6 inches in diameter) mixed brush, slash and rocks piled along the outboard edge of the work area. Brush barriers will not be used in agricultural areas, wetlands, or other environmentally sensitive areas. Brush will not be obtained from areas outside the approved ROW to create the brush barrier. A brush barrier is particularly useful on the downslope edge of the ROW in side slope areas where heavier debris may commonly roll off the ROW. Brush barriers should be a minimum of 3 feet high, a minimum of 5 feet thick at the base. Brush barriers may be constructed with or without filter fabric cover. Gaps will be left in the brush barrier at approximately 100-foot intervals (see Appendix A – STD & SPEC 3.06) to allow for wildlife passage.

A broad based dip is utilized as an alternative to cross drain culverts to remove water across and off access roads. Broad based dips are designed to be used on outsloped roads and for grades of less than 10%. The broad based dip consists of a section of road reverse graded to 3% for 20-feet followed by an 80-foot section of regularly graded road. On slopes between 8 and 10% the broad based dip should be surfaced with 4-inches of crushed stone (see Appendix B - MVP-ES5).

Turbidity curtains are a floating system that is used to contain sediment and silt that may be suspended in water when working in streams and lakes. The system consists of a series of floatation elements connected to each other with an attached fabric skirt hanging below that is anchored to the stream or lake bed (see Appendix A – STD & SPEC 3.27)

3.4 TEMPORARY DIVERSION DIKE (STD & SPEC 3.09)

A temporary diversion dike is intended to divert overland sheet flow to a stabilized outlet or a sediment-trapping facility during construction and during the establishment of permanent stabilization on sloping disturbed areas. When used at the top of a slope, the structure protects exposed slopes by keeping upland run-on (sheetflow) from entering the disturbed area. When used at the base of a slope, the structure protects downslope areas by diverting sediment laden runoff to a sediment trapping facility.

The temporary diversion dike will be stabilized to prevent erosion during construction and the gradient of the channel behind the dike will be positive to assure drainage. The channel will be either parabolic or trapezoidal to inhibit high velocity that can occur with a v-ditch. The diversion ditch will be "turned out" to an outlet at a spacing of no greater than 150-feet between outlets. The outlets will be protected with a sediment sump and compost filter sock or silt fence. Additional construction details include:

- Rolled erosion control product and/or mulching shall be used to stabilize the temporary compacted soil berm, diversion ditch, and temporary fill slope.

- Spoil from the pipeline trench to be used to construct the temporary soil berm.
- Outlet trench to be cut from the pipeline trench to the diversion ditch at trench plugs/breakers and at low points in the pipeline trench.
- Temporary fill slope to be constructed no steeper than 2h:1v.
- Side slopes of temporary soil berm and diversion ditch shall be no steeper than 2h:1v.
- Ends of compost filter sock at sump outlet to be turned upslope and butted up against the berm to prevent flow from passing around compost filter sock.
- Outlets shall be spaced no more than 150 feet.
- This device shall not be used on any areas that have a pipeline slope exceeding 12%.

See Appendix A –STD & SPEC: Plate 3.09 and associated additional details.

3.5 TEMPORARY SLOPE BREAKERS/TEMPORARY RIGHT-OF-WAY DIVERSION (STD & SPEC 3.11)

Temporary slope breakers, ROW diversions or waterbars, are intended to reduce runoff velocity and divert storm water off the construction ROW. Temporary diversions may be constructed of soil from the site, gravel (provided the gravel can be completely removed at the end of construction), or with a line of staked bales (see sediment barriers described above) or sand bags where conditions prohibit using compacted soil (e.g., on a rocky slope with insufficient soil to create interceptor diversions). The minimum dimensions of an interceptor diversion are 18 inches tall and 6 feet wide at the base (see Appendix A – STD & SPEC: Plate 3.11-1).

Temporary diversions will be spaced according to the maximum spacing as identified below. In addition, they will be located 25 feet from the edge of waterbodies and at the base of slopes adjacent to road or railroad crossings. Temporary slope breakers will discharge to an undisturbed heavily vegetated area when possible or the discharge point will be stabilized to prevent erosion and trap sediment (use a sediment barrier described in Section 3.0). Care will be taken not to locate discharge points at or adjacent to wetlands, waterbodies or other environmentally sensitive areas. Temporary diversions will be inspected daily and repaired at the end of each workday as necessary to maintain function and prevent erosion. Interceptor diversions may be damaged, even removed, during daily construction operations, but will be restored at the close of each workday.

In addition to the temporary installations, some slope breakers will remain as permanent BMPs particularly in steep slopes, in forested areas and adjacent to streams and wetlands to provide long-term protection from erosion and sedimentation. Finally, as described in Section 4.0 – Stormwater Management Requirements some slope breakers will be designed to include post construction stormwater management features (i.e. compost amended soil to remove phosphorous and aid in retention).

Outlet protection, if needed, will be installed per STD & SPEC 3.18 Outlet Protection.

The spacing for Temporary Right-of-Way Diversions presented in STD & SPEC 3.11 Table 3.11A is outlined below:

SPACING OF TEMPORARY RIGHT-OF-WAY DIVERSIONS

Pipeline Grade	Distance (feet)
<7%	100
Between 7% and 25%	75
Between 25% and 40%	50
Greater than 40%	25

MVP will submit a variance request at the time of plan submission in accordance with VESCL Sec.10.1-563(B).

3.6 TEMPORARY STREAM CROSSING (EQUIPMENT CROSSING) (STD & SPEC 3.24)

When a watercourse (any channel with defined banks, flowing or otherwise) on the ROW or on an access road must be crossed more than twice for construction, a temporary stream crossing (or equipment crossing) will be installed. Clearing equipment is permitted to ford stream crossings (one pass in and one pass out) because temporary stream crossings cannot be installed until grading is done; however, no other equipment is permitted to ford across streams. Small channels can be spanned with timber mats. Larger channels must be filled with flume pipe sufficient to carry a 10-year storm flow (see Appendix A – STD & SPEC 3.24: Table 3.24-A) and covered with 6 inches of coarse aggregate (VDOT #1). Minimum culvert size is 18 inches and the culvert must extend past the edges of the temporary stream crossing such that mud is not deposited in the stream channel. All materials used to construct a temporary stream crossing must be removed once the crossing is no longer needed for construction unless additional state and federal permits have been acquired for a permanent bridge (see Appendix A – STD & SPEC: Plates 3.24-1 and -2).

The following design criteria will be used for Temporary Stream Crossings for Equipment:

1. Temporary Bridge Crossing
    a. Structures may be designed in various configurations. However, the materials used to construct the bridge must be able to withstand the anticipated loading of the construction traffic.
    b. Crossing Alignment – The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15 degrees from a line drawn perpendicular to the centerline of the stream at the intended crossing location.
    c. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or ROW restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.
    d. A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with STD & SPEC 3.11, Temporary

Right of Way Diversion. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

e. Appropriate perimeter controls such as Silt Fence (STD & SPEC 3.05) or Turbidity Curtain (STD & SPEC 3.27) must be employed when necessary along banks of stream parallel to the same.

f. All crossings shall have one traffic lane. The minimum width shall be 12 feet with a maximum width of 20 feet.

g. Further design/construction recommendations for temporary bridge construction may be found in Construction Specifications.

2. Temporary Culvert Crossing

a. Where culverts are installed, VDOT #1 Coarse Aggregate or larger will be used to form the crossing. The depth of stone cover over the culvert shall be equal to one-half the diameter of the culvert or 12 inches, whichever, is greater. To protect the sides of the diversion from erosion, riprap shall be used and designed in accordance with STD & SPEC 3.19 – Riprap (see Appendix A – STD & SPEC: Plate 3.24-2).

b. If the structure will remain in place for up to 14 calendar days, the culvert shall be large enough to convey the flow from a 2-year frequency storm without appreciably altering the stream flow characteristics. See Table 3.24-A (Appendix A) for aid in selecting an appropriate culvert size (note all assumptions). If the structure will remain in place 14 days to one year, the culvert shall be large enough to convey the flow from a 10-year frequency storm. In this case, the hydrologic calculation and subsequent culvert size must be done for the specific watershed characteristics. If the structure must remain in place over 1year, it must be designed as a permanent measure by a qualified professional.

c. Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert that may be used is 18 inches.

d. All culverts shall be strong enough to support their cross-sectioned area under maximum expected loads.

e. The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.

f. The slope of the culvert shall be at least 0.25 inches per foot.

g. Crossing Alignment – The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15 degrees from a line drawn perpendicular to the centerline of the stream at the intended crossing location.

h. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or ROW restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.

i. The approaches to the structure shall consist of stone pads meeting the following specifications:

i. Stone: VDOT #1.

ii. Minimum thickness: 6 inches

iii. Minimum width: equal to the width of the structure

j. A water diverting structure such as a swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with STD & SPEC 3.11, Temporary Right of Way Diversions. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

A copy of Tables 3.24-A (Pipe Diameter (Inches) for Stream Crossings) of the VESCH is provided in Appendix A.

The above-stated stream-crossing procedures will be altered if required to conform to any incompatible or more stringent requirement imposed by the United States Army Corps of Engineers, Virginia Marine Resource Commission, or other appropriate federal or state authority.

3.7 DEWATERING STRUCTURE (STD & SPEC 3.26)

A dewatering structure filters sediment from water pumped out of excavations. The style most commonly used for pipeline construction is an above-grade pit made of staked bales, filter fabric, and gravel; however, other structures (or a combination thereof) are available. In certain instances, a pumped water filter bag will be placed in the dewatering structure to provide additional sediment control. An alternative to a dewatering structure is to use a pumped water filter bag over the discharge end of the hose. The Environmental Inspector will monitor use of filter bags to ensure that they are changed frequently enough to ensure proper functioning (see Appendix A – STD & SPEC: Plates 3.26-1, -2, and -3, and Appendix B - MVP-ES2). Used filter bags will be disposed of at an authorized waste facility.

3.8 ROCK CHECK DAM (STD & SPEC 3.20)

Rock check dams are used in drainage ditches and small channels on and around LDAs until final stabilization is complete. They should be installed immediately following construction of the drainage ditch, but prior to any adjacent disturbance.

Rock check dams should not be used in a live stream or any waterbody that meets the definition of a Waters of the United States.

Check dams should be checked for sediment accumulation after each runoff-producing storm event. Sediment should be removed when it reaches one half of the original height of the measure.

Regular inspections should be made to insure that the center of the dam is lower than the edges. Erosion caused by high flows around the edges of the dam should be corrected immediately.

3.9 OUTLET PROTECTION (STD & SPEC 3.18)

Outlet protection is used to prevent scour at stormwater outlets, to protect the outlet structure, and to minimize the potential for downstream erosion by reducing the velocity and energy of concentrated stormwater flows.

The outlets of pipes and structurally lined channels are points of critical erosion potential. Stormwater which is transported through man-made conveyance systems at design capacity generally reaches a velocity which exceeds the capacity of the receiving channel or area to resist erosion. To prevent scour at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

Design of all Outlet Protection Devices shall be in accordance with STD & SPEC 3.18 of VESCH.

3.10 EQUIPMENT CLEANING STATIONS

In order to limit the potential for the spread of noxious weeds, MVP will establish equipment cleaning stations throughout the Project areas. These facilities will be used to ensure equipment is free of debris before being transported to a new construction spread. During construction, the EI will ensure all contractors clean the tracks, tires, and blades of equipment by hand or compressed air to remove any excess soil and vegetative materials prior to movement of equipment out of known weed or soil-borne pest infested areas.

In addition, prior to mobilization, MVP will require contractors to thoroughly clean all construction equipment prior to moving equipment to the Project area. Equipment will be cleaned of soil, vegetative matter and other construction materials to limit the spread of noxious weeds, insects, or other soil-borne pests.

4.0 STORMWATER MANAGEMENT REQUIREMENTS

In addition to the approved Erosion and Sedimentation Control Plans, since the Project creates a land disturbance of greater than 1 acre and is located outside of Chesapeake Bay Preservation Areas, MVP will demonstrate compliance with design criteria requirements water quantity Guidance Memo No. 16-2001 (9VAC-25-870-66). The stormwater quality and quantity compliance demonstrations will be performed using the methodologies and assumptions as described below. For additional details on the methodology see Appendix D.

4.1 POST-DEVELOPMENT CONDITION

The typical 125-foot wide pipeline construction corridor within the site area will be restored as follows in accordance with MVP's planned maintenance and restoration activities detailed in Sections 2.4.1 and 2.9.2 as well as Appendix E – Post Development Figure, of this document:

- 75-foot temporary construction ROW will be restored to pre-development conditions.
    - If forested, post-development condition will be brush consisting of woody species (seeded and allowed to naturally return to forest condition subject to landowner actions).
    - If agricultural land, post-development condition will return the temporary ROW to agricultural use and will be modeled as such in the stormwater calculations.
    - If pre-development conditions included any impervious cover, such as asphalt or gravel access roads, these impervious surfaces will remain in the post-development condition.
    - Other pre-development conditions such as meadow, wetland, lawn, etc. will be restored to pre-development conditions and will be modeled as such in the stormwater calculations.
- 50-foot permanent ROW will be seeded and restored to meadow conditions
    - Mowing and general maintenance will be consistent with the Forest & Open Space practices listed in the Virginia Runoff Reduction Method (VRRM) Compliance Spreadsheet User's Guide & Documentation (April 2016) Table 1. Land Cover Guidance for VRRM Compliance Spreadsheets.
    - The full width permanent ROW will not be mowed any more frequently than once every three (3) years.
    - A corridor not exceeding 10 feet in width located directly over the pipeline will be mowed annually for inspection purposes in accordance with FERC PLAN and PROCEDURES.

4.2 PRECIPITATION VALUES

Precipitation values used in stormwater calculations will be tailored to the Project.

4.2.1 Annual Precipitation

Annual precipitation values range from 35 to 60 inches along the length of the Project. Therefore, local annual precipitation values will be used when performing water quality calculations (per DEQ, Stormwater Management Technical Meeting, 29 November 2016, Virginia Department of Environmental Quality, Richmond, VA). Refer to Figures 1 and 2 below for local annual precipitation values obtained from PRISM weather stations.

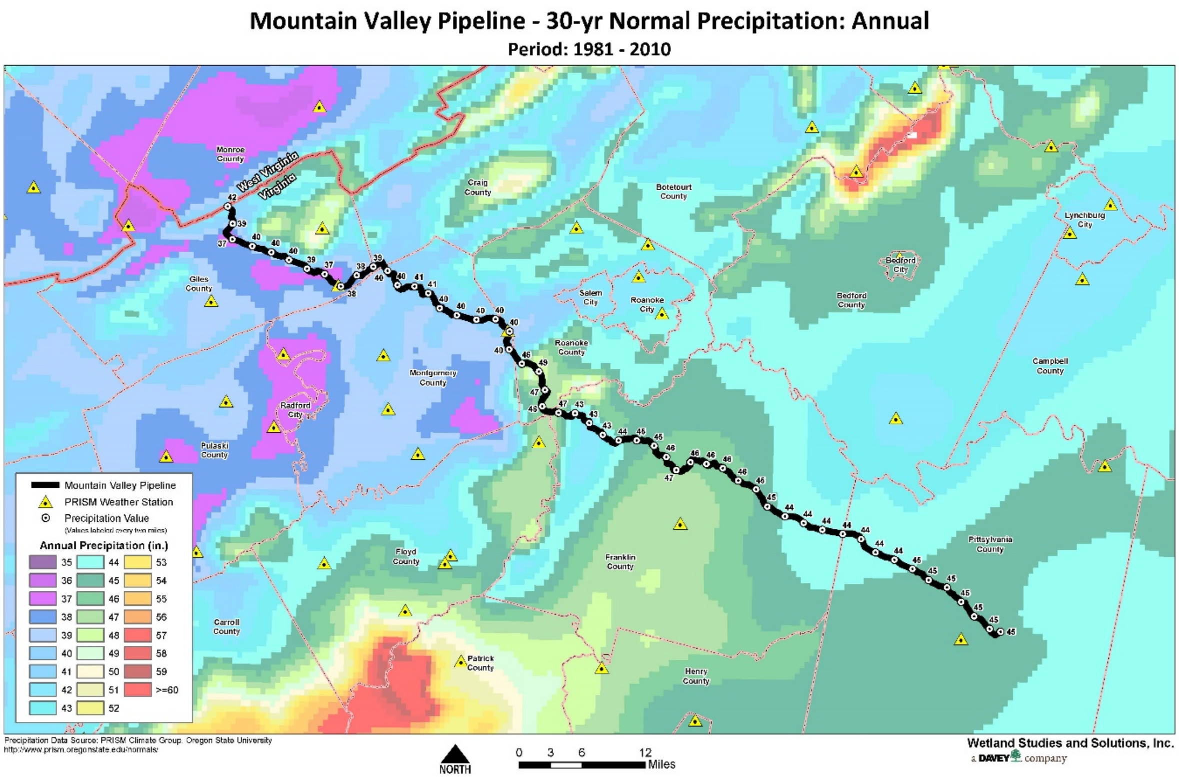

Figure 1. 30-year Annual Normal Precipitation – Raw Data

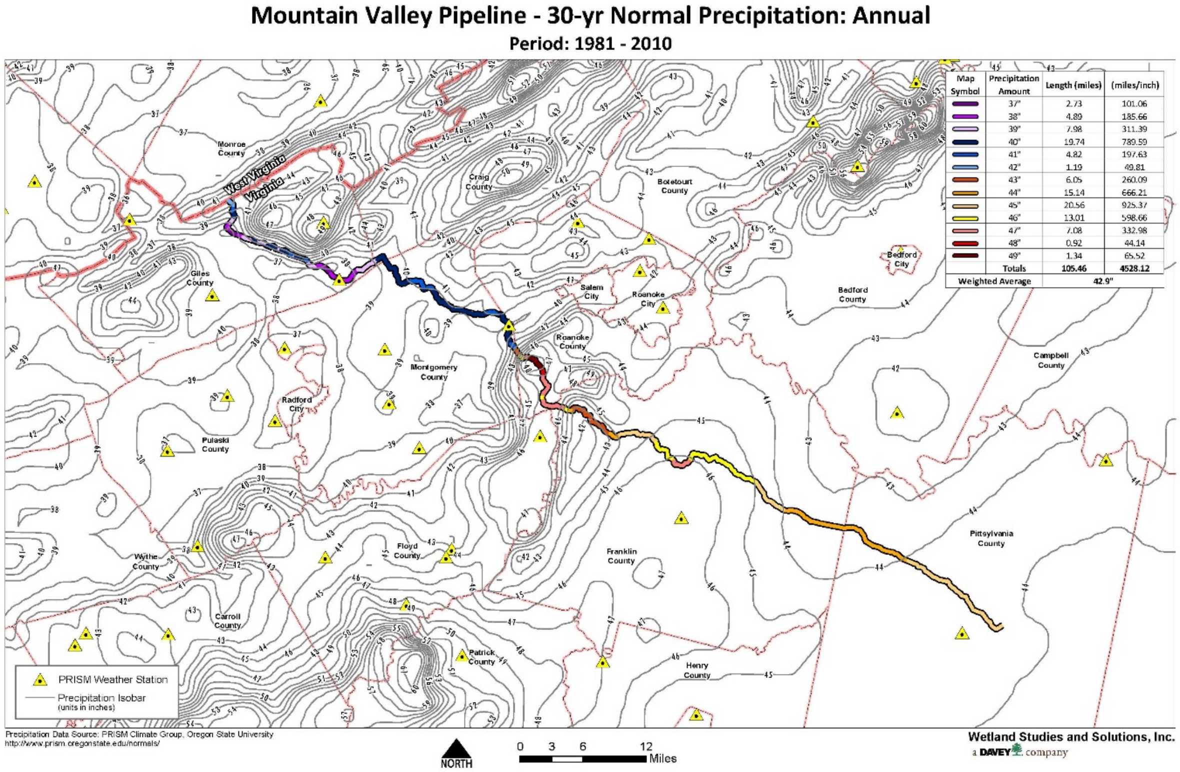

Figure 2. 30-year Annual Normal Precipitation – Pipeline Weighted Average Precipitation with isobars

4.2.2 Design Storms

Design storm values for the 1-, 2- and 10-year 24-hour storms were compiled from multiple sources including local code, the Virginia Stormwater Handbook 1999 Edition, the Virginia Stormwater Handbook DRAFT 2013 Edition, and the NOAA Atlas 14 data for the stations closest to the current pipeline alignment. To meet stormwater management requirements, projects are typically subject to the most stringent regulation. Therefore, the maximum rainfall intensity of the four sources will be used in stormwater calculations as presented in Tables 1-6 below.

Tables 1-6. Design Storm Values by County

Giles County, VA

Frequency Storm	24-Hour Rainfall
1-Year	2.40
2-Year	2.90
5-Year	3.90
10-Year	4.70
25-Year	5.00
50-Year	5.90
100-Year	6.40

Roanoke County, VA

Frequency Storm	24-Hour Rainfall
1-Year	3.00
2-Year	3.50
5-Year	4.50
10-Year	5.00
25-Year	6.00
50-Year	6.70
100-Year	7.50

Pittsylvania County, VA

Frequency Storm	24-Hour Rainfall
1-Year	2.80
2-Year	3.50
5-Year	4.50
10-Year	5.20
25-Year	6.30
50-Year	7.29
100-Year	8.38

Montgomery County, VA

Frequency Storm	24-Hour Rainfall
1-Year	2.60
2-Year	3.20
5-Year	4.00
10-Year	5.00
25-Year	5.80
50-Year	6.60
100-Year	7.60

Franklin County, VA

Frequency Storm	24-Hour Rainfall
1-Year	3.30
2-Year	3.70
5-Year	4.70
10-Year	5.70
25-Year	6.40
50-Year	7.40
100-Year	8.50

Craig County, VA

Frequency Storm	24-Hour Rainfall
1-Year	2.60
2-Year	3.14
5-Year	4.00
10-Year	4.70
25-Year	5.72
50-Year	6.57
100-Year	7.50

4.3 STORMWATER QUALITY CALCULATIONS

Stormwater quality will be evaluated using the Virginia Runoff Reduction Method (VRRM). The stormwater quality evaluation will demonstrate that the total phosphorous load does not exceed the threshold of 0.41 lbs/acre-year for new development. New impervious cover within the Project LOD will include access roads and pad sites. In instances where existing impervious areas, such as access roads, are to be used or improved for the Project, VRRM for re-development calculations will demonstrate either 10% or 20% reduction from predevelopment phosphorus loads based on land disturbance less than or greater than one acre, respectively.

To utilize the site specific annual rainfall values, noted in Section 4.2.1, Version 2.8 of the VRRM spreadsheet will be used for design. At the Transco Interconnect site in Pittsylvania County, Version 3.0 of the VRRM spreadsheet will be used for design (per DEQ, Project Standards and Specifications Meeting, 09 March 2017, Virginia Department of Environmental Quality, Richmond, VA), because the V3.0 Redevelopment VRRM spreadsheet accounts for lower total phosphorus loading rates for projects containing pre- and post-construction forested areas.

Only the site area, or the area within the LOD, will be considered when evaluating stormwater quality in each drainage area. Appropriate post-developed land covers will be used to calculate phosphorous loading per the VRRM spreadsheet. For pre-developed forested areas, under normal operating conditions, the post construction ROW will be considered Forest/Open Space land cover for water quality calculations. For pre-developed non-forested areas, under normal operating conditions these areas will revert to pre-developed land use (e.g. agricultural uses including tilling, pasture, hayfield, etc.). Therefore, the post construction ROW in non-forested areas will be based on Table 1: Land Cover Guidance for VRRM Compliance Spreadsheets, Virginia Runoff Reduction Method Compliance Spreadsheet User's Guide & Documentation dated April 2016.

For the majority of this Project, stormwater BMPs will treat runoff to achieve the VRRM calculated total phosphorus load limits. MVP will utilize specifications from the published 2011 Virginia Stormwater BMP Clearinghouse for BMP design. Although all BMPs will be considered for use to satisfy quality requirements, the specifications listed below are those most likely to be implemented with this Project:

- Specification No. 2 Sheet flow to a vegetated filter strip or conserved open space
- Specification No. 3 Grass channels
- Specification No. 4 Soil compost amendment

4.4 STORMWATER QUANTITY CALCULATIONS

Stormwater quantity will be modeled using the Hydraflow Hydrographs extension for AutoCAD Civil 3D. The Natural Resource Conservation Service (NRCS; formerly Soil Conservation Service [SCS]) Technical Release 55 (TR-55) methods will be utilized to analyze site hydrology in Hydraflow Hydrographs for the 1-, 2-, and 10-year 24-hour storm events.

4.4.1 Energy Balance Method

The resulting peak flow rates and runoff volumes for the 1-year 24-hour storm event will be used as inputs when completing the energy balance method calculations, as detailed in 9VAC25-870-66. B.3.a and below.

Equation 1

$$Q_{Developed} \leq I.F.* \left(Q_{Pre-developed} * RV_{Pre-developed}\right)/RV_{Developed}$$

where:

$Q_{Developed}$	=	The allowable peak flow rate of runoff from the developed site
I.F.	=	Improvement Factor (0.8 for sites > 1 acre; 0.9 for sites ≤ 1 acre)
$RV_{Developed}$	=	Volume of runoff from the site in the developed condition
$Q_{Pre-Developed}$	=	The peak flow rate of runoff from the pre-developed site
$RV_{Pre-Developed}$	=	Volume of runoff from the site in pre-developed condition

- The majority of improvement factors will be 0.8.
- The majority of pre-developed conditions are forested.

Post-development peak flows must always be less than or equal to pre-development peak flows.

Equation 2

$$Q_{Developed} \leq Q_{pre-developed}$$

However, post-development peak flows ($Q_{Developed}$) need never be less than the following:

Equation 3

$$(Q_{Forest} * RV_{Forest})/RV_{Developed}$$

where:

Q_{Forest}	=	The peak flow rate of runoff from the site assuming a forest condition
RV_{Forest}	=	Volume of runoff from the site assuming a forest condition
$RV_{Developed}$	=	Volume of runoff from the site in the developed condition

With the improvement factor, the majority of drainage areas (being forested) will results in a $Q_{Developed}$ from Equation 1 lower than the $Q_{Developed}$ value determined using Equation 3. Therefore, Equation 3 will be used for the majority of the Project to determine compliance with the Energy Balance Method and stormwater quantity requirements.

Runoff volume (RV) and peak flow rate (Q) are calculated in Hydraflow Hydrographs using TR-55 methodology, and the computed values corresponding to the 1-year 24-hour storm event for the pre-developed, developed, and forest conditions are used to determine if the energy balance requirements (i.e., Equations 1 through 3 above) have been satisfied.

Stormwater quantity BMP design will be an iterative process during which BMPs will be added across the drainage area as necessary until the energy balance requirements are satisfied.

4.4.2 Curve Numbers

MVP will utilize curve numbers for the appropriate pre- and post-development cover type, in good condition, and hydrologic soil group (HSG) as listed in the TR-55 Tables 2-2a-d, excerpted below:

Table 7. Post-Development Condition Curve Numbers

Post-Development Condition within the LOD		Hydrologic Soil Group			
Description	TR-55 Land Use	A	B	C	D
Undisturbed Forest	Woods, Good Condition	30	55	70	77
Re-forested	Woods, Good Condition	30	55	70	77
Unmaintained ROW	Brush, Good Condition	30	48	65	73
Maintained ROW	Meadow	30	58	71	78
Gravel Access Road (with ROW)	Impervious Area, Gravel	76	85	89	91
Compacted Well-Graded Gravel (no ROW)	Impervious Area, Paved	98	98	98	98
Asphalt Access Road (with ROW)	Impervious Area, Paved, open ditches	83	89	92	93
Asphalt Access Road (no ROW)	Impervious Area, Paved	98	98	98	98
Concrete Pads	Impervious Area, Paved	98	98	98	98

For pre-developed wooded areas, the post-development cover types will be modeled, per Section 4.1 Post-Development Condition, as the following:

- Brush in good condition for the 75-foot temporary construction ROW/workspace areas; and
- Meadow for the 50-foot permanent ROW.

4.4.3 Drainage Area Delineation

Drainage areas along the proposed pipeline route will be delineated based on rivers and tributaries that have been delineated by, and are therefore recognized by, the VADEQ. The portion of the corresponding VADEQ river/tributary drainage area that runs on to the Project LOD will be considered for quantity requirements. For pipeline sections that run across/through valleys (i.e., in the vicinity of stream crossings), the drainage area considered will be limited to the LOD for quality.

4.4.4 Time of Concentration

For the pre-developed condition, the time of concentration will be calculated in accordance with TR-55 using the flow path from the most remote location within the drainage area to the outlet. For the developed condition, the time of concentration will be calculated in accordance with TR-55 using a flow path that is representative of the hydrologic changes following construction (i.e., changes in surface water runoff due to permanent waterbars, stormwater BMPs, etc.).

4.4.5 Sheetflow

If pre-development runoff conditions include sheetflow, and sheetflow can be maintained in the post-development condition, stormwater quantity regulations will be satisfied demonstrating no adverse effects on downstream properties per 9VAC-25-870-66.D.

No adverse effects will be demonstrated by calculating the sheet flow velocity for the post-development 2-year 24-hour storm and comparing it to permissible velocities. Travel time will be calculated using Manning's kinematic solution:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

where:	T_t	=	Travel time (hours)
	n	=	Manning's roughness coefficient
	L	=	Flow length (feet)
	P_2	=	2-year 24-hour rainfall (inches)
	s	=	Slope of hydraulic grade line (foot/foot)

The sheet flow travel time will then be converted to velocity via the following equation:

$$V = \frac{L}{3600 T_t}$$

where:	V	=	Average velocity (foot/second)
	3600	=	Conversion from hours to seconds

Calculated post-development sheet flow velocities will be less than the permissible velocities as shown in VESCH Tables 5-14 Permissible Velocities for Grass Lined Channels and Table 5-22 Permissible Velocities for Unlined Earthen Channels (reproduced below).

Table 5-14
Permissible Velocities for Grass-Lined Channels

Channel Slope	Lining	Velocity* (ft/sec)
0-5%	Bermudagrass	6
	Reed Canarygrass Tall Fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains Temporary vegetation	2.5
5-10%	Bermudagrass	5
	Reed Canarygrass Tall Fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Bermudagrass	4
	Reed Canarygrass Tall Fescue Kentucky bluegrass	3

* For highly erodible soils, decrease permissible velocities by 25%

Attachment 1 **Mountain Valley Pipeline – Impaired Waters with TMDLs (DEQ/EPA)**

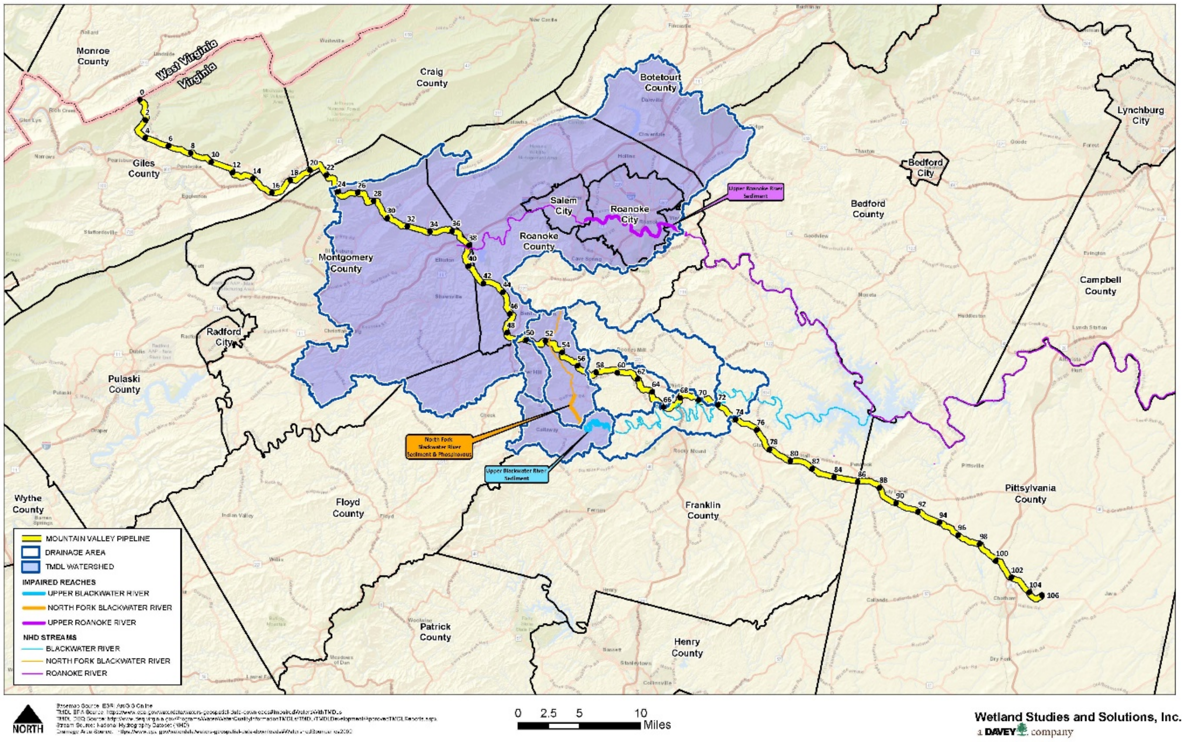

Table 5-22
Permissible Velocities for Unlined Earthen Channels

Soil Types	Permissible Velocity (ft/sec)
Fine Sand (noncolloidal)	2.5
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (noncolloidal)	5.5
Alluvial Silts (noncolloidal)	3.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Shales and Hard Pans	6.0
Source: American Society of Civil Engineers	

If necessary to dissipate concentrated flow into sheet flow, level spreaders will be designed per VESCH STD & SPEC 3.21 (see Appendix A)

4.5 TOTAL MAXIMUM DAILY LOADS

MVP has reviewed federal, state and local regulations applicable to the six (6) counties within the Project for impaired waterbodies that have an established Total Maximum Daily Loads (TMDL) for certain pollutants. The pollutants of potential concern are nutrients, including nitrogen and phosphorous, (during post-construction) and sediment (during construction and post-construction). The Project traverses the watersheds of impaired waterbodies with TMDLs noted below in Figure 4 and Table 8.

Figure 4. Impaired Watersheds

Table 8. TMDL Waterbodies

County	Basin Name	Waterbody Name	Pollutant(s)
Craig	N/A	N/A	N/A
Giles	N/A	N/A	N/A
Montgomery	Roanoke River	Upper Roanoke River	Sediment
Roanoke	Roanoke River	Upper Roanoke River	Sediment
Franklin	Roanoke River	North Fork Blackwater River Upper Blackwater River	Sediment, Total Phosphorous Sediment
Pittsylvania	N/A	N/A	N/A

The total point source wasteload allocation (WLA) for the impaired waterbodies can be found in Table 9 below.

Table 9. Total Wasteload Allocations

Stream Name	TMDL Title	City/ County	WBID[1]	Pollutant	WLA	Units
North Fork Blackwater River	Total Maximum Daily Load (TMDL) Development for the Upper Blackwater River Watershed	Franklin	L08R	Sediment	0	T/YR
North Fork Blackwater River	Total Maximum Daily Load (TMDL) Development for the Upper Blackwater River Watershed	Franklin	L08R	Phosphorus	0	T/YR
Upper Blackwater River	Total Maximum Daily Load (TMDL) Development for the Upper Blackwater River Watershed	Franklin	L08R	Sediment	0.526	T/YR
Roanoke River	Benthic TMDL Development for the Roanoke River, Virginia	Roanoke, Montgomery	L04R	Sediment	5,189	T/YR

[1]WBID = Waterbody Identification Number

For all work performed within the boundaries of the impaired waters listed above, the measures listed below will be implemented.

- The impaired water(s), approved TMDL(s), and pollutant(s) of concern, when applicable, shall be identified in the SWPPP;
- 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, soil and weather conditions permitting;
- Fertilizers shall be applied in accordance with manufacturer's recommendations or an approved nutrient management plan and shall not be applied during rainfall events; and

- The applicable ESC control and SWM BMP inspection frequency shall be increased as noted in Section 2.0 above.

5.0 SPECIAL PROCEDURES

MVP will implement specialized construction procedures in areas deemed an environmentally sensitive area such as waterbody and wetland crossings, areas of steep slopes and other areas of concern as identified below.

5.1 WATERBODY AND WETLAND CROSSINGS

Wetlands and waterbodies are natural resources given additional protection under the law because they provide important ecological benefits which may be altered or harmed by construction activities. Wetlands are areas where the plants have adapted to saturated soil conditions for extended periods of time. Wetlands often do not have standing water or even saturated soil at all times during the year, and may host plants from flowers and grasses to common shrubs and trees. Waterbody is a term used for any permanent standing or flowing water, or defined channel, such as streams, rivers, ponds and reservoirs. Streams (the area from top of bank to top of bank) may be one of the following: perennial, meaning they typically have some flowing water year round (except in cases of drought), intermittent, meaning they only have flowing water during high flow periods such as spring but they have defined banks and stream bed, and ephemeral, meaning they only exists for a short period following precipitation or snowmelt.

A qualified professional (i.e. wetland and stream biologist) will identify all wetland and water body crossings during the planning and survey phase of the Project.

For every waterbody and wetland, a buffer will be added to both sides of each crossing to ensure that any transitional area is also treated as an environmentally sensitive area. Buffers will extend 50 feet where possible, or as far as topographic conditions permit, along the right-of-way from where the trench centerline enters the wetland and waterbody.

To minimize impacts to waterbody and wetland crossings, they will be treated as separate construction entities, except during clearing activities, and efforts will be made to cross these areas during low flow. Once grubbing and grading starts at a waterbody or wetland crossing it will be actively conducted for consecutive days until the crossing is completed and the work area restored. In general, the same measures as already discussed for upland construction also apply to waterbody and wetland crossings. Exceptions and Procedures of special emphasis are discussed below. Permits may include conditions that further modify these requirements. Crossings will be constructed as close to perpendicular to the axis of the waterbody channel as engineering and routing conditions permit. If the pipeline parallels a waterbody, at least 15 feet of undisturbed vegetation will be maintained between the waterbody and the right-of-way, if possible, except at the crossing location. Where waterbodies meander or have multiple channels, the pipeline will be routed to minimize the number of waterbody crossings.

The methods described in this section will be employed unless incompatible or more stringent requirements are imposed by the U.S. Army Corps of Engineers, Virginia Marine Resources Commission, or other appropriate federal or state authority.

<u>Time Windows for Construction</u>: If the below indicated species is present within the waterbody, no in-stream construction activities will be conducted during the following time windows unless written approval is received from the appropriate federal or state agency:

- Coldwater Fisheries - March 1 – June 30; and
- Warmwater Fisheries - April 15 – July 15

- Natural Trout Streams October 1 - March 31 for Brown Trout (Salmo trutta) and Brook Trout (Salvelinus fontinalis) waters, and March 15 - May 15 for Rainbow Trout (Oncorhynchus mykiss) waters;
- Stockable Trout Streams - there is no time of year restrictions for stockable trout; however, as required by the VDGIF, MVP will consult with the VDGIF regional offices before constructing in stockable trout streams.
- Roanoke Log Perch (Percina rex) and Orangefin madtom (Noturus gilberti) waters - March 15 - June 30.
- Atlantic pigtoe (Fusconaia masoni) and James spinymussel (Pleurobema collina) – May 15 – July 31
- Green floater (Lasmigona subviridis) and Yellow lampmussel (Lampsilis cariosa)– April 15 – June 15 and August 15 - September 30

Planning and Survey: MVP intends to employ one of the Utility Stream Crossing (STD & SPEC 3.25) methods to complete open water crossings utilizing these dry-ditch methods. The method selected during planning and surveying may need to be altered based on field conditions at the time of construction. Alterations must be approved by the Construction Supervisor and the LEI/EI prior to implementation. MVP will contact the Plan–approving Authority if necessary.

The principal methods of crossing waterbodies in the Commonwealth will be open-cut dry-ditch. These methods include Flume Pipe Crossing (Appendix A – STD & SPEC: Plate 3.25-3), Cofferdam Crossing (Appendix A – STD & SPEC: Plate 3.25-4) and Dam and Pump (Appendix B –MVP-15). MVP does not propose to conduct any waterbody crossings via directional drill methods. In the event a directional drill method is needed, the crossing would be conducted in accordance with these details following approval of necessary federal and state permitting requirements.

For crossings of all state-designated fisheries as well as waterbodies with sensitive species concerns, all construction equipment will cross the waterbody on an equipment bridge. Equipment bridges are not required at minor waterbodies that do not have a state-designated fishery classification (for example, agricultural or intermittent drainage ditches).

For crossings of waterbodies greater than 10 feet in width, use of equipment operating in the waterbody will be limited to that needed to construct the crossing. All other construction equipment must cross on an equipment bridge. Every attempt will be made if wet-ditch open-cut crossing is utilized to complete trenching and backfill work within the waterbody (not including blasting) within 48 hours, unless site-specific conditions make completion within 48 hours infeasible.

Wetland crossings will be constructed using standard trench-and-backfill methods. Heavy equipment working in wetlands will utilize equipment mats or other suitable methods to minimize soil disturbance and compaction.

Staging areas for waterbody and wetland crossings will be located outside the buffer areas and will be the minimum necessary to stage the waterbody or wetland crossing. No refueling, hazardous materials storage, equipment maintenance, or equipment parking will take place within 100 feet of the waterbody or wetland crossing. If pumps are being used within the waterbody or wetland crossing, small quantities of fuel in Gerry cans may be stored on site within a spill containment device, otherwise fuel may not be stored within waterbody and wetland crossings. Equipment and vehicles will not be washed in any waterways. The LEI/EI will specify additional stabilization measures as needed to prevent equipment from rutting within waterbody and wetland crossings.

Waterbody and wetland crossings will be clearly marked in the field prior to the start of tree clearing activities.

Additional Temporary Workspace (ATWS) and Access Roads: Clearing of vegetation between extra work areas and the edge of the wetland will be limited to the permitted construction ROW. The size of extra work areas will be limited to the minimum needed to construct the waterbody crossing. The only access roads, other than the construction right-of-way, that will be used in wetlands are those existing roads that can be used with minimal or no modification to the wetland.

Temporary Erosion and Sediment Control: Sediment barriers will be installed immediately after initial disturbance of the waterbody or adjacent upland. Sediment barriers will 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. Sediment barriers will be installed across the entire construction right-of-way at all waterbody crossings. Where waterbodies are adjacent to the construction right-of-way, sediment barriers will be installed along the edge of the construction right-of-way as necessary to contain spoil and sediment within the ROW. Trench plugs will be used at all waterbody crossings to prevent diversion of water into upland portions of the pipeline trench and to keep any accumulated trench water out of the waterbody. Trench plugs will be of sufficient size to withstand upslope water pressure.

Clearing: Clearing operations will be permitted for two (2) passes through each waterbody or wetland crossing, but no grubbing or grading will be conducted until the contractor is prepared to install the pipe and backfill. Care will be taken during clearing operations not to deposit mud in open water, and to minimize rutting of the right-of-way. All woody debris will be removed from within the waterbody or wetland crossing for disposal. Vegetation will be cut off at ground level, leaving existing root systems in place, and removed from the wetland for disposal. Timber riprap may be employed to stabilize the equipment work area provided all timber is obtained from within the approved construction work area. All timber riprap must be installed to facilitate removal upon completion of construction. Any disturbed soil will be mulched before the clearing crew leaves the waterbody or wetland crossing. MVP reduced the construction LOD at wetland crossings from 125 feet to 75 feet to minimize impacts. Clearing activities within wetland areas will be restricted to the 75-foot temporary construction LOD.

Grubbing and Grading: Before grading begins and as grubbing progresses, sediment barriers (staked bales or silt fence, compost filter socks, etc.) will be installed across the construction area at the edge of the water or the edge of the wetland, and along the sides of the construction work area as needed to prevent the flow of spoil into the waterbody or wetland. Clearing of vegetation in wetlands would be limited to trees and shrubs, which would be cut flush with the surface of the ground and removed from the wetland. Stump removal, topsoil segregation, and excavation would be limited to the area immediately over the trench line within the 50-foot permanent ROW easement per NWP12 Regional Condition 3.b.iii, FERC PROCEDURES and Project's FERC Certificate conditions (see Appendix B MVP-53). Trees located within 15 feet of the pipeline with roots that could compromise the integrity of the pipeline coating may be selectively cut and removed from the permanent ROW. A limited amount of stump removal and grading may be conducted within the permanent ROW easement in wetlands to ensure a safe working environment. .In wetlands, very little grading is expected, as topography is generally flat and low-lying.

Per MS-13, when a live waterbody must be crossed by construction vehicles more than twice in a 6-month period, a temporary stream crossing of non-erodible material must be provided. If a flume crossing is planned, the flume to carry the stream flow across the ditch may also be installed at this time. The stream crossing process using a flume would include the installation of the flume, continuing with the trench excavation, the pipeline installation, backfilling of the trench and ending with the stabilization of the stream bank. This process will be completed within a 72-hour period from flume installation to stabilization of the stream bank. If blasting is required, and not intended to be included in the 72-hour time limit, then a variance may be required from the VADEQ.

Temporary ROW diversions (interceptor diversions) will be installed at the ends of the waterbody or wetland crossing.

Equipment Bridges: Only clearing equipment may cross waterbodies before installation of equipment bridges. The number of such crossings of each waterbody will be limited to one per piece of equipment. Soil will not be used to construct or stabilize equipment bridges. Equipment bridges will be constructed using one of the following methods:

- Equipment pads and culvert(s);
- Clean rock fill and culvert(s) that conforms to the requirements in STD & SPEC 3.24 (Appendix A – STD & SPEC: Plate 3.24-2)
- Flexi-float or portable bridge(s) (Appendix A – STD & SPEC: Plate 3.24-1).

Each equipment bridge will be designed and maintained to withstand and pass the highest flow that would occur while the bridge is in place and prevent soil from entering the waterbody. Equipment bridges will be removed following completion of restoration of the ROW permanent seeding unless it is authorized to remain as a permanent bridge. If there will be more than 30 days between final cleanup and the beginning of permanent seeding and reasonable alternative access to the right-of-way is available, equipment bridges will be removed as soon as possible after final cleanup.

Trenching: Trenching activities will begin promptly after grading is completed. If trenching of adjacent upland areas has been completed but will not be backfilled before the waterbody or wetland crossing is trenched, a trench plug will be left in place at the end of the waterbody or wetland crossing to prevent storm water runoff from entering the waterbody or wetland by way of the trench. During excavation, the top one-foot of wetland soil or streambed substrate will be segregated and stockpiled separate from the trench spoil. This segregated material will be utilized during restoration of the waterbody or wetland to enhance restoration with the native seedbank and substrate materials.

Any water that must be removed from the work area will be discharged through a dewatering structure. Discharge points will be located in an upland area, including the buffer, whenever possible. The discharge will be carefully monitored to prevent erosion and sedimentation in the waterbody or wetland, and in such a manner that no heavily silt-laden water flows into any waterbody.

A minimum of the top one (1) foot of topsoil will be conserved from over the trench in wetlands without standing water or saturated soil.

If standing water or saturated soils are present, low-ground-weight construction equipment, will be used or normal equipment will be operated on timber riprap, prefabricated equipment mats, or geotextile fabric overlain with gravel. Geotextile fabric used for this purpose must be strong enough to allow removal of all gravel and fabric from the wetland.

Spoil Pile Placement and Control: All spoil from waterbody crossings will be placed in the construction right-of-way at least 10 feet from the water's edge or in additional extra work area as described above. Sediment barriers will be used to prevent the flow of spoil into any waterbody.

Pipe Installation: For smaller crossings, the pipe string will be assembled outside the waterbody or wetland crossing and carried or floated into position, depending on site conditions. For larger crossings, pipe assembly will be conducted outside of the waterbody or wetland crossing except for those crossings that utilize the porta-dam crossing method. For all large porta-dam crossing methods, assembly will be conducted in the dry area behind the porta-dam. All welding and coating debris will be fully removed from the waterbody or wetland crossing prior to retuning flow to the waterbody. MVP will utilize saddle bags filled with clean pea gravel or sand for pipe weights within waterbody or wetland crossings to insure negative buoyancy.

Backfilling: Backfilling will begin promptly after pipe installation is completed. Permanent trench breakers will be installed in the banks of stream channels and at the ends of wetlands. In trout streams, the top 12 inches of backfill will be made with clean native stream substrate.

Final Grading: Final grading will begin promptly after backfilling is completed. If final grade is reached on any portion of the site, vegetation will be established to prevent erosion. Temporary seeding will be applied within 7 days if any portion of the site will remain dormant for more than 14 days to prevent erosion. Disturbed areas will be restored to pre-construction contours, and in wetlands, topsoil will be replaced preserving the native seed bank which will enable restoration with native plant species. Sediment barriers at the edge of the wetland or edge of the water will be repaired or replaced as necessary. Permanent ROW diversions (interceptor diversions) will be installed at the edge of the buffer area or base of the slope nearest the waterbody and wetland. All materials used to stabilize the equipment work area will be removed (e.g. timber riprap or timber mats). 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.

If soil and weather conditions prevent final grade to be established (e.g. if the permit specified a winter construction window), a temporary approximate grade will be established. ESC measures will be restored or replaced as needed, and temporary stabilization will be applied.

Restoration: Restoration will begin immediately after final grade is established. Stream banks will be restored by vegetative stabilization (STD & SPEC 3.22) where site conditions warrant or by riprap (STD & SPEC 3.19) where banks slope are 3h:1v or steeper. Vegetative stabilization generally includes planting a perennial conservation seed mix from Table 3.32-B (see Appendix A). If grubbing has not been extensive, then native shrub and tree species are expected to sprout and regenerate naturally. Stream banks will be seededprior to mulch application. A sediment barrier will be maintained at the edge of the water until revegetation of the streambank is successful.

Wetlands will be temporarily seeded in accordance with Typical Construction Detail MVP-ES11.4 (Appendix B) and mulched with clean straw (where required), then allowed to revegetate with native seedbank present in the segregated topsoil. A sediment barrier will be maintained around the restored area until revegetation is successful.

In wetlands where saturated conditions or standing water is present, topsoil segregation will be conducted to the extent practicable. Following installation of the pipeline, the trench will be backfilled using native wetland soils and restored to preexisting conditions. No soil or rock will be imported for use during backfilling of the trench. Annual ryegrass will be applied to wetland areas to temporarily stabilize the area while the native wetland seedbank reestablishes the area with native vegetation. No seeding should be conducted in areas of standing water. The riparian buffers will be restored using the procedures discussed above for upland areas.

For all affected forested wetlands, restoration activities will be conducted in accordance with the Project's approved permit conditions and mitigation requirements. If saplings are required to be planted within the temporary ROW areas, this will be conducted in accordance with Section 2.9.6 – Bare Root Seeding Sapling and Shrub Planting (see Appendix A – STD & SPEC: Plates 3.37-4, 3.38-8, and 3.38-9) unless otherwise specified by applicable permit conditions.

5.2 SPECIALIZED CROSSING PROCEDURES

MVP has considered specialized procedures for use during Project planning, permitting and implementation at waterbody and wetland crossings. A discussion of these construction procedures that may be implemented during construction is included in the following sections.

5.2.1 Horizontal Directional Drilling

Horizontal directional drilling (HDD) is a method that allows for trenchless construction across an area by pre-drilling a hole below the depth of a conventional pipeline lay and then pulling the pipeline through the pre-drilled borehole. Although HDD can be an appropriate method is some situations, MVP has evaluated this option and concluded that is not practicable at any location along the MVP route. The length of pipeline that can be installed by HDD depends upon soil conditions and pipe diameters and is limited by available technology and equipment sizes. The HDD method also requires large staging areas on both sides of the crossing to accommodate the necessary equipment and materials. In addition, because it is necessary to prefabricate a section of pipe aboveground that is equal to the length of the HDD, and because existing surface features such as roads and railroads could restrict the length of the prefabricated section to less than that of the HDD, the HDD method may not be appropriate for every site condition encountered. Due to a relatively greater risk of inadvertent returns and increased environmental sensitivity, the use of HDD in karst areas was excluded from consideration. Due to design limitations inherent with the size of the pipe and the difficult terrain, often not allowing adequate pullback space, in conjunction with other material considerations, MVP determined through an alternatives analysis that the HDD method is not preferred for any location along the MVP route. Therefore, MVP does not plan to utilize HDD at any location along the proposed route, including in areas of karst terrain. If implementation of an HDD becomes necessary for reasons beyond MVP's control, an HDD contingency plan will be developed and geotechnical investigations will be conducted. Should this occur, MVP will conduct further consultation with VADEQ and other regulatory agencies.

5.2.2 Conventional Bore Method

Some waterbodies crossed by the Project are directly associated with or adjacent to roads or railroads. Where these roads or railroads are to be crossed using a horizontal boring machine, the waterbody will typically be included within the length of the bore. Some elevated or channelized waterbodies, such as irrigation ditches, may also be successfully bored, depending upon the groundwater level in the area. To complete a horizontal bore, two pits will be excavated, one on each side of the feature to be bored. A boring machine will be lowered into one pit, and a horizontal hole will be bored to a diameter equal to the diameter of the pipe (or casing, if required) at the depth of the pipeline installation. The pipeline section and/or casing will then be pushed through the bore to the opposite pit. If additional pipeline sections are required to span the length of the bore, they will be welded to the first section of the pipeline in the bore pit before being pushed through the bore (see Appendix B –MVP-51 Typical Waterbody Conventional Bore).

5.2.3 Flume Pipe Method

If the stream crossing is less than ten feet wide the flume pipe method may be used. The flume pipe method is typically used in combination with an equipment crossing and starts with the installation of the dam, pump, and flume, continuing with the trench excavation, the pipeline installation, backfilling of the trench and ending with the stabilization of the stream bank. This process will be completed as fast as practicable from flume installation to stabilization of the stream bank. The flume pipe crossing must be made operational prior to the start of construction in the stream. No material will be removed from the stream until the flume is in place. The flume is sandbagged at each end to direct the stream flow through the flume, and the outlet is protected with riprap to minimize scour. The pipeline trench can then be excavated (while dry), the pipe installed and backfilling completed with the flume pipe in place. Spoil piles will be kept a minimum of 10 feet from the water's edge and will be contained by sediment barriers. Trenching and backfilling must be completed and the disturbed stream banks must be stabilized with riprap or vegetation before the flumes for the pipeline and equipment crossings are removed (see Appendix A – STD & SPEC: 3.23 and STD & SPEC 3.25: Plate 3.25-3, respectively).

5.2.4 Cofferdam (Porta-dam) Method

This method may be used for crossing channels 10 feet or wider, and will be designed so as not to prevent the flow of the stream. A cofferdam will be constructed within the construction ROW (using cofferdam products, etc.), enclosing approximately 60% the streambed in a semi-circle (see Appendix A – STD & SPEC: Plate 3.25-4). The cofferdam should seal tightly to the streambed to minimize water from entering the construction area. Pumps will be needed to keep water out of excavations. All earth disturbance will occur in the dry area behind the cofferdam. The pipe will be installed and the disturbed area backfilled and stabilized. Sediment barriers at the waterline should be in good working order before the cofferdam is removed. Stabilization will be with either riprap or vegetation. The cofferdam is then set up from the opposite bank and extends far enough to include the tie-in point in mid-stream. The remainder of the pipe is installed and the tie-in weld is made. Clean up follows the same procedures described above.

5.2.5 Pump-Around (Dam and Pump) Method

The pump-around method is a "dry ditch" construction technique utilizing pumps and hoses to convey waterbody flow around the excavation area (see Appendix B - MVP-ES8). The following restrictions apply when using the pump-around method.

- Sandbag bulkheads or porta-dams shall be constructed above and below the area of excavation.
- Stand-by pump(s) and hose(s) must be on-site during the crossing.
- Pumps shall have secondary containment in accordance with the SPCC Plan.
- Downstream flow must be maintained throughout trenching, pipe laying and backfilling operations.
- Screening (intake hose) must meet the minimum specification per agency requirements.
- Dewater structure with energy dissipater shall be utilized to prevent scour and increased sedimentation.
- Filter bags can be used to maintain clean water.

5.3 AREAS OF SPECIAL CONCERN

MVP has identified areas of special concern that exist with the Project area. A discussion of these areas follows.

5.3.1 Steep Slope Areas

Slope gradients will be identified on the Project ESC plans in steep slope areas. Potential for erosion may be present in areas of steep slopes and increases as slope length increases. Additional erosion and sediment control measures may be necessary in these areas based upon field conditions at the time of construction. Refer to Table 10 for the slope ranges and erosion hazard.

Table 10. Erosion Hazard Ratings

Slope Gradient	Length of Slope	Erosion Hazard Rating
0-7%	< 300 feet	Low
7-15%	< 150 feet	Moderate
0-7% 7-15% ≥15%	> 300 feet > 150 feet > 75 feet	High

Additionally, steep slopes are defined differently for each of the six counties within the Project, detailed in Table 11 below.

County	Steep Slope Definition	Source	Notes
Craig	Not defined	N/A	**No local definitions found**
Giles	> 20%	Giles Co. 2012 Comp Plan	Revision adopted 2012; Natural Resources-Slope
Montgomery	> 25%	Montgomery Co. 2025 Comp Plan	Adopted 2004, revised 2011; Planning and Land Use Policies, PLU 1.2; also mentioned in Co. Code Sec 10-39(h)4
Roanoke	> 33%	Roanoke Co. Code	Sec. 8.1.3 – Definitions; Chapter 12 Stormwater Design Manual
Franklin	> 25%	Franklin Co. 2025 Comp Plan	Adopted 2007; also mentioned in Co. Code Sec 25-189(f)(4) in regards to required open space for residential cluster development
Pittsylvania	> 25%	Pittsylvania Co. 2010 Comp Plan	Chapter 2 -Natural and Cultural Environment

Construction activities within areas considered as steep slope conditions will be conducted in accordance with the BMPs presented in the Project's Landslide Mitigation Plan and MVP's steep slope typical details (see Appendices F and B, respectively).

5.3.2 Soils Properties

Soils mapping information for soils crossed by the Project will be provided on the Existing Conditions plan drawing set included as part of the ESC/SWM packages for each Project construction spread submitted to VADEQ for review. The soil erodibility factor (K) denotes the sensitivity of different soils to the forces of erosion. Areas that have a high erodibility rating will be noted as a critical area on the Project's Existing Conditions plans. Additional erosion and sediment control measures may be necessary in these areas based upon field conditions at the time of construction. Refer to Table 12 for the erodibility factors.

Table 12. Erodibility Factor

Erodibility Factor (K)	Erodibility Rating
≤ 0.23	Low
0.23 - 0.36	Moderate
≥ 0.36	High

The soil reactivity (pH) is a major factor in the establishment of vegetation and permanent stabilization of the disturbed areas. The surface soil pH and associated lime application rate are specified in Section 2.9.2 (Permanent Seeding) and will be noted on the Project ESC plans. Additional information regarding acid forming materials (soils/rock) are detailed below in Section 5.3.4 and under Appendix G.

Sensitive soils such as agricultural soils (prime farmlands or farmland soils of statewide importance), wetland soils and topsoil in all areas of the Project will be segregated during implementation of the Project. During preparation of the LOD and trench excavation, topsoil will be segregated and stockpiled separately from excavated subsoil. Topsoil will be temporarily stabilized with mulch and seeded (as needed) in accordance with typical construction detail MVP-ES45 (Appendix B). Following installation of the pipeline and backfilling of the trench with subsoil, MVP will disc the subsoil in accordance with Section 2.8.3 (Soil Compaction Mitigation) to enhance revegetation of the ROW. During backfill and final grading, topsoil and subsoil will be returned to their original profile. Permanent slope breakers will be installed in accordance with typical construction detail MVP-17 and MVP-18 (Appendix B). Once the topsoil has been returned to its original profile, additional soil compaction mitigation will be conducted over the full LOD followed by permanent seed and mulch installation. No impacts to sensitive soils are anticipated.

While there are no glacially derived soils in Virginia and lacustrine derived soils are minimal, none were identified in the surfical geologic review of the pipeline corridor. MVP has identified soils along the pipeline with similar characteristics that may result in high silt content, high water tables, poor drainage characteristics and that are sometimes hydric. In addition, soils that contain fragipan may restrict infiltration and form discontinuous perched water tables. These soil conditions will be addressed in the ESC/SWM plans prepared for each Project construction spread.

5.3.3 Landslide Prone Areas

Many portions of the Project route are located in landslide susceptible areas. Landslides in the Project area occur primarily in weathered bedrock or colluvial soil and within old landslide debris located on steep slopes. MVP developed the Landslide Mitigation Plan (LMP) to address areas of concern identified prior to construction and present mitigation strategies that may be implemented at other areas during construction. The LMP areas were identified by reviewing available historic aerial photographs, soils data, and topographic maps. Construction operations will be staffed with geotechnical personnel who will identify additional areas in which the LMP mitigation measures will be implemented (and additional mitigation measures, as necessary). A copy of the LMP is located in Appendix F.

5.3.4 Acidic Soils Areas

Areas of acidic soils are known to occur within portions of the Project area in Virginia. In order to identify and mitigate potential impacts should these soils be encountered, MVP developed an Acid Forming Materials Identification and Testing Work (AFM) Plan for implementation during Project activities. The AFM Plan is provided under Appendix G.

5.3.5 Karst Areas

Portions of the Project route are located in areas containing karst and features within ¼-mile (generally termed the secondary karst buffer) and within 150 feet (corresponding to the construction easement) of the proposed route were identified through desktop review of public and proprietary data. Field confirmation was completed on properties where landowners allowed access in order to verify the desktop review results and identify previously unmapped karst features.

MVP prepared a Karst Hazards Assessment that described construction methods to mitigate or eliminate potential impacts (see Appendix H) for karst features that cannot be avoided through minor variations within the construction easement. Mountain Valley will deploy Karst Specialist inspection teams during construction to monitor karst features and provide recommendations for avoidance or mitigation. Locations of all karst features identified during Project investigations will be included on the ESC and SWM plan drawings submitted to VADEQ for each construction spread.

5.3.6 Waterbody And Wetland Areas

During planning, routing and design phases of the Project, MVP conducted desktop analysis and field delineations to identify waterbody and wetland areas within the Project study corridor. Identified waterbody resources include: streams (unnamed as well as named tributaries), springs/seeps, water supply wells, ponds and other surface impoundments as well as wetlands. Desktop review as well as field verification was utilized to identify private ponds located within 1,500 feet downslope of the Project LOD. All waterbody and wetland resources identified within the Project LOD and areas immediately adjacent to the LOD (including temporary workspaces, ATWS, contractor yards, access roads, etc.) will be depicted on the Project ESC and SWM plan drawings. All waterbody and wetland areas disturbed by Project construction activities will be permitted under the US Army Corps of Engineers / VADEQ NWP12-Joint Permit Application process.

Project ESC plans are designed with appropriate BMPs to protect all crossed and adjacent resources including waterbody and wetland areas from potential sedimentation as result of Project construction activities.

5.3.7 Other Environmentally Sensitive Areas

During routing, field investigations and design of the Project, MVP identified other environmentally sensitive areas through portions of the Project. Other environmentally sensitive areas include but not limited to the following: threatened and endangered species areas, cultural significant areas (cemeteries, historical or archaeological resources), or areas identified by landowners as being of concern. Since environmentally sensitive areas are treated as confidential for the protection of those resources, specific identification of these resources are not provided. MVP will comply with all mitigation requirements imposed by the relevant federal or state agencies with authority for these resources – such as any requirements developed through the Endangered Species Act and National Historic Preservation Act consultation processes – and will utilize appropriate BMPs deployed during construction as an additional level of protection for these areas.

5.3.8 Water Supply Sources

MVP developed a Water Resources Identification and Testing Plan which outlines procedures for identification and testing of both private and public water supply. MVP identified public water supply sources within three miles downstream of the Project as well as private water supply resources (springs/wells) within 150 feet of the Project LOD in non-karst areas and within 500 feet of the LOD in karst areas. MVP conducted desktop reviews supplemented by field verification (where access has been granted) as well as in discussions with property owners to identify locations of private water supplies. Landowners and public water suppliers with water supply resources located within the parameters listed above are being contacted regarding access to request permission for MVP to complete baseline testing prior to Project construction activities. As noted in Section 5.3.6, these resources will be identified on the ESC Plans.

5.3.9 Subsurface Drainage Areas

Project activities in Virginia are likely to encounter subsurface drainage features during construction activities. These include drain tiles and irrigation lines. Locations of these resources are identified during routing, landowner discussions during ROW acquisition and when exposed during construction implementation of the Project. Locations will be identified during pre-construction stakeout (when known). All drain tiles including septic (sewer) drain field lines, drain tiles and irrigation lines damaged or disturbed during construction will be repaired and returned to their original condition and function. Any disruption to service and alternative mitigation measures will be coordinated with the affected landowner.

During construction of the Project, MVP will install permanent trench breaker drains to facilitate removal of accumulated groundwater from the pipeline trench. Permanent trench breaker drains will be installed and maintained in accordance with typical construction details MVP-20 Typical Trench Breaker and MVP-35 Trench Breaker Daylight Drain (Appendix B). In addition, MVP will install cutoff drains to convey subsurface flow/groundwater through the permanent ROW in areas of side-hill construction per typical construction details MVP-36 through MVP-38 and MVP-43 and MVP-44 (Appendix B), respectively. Appropriate outlet protection will be installed as needed. All trench breaker drains and cut-off drain installations will be noted on the ESC/SWM drawings following installation.

5.3.10 Drainage Features

Non-jurisdictional drainage features such as roadside ditches, swales, diversion ditches and diversion terraces will be crossed during construction activities. During construction, MVP will maintain service through these drainage features during Project construction activities. This will include installation of temporary culverts or pump around contingency if water is present at time of crossing installation. Following installation of the Project, all non-jurisdictional drainage features will be returned to pre-construction contours and conditions.

5.3.11 Utility Line Crossings

Portions of the Project route will cross existing public and private utility corridors. Many of the locations were identified during field routing activities and during property owner negotiations. Locations of these utilities are not depicted on the Project ECS plans to minimize potential for misidentification of the utility location. In order to accurately depict utility locations prior to commencement of Project earth disturbing activities, Mountain Valley's contractors will notify Miss Utility of Virginia at www/va811.com or 1-800-552-7001 to have existing utility line locations delineated. For distribution and service lines that are not covered by the VA811 notice, MVP will coordinate with the property owner to identify approximate line locations. In addition, MVP contractors will utilize appropriate line locating equipment to identify locations of buried service lines (gas/water/electric) that are not covered by the VA811 system. Appropriate signage will be installed to identify locations of existing utilities prior to commencing construction.

Aboveground utility lines including electric (distribution and transmission), telephone, tv cable, or other will be appropriately delineated. Aboveground utility locations are typically identified using a combination of signage, dedicated spotter and physical barriers placed in proximity to the utility line. Examples include use of ground signage and hazard or car lot ribbon tied to non-conductive goal posts placed on either side of the LOD. Locations of overhead utility crossings that require identification are determined during pre-construction stakeout of the LOD and appropriate marking installed at that time.

6.0 MAINTENANCE OF PERMANENT RIGHT-OF-WAY

6.1 MONITORING AND MAINTENANCE

Follow-up inspections of all disturbed areas after the first and second growing seasons will be conducted to determine the success of revegetation. In general, revegetation cannot be determined to be fully established until it has been maintained for one full year after planting. Permanent vegetation shall not be considered established until a ground cover is achieved that is uniform, mature enough to survive and will inhibit erosion. If vegetative cover and density is not acceptable or there are excessive noxious weeds after two full growing seasons, a professional agronomist will determine the need for additional restoration measures (such as fertilizing or reseeding). When necessary, the measures recommended by the agronomist will be implemented. 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.

Drainage and irrigation systems will be monitored and problems resulting from pipeline construction in active agricultural areas will be corrected. Trench breaker drains and cut-off drains installed within the pipeline trench will be monitored and maintained functional during operation of the Project. Outlet locations will be field identified via appropriate measures (i.e. signage, flagging, etc.).

Normally, the entire permanent ROW will be maintained. Maintaining this width is necessary for the following reasons:

- Access for routine pipeline patrols and corrosion surveys.
- Access in the event that emergency repairs of the pipeline are needed.
- Visibility during aerial patrols. The full width of the ROW will be kept clear where overhanging foliage decreases visibility.

Vegetation maintenance adjacent to waterbodies will be limited to allow a riparian strip at least 25-feet wide, as measured from the waterbody's ordinary high water mark, to permanently revegetate with native plant species across the entire ROW. However, to facilitate periodic pipeline corrosion/leak surveys, a corridor centered on the pipeline and up to 10 feet wide will be mowed annually and may be maintained in an herbaceous state. In addition, trees that are located within 15 feet of the pipeline and are greater than 15 feet in height may be cut and removed from the ROW.

The success of wetland revegetation will be monitored in accordance with the FERC PLAN AND PROCEDURES and any other requirements from the U.S. Army Corps of Engineers.

Shrubs or other vegetation used to screen long sections of the ROW from public view will be properly maintained. Efforts to control unauthorized off-road vehicle use, in cooperation with the landowner, will continue throughout the life of the Project. Signs, gates, and vehicle trails will be maintained as necessary.

6.1.1 Long Term Responsibility and Maintenance

Upon completion of any Project MVP will provide the VADEQ with a document with the following information:

- The responsible parties that will provide for the long term maintenance of the Project;
- Maintenance Agreements, with DEQ review and approval, for any applicable structural BMPs; and
- MVP will comply with Table 1 – Forest & Open Space from the Virginia Runoff Reduction Method Compliance Spreadsheet User's Guide & Documentation (April 2016), in regards to mowing and general maintenance.

6.2 MAINTENANCE TECHNIQUES

6.2.1 Mowing

ROW will be maintained in compliance with Table 1 – Forest & Open Space from the Virginia Runoff Reduction Method Compliance Spreadsheet User's Guide & Documentation (April 2016), in regards to mowing and general maintenance. However, to facilitate periodic corrosion and leak surveys, a corridor not exceeding 10 feet in width centered on the pipeline may be maintained annually in an herbaceous state (brush hogged no more than annually). Full ROW clearing is to occur no more frequently than once every 3 years. In no case shall routine vegetation maintenance clearing occur between April 15 and August 1 of any year.

In wetland areas, no routine vegetation mowing or clearing will be conducted over the full width of the permanent ROW in wetlands. In order to facilitate periodic inspections, a corridor centered over 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 the pipeline coating may be selectively cut and removed from the permanent ROW. Native herbaceous and woody shrub species will be allowed to reestablish in wetland ROW as noted above.

In order to control spread of exotic, noxious and invasive plant species during operation of the Project, MVP developed and will implement the MVP Exotic and Invasive Species Control (E&ISC) Plan (dated July 2016). The E&ISC Plan is provided in Appendix I. 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.

6.2.2 Wetland Right-of-Ways

Maintenance of permanent ROW in wetlands will be performed in compliance with all applicable wetland permit conditions as well as Section 2.9.7 – After Restoration of these Standards and Specifications, and FERC's PLAN AND PROCEDURES. There will be no herbicides or pesticides applied in or within 100 feet of a wetland boundary, except as allowed by the appropriate federal or state agency.

6.3 EROSION CONTROL

Erosion issues identified on the pipeline ROW during facility operations will be reported to the local MVP Operations Supervisor and addressed accordingly. These reports may originate from landowners, agencies, or MVP personnel performing routine patrols. Corrective measures will be performed as needed.

6.3.1 Routine Pipeline Patrol

Routine pipeline ROW inspections will be performed to ensure that MVP can maintain continuous, reliable service to its customers. During these inspections, all permanent ESC devices installed during construction will be inspected to ensure that they are functioning properly. In addition, attention should be given to:

- Fallen timber or other perils to the pipeline;
- Signs of ground settlement/movement that might endanger the pipeline or adjacent lands;
- Signs of encroachment on the pipeline or pipeline ROW;
- Missing or damaged line markers or fence enclosures;
- Emergency contact information is posted on all enclosures and line markers verification;
- Areas of erosion and washouts across the ROW;
- Permanent ROW diversions (Slope Breakers);
- Waterbody crossings; and

- Any other conditions that could imperil the pipeline or conflict with MVP's rights under existing ROW agreements.

The local MVP Operations Supervisor will be notified of any conditions that need attention. Corrective measures taken will be documented and performed on a priority or as needed basis.

6.4 REPORTING

The project administrator shall maintain records that identify by milepost:

1. Method of application, application rate, and type of fertilizer, pH modifying agent, seed, and mulch used;
2. Acreage treated:
3. Dates of backfilling and seeding; and
4. Names of landowners requesting special seeding treatment and a description of the follow-up actions.
5. Weekly e-reporting to the applicable VADEQ regional office.

7.0 VIRGINIA EROSION AND SEDIMENT CONTROL REGULATIONS (9VAC25-840-40) MINIMUM STANDARDS

An erosion and sediment control program adopted by an operator must be consistent with the following criteria, techniques and methods:

Minimum Standard 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.

Minimum Standard 2 – During construction of the project, soil stockpiles 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.

Minimum Standard 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.

Minimum Standard 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.

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

Minimum Standard 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.

Minimum Standard 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.

Minimum Standard 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.

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

Minimum Standard 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.

Minimum Standard 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.

Minimum Standard 12 – When work in a live watercourse is preformed, cautions shall be taken to minimize encroachment, control sediment transport and stabilize the work area to the greatest extent possible during construction. Non-erodible material shall be used in the construction of causeways and cofferdams. Earthen fill may be used for these structures if armored by non-erodible cover materials.

Minimum Standard 13 – When a live water course must be crossed by construction vehicles more than twice in any six-month period, a temporary vehicular stream crossing constructed of non-erodible material shall be provided.

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

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

Minimum Standard 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. NOTE: MVP has requested a variance with regard to Minimum Standard 16-A.

B. Excavated material shall be placed on the uphill side of trenches. NOTE: MVP has requested a variance with regard to Minimum Standard 16-B.

C. Effluent from dewatering devices 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 offsite 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 these regulations.

F. Applicable safety regulations shall be complied with.

Minimum Standard 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 moved from the roads by shoveling or sweeping and transported to a sediment control disposal area. Street washing shall be allowed only after sediment has been removed in this manner. This provision shall apply to individual development lots as well as to larger land-disturbing activities.

Minimum Standard 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.

Minimum Standard 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 project 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 analyses 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 2-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 10-year storm to verify that stormwater will not overtop its banks and by the use of a 2-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 10-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 10-year storm will not overtop the banks and a 2-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 10-year storm is contained within the appurtenances;

   (3) Develop a site design that will not cause the pre-development peak runoff rate from a 2-year storm to increase when runoff outfalls into a natural channel or will not cause the pre-development peak runoff rate from a 10-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 of the subject project.

F. If the applicant chooses an option that includes stormwater detention, the applicant 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 dissipaters 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 SWM 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 (i) are in accordance with provisions for time limits on applicability of approved design criteria in 9VAC25-870-47 or grandfathering in 9VAC25-870-48 of the Virginia Stormwater Management Program (VSMP) Regulation, in which case the flow rate capacity and velocity requirements of § 62.1-44.15:52 A of the Act shall apply, or (ii) are exempt pursuant to § 62.1-44.15:34 C 7 of the Act.

N. Compliance with the water quantity minimum standards set out in 9VAC25-870-66 of the Virginia Stormwater Management Program (VSMP) Regulation shall be deemed to satisfy the requirements of this subdivision 19. *Note: The Energy Balance Method (EBM) is included within the water quantity minimum standards (9VAC25-870-66) as section 9VAC25-870-66.B.3. MVP will meet all*

EBM requirements per Section 2.11.5 of these Standards & Specifications. Satisfying EBM will satisfy water quantity minimum standards and, therefore, satisfy subdivision MS-19.

In addition to the minimum erosion and sedimentation control standards and specifications, MVP is required to complete and submit SWM calculations regarding water quantity per Section 9VAC25-870-66 and water quality per Section 9VAC25-870-65 and -96 of the Virginia Stormwater Management Program Regulation. The calculations will be provided under separate cover along with the design elements required to meet stormwater quantity and quality requirements which will be depicted on the Project ESC plans.

7.1 TABLE OF VESCH STANDARDS AND SPECIFICATIONS

(From Chapter 3 of Virginia Erosion and Sediment Control Handbook)

Control Measure	Ref.	Purpose
Safety Fence	3.01	To prohibit undesirable uses of erosion control measures.
Temporary Stone Construction Road	3.02	To reduce the soil transported onto public roads and other paved areas.
Construction Road Stabilization	3.03	To reduce erosion caused by vehicles during wet weather.
Straw Bale Barrier	3.04	To intercept and detain sediment and decrease flow velocities from limited sized drainage areas temporarily (Max effective life = 3 months).
Silt Fence	3.05	To intercept and detain sediment and decrease flow velocities from limited sized drainage areas temporarily (Max effective life = 6 months).
Brush Barrier	3.06	To intercept and detain sediment and decrease flow velocities from limited sized drainage areas temporarily.
Storm Drain Inlet Protection	3.07	To trap sediment around drop inlets or curb inlet structures from limited sized drainage area (less than one acre).
Culvert Inlet Protection	3.08	To trap sediment at the inlet to storm sewer culverts.
Temporary Diversion Dike	3.09	To divert sediment laden runoff to a sediment trapping structure (Max effective life =18 months).
Temporary Fill Diversion	3.10	To divert runoff away from the unprotected fill slope to a stabilized outlet or sediment trapping structure (Max effective life = 7 days).
Temporary Right-of-way Diversion	3.11	To shorten the flow length within the disturbed strip of right-of-way and divert the runoff to stabilized outlet.
Diversion	3.12	To reduce slope length and intercept and divert stormwater runoff to stabilized outlet at non-erosive velocities by constructing a permanent channel.
Temporary Sediment Trap	3.13	To detain sediment-laden runoff from small disturbed areas for enough time to allow most of the suspended solids to settle out in a small ponding area.

Control Measure	Ref.	Purpose
Temporary Sediment Basin	3.14	To detain sediment-laden runoff from drainage areas 3 acres or greater for enough time to allow most of the suspended solids to settle out in a dam with a controlled stormwater release structure.
Temporary Slope Drain	3.15	To conduct concentrated runoff safely from the top to the bottom of a disturbed slope without causing erosion on or below the slope by installing flexible tubing before permanent drainage structure.
Paved Flume	3.16	To conduct concentrated runoff safely from the top to the bottom of a disturbed slope without causing erosion on or below the slope by constructing a permanent concrete lined channel.
Stormwater Conveyance Channel	3.17	A permanent channel designed to carry concentrated flows without erosion.
Outlet Protection	3.18	To reduce erosion and under-cutting from scouring at outlets and to reduce flow velocities before stormwater enters receiving channels below these outlets.
Riprap	3.19	To prevent erosion wherever soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that soil may erode under design flow conditions.
Rock Check Dams	3.20	To reduce the velocity of concentrated flows, reducing erosion of the swale or ditch by constructing small temporary stone dams.
Level Spreader	3.21	To convert concentrated, sediment-free runoff to sheet flow and release it onto areas of undisturbed soil that is stabilized by existing vegetation.
Vegetative Streambank Stabilization	3.22	To protect the banks from erosion by establishing appropriate vegetation.
Structural Streambank Stabilization	3.23	To protect the banks from erosion with permanent structural measures.
Temporary Vehicular Stream Crossing	3.24	To provide vehicular access to construction activities on either side of the stream while keeping the sediment out of the stream and preventing damage to the channel bed and banks.
Utility Stream Crossing	3.25	To prevent sediment from entering affected watercourse and minimize the amount of disturbance within the stream itself.
Dewatering Structure	3.26	To establish a temporary settling and filtering device for water which is discharged from dewatering activities.
Turbidity Curtain	3.27	To provide sedimentation protection for a watercourse from upslope land disturbance or from dredging or filling

Control Measure	Ref.	Purpose
		within the watercourse or to minimize sediment transport from a disturbed area adjacent to or within a body of water
Subsurface Drain	3.28	To intercept and convey groundwater by installing a perforated conduit beneath the ground. To prevent sloping soils from becoming excessively wet. To improve the quality of the vegetative growth medium in excessively wet areas.
Surface Roughing	3.29	To reduce runoff velocity, to provide sediment trapping and to increase infiltration to facilitate vegetation establishment on exposed slopes.
Topsoiling	3.30	To provide a suitable growth medium for vegetation used to stabilize disturbed areas by preserving and using the topsoil.
Temporary Seeding	3.31	To establish temporary on vegetative cover on disturbed areas that will not be brought to final grade for periods of 14 days to one year by seeding permanently.
Permanent Seeding	3.32	To establish perennial vegetative cover by planting seed on rough-grade areas that will not be brought to final grade for a year or more or where permanent vegetative cover is needed on final-graded areas.
Sodding	3.33	To provide immediate protection against erosion by establishing permanent grass stands with sod in grassed swales and waterways or in areas where an immediate aesthetic effect is desirable.
Bermuda grass and Zoysia grass Establishment	3.34	To stabilize final-graded areas where establishment by sod is not preferred.
Mulching	3.35	To prevent erosion and reduce overland flow velocities by applying plant residues or other suitable materials to disturbed surfaces.
Soil Stabilization Blankets and Matting	3.36	To prevent erosion by installing a protective blanket (Treatment 1) or a soil stabilization mat (Treatment 2) on a prepared planting of a steep slope, channel or shoreline.
Trees, Shrubs, Vines, and Ground Covers	3.37	To stabilize disturbed areas by planting trees, shrubs, vines, and ground covers where turf is not preferred.
Tree Preservation and Protection	3.38	To ensure the survival of desirable trees where they will be effective for erosion and sediment control and provide other environmental and aesthetic benefits.
Dust Control	3.39	To prevent soil loss and reduce the presence of potentially harmful airborne substance by reducing surface and air movement of dust during land disturbances and construction activities.

LIST OF STDS & SPECS

Virginia E&S Control Handbook Standard Details

By referencing these VESCH Plates, Drawings, and Details, these Standards and Specifications shall be in compliance with all other applicable control measure information as laid out in the VESCH.

Drawing No.	Drawing Title
3.01	Safety Fence
3.02	Temporary Stone Construction Entrance
3.03	Construction Road Stabilization
3.04	Straw Bale Barrier
3.05	Silt Fence
3.06	Brush Barrier
3.07	Storm Drain Inlet Protection
3.08	Culvert Inlet Protection
3.09	Diversion Dike
3.10	Temporary Fill Diversion
3.11	Temporary Right-of-Way Diversion
3.13	Temporary Sediment Trap
3.15	Temporary Slope Drain
3.18	Outlet Protection
3.19	Riprap
3.20	Rock Check Dam
3.21	Level Spreader
3.22	Vegetative Stream Bank Stabilization
3.23	Structural Streambank Stabilization
3.24	Temporary Vehicular Crossing
3.25	Utility Stream Crossing
3.26	Dewatering Structure
3.27	Turbidity Curtain
3.28	Subsurface Drain
3.29	Surface Roughening
3.30	Topsoiling
3.31	Temporary Seeding
3.32	Permanent Seeding
3.35	Mulching
3.36	Soil Stabilization Blankets and Matting
3.37	Trees, Shrubs, Vines and Ground Covers
3.38	Tree Preservation and Protection
3.39	Dust Control

LIST OF FIGURES

MVP E&S Control Handbook Standard Details

MVP-ES23.5	Riprap Apron
MVP-ES23.6	Riprap Apron
MVP-ES23.7	Riprap Apron
MVP-ES23.8	Riprap Apron
MVP-ES24.1	Earthen Level Spreader
MVP-ES24.2	Earthen Level Spreader
MVP-ES25	Riprap Streambank Protection with Optional Live Stakes
MVP-ES26	Rock Riprap Protection Area
MVP-ES27	Gabion Streambank Protection
MVP-ES28.1	Bioengineering
MVP-ES28.2	Bioengineering
MVP-ES29.1	Live Fascines
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APPENDIX A – STD & SPEC

STD & SPEC 3.01

SAFETY FENCE

SAF

Definition

A protective barrier installed to prevent access to an erosion control measure.

Purpose

To prohibit the undesirable use of an erosion control measure by the public.

Conditions Where Practice Applies

Applicable to any control measure or series of measures which can be considered unsafe by virtue of potential for access by the public.

Planning Considerations

The safety of the public must always be considered at both the planning and implementation phases of a land-disturbing activity. If there is any question concerning the risk of a particular erosion control measure to the general public, the measure should be relocated to a safer area, or an appropriate safety fence should be installed to prevent undesired access. Many times, the danger posed by a control may not be easily seen by plan designers and reviewers - that is when the on-site contractor or inspector must correct such situations in the field. Properly designed and installed safety fences prevent the trespassing of people into potentially dangerous areas, such as children using a sediment basin or a stormwater retention structure as play areas. The installation of these fences will protect people from hazards and the owner from possible litigation.

Two different types of fence will be discussed in this specification. The designer, developer, and contractor should always be sure that the most appropriate type of fence is utilized for a particular need.

Design Criteria

1. Safety fences should be located so as to create a formidable barrier to undesired access, while allowing for the continuation of necessary construction operations.

2. Safety fences are most applicable to the construction of berms, traps, and dams. In use with those structures, safety fences should be located far enough beyond the outer toe of the embankment to allow for the passage of maintenance vehicles. Fences should not be installed across the slope of a dam or dike.

3. The height of the fence shall be a minimum of 5 feet for plastic fence and 6 feet for metal fence. A fence must never be so short as to become an attraction for children to climb on or over.

4. Signs noting potential hazards such as "DANGER-QUICKSAND" or "HAZARDOUS AREA - KEEP OUT" should be posted and easily seen by anyone approaching the protected area.

5. Plastic (polyethylene) fence may be used as safety fencing, primarily in situations where the need is for a temporary barrier (see Plate 3.01-1). The fence should meet the physical requirements noted in the following table:

TABLE 3.01-A

PHYSICAL PROPERTIES OF PLASTIC SAFETY FENCE

Physical Property	Test	Requirements
Recommended color	N/A	"International" orange
Tensile yield	ASTM D638	Average 2000 lbs. per 4 ft. width
Ultimate tensile strength	ASTM D638	Average 2900 lbs. per 4 ft. width
Elongation at break(%)	ASTM D638	Greater than 1000%
Chemical resistance	N/A	Inert to most chemicals and acids

Source: Conwed Plastics

6. Metal or "chain-link" fence should be used when a potentially dangerous control measure will remain in place permanently, such as a stormwater detention or retention basin (see Plate 3.01-1). However, they may also be used for measures which will only serve a temporary function, at the discretion of those responsible for project safety. The metal fence must meet the following physical requirements:

    a. Fabric shall be zinc-coated steel, 2-inch mesh, 9-gauge, minimum.

    b. Zinc coating shall have a minimum weight of 1.8 ounces per square foot.

    c. Posts shall be steel pipe, zinc-coated.

    d. Top nails shall be steel pipe, zinc-coated.

    e. Braces shall be made of zinc-coated steel.

    f. Gates shall be single or double swing, zinc-coated steel. They shall be a minimum of 12-feet wide.

Construction Specifications

1. Safety fences must be installed prior to the E&S measure becoming accessible.

2. The polyethylene web of the plastic safety fence shall be secured to a conventional metal "T" or "U" post driven into the ground to a minimum depth of 18 inches; posts should be spaced at 6-foot centers. See "perspective" view in Plate 3.01-1.

3. The metal safety fence shall be installed as per the following procedure:

    a. Line posts shall be placed at intervals of 10 feet measured from center to center of adjacent posts. In determining the post spacing, measurement will be made parallel with the ground surface. See "perspective" view in Plate 3.01-1.

    b. Posts will be set in concrete and backfilled or anchored by other acceptable means.

    c. Posts set in the tops of concrete walls shall be grouted into preformed holes to a minimum depth of 12 inches.

    d. All corner posts, end posts, gate posts, and pull posts shall be embedded, braced, and trussed as shown in the "Standard Fence - Chain Link" detail found in the latest version of the Virginia Department of Transportation (VDOT) Road and Bridge Standards.

    e. Fencing fabric shall not be stretched until at least 4 days after the posts are grouted into walls or 14 days after the posts are set into concrete.

    f. The fabric shall be stretched taut and securely fastened, by means of tie clips, to the posts at intervals not exceeding 15 inches and to the top rails or tension wires at intervals not exceeding 2 feet. Care shall be taken to equalize the tension on each side of each post.

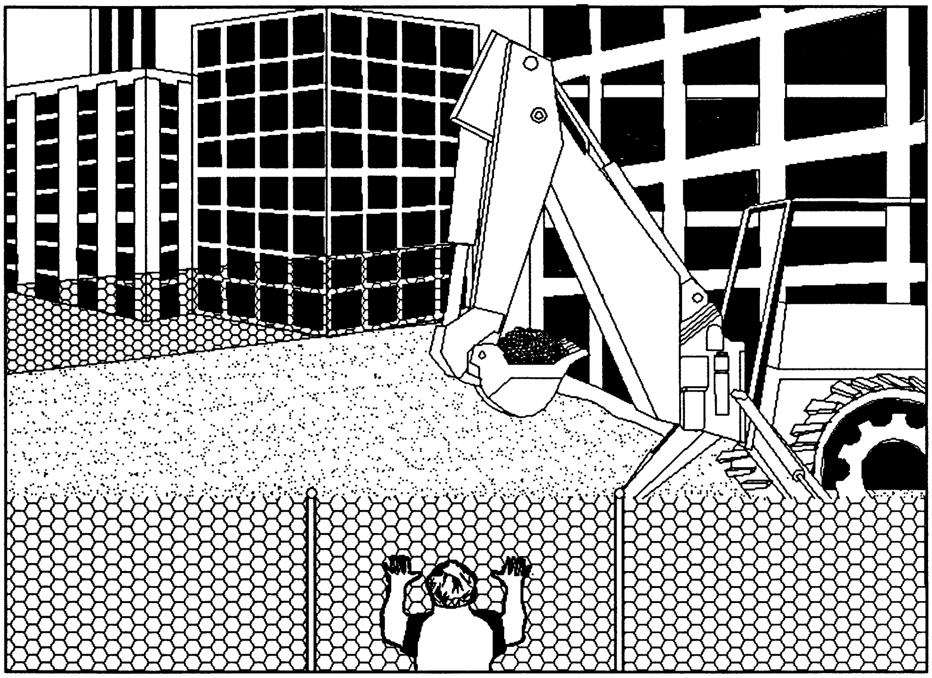
4. Applicable warning signs noting hazardous conditions must be installed immediately upon installation of safety fence.

Maintenance

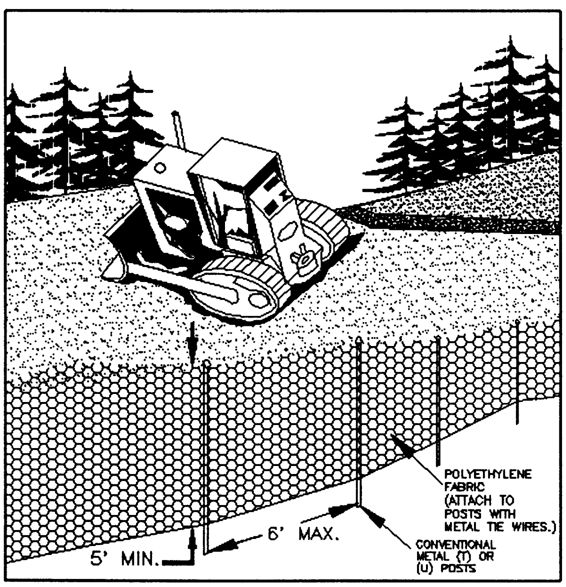
1. Safety fence shall be checked regularly for weather-related or other damage. Any necessary repairs must be made immediately.

2. Care should be taken to secure all access points (gates) at the end of each working day. All locking devices must be repaired or replaced as necessary.

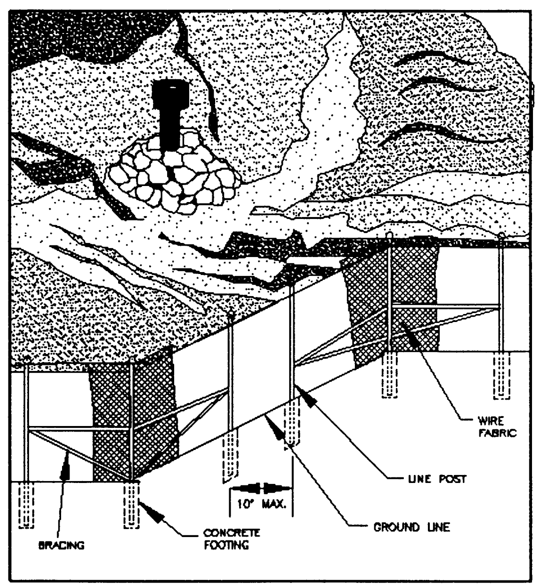
SAFETY FENCE



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

STD & SPEC 3.02

TEMPORARY STONE CONSTRUCTION ENTRANCE

CE

Definition

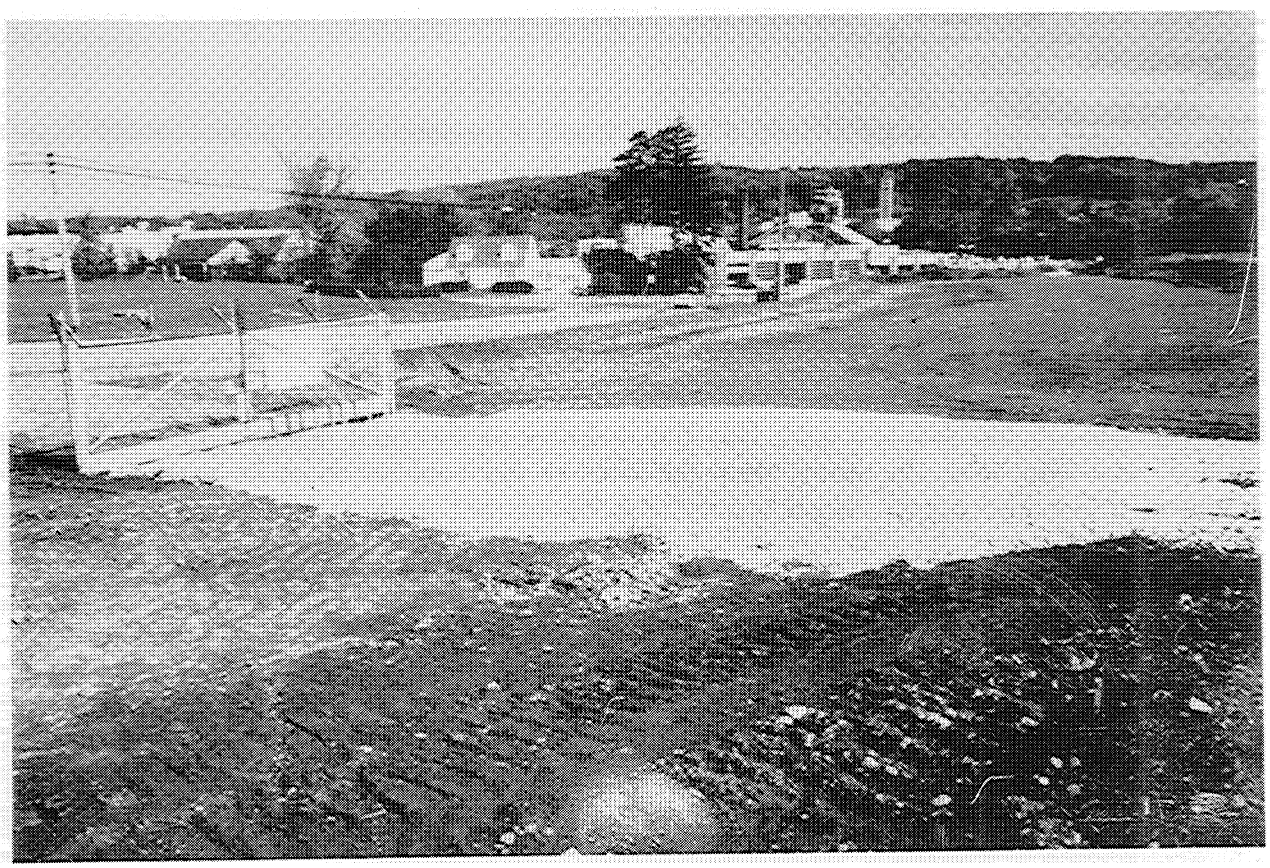
A stabilized stone pad with a filter fabric underliner located at points of vehicular ingress and egress on a construction site.

Purpose

To reduce the amount of mud transported onto paved public roads by motor vehicles or runoff.

Conditions Where Practice Applies

Wherever traffic will be leaving a construction site and move directly onto a public road or other paved area.



Planning Considerations

Minimum Standard #17 (MS #17) requires that provisions be made to minimize the transport of sediment by vehicular traffic onto a paved surface. Construction entrances provide an area where a significant amount of mud can be removed from construction vehicle tires before they enter a public road and, just as important, the soil adjacent to the paved surface can be kept intact. A filter fabric liner is used as a "separator" to minimize the dissipation of aggregate into the underlying soil due to construction traffic loads. If the action of the vehicles traveling over the gravel pad is not sufficient to remove the majority of the mud or there exists an especially sensitive traffic situation on the adjacent paved road, the tires must be washed before the vehicle enters the public road. If washing is necessary, provisions must be made to intercept the wash water and trap the sediment so it can be collected and stabilized. Construction entrances should be used in conjunction with the stabilization of construction roads (see Std. & Spec. 3.03, CONSTRUCTION ROAD STABILIZATION) to reduce the amount of mud picked up by construction vehicles and to do a better job of mud removal. Other innovative techniques for accomplishing the same purpose (such as a bituminous entrance) can be utilized, but only after specific plans and details are submitted to and approved by the appropriate Plan-Approving Authority.

Design Criteria

Aggregate Size

VDOT #1 Coarse Aggregate (2- to 3-inch stone) should be used.

Entrance Dimensions

The aggregate layer must be at least 6 inches thick; a minimum three inches of aggregate should be placed in a cut section to give the entrance added stability and to help secure filter cloth separator. It must extend the full width of the vehicular ingress and egress area and have a minimum 12-foot width. The length of the entrance must be at least 70 feet (see Plate 3.02-1).

Washing

If conditions on the site are such that the majority of the mud is not removed by the vehicles traveling over the stone, then the tires of the vehicles must be washed before entering the public road. Wash water must be carried away from the entrance to a approved settling area to remove sediment. All sediment shall be prevented from entering storm drains, ditches, or watercourses. A wash rack may also be used to make washing more convenient and effective (see Plate 3.02-1).

Location

The entrance should be located to provide for maximum utilization by all construction vehicles.

Construction Specifications

The area of the entrance must be excavated a minimum of 3 inches and must be cleared of all vegetation, roots, and other objectionable material. The filter fabric underliner will then be placed the full width and length of the entrance.

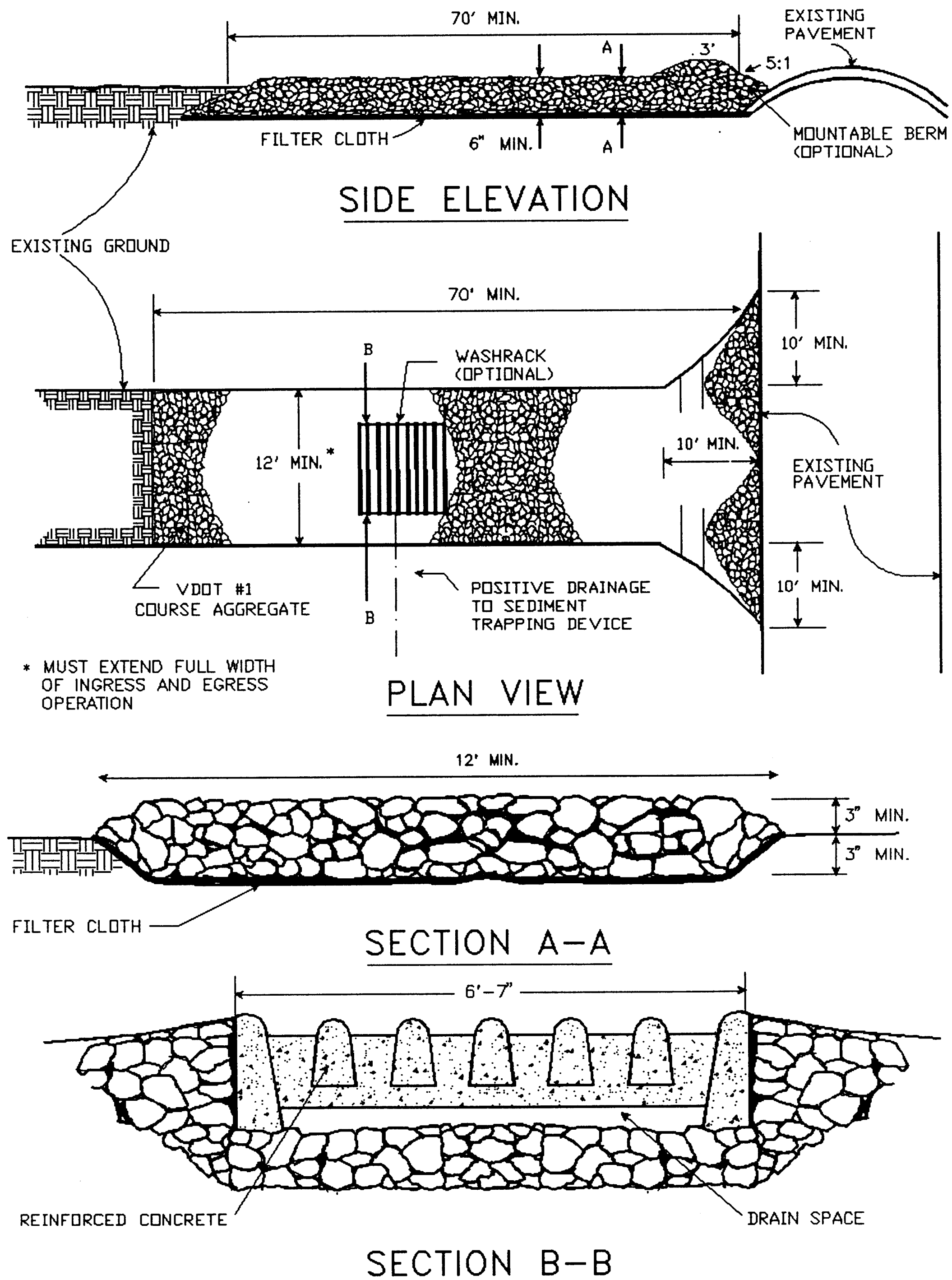
Following the installation of the filter cloth, the stone shall be placed to the specified dimensions. If wash racks are used, they should be installed according to manufacturer's specifications. Any drainage facilities required because of washing should be constructed according to specifications. Conveyance of surface water under entrance, through culverts, shall be provided as required. If such conveyance is impossible, the construction of a "mountable" berm with 5:1 slopes will be permitted.

The filter cloth utilized shall be a woven or nonwoven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The fabric shall be inert to commonly encountered chemicals and hydrocarbons, be mildew and rot resistant, and conform to the physical properties noted in Table 3.02-A.

Maintenance

The entrance shall be maintained in a condition which will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with additional stone or the washing and reworking of existing stone as conditions demand and repair and/or cleanout of any structures used to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately. The use of water trucks to remove materials dropped, washed, or tracked onto roadways will not be permitted under any circumstances.

STONE CONSTRUCTION ENTRANCE



Source: Adapted from 1983 Maryland Standards for Soil Erosion and Sediment Control, and Va. DSWC

Plate 3.02-1

TABLE 3.02-A

CONSTRUCTION SPECIFICATIONS FOR FILTER CLOTH UNDERLINER

Fabric Properties[1]	Light-Duty Entrance[2] (Graded Subgrade)	Heavy-Duty Entrance[3] (Rough Graded)	Test Method
Grab Tensile Strength (lbs.)	200	220	ASTM D1682
Elongation at Failure (%)	50	220	ASTM D1682
Mullen Burst Strength (lbs.)	190	430	ASTM D3786
Puncture Strength (lbs.)	40	125	ASTM D751 (modified)
Equivalent Opening Size (mm)	40-80	40-80	U.S. Standard Sieve CW-02215

[1] Fabrics not meeting these specifications may be used only when design procedure and supporting documentation are supplied to determine aggregate depth and fabric strength.

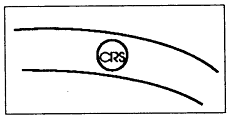
[2] Light Duty Entrance: Sites that have been graded to subgrade and where most travel would be single axle vehicles and an occasional multi-axle truck. Examples of fabrics which can be used are: Trevira Spunbond 1115, Mirafi 100X, Typar 3401, or equivalent.

[3] Heavy Duty Entrance: Sites with only rough grading and where most travel would be multi-axle vehicles. Examples of fabrics which can be used are: Trevira Spunbond 1135, Mirafi 600X, or equivalent.

Source: Virginia Highway and Transportation Research Council (VHTRC)

STD & SPEC 3.03

CONSTRUCTION ROAD STABILIZATION



CRS

Definition

The temporary stabilization of access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes with stone immediately after grading.

Purposes

1. To reduce the erosion of temporary roadbeds by construction traffic during wet weather.

2. To reduce the erosion and subsequent regrading of permanent roadbeds between the time of initial grading and final stabilization.

Conditions Where Practice Applies

Wherever stone-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

Planning Considerations

Areas which are graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy quagmires which generate significant quantities of sediment that may pollute nearby streams or be transported off site on the wheels of construction vehicles. Dirt roads can become so unstable during wet weather that they are virtually unusable.

Immediate stabilization of such areas with stone may cost money at the outset, but it may actually save money in the long run by increasing the usefulness of the road during wet weather.

Permanent roads and parking areas should be paved as soon as possible after grading. However, it is understandable that weather conditions or the potential for damage may not make paving feasible in the early phases of the development project. As an alternative, the early application of stone may solve potential erosion and stability problems and eliminate later regrading costs. Some of the stone will also probably remain in place for use as part of the final base course in the construction of the road.

Specifications

Temporary Access Roads and Parking Areas

1. Temporary roads shall follow the contour of the natural terrain to the extent possible. Slopes should not exceed 10 percent.

2. Temporary parking areas should be located on naturally flat areas to minimize grading. Grades should be sufficient to provide drainage but should not exceed 4 percent.

3. Roadbeds shall be at least 14 feet wide for one-way traffic and 20 feet wide for two-way traffic.

4. All cuts and fills shall be 2:1 or flatter to the extent possible.

5. Drainage ditches shall be provided as needed and shall be designed and constructed in accordance with STORMWATER CONVEYANCE CHANNEL, Std. & Spec. 3.17.

6. The roadbed or parking surface shall be cleared of all vegetation, roots and other objectionable material.

7. A 6-inch course of VDOT #1 Coarse Aggregate shall be applied immediately after grading or the completion of utility installation within the right-of-way. Filter fabric may be applied to the roadbed for additional stability. Design specifications for filter fabric can be found within Std. & Spec. 3.02, TEMPORARY STONE CONSTRUCTION ENTRANCE. In "heavy duty" traffic situations (see Table 3.02-A), stone should be placed at an 8- to 10-inch depth to avoid excessive dissipation or maintenance needs.

Permanent Roads and Parking Areas

Permanent roads and parking areas shall be designed and constructed in accordance with applicable VDOT or local criteria except that an initial base course of gravel of at least 6 inches shall be applied immediately following grading.

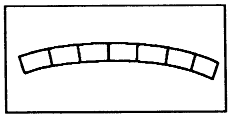
Vegetation

All roadside ditches, cuts, fills and disturbed areas adjacent to parking areas and roads shall be stabilized with appropriate temporary or permanent vegetation according to the applicable standards and specifications contained in this handbook.

Maintenance

Both temporary and permanent roads and parking areas may require periodic top dressing with new gravel. Seeded areas adjacent to the roads and parking areas should be checked periodically to ensure that a vigorous stand of vegetation is maintained. Roadside ditches and other drainage structures should be checked regularly to ensure that they do not become clogged with silt or other debris.

STD & SPEC 3.04



STRAW BALE BARRIER

STB

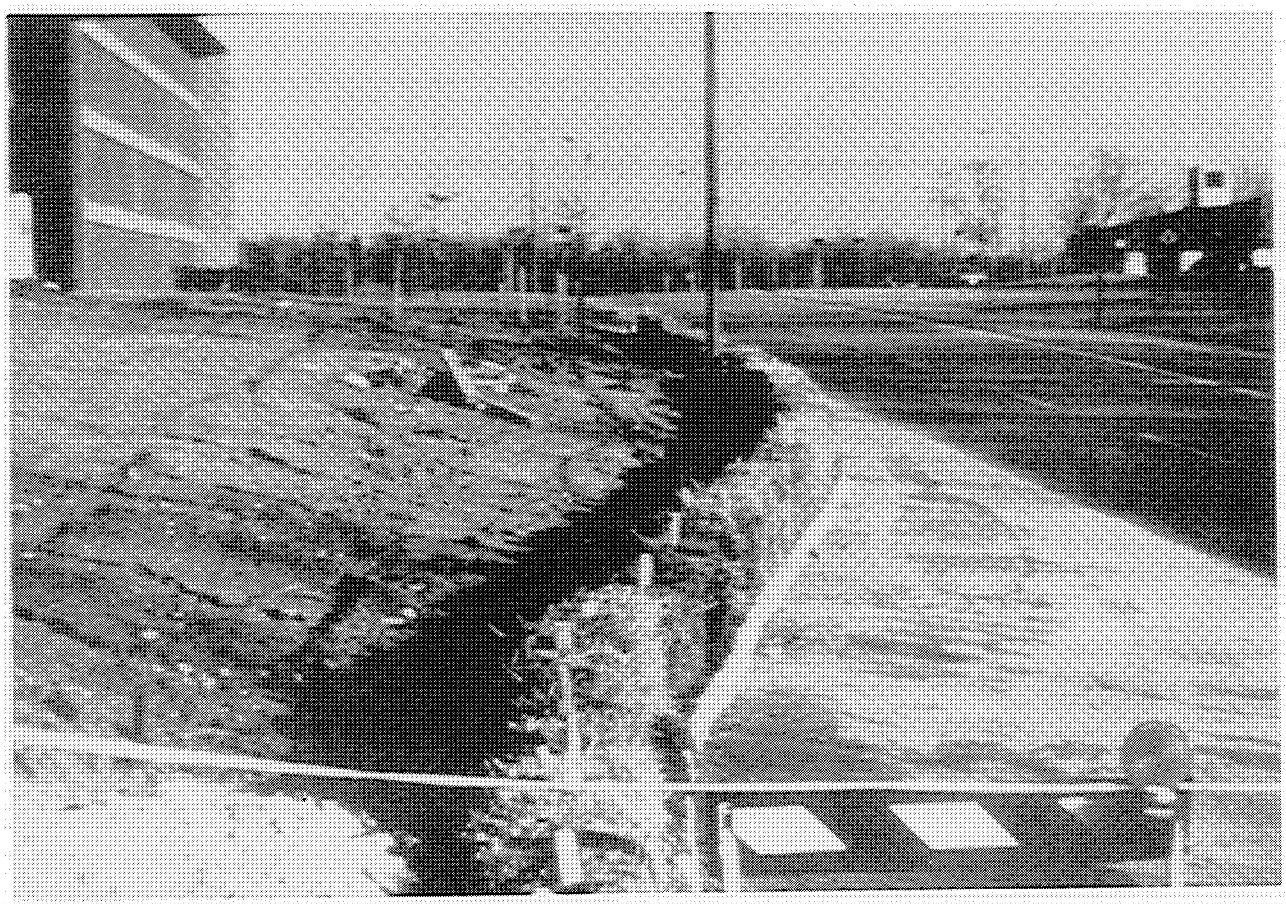
Definition

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas of limited extent in order to prevent sediment from leaving the construction site.

2. To decrease the velocity of sheet flows.



Conditions Where Practice Applies

1. Below disturbed areas subject to sheet and rill erosion.

2. Where the size of the drainage area is no greater than one-fourth of an acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 50 percent (2:1).

3. Where effectiveness is required for less than 3 months.

4. Under no circumstances should straw bale barriers be constructed in live streams or in swales where there is the possibility of a washout.

5. The measure should not be used where water may concentrate in defined ditches and minor swales.

6. Straw bale barriers shall not be used on areas where rock or another hard surface prevents the full and uniform anchoring of the barrier.

Planning Considerations

Based on observations made in Virginia, Pennsylvania, Maryland and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be - especially when used to slow down and filter concentrated flows. They should be used judiciously and with caution as erosion control measures. There are three major reasons for such ineffectiveness.

First, improper utilization of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water depth and velocities have destroyed or damaged the control. Secondly, improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, has allowed undercutting and end flow. This has resulted in additions of, rather than removal of, sediment from runoff waters. Finally, inadequate maintenance lowers the effectiveness of these barriers. Trapping efficiencies of carefully installed straw bale barriers on one project in Virginia dropped from 57% to 16% in one month due to lack of maintenance.

There are serious questions about the continued use of straw bale barriers as they are presently installed and maintained. Averaging from $3 to $6 per linear foot, the thousands of straw bale barriers used annually in Virginia represent such a considerable expense that optimum installation procedures should be emphasized.

Design Criteria

A formal design is not required. However, an effort should be made to locate the straw bale barrier, as well as other perimeter controls, at least 5 to 7 feet from the base of disturbed slopes with grades greater than 7%. This will help prevent the measure from being rendered useless following the initial movement of soil.

Construction Specifications

Sheet Flow Application

1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

2. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings (see Plate 3.04-1).

3. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. After the bales are staked and chinked (gaps filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier (see Plate 3.04-1).

4. Each bale shall be securely anchored by at least two stakes (minimum dimensions 2 inches x 2 inches x 36 inches) or standard "T" or "U" steel posts (minimum weight of 1.33 pounds per linear foot) driven through the bale. The first stake or steel post in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or steel pickets shall be driven a minimum 18 inches deep into the ground to securely anchor the bales.

5. The gaps between bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency.

6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

Maintenance

1. Straw bale barriers shall be inspected immediately after each rainfall and at least daily during prolonged rainfall.

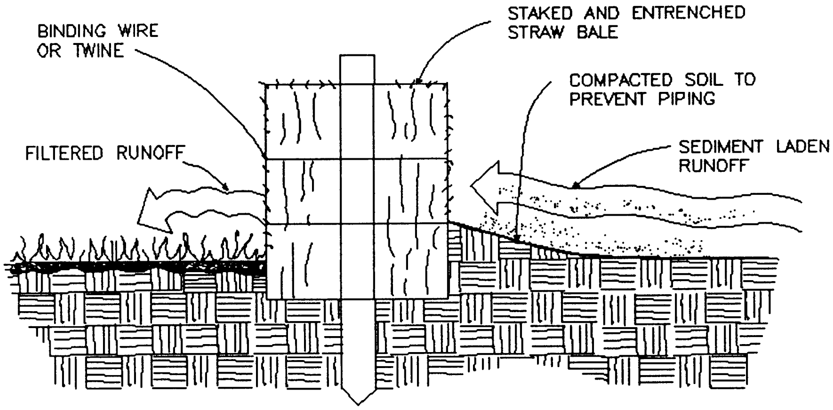
2. Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales.

3. Necessary repairs to barriers or replacement of bales shall be accomplished promptly.

4. Sediment deposits should be removed after each rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.

5. Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.

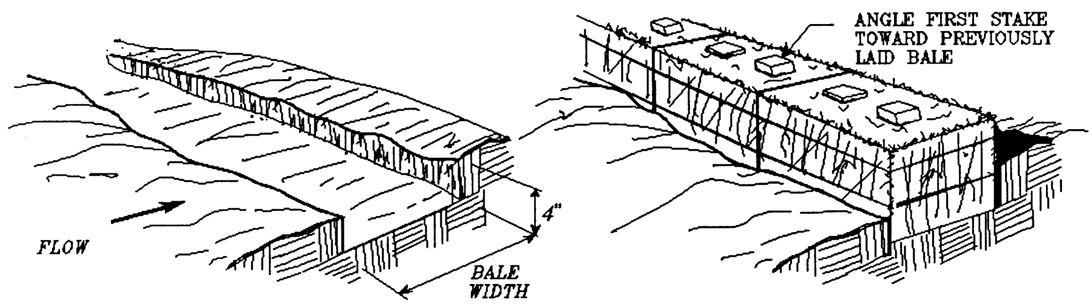
STRAW BALE BARRIER

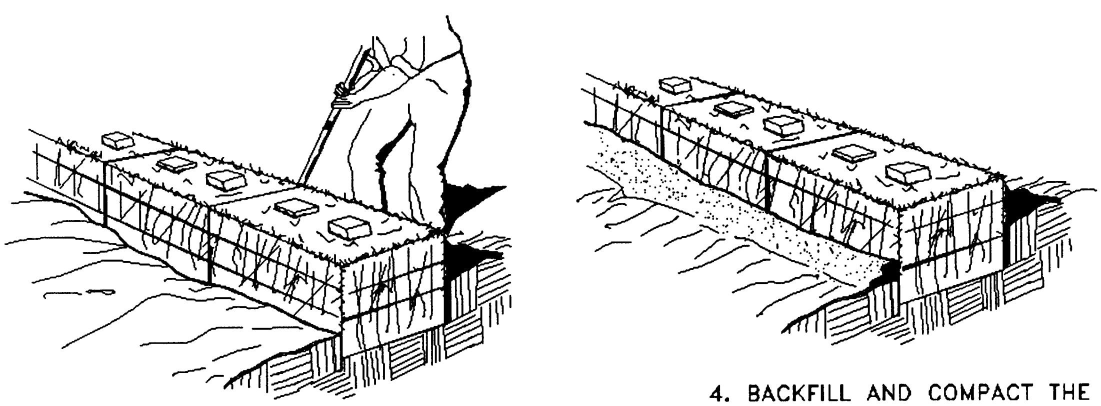


PROPERLY INSTALLED STRAW BALE
(CROSS SECTION)

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

Source: Va. DSWC

Plate 3.04-1

STD & SPEC 3.05

x—x—x—x

SILT FENCE

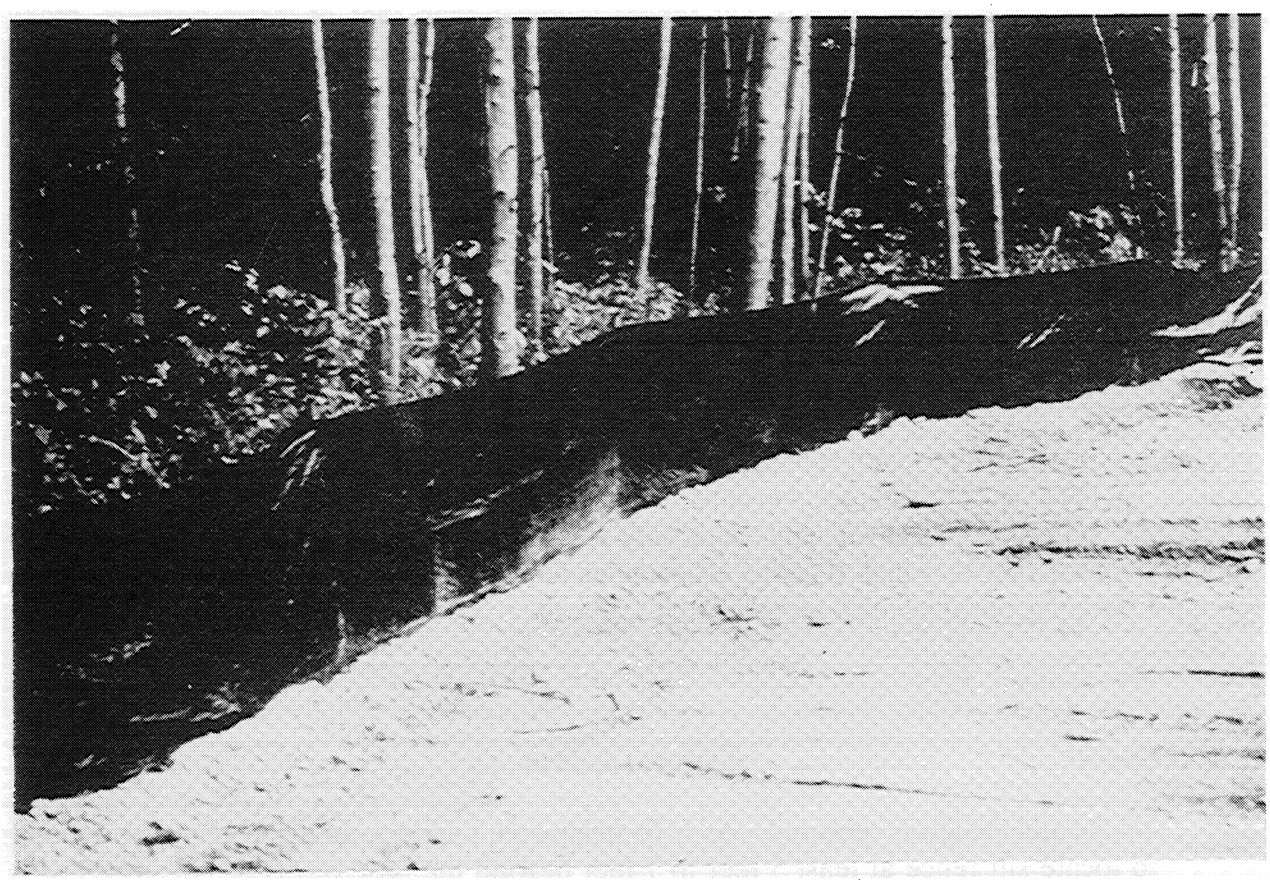
SF

Definition

A temporary sediment barrier consisting of a synthetic filter fabric stretched across and attached to supporting posts and entrenched.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.
2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.



Conditions Where Practice Applies

1. Below disturbed areas where erosion would occur in the form of sheet and rill erosion.

2. Where the size of the drainage area is no more than one quarter acre per 100 feet of silt fence length; the maximum slope length behind the barrier is 100 feet; and the maximum gradient behind the barrier is 50 percent (2:1).

3. In minor swales or ditch lines where the maximum contributing drainage area is no greater than 1 acre and flow is no greater than 1 cfs.

4. Silt fence will not be used in areas where rock or some other hard surface prevents the full and uniform depth anchoring of the barrier.

Planning Considerations

Laboratory work at the Virginia Highway and Transportation Research Council (VHTRC) has shown that silt fences can trap a much higher percentage of suspended sediments than straw bales, though silt fence passes the sediment-laden water slower. Silt fences are preferable to straw barriers in many cases because of their durability and potential cost savings. While the failure rate of silt fences is lower than that of straw barriers, many instances have been observed where silt fences are improperly installed, inviting failure and sediment loss. The installation methods outlined here can improve performance and reduce failures.

As noted, flow rate through silt fence is significantly lower than the flow rate for straw bale barriers. This creates more ponding and hence more time for sediment to fall out. Table 3.05-A demonstrates these relationships.

Both woven and non-woven synthetic fabrics are commercially available. The woven fabrics generally display higher strength than the non-woven fabrics and, in most cases, do not require any additional reinforcement. When tested under acid and alkaline water conditions, most of the woven fabrics increase in strength, while the reactions of non-woven fabrics to these conditions are variable. The same is true of testing under extensive ultraviolet radiation. Permeability rates vary regardless of fabric type. While all of the fabrics demonstrate very high filtering efficiencies for sandy sediments, there is considerable variation among both woven and non-woven fabrics when filtering the finer silt and clay particles.

Design Criteria

1. No formal design is required. As with straw bale barriers, an effort should be made to locate silt fence at least 5 feet to 7 feet beyond the base of disturbed slopes with grades greater than 7%.

TABLE 3.05-A

TYPICAL FLOW RATES AND FILTERING EFFICIENCIES OF PERIMETER CONTROL

Material	Flow Rate (gal./sq.ft./min)	Filter Efficiency(%)
Straw	5.6	67
Synthetic Fabric	0.3	97

Source: VHTRC

2. The use of silt fences, because they have such a low permeability, is limited to situations in which only sheet or overland flows are expected and where concentrated flows originate from drainage areas of 1 acre or less.

3. Field experience has demonstrated that, in many instances, silt fence is installed too short (less than 16 inches above ground elevation). The short fence is subject to breaching during even small storm events and will require maintenance "clean outs" more often. Properly supported silt fence which stands 24 to 34 inches above the existing grade tends to promote more effective sediment control.

Construction Specifications

Materials

1. Synthetic filter fabric shall be a pervious sheet of propylene, nylon, polyester or ethylene yarn and shall be certified by the manufacturer or supplier as conforming to the requirements noted in Table 3.05-B.

2. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0° F to 120° F.

3. If wooden stakes are utilized for silt fence construction, they must have a diameter of 2 inches when oak is used and 4 inches when pine is used. Wooden stakes must have a minimum length of 5 feet.

TABLE 3.05-B

PHYSICAL PROPERTIES OF FILTER FABRIC IN SILT FENCE

Physical Property	Test	Requirements
Filtering Efficiency	ASTM 5141	75% (minimum)
Tensile Strength at 20% (max.) Elongation*	VTM-52	Extra Strength - 50 lbs./linear inch (minimum) Standard Strength - 30 lbs./linear inch (minimum)
Flow Rate	ASTM 5141	0.2 gal./sq.ft./ minute (minimum)
Ultraviolet Radiation Stability %	ASTM-G-26	90% (minimum)

* Requirements reduced by 50% after six months of installation.

Source: VHTRC

4. If steel posts (standard "U" or "T" section) are utilized for silt fence construction, they must have a minimum weight of 1.33 pounds per linear foot and shall have a minimum length of 5 feet.

5. Wire fence reinforcement for silt fences using standard-strength filter cloth shall be a minimum of 14 gauge and shall have a maximum mesh spacing of 6 inches.

Installation

1. The height of a silt fence shall be a minimum of 16 inches above the original ground surface and shall not exceed 34 inches above ground elevation.

2. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are unavoidable, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed.

3. A trench shall be excavated approximately 4-inches wide and 4-inches deep on the upslope side of the proposed location of the measure.

4. When wire support is used, standard-strength filter cloth may be used. Posts for this type of installation shall be placed a maximum of 10-feet apart (see Plate 3.05-1). The wire mesh fence must be fastened securely to the upslope side of the posts using heavy duty wire staples at least one inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of two inches and shall not extend more than 34 inches above the original ground surface. The standard-strength fabric shall be stapled or wired to the wire fence, and 8 inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees.

5. When wire support is not used, extra-strength filter cloth shall be used. Posts for this type of fabric shall be placed a maximum of 6-feet apart (see Plate 3.05-2). The filter fabric shall be fastened securely to the upslope side of the posts using one inch long (minimum) heavy-duty wire staples or tie wires and eight inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees. This method of installation has been found to be more commonplace than #4.

6. If a silt fence is to be constructed across a ditch line or swale, the measure must be of sufficient length to eliminate endflow, and the plan configuration shall resemble an arc or horseshoe with the ends oriented upslope (see Plate 3.05-2). Extra-strength filter fabric shall be used for this application with a maximum 3-foot spacing of posts.

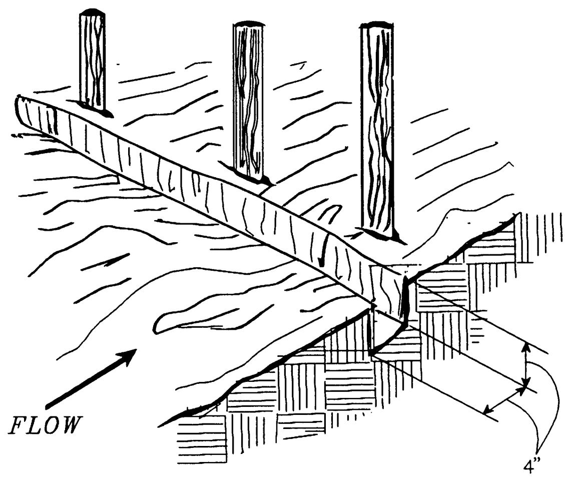
   All other installation requirements noted in #5 apply.

7. The 4-inch by 4-inch trench shall be backfilled and the soil compacted over the filter fabric.

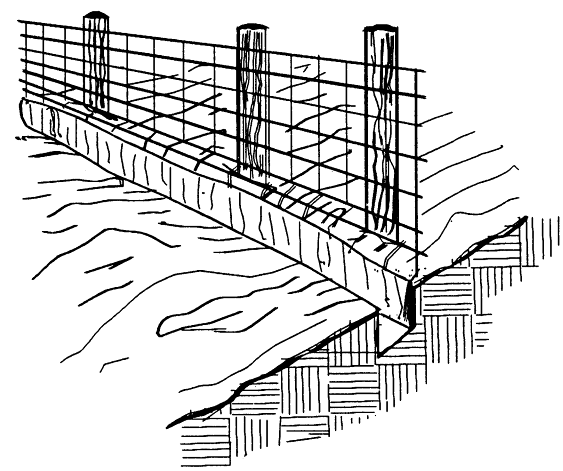
8. Silt fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

CONSTRUCTION OF A SILT FENCE (WITH WIRE SUPPORT)

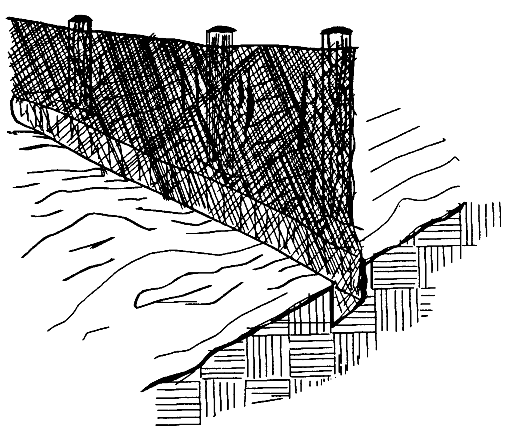
1. SET POSTS AND EXCAVATE A 4"X4" TRENCH UPSLOPE ALONG THE LINE OF POSTS.



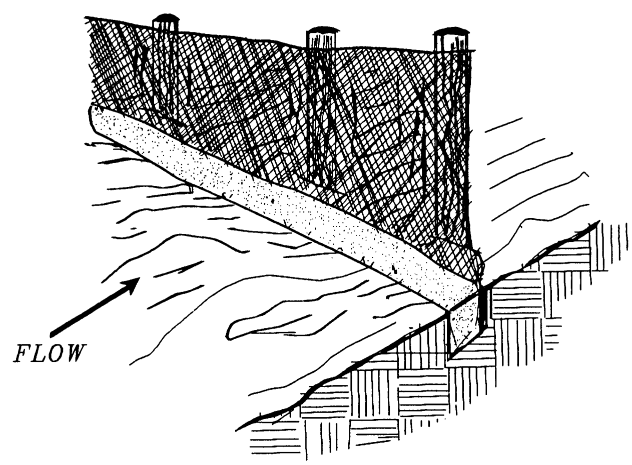
2. STAPLE WIRE FENCING TO THE POSTS.



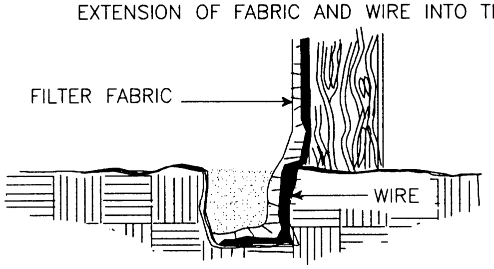
3. ATTACH THE FILTER FABRIC TO THE WIRE FENCE AND EXTEND IT INTO THE TRENCH.



4. BACKFILL AND COMPACT THE EXCAVATED SOIL.



EXTENSION OF FABRIC AND WIRE INTO THE TRENCH.

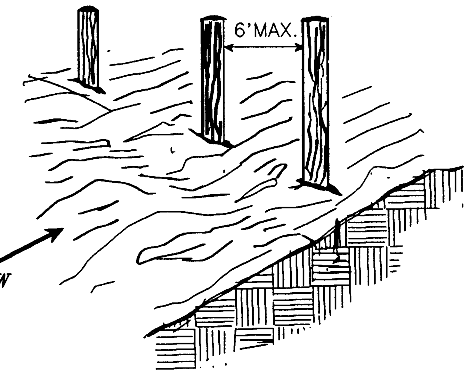


Source: Adapted from Installation of Straw and Fabric Filter Barriers for Sediment Control, Sherwood and Wyant

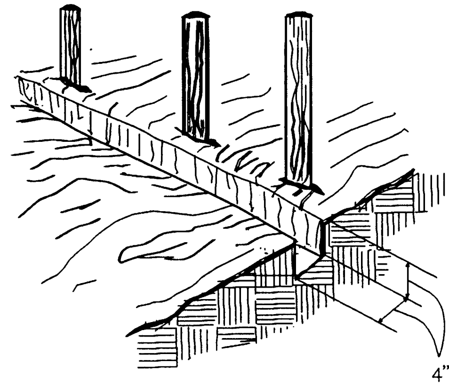
Plate 3.05-1

CONSTRUCTION OF A SILT FENCE (WITHOUT WIRE SUPPORT)

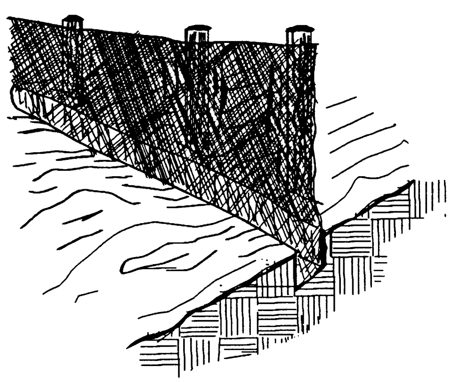
1. SET THE STAKES.



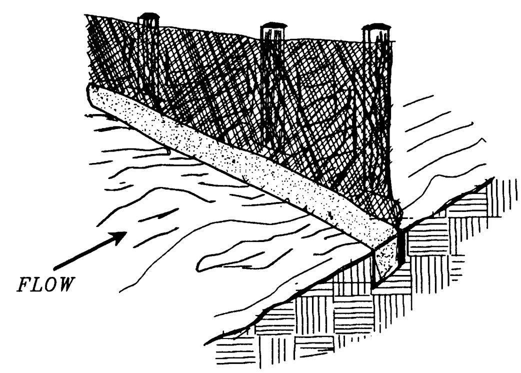
2. EXCAVATE A 4"X 4" TRENCH UPSLOPE ALONG THE LINE OF STAKES.



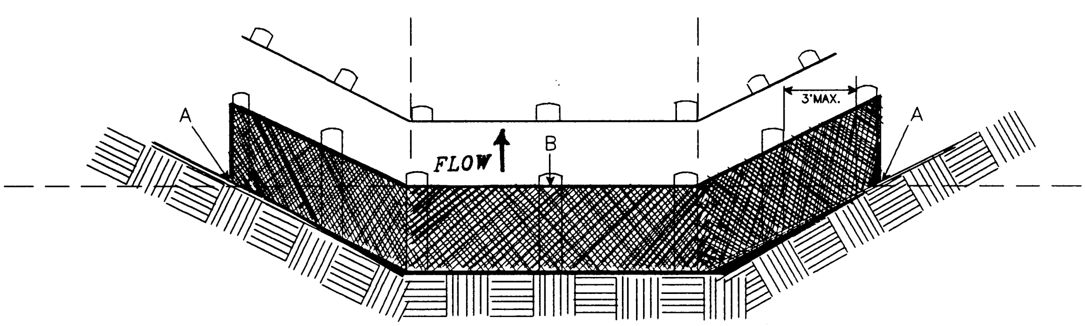
3. STAPLE FILTER MATERIAL TO STAKES AND EXTEND IT INTO THE TRENCH.



4. BACKFILL AND COMPACT THE EXCAVATED SOIL.



SHEET FLOW INSTALLATION
(PERSPECTIVE VIEW)



POINTS A SHOULD BE HIGHER THAN POINT B.

DRAINAGEWAY INSTALLATION
(FRONT ELEVATION)

Source: Adapted from Installation of Straw and Fabric Filter Barriers for Sediment Control, Sherwood and Wyant

Plate 3.05-2

Maintenance

1. Silt fences shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately.

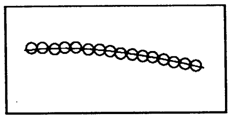
2. Close attention shall be paid to the repair of damaged silt fence resulting from end runs and undercutting.

3. Should the fabric on a silt fence decompose or become ineffective prior to the end of the expected usable life and the barrier still be necessary, the fabric shall be replaced promptly.

4. Sediment deposits should be removed after each storm event. They must be removed when deposits reach approximately one-half the height of the barrier.

5. Any sediment deposits remaining in place after the silt fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

STD & SPEC 3.06



BRUSH BARRIER

(BB)

Definition

A temporary sediment barrier constructed at the perimeter of a disturbed area from the residue materials available from clearing and grubbing the site.

Purpose

To intercept and retain sediment from disturbed areas of limited extent, preventing sediment from leaving the site.

Conditions Where Practice Applies

1. Below disturbed areas subject to sheet and rill erosion, where enough residue material is available for construction of such a barrier.

2. Where the size of the drainage area is no greater than one-fourth of an acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 50 percent (2:1).

Planning Considerations

Organic litter and spoil material from site clearing operations is usually burned or hauled away to be dumped elsewhere. Much of this material can be used effectively on the construction site itself. During clearing and grubbing operations, equipment can push or dump the mixture of limbs, small vegetation and root mat along with minor amounts of rock into windrows along the toe of a slope where erosion and accelerated runoff are expected. Because brush barriers are fairly stable and composed of natural materials, maintenance requirements are small. Field experience has shown, however, that many brush barrier installations are not effective when there are large voids created by the use of material which is too large (such as tree stumps) to provide a compact, dense barrier. Therefore, it is necessary to use residual material under 6 inches in diameter which will create a more uniform barrier <u>or</u> utilize a filter fabric overlay to promote enhanced filtration of sediment-laden runoff.

Design Criteria

A formal design is not required.

Construction Specifications

Without Filter Cloth

1. The height of a brush barrier shall be a minimum of 3 feet.

2. The width of a brush barrier shall be a minimum of 5 feet at its base (the sizes of brush barriers may vary considerably based upon the amount of material available and the judgement of the design engineer).

3. The barrier shall be constructed by piling brush, stone, root mat and other material from the clearing process into a mounded row on the contour. <u>Material larger than 6 inches in diameter should not be used</u> to create the mound as the non-homogeneity of the mixture can lead to voids where sediment-laden flows can easily pass.

If a Filter is Used (see Plate 3.06-1)

1. Filter fabric must meet the minimum physical requirements noted in Table 3.05-B.

2. The filter fabric shall be cut into lengths sufficient to lay across the barrier from its up-slope base to just beyond its peak. Where joints are necessary, the fabric shall be spliced together with a minimum 6-inch overlap and securely sealed.

3. A trench shall be excavated 6-inches wide and 4-inches deep along the length of the barrier and immediately uphill from the barrier.

4. The lengths of filter fabric shall be draped across the width of the barrier with the uphill edge placed in the trench and the edges of adjacent pieces overlapping each other.

5. The filter fabric shall be secured in the trench with stakes set approximately 36 inches on center.

6. The trench shall be backfilled and the soil compacted over the filter fabric.

7. Set stakes into the ground along the downhill edge of the brush barrier, and anchor the fabric by tying twine from the fabric to the stakes.

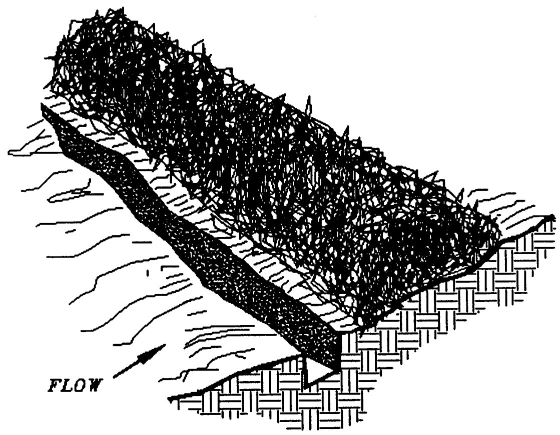
Maintenance

1. Brush barriers shall be inspected after each rainfall and necessary repairs shall be made promptly.

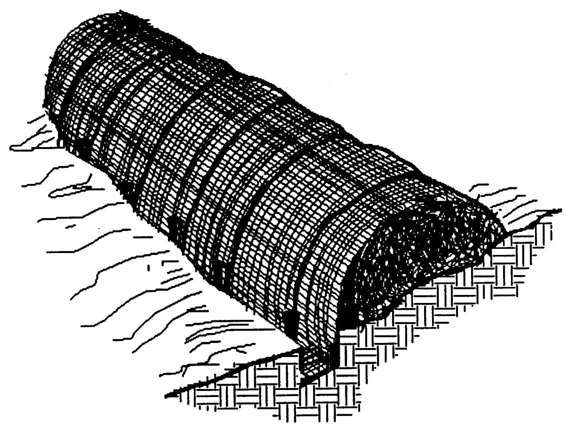
2. Sediment deposits must be removed when they reach approximately one-half the height of the barrier.

CONSTRUCTION OF A BRUSH BARRIER COVERED BY FILTER FABRIC

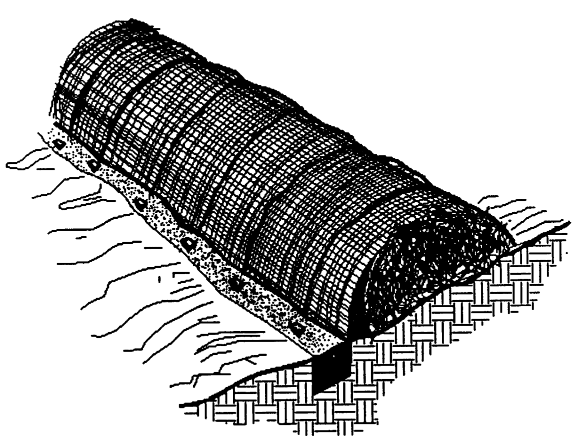
(TREE/RESIDUAL MATERIAL WITH DIAMETER > 6")



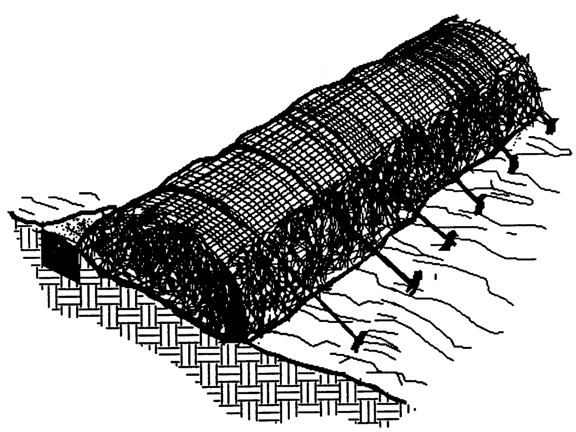
1. EXCAVATE A 4"X 4" TRENCH ALONG THE UPHILL EDGE OF THE BRUSH BARRIER.



2. DRAPE FILTER FABRIC OVER THE BRUSH BARRIER AND INTO THE TRENCH. FABRIC SHOULD BE SECURED IN THE TRENCH WITH STAKES SET APPROXIMATELY 36" O.C.



3. BACKFILL AND COMPACT THE EXCAVATED SOIL.

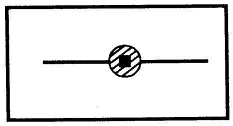


4. SET STAKES ALONG THE DOWN-HILL EDGE OF THE BRUSH BARRIER, AND ANCHOR BY TYING TWINE FROM THE FABRIC TO THE STAKES.

Source: Va. DSWC

Plate 3.06-1

STD & SPEC 3.07



STORM DRAIN INLET PROTECTION

IP

Definition

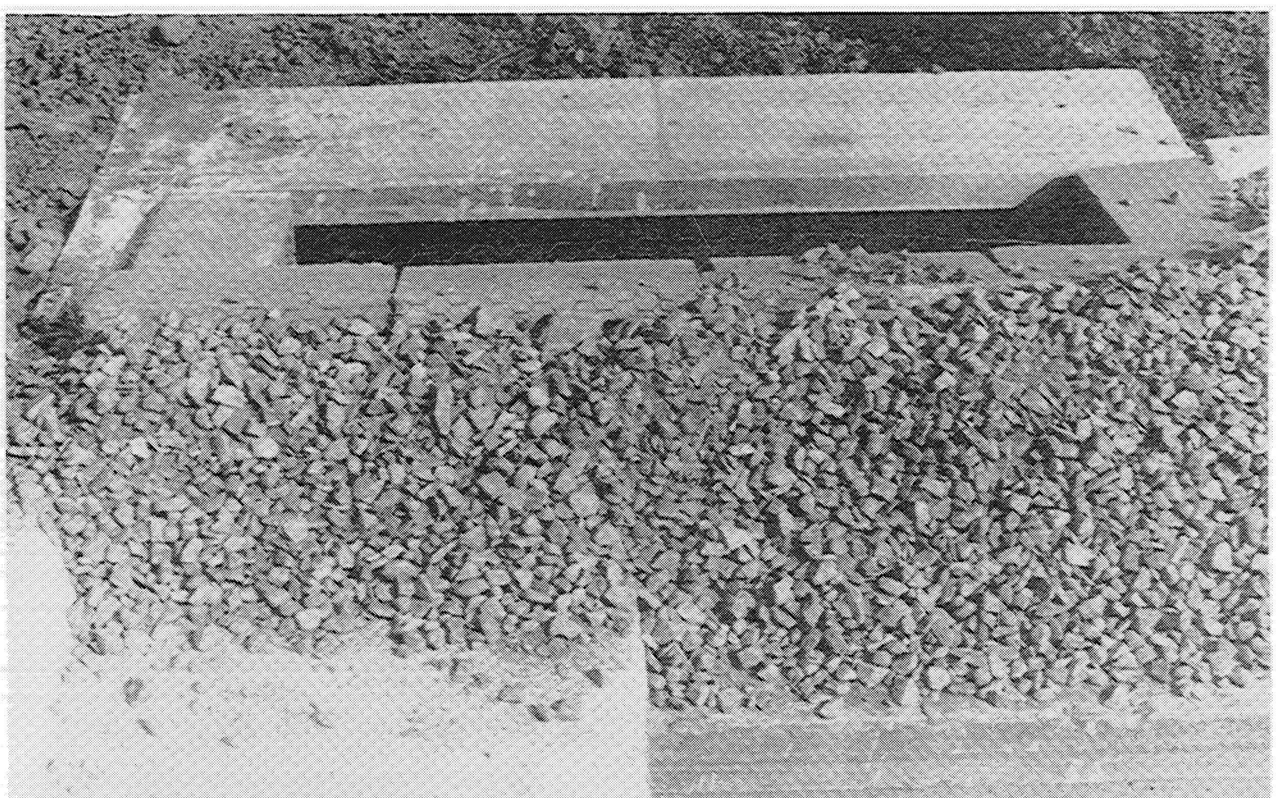
A sediment filter or an excavated impounding area around a storm drain drop inlet or curb inlet.

Purpose

To prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

Conditions Where Practice Applies

Where storm drain inlets are to be made operational before permanent stabilization of the corresponding disturbed drainage area. Different types of structures are applicable to different conditions (see Plates 3.07-1 through 3.07-8).



Planning Considerations

Storm sewers which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainageways. In case of extreme sediment loading, the storm sewer itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

This practice contains several types of inlet filters and traps which have different applications dependent upon site conditions and type of inlet. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the appropriate Plan-Approving Authority.

Care should be taken when choosing a specific type of inlet protection. Field experience has shown that inlet protection which causes excessive ponding in an area of high construction activity may become so inconvenient that it is removed or bypassed, thus transmitting sediment-laden flows unchecked. In such situations, a structure with an adequate overflow mechanism should be utilized.

The following inlet protection devices are for drainage areas of one acre or less. Runoff from larger disturbed areas should be routed to a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13) or a TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14).

The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

Stone is utilized as the chief ponding/filtering agent in most of the inlet protection types described in this specification. The various types of "coarse aggregates" which are depicted are able to filter out sediment mainly through slowing down flows directed to the inlet by creating an increased flow path for the stormwater (through void space in the respective stone). The stone filtering medium by no means slows stormwater flowrate as does filter cloth and therefore cannot provide the same degree of filter efficiency when smaller silt and clay particles are introduced into stormwater flows. However, as mentioned earlier, excessive ponding in busy areas adjacent to stormwater inlets is in many cases unacceptable - that is why stone must be utilized with many installations.

Fortunately, in most instances, inlet protection utilizing stone should not be the sole control measure. At the time that storm sewer inlet and associated appurtances become operational, areas adjacent to the structures are most likely at final grade or will not be altered for extended periods; this is the time when TEMPORARY SEEDING (Std. & Spec. 3.31) and other appropriate controls should be implemented to enhance sediment-loss mitigation. In addition, by varying stone sizes used in the construction of inlet protection, a greater degree of sediment removal can be obtained. As an option, filter cloth can be used with the stone in these devices to further enhance sediment removal. Notably, the potential inconvenience of excessive ponding must be examined with these choices, especially the latter.

Design Criteria

1. The drainage area shall be no greater than 1 acre.

2. The inlet protection device shall be constructed in a manner that will facilitate clean-out and disposal of trapped sediment and minimize interference with construction activities.

3. The inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.

4. Design criteria more specific to each particular inlet protection device will be found on Plates 3.07-1 through 3.07-8.

5. For the inlet protection devices which utilize stone as the chief ponding/filtering medium, a range of stone sizes is offered; VDOT #3, #357, or #5 Coarse Aggregate should be used. The designer/plan reviewer should attempt to get the greatest amount of filtering action possible (by using smaller-sized stone), while not creating significant ponding problems.

6. In all designs which utilize stone with a wire-mesh support as a filtering mechanism, the stone can be completely wrapped with the wire mesh to improve stability and provide easier cleaning.

7. Filter Fabric may be added to any of the devices which utilize "coarse aggregate" stone to significantly enhance sediment removal. The fabric, which must meet the physical requirements noted for "extra strength" found in Table 3.05-B, should be secured between the stone and the inlet (on wire-mesh if it is present). As a result of the significant increase in filter efficiency provided by the fabric, a larger range of stone sizes (VDOT #1, #2 or #3 Coarse Aggregate) may be utilized with such a configuration. The larger stone will help keep larger sediment masses from clogging the cloth. Notably, significant ponding may occur at the inlet if filter cloth is utilized in this manner.

Construction Specifications

1. Silt Fence Drop Inlet Protection

   a. Silt Fence shall conform to the construction specifications for "extra strength" found in Table 3.05-B and shall be cut from a continuous roll to avoid joints.

   b. For stakes, use 2 x 4-inch wood (preferred) or equivalent metal with a minimum length of 3 feet.

c. Space stakes evenly around the perimeter of the inlet a maximum of 3-feet apart, and securely drive them into the ground, approximately 18-inches deep (see Plate 3.07-1).

d. To provide needed stability to the installation, frame with 2 x 4-inch wood strips around the crest of the overflow area at a maximum of 1½ feet above the drop inlet crest.

e. Place the bottom 12 inches of the fabric in a trench (see Plate 3.07-1) and backfill the trench with 12 inches of compacted soil.

f. Fasten fabric securely by staples or wire to the stakes and frame. Joints must be overlapped to the next stake.

g. It may be necessary to build a temporary dike on the downslope side of the structure to prevent bypass flow.

2. Gravel and Wire Mesh Drop Inlet Sediment Filter

a. Wire mesh shall be laid over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Wire mesh with 1/2-inch openings shall be used. If more than one strip of mesh is necessary, the strips shall be overlapped.

b. Coarse aggregate shall be placed over the wire mesh as indicated on Plate 3.07-2. The depth of stone shall be at least 12 inches over the entire inlet opening. The stone shall extend beyond the inlet opening at least 18 inches on all sides.

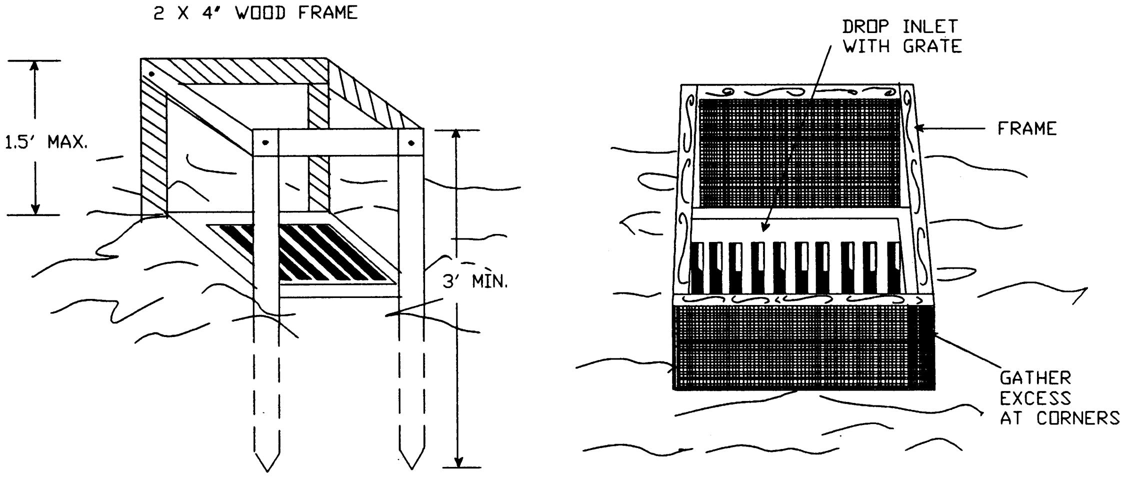
c. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned and/or replaced.

Note: This filtering device has no overflow mechanism; therefore, ponding is likely especially if sediment is not removed regularly. This type of device must never be used where overflow may endanger an exposed fill slope. Consideration should also be given to the possible effects of ponding on traffic movement, nearby structures, working areas, adjacent property, etc.

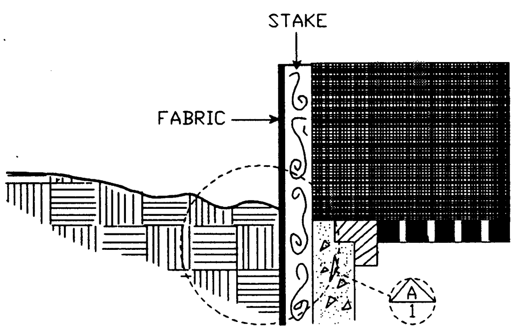
3. Block and Gravel Drop Inlet Sediment Filter

a. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, with the ends of adjacent blocks abutting. The height of the barrier can be varied, depending on design needs, by stacking combinations of 4-inch, 8-inch and 12-inch wide blocks. The barrier of blocks shall be at least 12-inches high and no greater than 24-inches high.

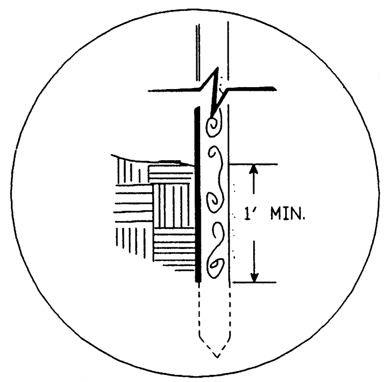
SILT FENCE DROP INLET PROTECTION



PERSPECTIVE VIEWS



ELEVATION OF STAKE AND FABRIC ORIENTATION



DETAIL A

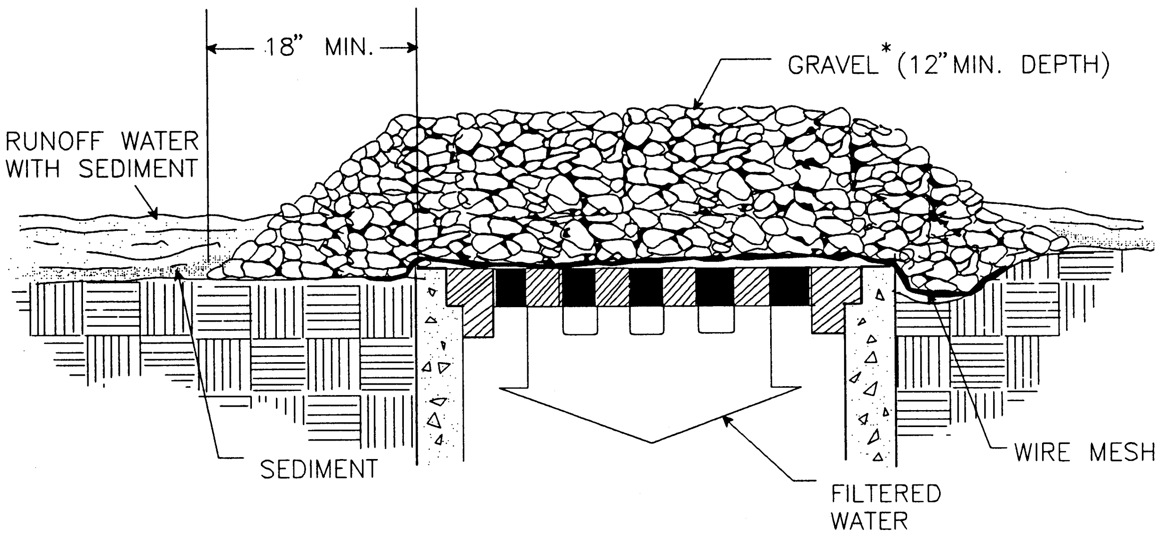
SPECIFIC APPLICATION

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.

Source: N.C. Erosion and Sediment Control Planning and Design Manual, 1988

Plate 3.07-1

GRAVEL AND WIRE MESH DROP INLET SEDIMENT FILTER



SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY CONCENTRATED FLOWS ARE EXPECTED, BUT NOT WHERE PONDING AROUND THE STRUCTURE MIGHT CAUSE EXCESSIVE INCONVENIENCE OR DAMAGE TO ADJACENT STRUCTURES AND UNPROTECTED AREAS.

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

Source: Va. DSWC

Plate 3.07-2

b. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire mesh with 1/2-inch openings shall be used.

c. Stone shall be piled against the wire to the top of the block barrier, as shown in Plate 3.07-3.

d. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and replaced.

4. Excavated Drop Inlet Sediment Trap

a. The excavated trap shall be sized to provide a minimum storage capacity calculated at the rate of 134 cubic yards per acre of drainage area. A trap shall be no less than 1-foot nor more than 2-feet deep measured from the top of the inlet structure. Side slopes shall not be steeper than 2:1 (see Plate 3.07-4).

b. The slope of the basin may vary to fit the drainage area and terrain. Observations must be made to check trap efficiency and modifications shall be made as necessary to ensure satisfactory trapping of sediment. Where an inlet is located so as to receive concentrated flows, such as in a highway median, it is recommended that the basin have a rectangular shape in a 2:1 (length/width) ratio, with the length oriented in the direction of the flow.

c. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one-half the design depth of the trap. Removed sediment shall be deposited in a suitable area and in a manner such that it will not erode.

5. Sod Drop Inlet Sediment Filter

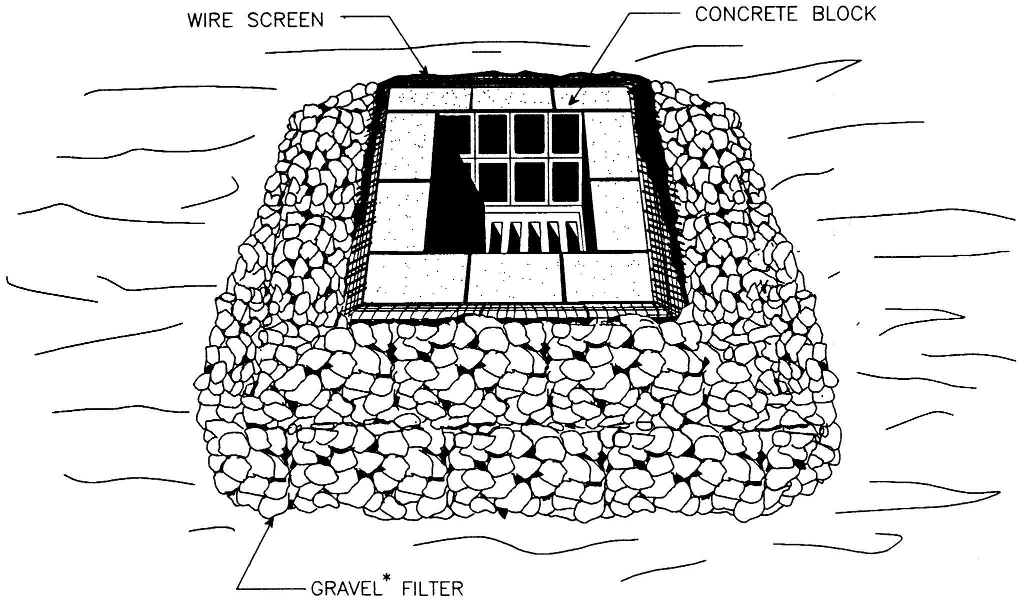
a. Soil shall be prepared and sod installed according to the specifications in Std. & Spec. 3.33, SODDING.

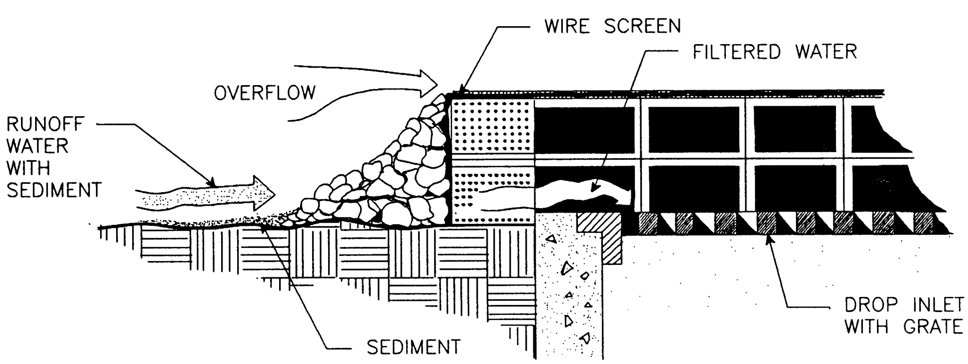
b. Sod shall be placed to form a turf mat covering the soil for a distance of 4 feet from each side of the inlet structure, as depicted in Plate 3.07-5.

6. Gravel Curb Inlet Sediment Filter

a. Wire mesh with 1/2-inch openings shall be placed over the curb inlet opening so that at least 12 inches of wire extends across the inlet cover and at least 12 inches of wire extends across the concrete gutter from the inlet opening, as depicted in Plate 3.07-6.

BLOCK AND GRAVEL DROP INLET SEDIMENT FILTER





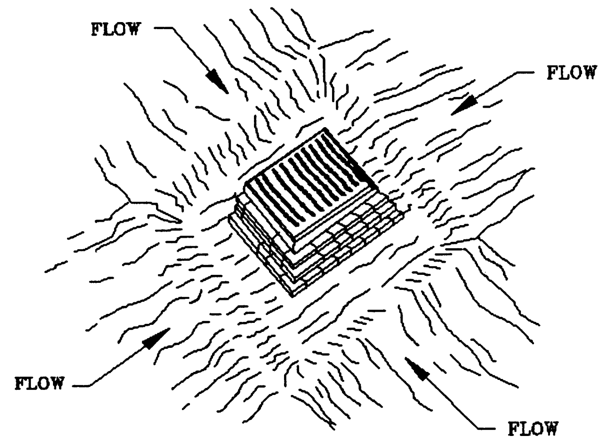
SPECIFIC APPLICATION

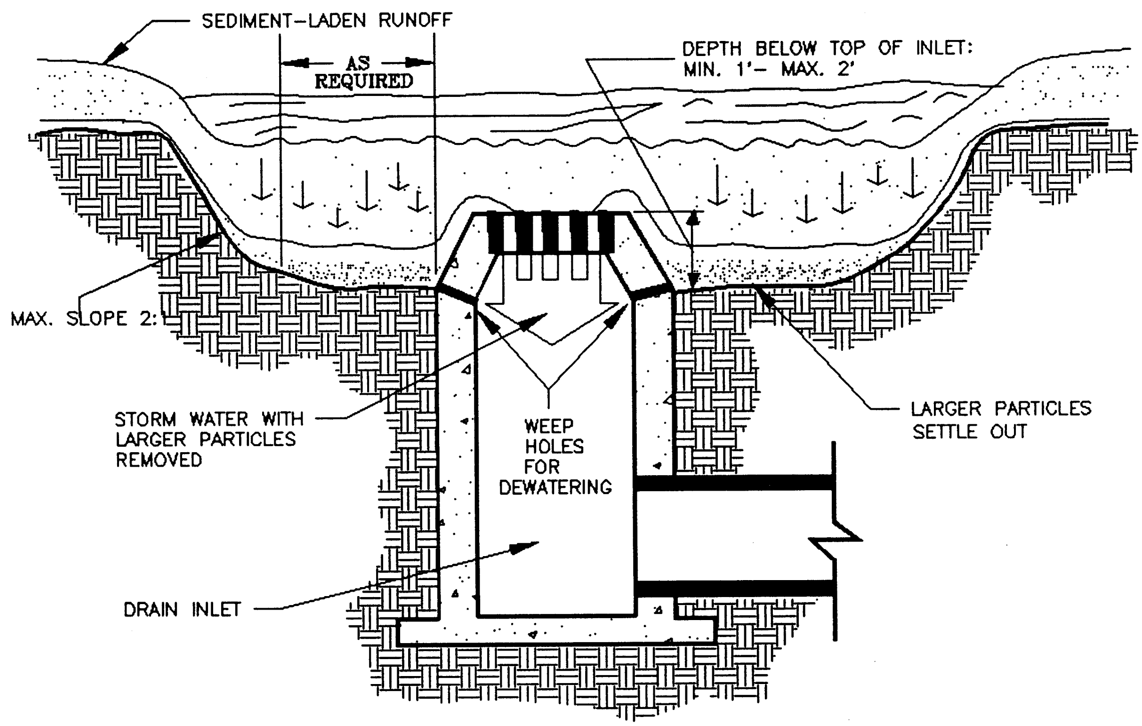
THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY FLOWS ARE EXPECTED AND WHERE AN OVERFLOW CAPACITY IS NECESSARY TO PREVENT EXCESSIVE PONDING AROUND THE STRUCTURE.

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

Source: Va. DSWC Plate 3.07-3

EXCAVATED DROP INLET SEDIMENT TRAP





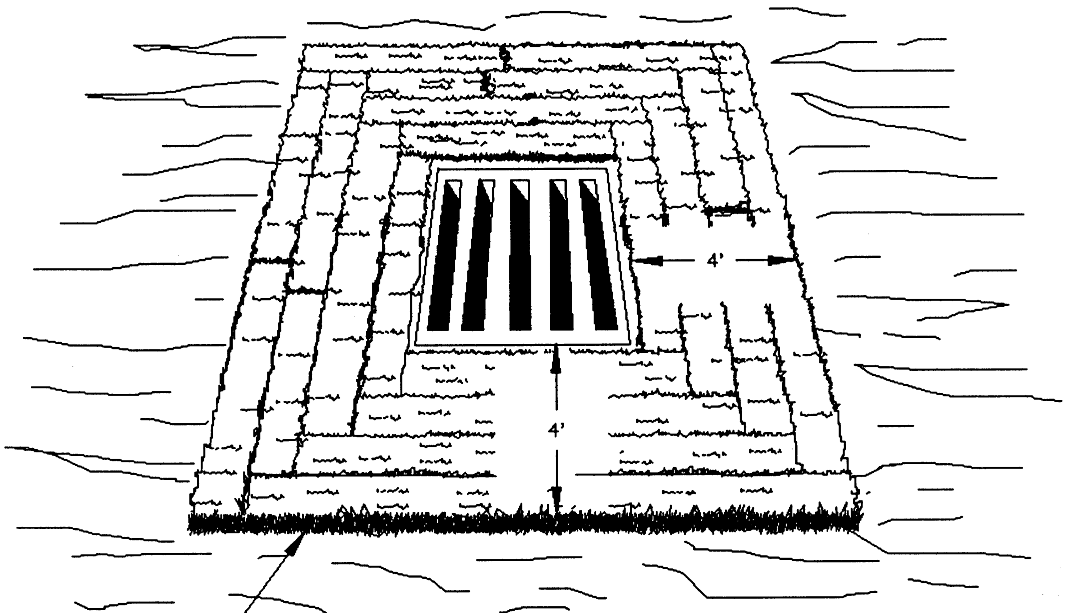
SPECIFIC APPLICATION

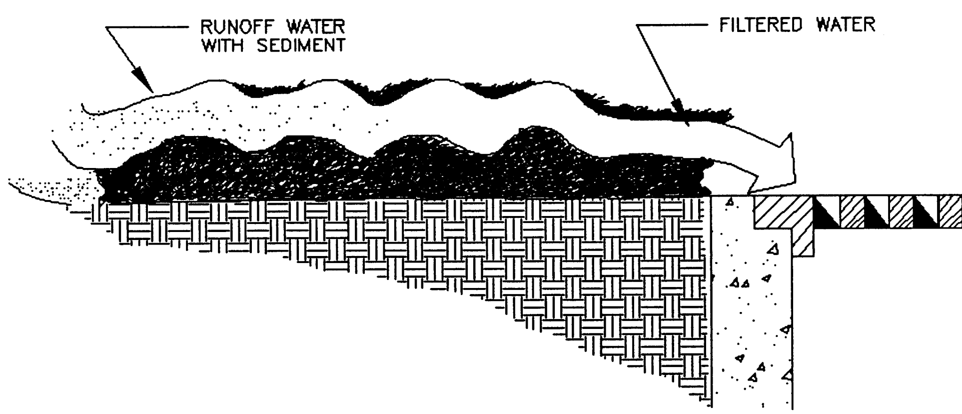
THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY FLOWS ARE EXPECTED AND WHERE AN OVERFLOW CAPABILITY AND EASE OF MAINTENANCE ARE DESIRABLE.

Source: Michigan Soil Erosion and Sediment Control Guidebook, 1975, and USDA-SCS

Plate 3.07-4

SOD DROP INLET SEDIMENT FILTER





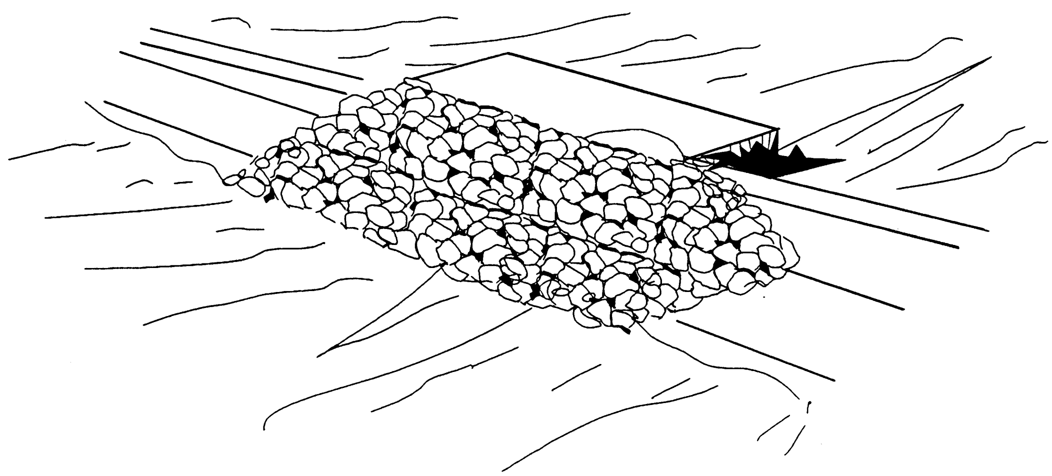
SPECIFIC APLLICATION

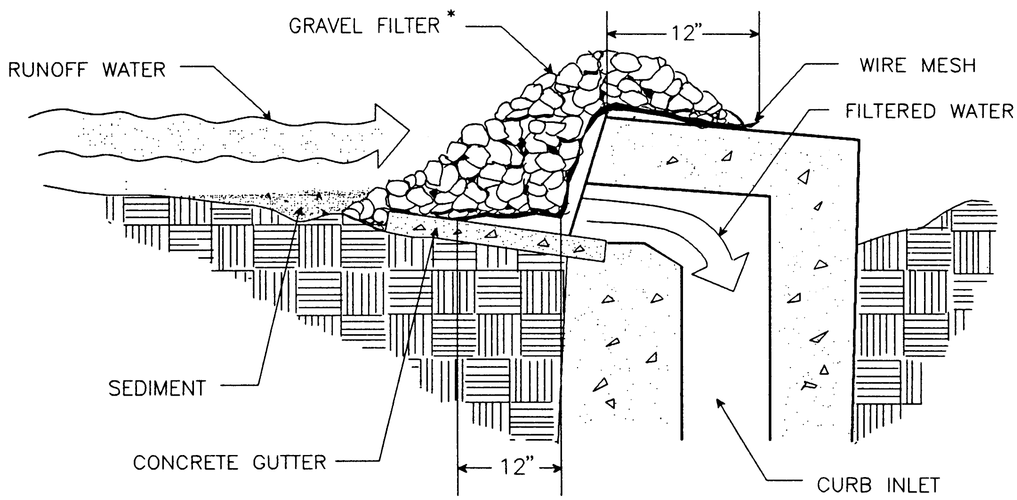
THIS METHOD OF INLET PROTECTION IS APPPLICABLE ONLY AT THE TIME OF PERMANENT SEEDING, TO PROTECT THE INLET FROM SEDIMENT AND MULCH MATERIAL UNTIL PERMANENT VEGETATION HAS BECOME ESTABLISHED.

Source: Va. DSWC

Plate 3.07-5

GRAVEL CURB INLET SEDIMENT FILTER





SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE AT CURB INLETS WHERE PONDING IN FRONT OF THE STRUCTURE IS NOT LIKELY TO CAUSE INCONVENIENCE OR DAMAGE TO ADJACENT STRUCTURES AND UNPROTECTED AREAS.

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

Source: Va. DSWC

Plate 3.07-6

b. Stone shall be piled against the wire so as to anchor it against the gutter and inlet cover and to cover the inlet opening completely.

c. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the block, cleaned and replaced.

7. Curb Inlet Protection with 2-inch x 4-inch Wooden Weir

a. Attach a continuous piece of wire mesh (30-inch minimum width x inlet throat length plus 4 feet) to the 2-inch x 4-inch wooden weir (with a total length of throat length plus 2 feet) as shown in Plate 3.07-7. Wood should be "construction grade" lumber.

b. Place a piece of approved "extra-strength" filter cloth of the same dimensions as the wire mesh over the wire mesh and securely attach to the 2-inch x 4-inch weir.

c. Securely nail the 2-inch x 4-inch weir to the 9-inch long vertical spacers which are to be located between the weir and inlet face at a maximum 6-foot spacing.

d. Place the assembly against the inlet throat and nail 2-foot (minimum) lengths of 2-inch x 4-inch board to the top of the weir at spacer locations. These 2-inch x 4-inch anchors shall extend across the inlet tops and be held in place by sandbags or alternate weight.

e. The assembly shall be placed so that the end spacers are a minimum 1 foot beyond both ends of the throat opening.

f. Form the wire mesh and filter cloth to the concrete gutter and against the face of curb on both sides of the inlet. Place coarse aggregate over the wire mesh and filter fabric in such a manner as to prevent water from entering the inlet under or around the filter cloth.

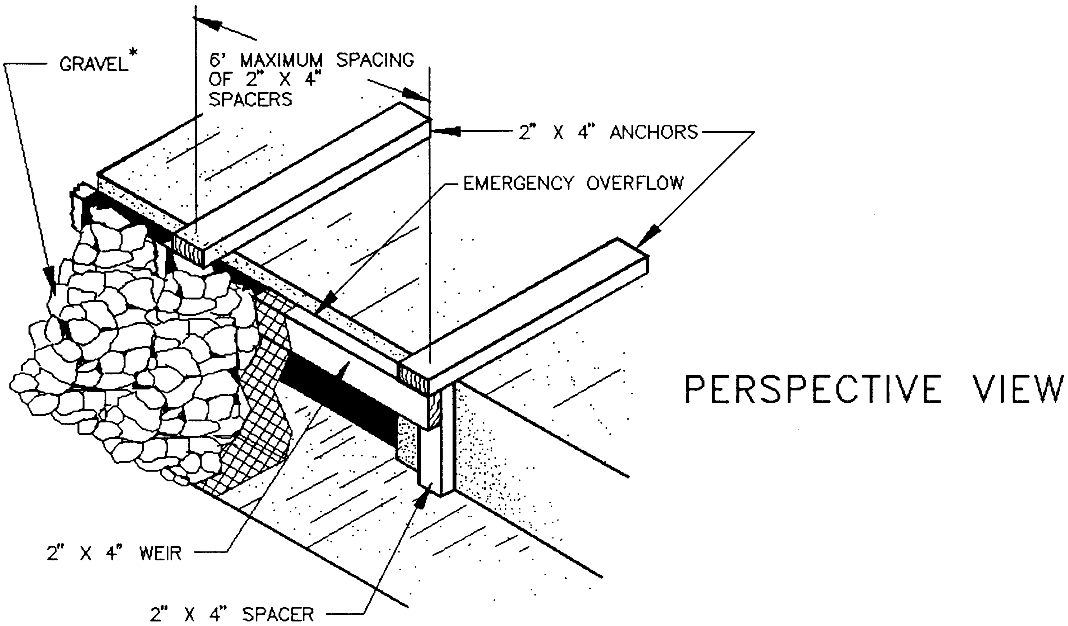
g. This type of protection must be inspected frequently and the filter cloth and stone replaced when clogged with sediment.

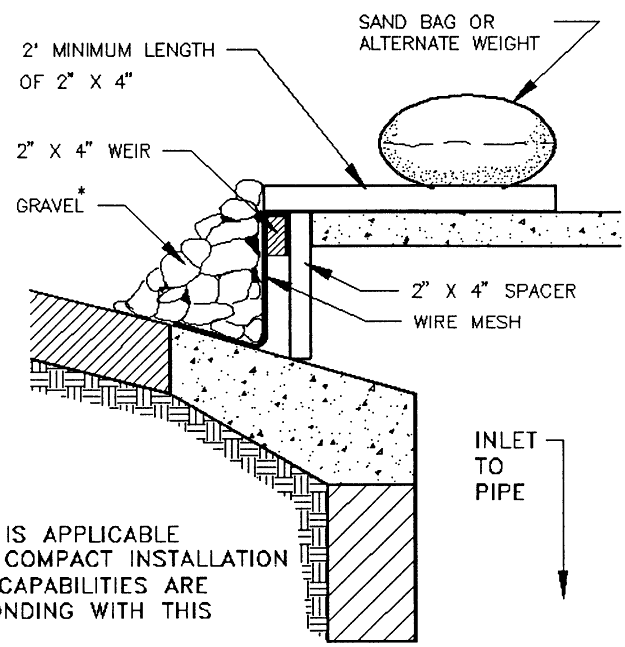
h. Assure that storm flow does not bypass inlet by installing temporary earth or asphalt dikes directing flow into inlet.

8. Block and Gravel Curb Inlet Sediment Filter

a. Two concrete blocks shall be placed on their sides abutting the curb at either side of the inlet opening.

CURB INLET PROTECTION WITH 2-INCH X 4-INCH WOODEN WEIR





SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE TO CURB INLETS WHERE A STURDY, COMPACT INSTALLATION IS DESIRED. EMERGENCY OVERFLOW CAPABILITIES ARE MINIMAL, SO EXPECT SIGNIFICANT PONDING WITH THIS MEASURE.

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

Source: 1983 Maryland Standards and Specifications for Soil Erosion and Sediment Control, and USDA-SCS

Plate 3.07-7

b. A 2-inch x 4-inch stud shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.

c. Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks as depicted in Plate 3.07-8.

d. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire mesh with 1/2-inch openings shall be used.

e. Coarse aggregate shall be piled against the wire to the top of the barrier as shown in Plate 3.07-8.

f. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and/or replaced.

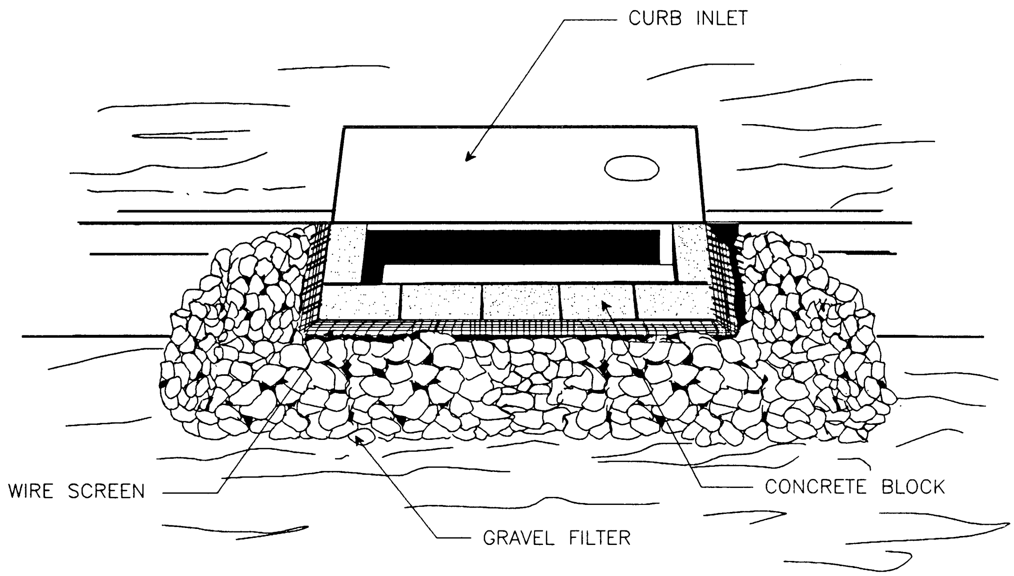
Maintenance

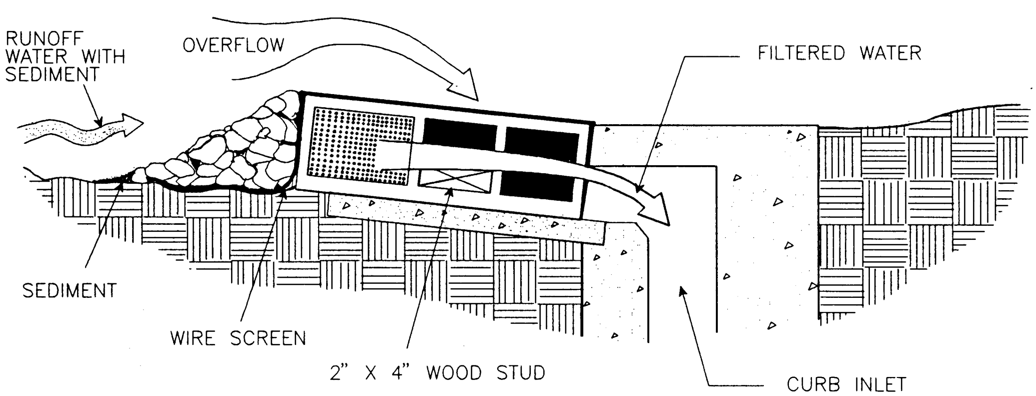
1. The structure shall be inspected after each rain and repairs made as needed.

2. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

3. Structures shall be removed and the area stabilized when the remaining drainage area has been properly stabilized.

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

Source: Va. DSWC

Plate 3.07-8

STD & SPEC 3.08

CULVERT INLET PROTECTION

CIP

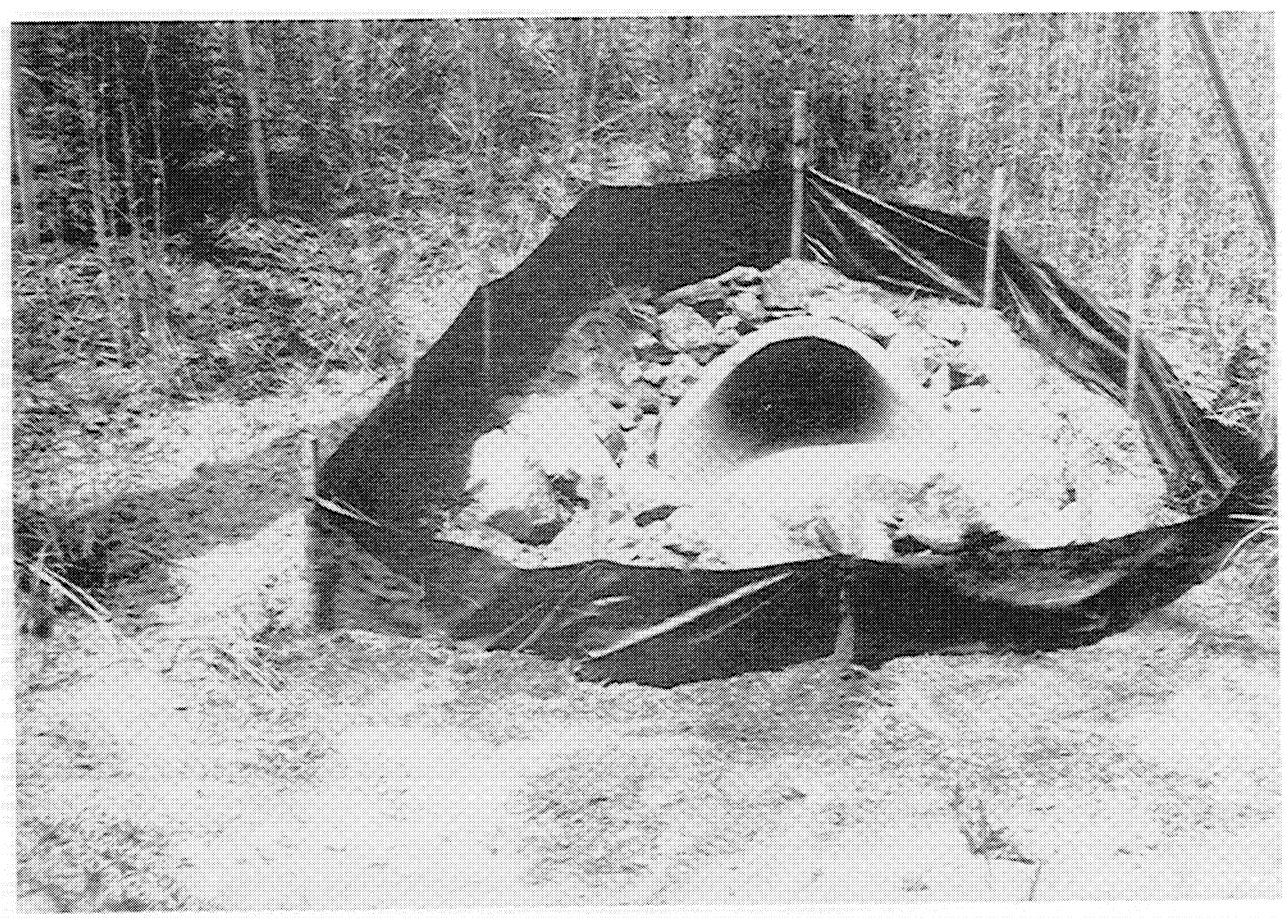
Definition

A sediment filter located at the inlet to storm sewer culverts.

Purposes

1. To prevent sediment from entering, accumulating in and being transferred by a culvert and associated drainage system prior to permanent stabilization of a disturbed project area.

2. To provide erosion control at culvert inlets during the phase of a project where elevation and drainage patterns change, causing original control measures to be ineffective or in need of removal.



Conditions Where Practice Applies

Where culvert and associated drainage system is to be made operational prior to permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different conditions (see Plates 3.08-1 and 3.08-2).

Planning Considerations

When construction on a project reaches a stage where culverts and other storm sewer appurtenances are installed and many areas are brought to a desired grade, the erosion control measures used in the early stages normally need to be modified or may need to be removed altogether. At that time, there is a need to provide protection at the points where runoff will leave the area via culverts and drop or curb inlets.

Similar to drop and curb inlets, culverts which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainageways. In case of extreme sediment loading, the pipe or pipe system itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the culvert by using one of the methods noted in this section.

General Guidelines (All Types)

1. The inlet protection device shall be constructed in a manner that will facilitate clean-out and disposal of trapped sediment and minimize interference with construction activities.

2. The inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.

3. Design criteria more specific to each particular inlet protection device will be found in Plates 3.08-1 through 3.08-2.

Design Criteria

1. Silt Fence Culvert Inlet Protection

    a. No formal design is required.

    b. Silt fence culvert inlet protection has an expected maximum usable life of three months.

    c. The maximum area draining to this practice shall not exceed one acre.

2. Culvert Inlet Sediment Trap

   a. Runoff storage requirements shall be in accordance with information outlined under Std. & Spec. 3.13, TEMPORARY SEDIMENT TRAP.

   b. Culvert inlet sediment traps have a maximum expected useful life of 18 months.

   c. The maximum area draining to this practice shall not exceed 3 acres.

Construction Specifications

1. Silt Fence Culvert Inlet Protection

   a. The height of the silt fence (in front of the culvert opening) shall be a minimum of 16 inches and shall not exceed 34 inches.

   b. Extra strength filter fabric with a maximum spacing of stakes of 3 feet shall be used to construct the measure.

   c. The placement of silt fence should be approximately 6 feet from the culvert in the direction of incoming flow, creating a "horseshoe" shape as shown in Plate 3.08-1.

   d. If silt fence cannot be installed properly or the flow and/or velocity of flow to the culvert protection is excessive and may breach the structure, the stone combination noted in Plate 3.08-1 should be utilized.

2. Culvert Inlet Sediment Trap

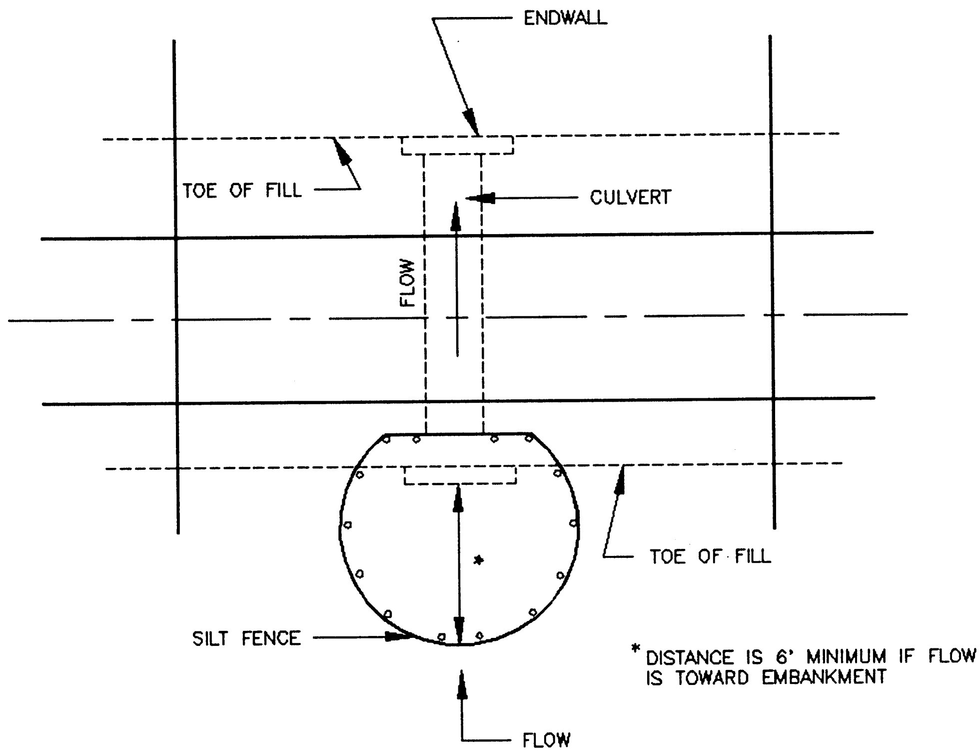
   a. Geometry of the design will be a "horseshoe" shape around the culvert inlet (see Plate 3.08-2).

   b. The toe of riprap (composing the sediment filter dam) shall be no closer than 24" from the culvert opening in order to provide an acceptable emergency outlet for flows from larger storm events.

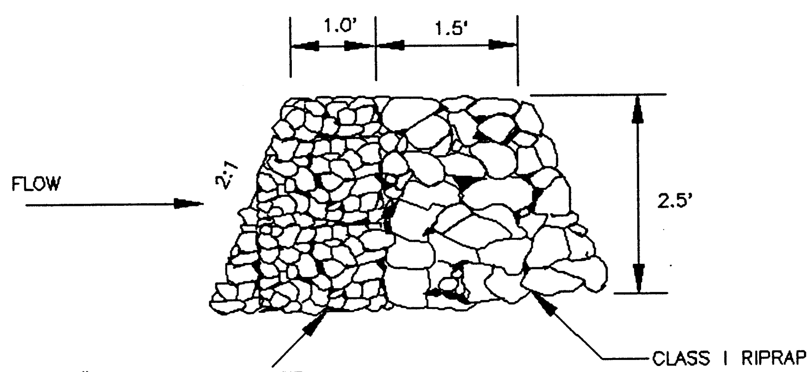
   c. All other "Construction Specifications" found within Std. & Spec. 3.13, TEMPORARY SEDIMENT TRAP, also apply to this practice.

   e. The proper installation of the culvert inlet sediment trap is a viable substitute for the installation of the TEMPORARY SEDIMENT TRAP.

SILT FENCE CULVERT INLET PROTECTION



OPTIONAL STONE COMBINATION**

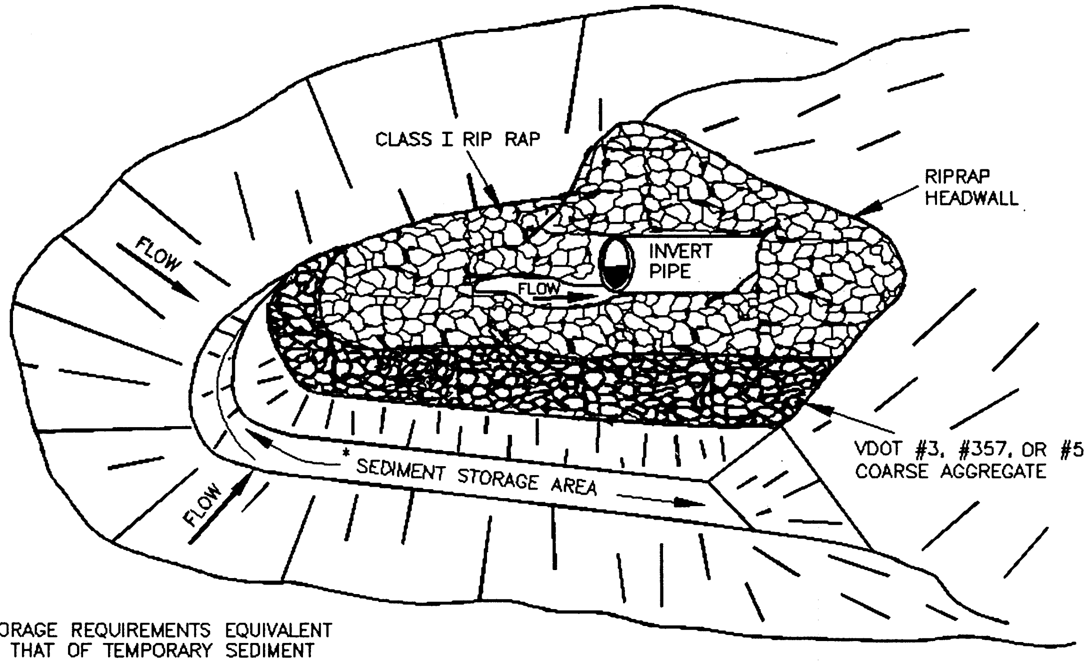


** VDOT #3, #357 OR #5 COARSE AGGREGATE TO REPLACE SILT FENCE IN " HORSESHOE " WHEN HIGH VELOCITY OF FLOW IS EXPECTED

Source: Adapted from VDOT Standard Sheets and Va. DSWC

Plate 3.08-1

CULVERT INLET SEDIMENT TRAP

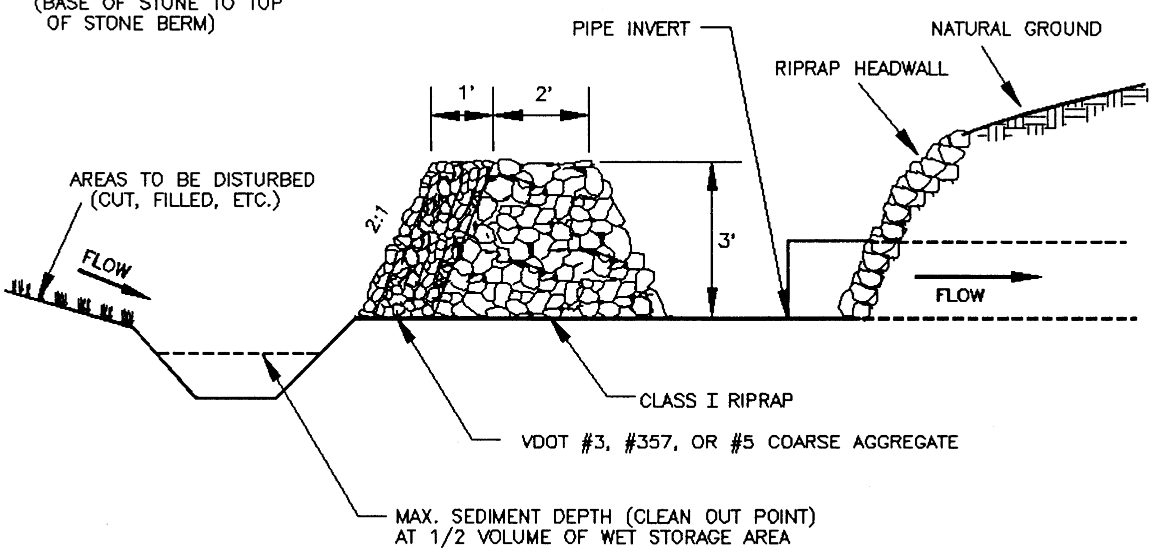


*STORAGE REQUIREMENTS EQUIVALENT TO THAT OF TEMPORARY SEDIMENT TRAP, STD. & SPEC. 3.13

67 C.Y./ACRE WET STORAGE (BELOW BASE OF STONE)

67 C.Y./ACRE DRY STORAGE (BASE OF STONE TO TOP OF STONE BERM)

PERSPECTIVE VIEW



ELEVATION

Source: North Carolina Sediment Control Commission

Plate 3.08-2

Maintenance

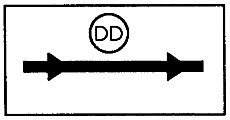
1. The structure shall be inspected after each rain and repairs made as needed.

2. Aggregate shall be replaced or cleaned when inspection reveals that clogged voids are causing ponding problems which interfere with on-site construction.

3. Sediment shall be removed and the impoundment restored to its original dimensions when sediment has accumulated to one-half the design depth. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

4. Temporary structures shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

STD & SPEC 3.09



TEMPORARY DIVERSION DIKE

(DD)

Definition

A temporary ridge of compacted soil constructed at the top or base of a sloping disturbed area.

Purposes

1. To divert storm runoff from upslope drainage areas away from unprotected disturbed areas and slopes to a stabilized outlet.

2. To divert sediment-laden runoff from a disturbed area to a sediment-trapping facility such as a sediment trap or sediment basin.

Conditions Where Practice Applies

Wherever stormwater runoff must be temporarily diverted to protect disturbed areas and slopes or retain sediment on site during construction. These structures generally have a life expectancy of 18 months or less, which can be prolonged with proper maintenance.

Planning Considerations

A temporary diversion dike is intended to divert overland sheet flow to a stabilized outlet or a sediment-trapping facility during establishment of permanent stabilization on sloping disturbed areas. When used a the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

As per M.S. #5, it is very important that a temporary diversion dike be stabilized immediately following installation with temporary or permanent vegetation to prevent erosion of the dike itself. The gradient of the channel behind the dike is also an important consideration. The dike must have a positive grade to assure drainage, but if the gradient is too great, precautions must be taken to prevent erosion due to high-velocity channel flow behind the dike. The cross-section of the channel which runs behind the dike should be of a parabolic or trapezoidal shape to help inhibit a high velocity of flow which could arise in a vee ditch.

This practice is considered an economical one because it uses material available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the dike with vegetation. Diversion dikes are preferable to silt fence because they are more durable, less expensive, and require much less maintenance when constructed properly. Along with a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13), they become a logical choice for a control measure once the control limits of the silt fence or straw bale barrier have been exceeded.

Temporary diversion dikes are often used as a perimeter control in association with a sediment trap or a sediment basin, or a series of sediment-trapping facilities, on moderate to large construction sites. If installed properly and in the first phase of grading, maintenance costs are very low. Often, cleaning of sediment-trapping facilities is the only associated maintenance requirement.

As specified herein, this practice is intended to be temporary. However, with more stringent design criteria, it can be made permanent in accordance with DIVERSIONS (Std. & Spec. 3.12).

Design Criteria

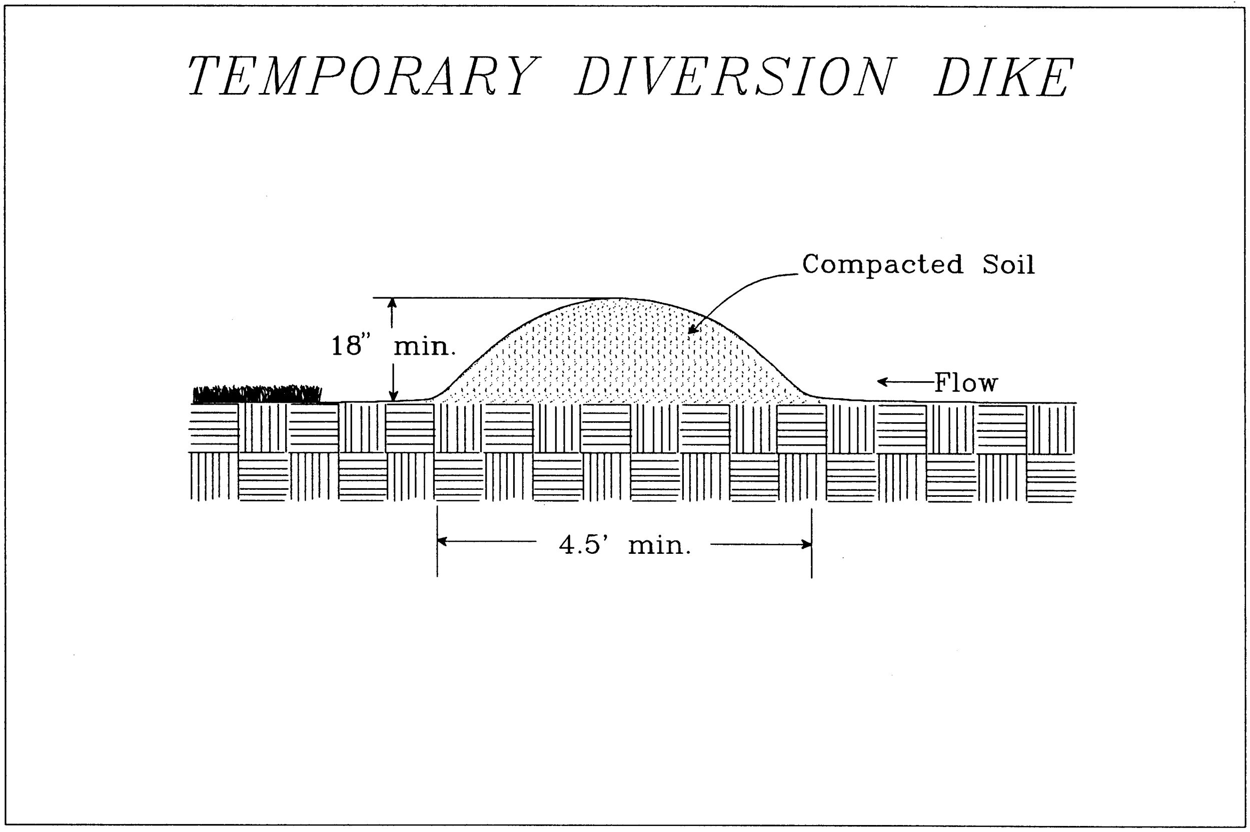
No formal design is required. The following criteria shall be met:

Drainage Area

The maximum allowable drainage area is 5 acres.

Height

The minimum allowable height measured from the upslope side of the dike is 18 inches (see Plate 3.09-1).



Source: Va. DSWC Plate 3.09-1

Side Slopes

1½:1 or flatter, along with a minimum base width of 4.5 feet (see Plate 3.09-1).

Grade

The channel behind the dike shall have a positive grade to a stabilized outlet. If the channel slope is less than or equal to 2%, no stabilization is required. If the slope is greater than 2%, the channel shall be stabilized in accordance with Std. & Spec. 3.17, STORMWATER CONVEYANCE CHANNEL.

Outlet

1. The diverted runoff, if free of sediment, must be released through a stabilized outlet or channel.

2. Sediment-laden runoff must be diverted and released through a sediment-trapping facility such as a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13) or TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14).

Construction Specifications

1. Temporary diversion dikes must be installed as a first step in the land-disturbing activity and must be functional prior to upslope land disturbance.

2. The dike should be adequately compacted to prevent failure.

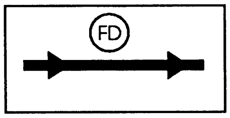
3. Temporary or permanent seeding and mulch shall be applied to the dike immediately following its construction.

4. The dike should be located to minimize damages by construction operations and traffic.

Maintenance

The measure shall be inspected after every storm and repairs made to the dike, flow channel, outlet or sediment trapping facility, as necessary. Once every two weeks, whether a storm event has occurred or not, the measure shall be inspected and repairs made if needed. Damages caused by construction traffic or other activity must be repaired before the end of each working day.

STD & SPEC 3.10



TEMPORARY FILL DIVERSION

FD

Definition

A channel with a supporting ridge of soil on the lower side, constructed along the top of an active earth fill.

Purpose

To divert storm runoff away from the unprotected slope of the fill to a stabilized outlet or sediment-trapping facility.

Conditions Where Practice Applies

Where the drainage area at the top of an active earth fill slopes toward the exposed slope and where continuous fill operations make the use of a DIVERSION (Std. & Spec. 3.12) unfeasible. This temporary structure should remain in place for less than one week.

Planning Considerations

One important principle of erosion and sediment control is to keep stormwater runoff away from exposed slopes. This is often accomplished by installing a dike, diversion, temporary slope drain or paved ditch at the top of a slope to carry the runoff away from the slope to a stabilized outlet. In general, these measures are installed after the final grade has been reached. On cuts, the measures may be installed at the beginning since the work proceeds from the top to the bottom of the slope, and the measures have little chance of being covered or damaged. On fills, the work proceeds from the bottom to the top and the elevation changes daily. It is therefore not feasible to construct a compacted dike or permanent diversion which may be covered by the next day's activity.

The temporary fill diversion is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed. This practice can be constructed by the use of a motor grader or a small dozer. To shape the diversion, the piece of machinery used may run near the top edge of the fill with its blade tilted to form the channel as depicted in Plate 3.10-1. This work would be done at the end of the working day and provide a channel with a berm to protect the slope. Wherever possible, the temporary diversion should be sloped to direct water to a stabilized outlet. If the runoff is diverted over the fill itself, the practice may cause erosion by concentrating water at a single point.

Good timing is essential to fill construction. The filling operation should be completed as quickly as possible and the permanent slope protection measures and slope stabilization measures installed as soon after completion as possible. With prompt and proper construction, the landowner or contractor will save both time and money in building, repairing and stabilizing the fill area. The longer the time period for construction and stabilization extends, the more prone the fill operation is to be damaged by erosion. Repairing the damages adds additional time and expense to the project.

Design Criteria

No formal design is required. The following criteria shall be met:

Drainage Area

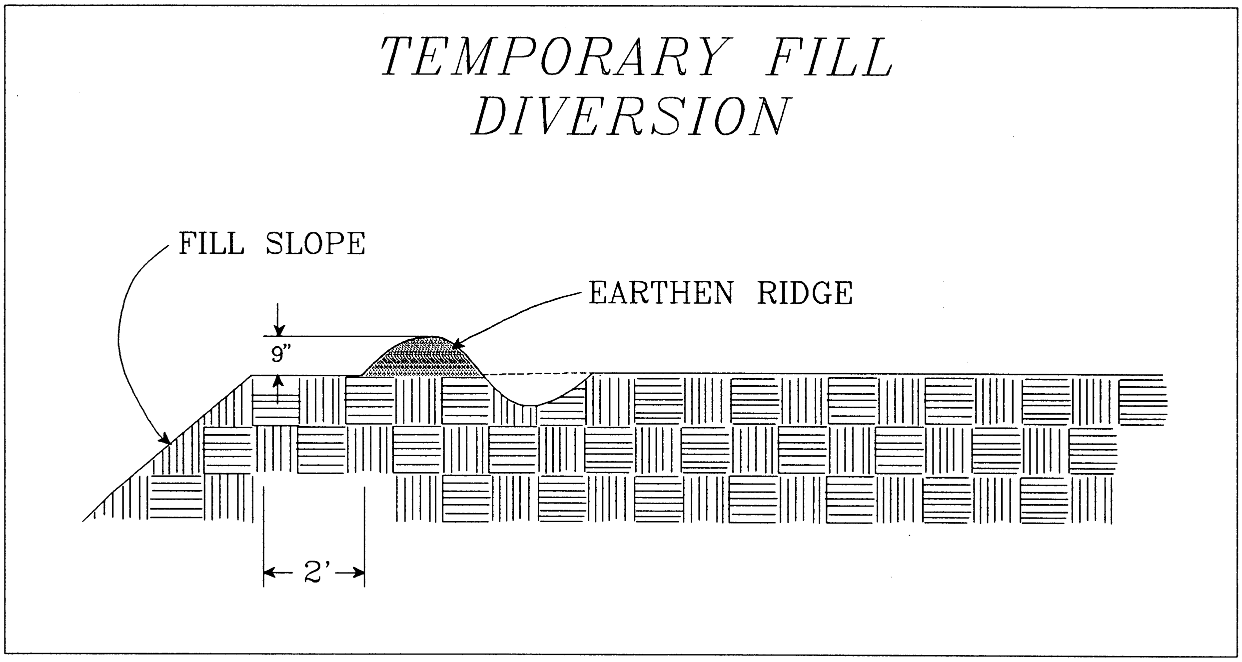
The maximum allowable drainage area is 5 acres.

Height

The minimum height of the supporting ridge shall be 9 inches (see Plate 3.10-1).

Grade

The channel shall have a positive grade to a stabilized outlet.



Source: Va. DSWC Plate 3.10-1

Outlet

The diverted runoff should be released through a stabilized outlet, slope drain or sediment trapping measure.

Construction Specifications

1. The diversion shall be constructed at the top of the fill at the end of each work day as needed.

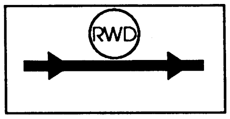
2. The diversion shall be located at least 2 feet inside the top edge of the fill (see Plate 3.10-1).

3. The supporting ridge shall be constructed with a uniform height along its entire length. Without uniform height, the fill diversion may be susceptible to breaching.

Maintenance

Since the practice is temporary and under most situations will be covered the next work day, the maintenance required should be low. If the practice is to remain in use for more than one day, an inspection will be made a the end of each work day and repairs made to the measure if needed. The contractor should avoid the placement of any material over the structure while it is in use. Construction traffic should not be permitted to cross the diversion.

STD & SPEC 3.11



TEMPORARY RIGHT-OF-WAY DIVERSION

RWD

Definition

A ridge of compacted soil or loose rock or gravel constructed across disturbed rights-of-way and similar sloping areas.

Purpose

To shorten the flow length within a sloping right-of-way, thereby reducing the erosion potential by diverting storm runoff to a stabilized outlet.

Conditions Where Practice Applies

Generally, earthen diversions are applicable where there will be little or no construction traffic within the right-of-way. Gravel structures are more applicable to roads and other rights-of-way which accommodate vehicular traffic.

Planning Considerations

Construction of utility lines and roads often requires the clearing of long strips of right-of-way over sloping terrain. The volume and velocity of stormwater runoff tend to increase in these cleared strips and the potential for erosion is much greater since the vegetative cover is diminished or removed. To compensate for the loss of vegetation, it is usually a good practice to break up the flow length within the cleared strip so that runoff does not have a chance to concentrate and cause erosion. At proper intervals, temporary right-of-way diversions can significantly reduce the amount of erosion which will occur until the area is permanently stabilized. Since many right-of-ways are constructed through heavily vegetated areas, runoff can often be diverted into a vegetative buffer strip (if it provides a minimum flow length of 75 feet).

Design Criteria

No formal design is required. The following criteria shall be met:

Height

The minimum allowable height of the diversion is 18 inches (see Plate 3.11-1).

Side Slopes

Side slopes should be 2:1 or flatter to allow the passage of construction traffic, along with a minimum base width of 6 feet (see Plate 3.11-1).

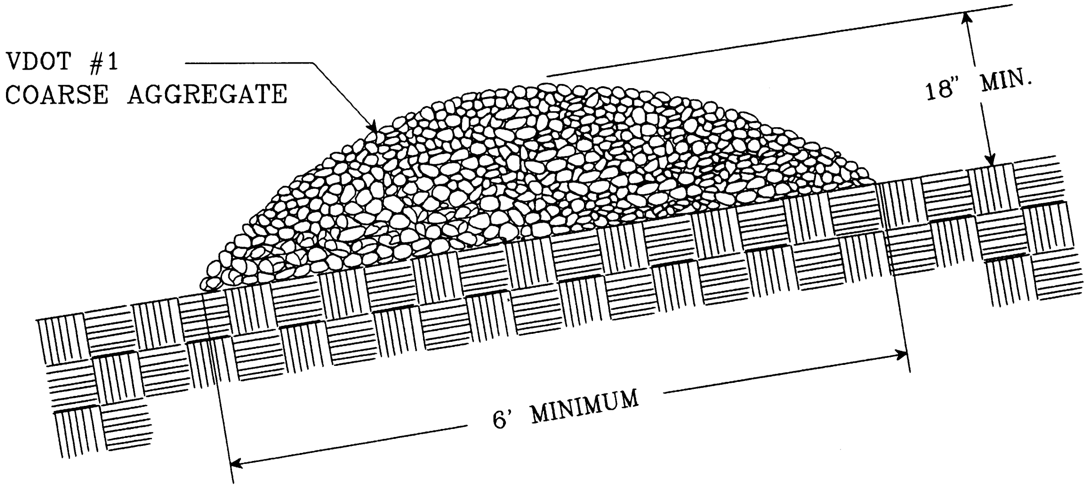
Width

The measure should be constructed completely across the disturbed portion of the right-of-way.

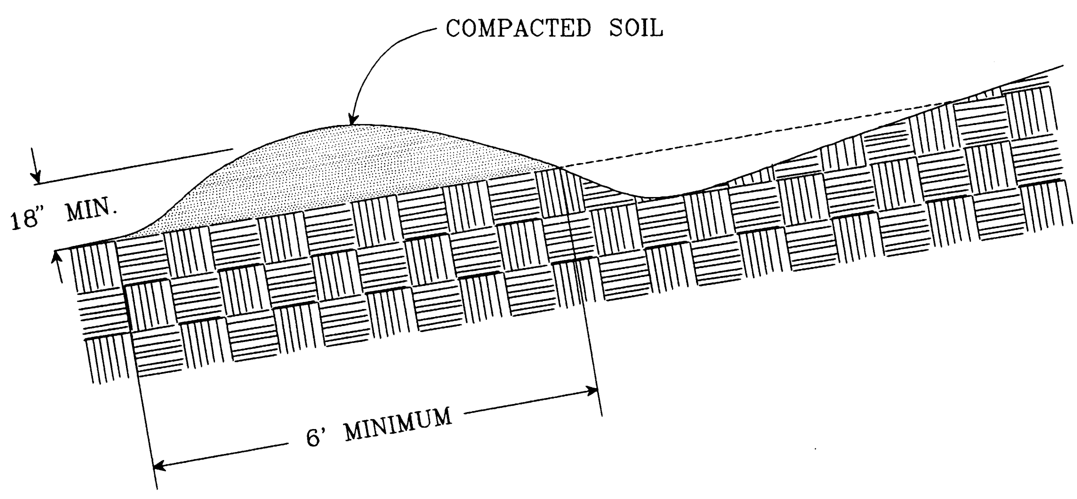
Spacing

Table 3.11-A will be used to determine the spacing of right-of-way diversions.

TEMPORARY RIGHT-OF-WAY DIVERSIONS



TYPICAL GRAVEL STRUCTURE



TYPICAL EARTHEN STRUCTURE

Source: Va. DSWC

Plate 3.11-1

TABLE 3.11-A

SPACING OF RIGHT-OF-WAY DIVERSIONS

% Slope	Spacing (ft.)
Less than 7%	100
Between 7% and 25%	75
Between 25% and 40%	50
Greater than 40%	25

Source: Va. DSWC

Grade

Positive drainage (with less than 2% slope) should be provided to a stabilized outlet, sediment-trapping facility, or a vegetative buffer strip of adequate size.

Outlet

Interceptor dikes must have an outlet which is not subject to erosion.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet. Concentrated flows should spread over the widest possible area after release. Flows with high sediment concentrations should pass through an appropriate sediment-trapping measure.

Construction Specifications

1. The diversion shall be installed as soon as the right-of-way has been cleared and/or graded.

2. All earthen diversions shall be machine- or hand-compacted in 8-inch lifts.

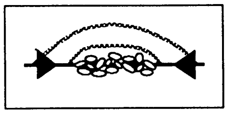
3. The outlet of the diversion shall be located on an undisturbed and stabilized area when at all possible. The field location should be adjusted as needed to utilize a stabilized outlet.

4. Earthen diversions which will not be subject to construction traffic should be stabilized in accordance with TEMPORARY SEEDING (Std. & Spec. 3.31).

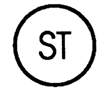
Maintenance

The practice shall be inspected after every rainfall and repairs made if necessary. At least once every two weeks, whether a storm has occurred or not, the measure shall be inspected and repairs made if needed. Right-of-way diversions, which are subject to damage by vehicular traffic, should be reshaped at the end of each working day.

STD & SPEC 3.13



TEMPORARY SEDIMENT TRAP



Definition

A temporary ponding area formed by constructing an earthen embankment with a stone outlet.

Purpose

To detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out.

Conditions Where Practice Applies

1. Below disturbed areas where the total contributing drainage area is less than 3 acres.

2. Where the sediment trap will be used no longer than 18 months (the maximum useful life is 18 months).

3. The sediment trap may be constructed either independently or in conjunction with a TEMPORARY DIVERSION DIKE (Std. & Spec. 3.09).

Planning Considerations

Sediment traps should be used only for small drainage areas. If the contributing drainage area is 3 acres or greater, refer to SEDIMENT BASIN (Std. & Spec. 3.14).

Sediment traps, along with other perimeter controls 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.

Recent studies have been conducted on the performance of sediment traps (and basins) which were constructed using the design criteria found in previous editions of this handbook. The studies indicate that the control measures only achieved a 46% removal of sediment which flowed into them during storm events which caused measurable outflow. To achieve a more acceptable removal rate (60%), it was necessary to revise the design of these measures in this handbook. The total initial storage volume for both the sediment trap and the TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14) has been doubled. There are both a "wet" storage volume and a drawdown or "dry" storage volume which help to enhance sediment fall-out and prevent excessive sediment losses during large storm events which occur during the advanced stages of land disturbance (28).

In most cases excavation will be required to attain the necessary storage volume. Also, sediment must be periodically removed from the trap to maintain the required volume. Plans should detail how excavated sediment is to be disposed of, such as by use in fill areas on site or removal to an approved off-site location.

As noted previously in this handbook, there are numerous other acceptable ways to design many of the erosion control practices within. This is certainly true in the case of the sediment trap. However, variations in its design should be considered judiciously by plan reviewers to ensure that the minimum storage requirements and structural integrity noted in this specification are maintained.

Design Criteria

Trap Capacity

The sediment trap must have an initial storage volume of 134 cubic yards per acre of drainage area, half of which shall be in the form of a permanent pool or wet storage to provide a stable settling medium. The remaining half shall be in the form of a drawdown or dry storage which will provide extended settling time during less frequent, larger storm events. The volume of the wet storage shall be measured from the low point of the excavated area to the base of the stone outlet structure. The volume of the dry storage shall be measured from the base of the stone outlet to the crest of the stone outlet (overflow mechanism). Sediment should be removed from the basin when the volume of the wet storage is reduced by one-half.

For a sediment trap, the wet storage volume may be approximated as follows:

$$V_1 = 0.85 \; x \; A_1 \; x \; D_1$$

where,

V_1 = the wet storage volume in cubic feet

A_1 = the surface area of the flooded area at the base of the stone outlet in square feet

D_1 = the maximum depth in feet, measured from the low point in the trap to the base of the stone outlet

The dry storage volume may be approximated as follows:

$$V_2 = \frac{A_1 + A_2}{2} \; x \; D_2$$

where,

V_2 = the dry storage volume in cubic feet

A_1 = the surface area of the flooded area at the base of the stone outlet in square feet

A_2 = the surface area of the flooded area at the crest of the stone outlet (overflow mechanism), in square feet

D_2 = the depth in feet, measured from the base of the stone outlet to the crest of the stone outlet

The designer should seek to provide a storage area which has a minimum 2:1 length to width ratio (measured from point of maximum runoff introduction to outlet).

Note: Conversion between cubic feet and cubic yards is as follows:

number of cubic feet x 0.037 = number of cubic yards

Excavation

Side slopes of excavated areas should be no steeper than 1:1. The maximum depth of excavation within the wet storage area should be 4 feet to facilitate clean-out and for site safety considerations.

Outlet

The outlet for the sediment trap shall consist of a stone section of the embankment located at the low point in the basin. A combination of coarse aggregate and riprap shall be used to provide for filtering/detention as well as outlet stability. The smaller stone shall be VDOT #3, #357, or #5 Coarse Aggregate (smaller stone sizes will enhance filter efficiency) and riprap shall be "Class I." Filter cloth which meets the physical requirements noted in Std. & Spec. 3.19, RIPRAP shall be placed at the stone-soil interface to act as a "separator." The minimum length of the outlet shall be 6 feet times the number of acres comprising the total area draining to the trap. The crest of the stone outlet must be at least 1.0 foot below the top of the embankment to ensure that the flow will travel over the stone and not the embankment. The outlet shall be configured as noted in Plate 3.13-2.

Embankment Cross-Section

The maximum height of the sediment trap embankment shall be 5 feet as measured from the base of the stone outlet. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in Plate 3.13-1. Side slopes of the embankment shall be 2:1 or flatter.

Removal

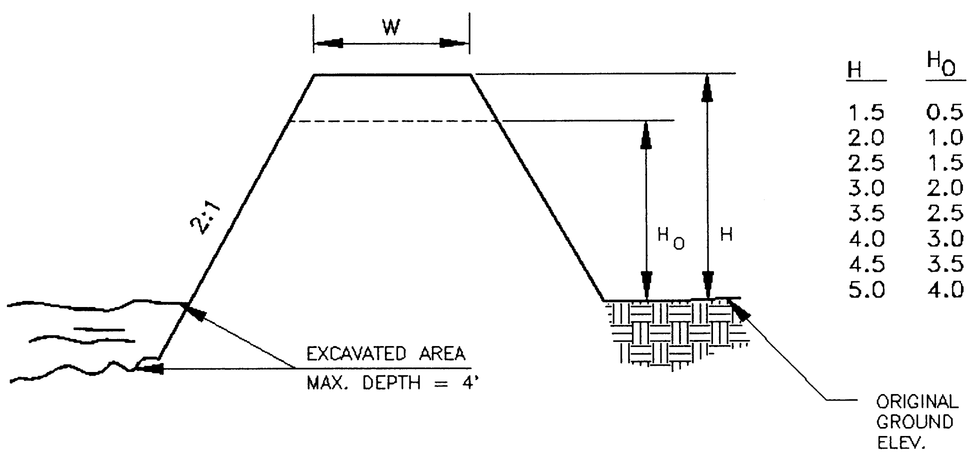
Sediment traps must be removed after the contributing drainage area is stabilized. Plans should show how the site of the sediment trap is to be graded and stabilized after removal.

Construction Specifications

1. The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat.

2. Fill material for the embankment shall be free of roots or other woody vegetation, organic material, large stones, and other objectionable material. The embankment should be compacted in 6-inch layers by traversing with construction equipment.

MINIMUM TOP WIDTH (W) REQUIRED FOR SEDIMENT TRAP EMBANKMENTS ACCORDING TO HEIGHT OF EMBANKMENT (FEET)



H	H_O	W
1.5	0.5	2.0
2.0	1.0	2.0
2.5	1.5	2.5
3.0	2.0	2.5
3.5	2.5	3.0
4.0	3.0	3.0
4.5	3.5	4.0
5.0	4.0	4.5

Source: Va. DSWC Plate 3.13-1

3. The earthen embankment shall be seeded with temporary or permanent vegetation (see Std. & Spec.'s 3.31 and 3.32) immediately after installation.

4. Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.

5. The structure shall be removed and the area stabilized when the upslope drainage area has been stabilized.

6. All cut and fill slopes shall be 2:1 or flatter (except for excavated, wet storage area which may be at a maximum 1:1 grade).

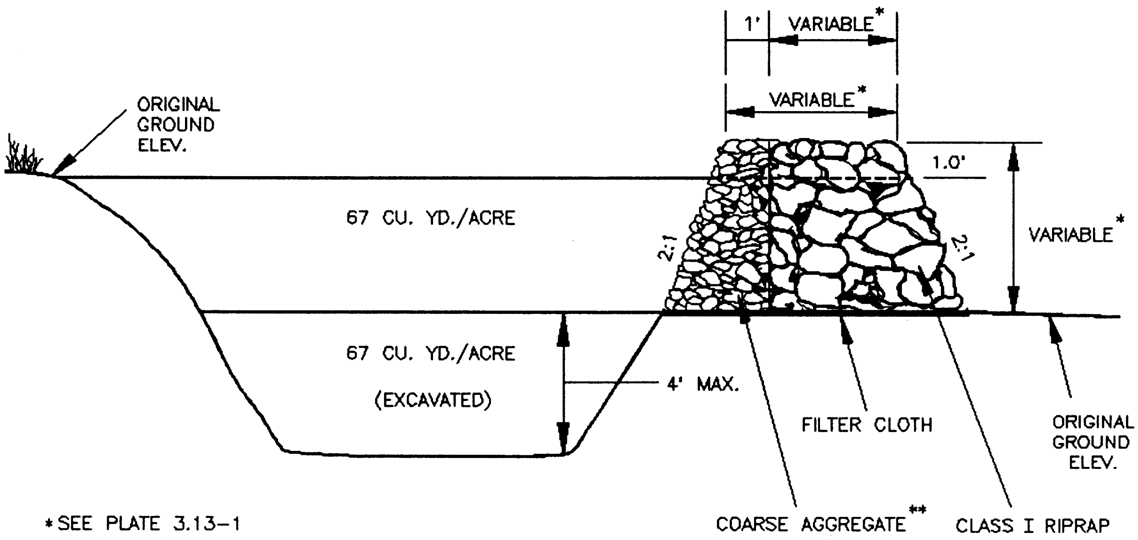
Maintenance

1. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design volume of the wet storage. Sediment removal from the basin shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

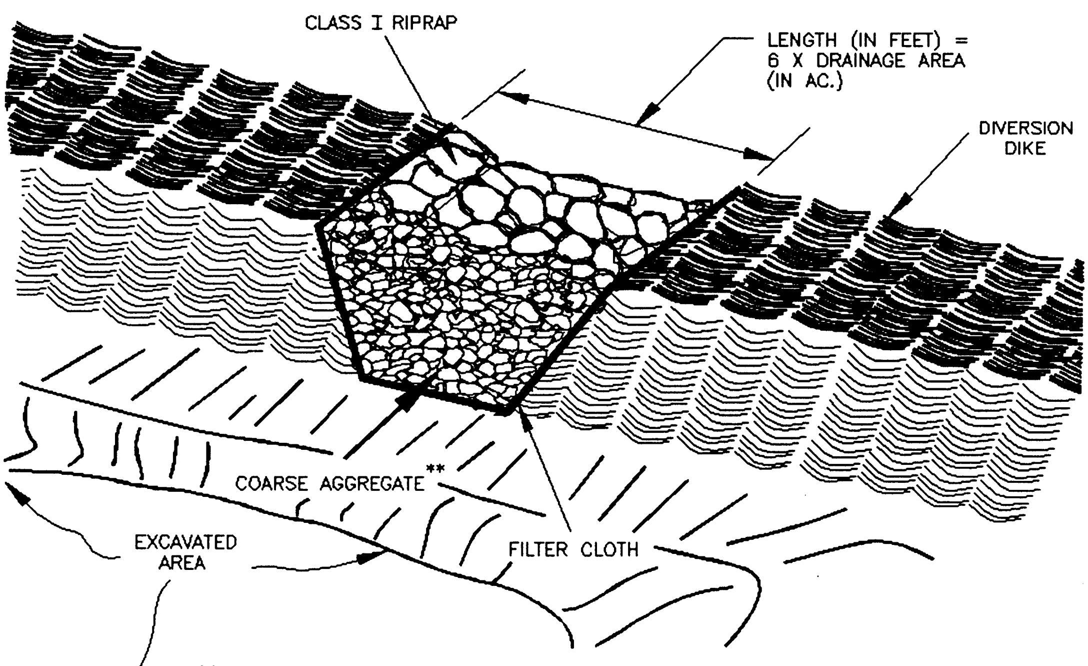
2. Filter stone shall be regularly checked to ensure that filtration performance is maintained. Stone choked with sediment shall be removed and cleaned or replaced.

3. The structure should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should be checked to ensure that its center is at least 1 foot below the top of the embankment.

TEMPORARY SEDIMENT TRAP



CROSS SECTION OF OUTLET



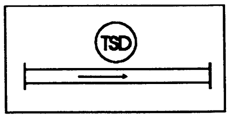
** COARSE AGGREGATE SHALL BE VDOT #3, #357 OR #5

OUTLET (PERSPECTIVE VIEW)

Source: Va. DSWC

Plate 3.13-2

STD & SPEC 3.15



TEMPORARY SLOPE DRAIN

TSD

Definition

A flexible tubing or conduit extending from the top to the bottom of a cut or fill slope.

Purpose

To temporarily conduct concentrated stormwater runoff safely down the face of a cut or fill slope without causing erosion on or below the slope.

Conditions Where Practice Applies

On cut or fill slopes where there is a potential for upslope flows to move over the face of the slope causing erosion and preventing adequate stabilization.

Planning Considerations

There is often a significant lag between the time a cut or fill slope is completed and the time a permanent drainage system can be installed. During this period, the slope is usually not stabilized and is particularly vulnerable to erosion. This situation also occurs on slope construction which is temporarily delayed before final grade is reached. Temporary slope drains can provide valuable protection of exposed slopes until permanent drainage structures can be installed or vegetation can be established.

Temporary slope drains can be used in conjunction with diversion dikes to convey runoff from the entire drainage area above a slope to the base of the slope without erosion. It is very important that these temporary structures be installed properly, since their failure will often result in severe gully erosion on the site and sedimentation below the slope. The entrance section must be securely entrenched, all connections must be watertight, and the conduit must be staked securely.

Design Criteria

Drainage Area

The maximum allowable drainage area per slope drain is 5 acres.

Flexible Conduit

The slope drain shall consist of heavy-duty, flexible material designed for this purpose. The diameter of the slope drain shall be equal over its entire length. Reinforced hold-down grommets shall be spaced at 10-foot (or less) intervals. Slope drains shall be sized as listed in Table 3.15-A.

Entrance Sections

The entrance to the slope drain shall consist of a standard VDOT flared end-section for metal pipe culverts (see Plates 3.15-2 and 3.15-3) with appropriate inlet protection as set forth in CULVERT INLET PROTECTION, Std. & Spec. 3.08. If ponding will cause a problem at the entrance and make such protection impractical, appropriate sediment-removing measures shall be taken at the outlet of the pipe. Extension collars shall consist of 12-inch long corrugated metal pipe. Watertight fittings shall be provided (see Plate 3.15-1).

Note: End-sections made of heavy-duty, flexible material may be utilized if determined by the Plan-Approving Authority to provide a stable inlet or outlet section.

TABLE 3.15-A

SIZE OF SLOPE DRAIN

Maximum Drainage Area (acres)	Pipe Diameter (inches)
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

Source: Va. DSWC

Dike Design

An earthen dike shall be used to direct stormwater runoff into the temporary slope drain and shall be constructed as set forth in DIVERSION, Std. & Spec. 3.12. See Plate 3.15-1 for placement of dike in relation to the slope drain.

The height of the dike at the centerline of the inlet shall be equal to the diameter of the pipe plus 6 inches. Where the dike height is greater than 18 inches at the inlet, it shall be sloped at the rate of 3:1 or flatter to connect with the remainder of the dike (see Plate 3.15-1).

Outlet Protection

The outlet of the slope drain must be protected from erosion as set forth in OUTLET PROTECTION, Std. & Spec. 3.18.

Construction Specifications

1. The measure shall be placed on undisturbed soil or well-compacted fill.

2. The entrance section shall slope toward the slope drain at the minimum rate of 1/2-inch per foot.

3. The soil around and under the entrance section shall be hand-tamped in 8-inch lifts to the top of the dike to prevent piping failure around the inlet.

4. The slope drain shall be securely staked to the slope at the grommets provided.

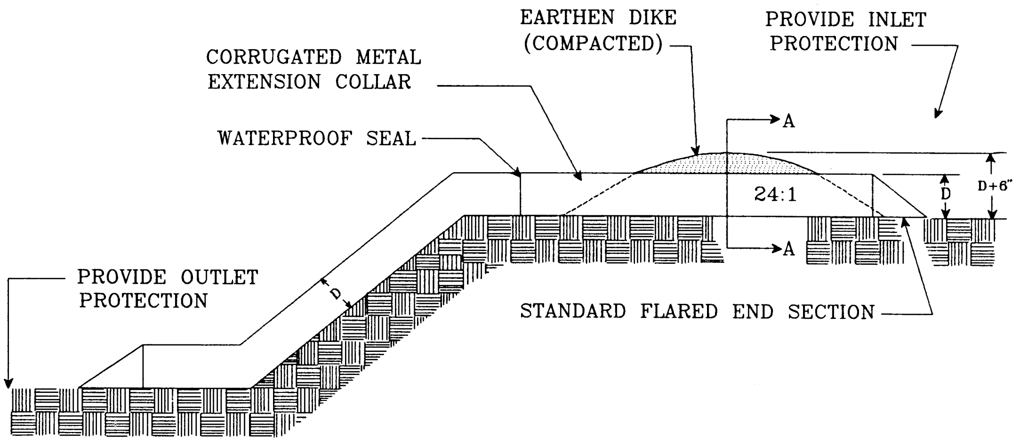
5. The slope drain sections shall be securely fastened together and have watertight fittings.

6. Install CULVERT INLET PROTECTION and OUTLET PROTECTION as per Std. & Spec.'s 3.08 and 3.18, respectively.

Maintenance

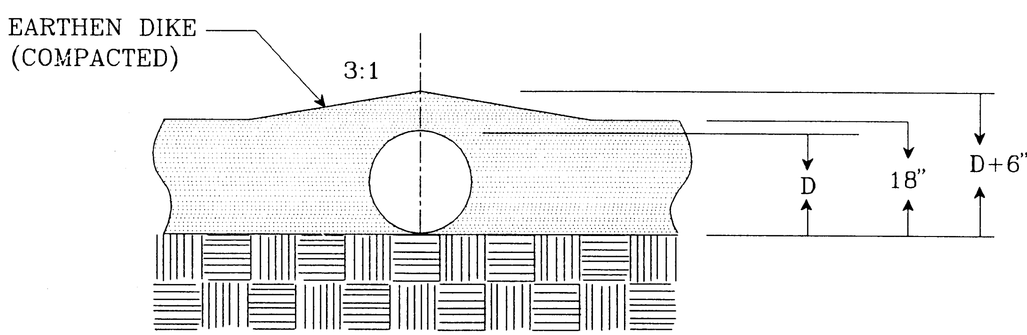
The slope drain structure shall be inspected weekly and after every storm, and repairs made if necessary. The contractor should avoid the placement of any material on and prevent construction traffic across the slope drain.

TEMPORARY SLOPE DRAIN



SECTION VIEW

NOTE: SEDIMENT MAY BE CONTROLLED AT OUTLET IF UPLAND PONDING WILL CREATE PROBLEMS

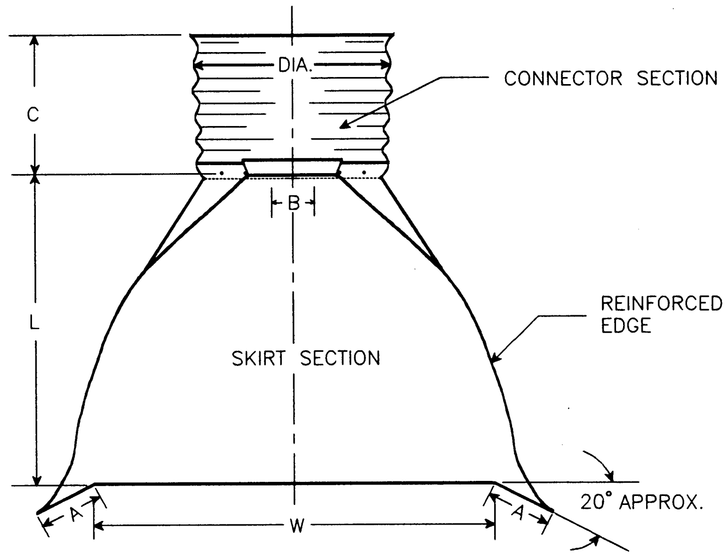


SECTION A – A

Source: Va. DSWC

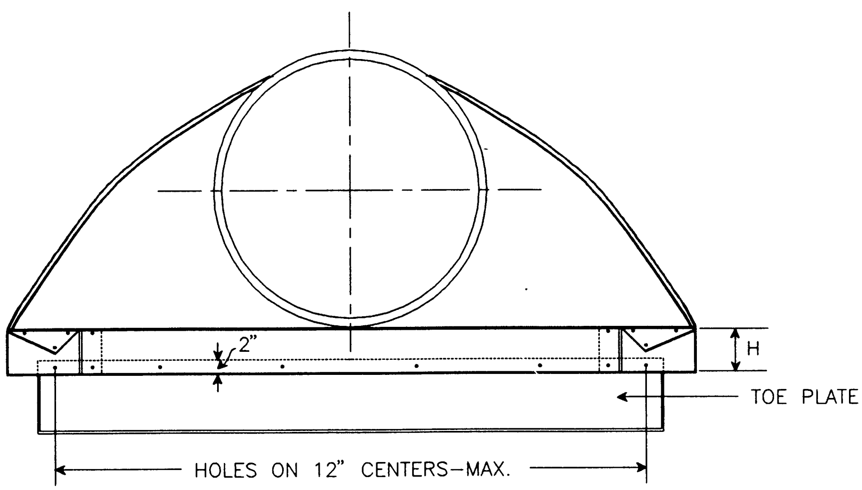
Plate 3.15-1

FLARED END–SECTION



PLAN

WHERE FLARED END–SECTIONS ARE TO BE USED WITH BITUMINOUS COATED AND PAVED METAL PIPE, THEY ARE TO BE GALVANIZED ONLY.

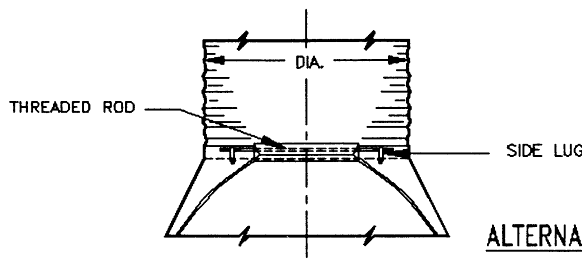


ELEVATION

Source: VDOT Road and Bridge Standards

Plate 3.15-2

FLARED END-SECTION
(CONTINUED)



ALTERNATE CONNECTION

TOE PLATE, WHERE NEEDED, TO BE PUNCHED TO MATCH IN SKIRT LIP. 3/8" GALV. BOLTS TO BE FURNISHED. LENGTH OF TOE PLATE IS W + 10" FOR 12" TO 30" DIA. PIPE AND W + 22" FOR 36" TO 60" DIA. PIPE.

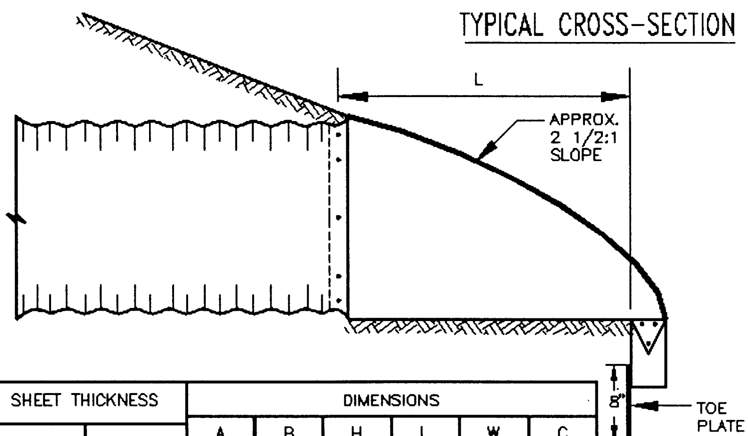
SKIRT SECTION FOR 12" TO 30" DIA. PIPE TO BE MADE IN ONE PIECE.

SKIRT SECTION FOR 36" TO 54" DIA. PIPE MAY BE MADE FROM TWO SHEETS JOINED BY RIVETING OR BOLTING ON CENTER LINE, 60" MAY BE CONSTRUCTED IN 3 PIECES.

CONNECTOR SECTION, CORNER PLATE AND TOE PLATE TO BE SAME SHEET THICKNESS AS SKIRT.

END-SECTIONS AND FITTINGS ARE TO BE GALVANIZED STEEL OR ALUMINUM ALLOY FOR USE WITH LIKE PIPE.

TYPICAL CROSS-SECTION



PIPE DIA.	SHEET THICKNESS		DIMENSIONS					
	STEEL	ALUMINUM	A 1" TOL.	B MAX.	H 1" TOL.	L 1 1/2" TOL.	W 2" TOL.	C
12"	.064"	.060"	6"	6"	6"	21"	24"	24"
15"	.064"	.060"	7"	8"	6"	26"	30"	24"
18"	.064"	.060"	8"	10"	6"	31"	36"	24"
21"	.064"	.060"	10"	12"	6"	36"	42"	24"
24"	.064"	.060"	10"	13"	6"	41"	48"	24"
27"/30"	.064"	.075"	12"	16"	8"	51"	60"	24"
36"	.064"	.075"	14"	19"	9"	60"	72"	36"
42"	.064"	.105"	16"	22"	11"	69"	84"	36"
48"	.064"	.105"	18"	27"	12"	78"	90"	24"
54"	.064"/.079"	.105"	18"	30"	12"	84"	102"	36"
60"	.064"/.109"	.105"/.135"	18"	33"	12"	87"	114"	36"

Source: VDOT Road and Bridge Standards

Plate 3.15-3

STD & SPEC 3.18

OUTLET PROTECTION

OP

Definition

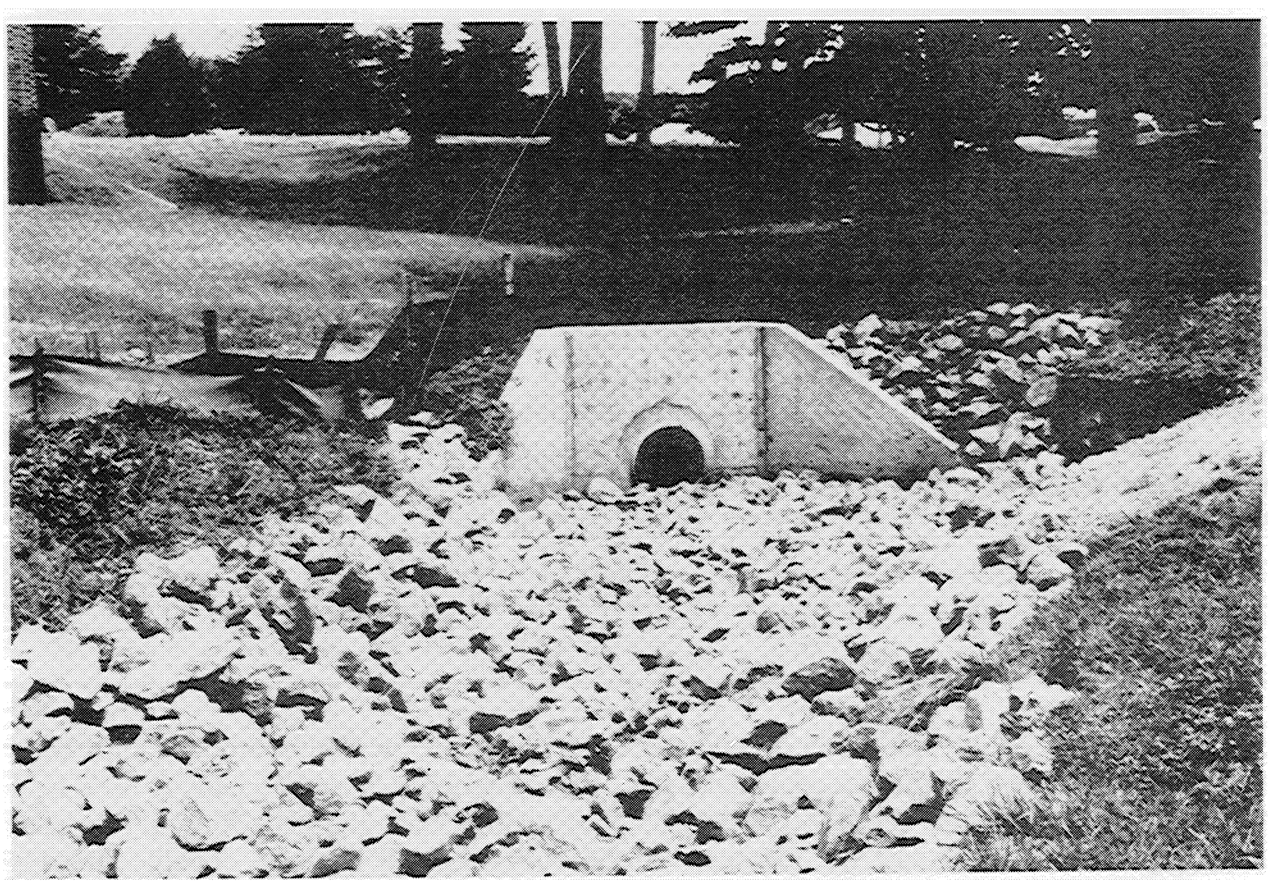
Structurally lined aprons or other acceptable energy dissipating devices placed at the outlets of pipes or paved channel sections.

Purpose

To prevent scour at stormwater outlets, to protect the outlet structure, and to minimize the potential for downstream erosion by reducing the velocity and energy of concentrated stormwater flows.

Conditions Where Practice Applies

Applicable to the outlets of all pipes and engineered channel sections.



Planning Considerations

The outlets of pipes and structurally lined channels are points of critical erosion potential. Stormwater which is transported through man-made conveyance systems at design capacity generally reaches a velocity which exceeds the capacity of the receiving channel or area to resist erosion. To prevent scour at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

The most commonly used device for outlet protection is a structurally lined apron. These aprons are generally lined with riprap, grouted riprap or concrete. They are constructed at a zero grade for a distance which is related to the outlet flow rate and the tailwater level. Criteria for designing such an apron are contained in this practice. Sample problems of outlet protection design are contained in Appendix 3.18-a.

Where flow is excessive for the economical use of an apron, excavated stilling basins may be used. Acceptable designs for stilling basins may be found in the following sources:

1. Hydraulic Design of Energy Dissipators for Culverts and Channels, Hydraulic Engineering Circular No. 14, U. S. Department of Transportation, Federal Highway Administration (83).

2. Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, U.S. Department of the Interior - Bureau of Reclamation, (74).

   Note: Both of the above are available from the U.S. Government Printing Office.

Design Criteria

The design of structurally lined aprons at the outlets of pipes and paved channel sections applies to the immediate area or reach below the pipe or channel and does not apply to continuous rock linings of channels or streams (See STORMWATER CONVEYANCE CHANNEL, Std. & Spec. 3.17). Notably, pipe or channel outlets at the top of cut slopes or on slopes steeper than 10% should not be protected using just outlet protection as a result of the reconcentration and large velocity of flow encountered as the flow leaves the structural apron. Outlet protection shall be designed according to the following criteria:

Pipe Outlets

(See Plate 3.18-1)

1. Tailwater depth: The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine tailwater depth (see Chapter 5, Engineering Calculations). If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a

Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition. Notably, in most cases where post-development stormwater runoff has been concentrated or increased, MS #19 will be satisfied only by outfall into a defined channel.

2. Apron length: The apron length shall be determined from the curves according to the tailwater condition:

   Minimum Tailwater - Use Plate 3.18-3.
   Maximum Tailwater - Use Plate 3.18-4.

3. Apron width: When the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank (whichever is less).

   If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

   a. The upstream end of the apron, adjacent to the pipe, shall have a width three times the diameter of the outlet pipe.

   b. For a Minimum Tailwater Condition, the downstream end of the apron shall have a width equal to the pipe diameter plus the length of the apron.

   c. For a Maximum Tailwater Condition, the downstream end shall have a width equal to the pipe diameter plus 0.4 times the length of the apron.

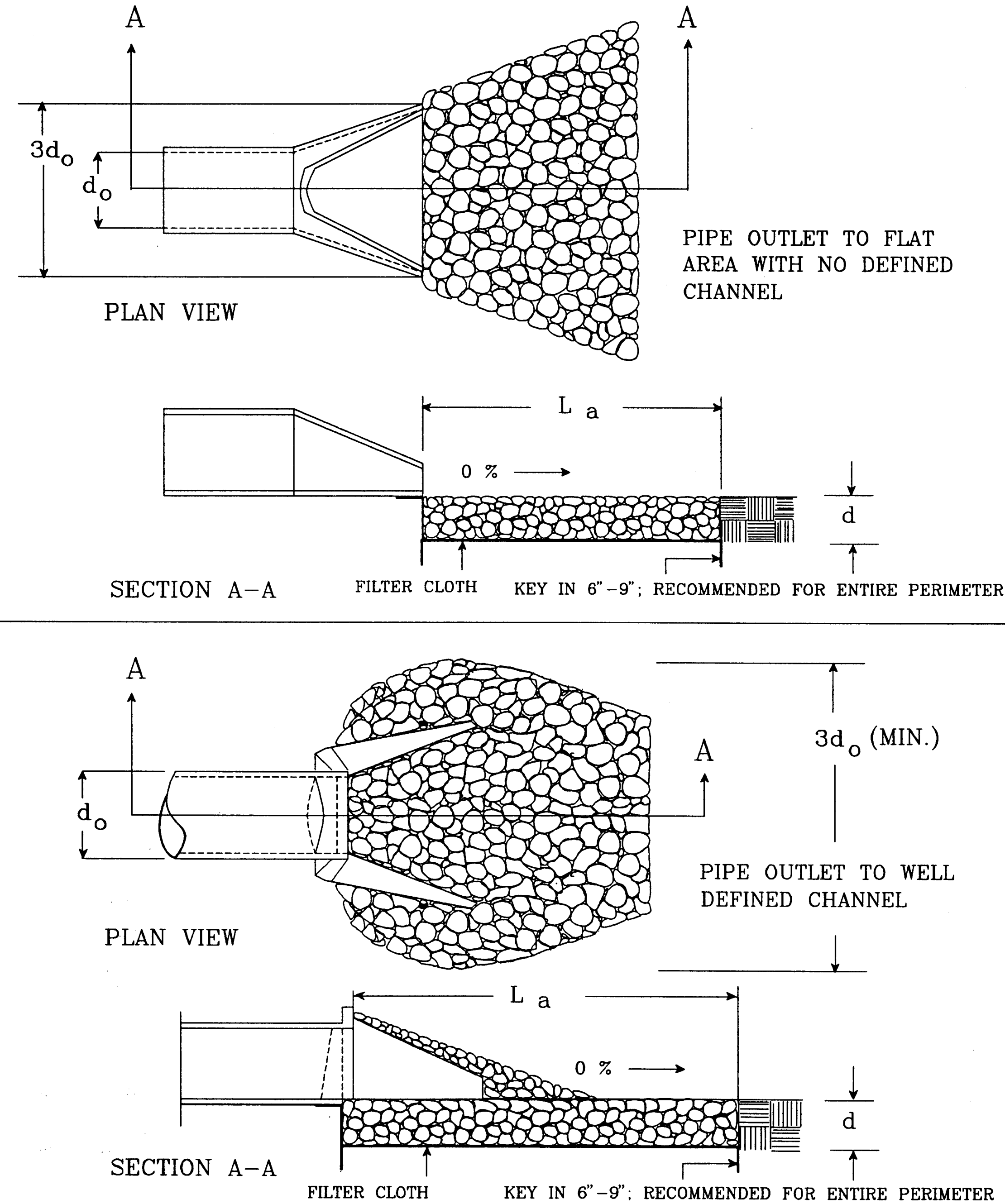
4. Bottom grade: The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

5. Side slopes: If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (horizontal: vertical).

6. Alignment: The apron shall be located so there are not bends in the horizontal alignment.

7. Materials: The apron may be lined with riprap, grouted riprap, concrete, or gabion baskets. The median sized stone for riprap shall be determined from the curves in Appendix 3.18-a (Plates 3.18-3 and 3.18-4) according to the tailwater condition. The gradation, quality and placement of riprap shall conform to Std. & Spec. 3.19, RIPRAP.

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.

Source: Va. DSWC

Plate 3.18-1

8. Filter cloth: In all cases, filter cloth shall be placed between the riprap and the underlying soil to prevent soil movement into and through the riprap. The material must meet or exceed the physical properties for filter cloth found in Std. & Spec. 3.19, RIPRAP. See Plate 3.18-1 for orientation details.

Paved Channel Outlets

(See Plate 3.18-2)

1. The flow velocity at the outlet of paved channels flowing at design capacity must not exceed the permissible velocity of the receiving channel (see Tables 3.18-A and 3.18-B)

2. The end of the paved channel shall merge smoothly with the receiving channel section. There shall be no overfall at the end of the paved section. Where the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a transition section shall be provided The maximum side divergence of the transition shall be 1 in 3F where;

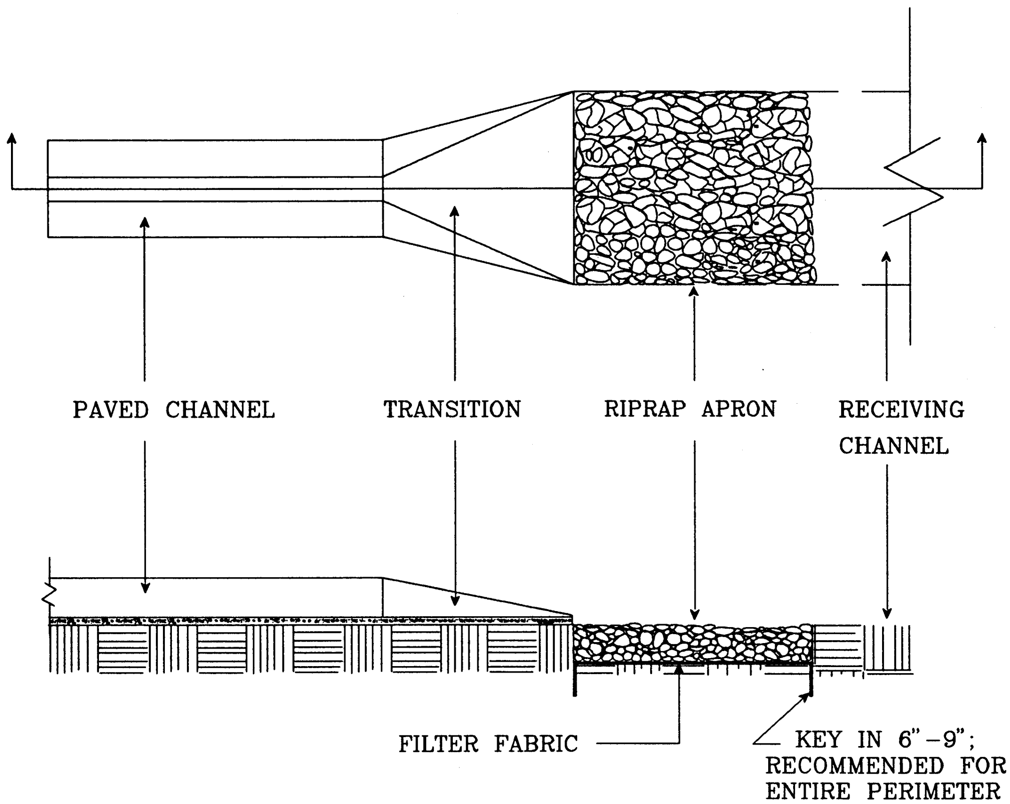
$$F = \frac{V}{\sqrt{gd}}$$

where,

F	=	Froude number
V	=	Velocity at beginning of transition (ft./sec.)
d	=	depth of flow at beginning of transition (ft.)
g	=	32.2 ft./sec.^{2}

3. Bends or curves in the horizontal alignment at the transition are not allowed unless the Froude number (F) is 1.0 or less, or the section is specifically designed for turbulent flow.

PAVED CHANNEL OUTLET



NOTES:

1. RIPRAP APRON REDUCES THE FLOW VELOCITY BELOW THE PERMISSIBLE VELOCITY OF THE NATURAL RECEIVING CHANNEL.
2. TRANSITION SIDE DIVERGENCE IS 1 IN 3F, WHERE

$$F = \text{FROUDE NUMBER} = \frac{V}{\sqrt{gd}}\text{, WHERE}$$

V = VELOCITY AT THE BEGINING OF THE TRANSITION

d = DEPTH OF FLOW AT THE BEGINING OF THE TRANSITION

$g = 32.2 \text{ ft./sec}^2$

Source: Va. DSWC

Plate 3.18-2

TABLE 3.18-A

PERMISSIBLE VELOCITIES FOR GRASS-LINED CHANNELS

Channel Slope	Lining	Velocity* (ft./sec.)
0 - 0.5%	Bermudagrass	6
	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains Temporary vegetation	2.5
5 - 10%	Bermudagrass	5
	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Bermudagrass	4
	Reed canarygrass Tall fescue Kentucky bluegrass	3

* For highly erodible soils, decrease permissible velocities by 25%.

Source: Soil and Water Conservation Engineering, Schwab, et. al. and American Society of Civil Engineers

TABLE 3.18-B?

PERMISSIBLE VELOCITIES FOR EARTH LININGS

Soil Types	Permissible Velocities (ft./sec.)
Fine Sand (noncolloidal)	2.5
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (colloidal)	5.5
Alluvial Silts (noncolloidal)	5.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Shales and Hard Plans	6.0

Source: Soil and Water Conservation Engineering, Schwab, et.al. and American Society of Civil Engineers

APPENDIX 3.18-a

Sample Problems: Outlet Protection Design

Example 1

Given: An 18-inch pipe discharges 24 cfs at design capacity onto a grassy slope (no defined channel).

Find: The required length, width and median stone size (d_{50}) for a riprap-lined apron.

Solution:

1. Since the pipe discharges onto a grassy slope with no defined channel, a Minimum Tailwater Condition may be assumed.

2. From Plate 3.18-3, an apron length (L_a) of 20 feet and a median stone size (d_{50}) of 0.8 ft. are determined.

3. The upstream apron width equals three times the pipe diameter; 3 x 1.5 ft = 4.5 ft.

4. The downstream apron width equals the apron length plus the pipe diameter; 20 ft. + 1.5 ft. = 21.5 ft.

Example 2

Given: The pipe in example No. 1 discharges into a channel with a triangular cross-section, 2 feet deep and 2:1 side slopes. The channel has a 2% slope and an "n" factor of .045.

Find: The required length, width and the median stone size (d_{50}) for a riprap lining.

Solution:

1. Determine the tailwater depth using Manning's Equation.

$$Q = \frac{1.49}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} A$$

$$24 = \frac{1.49}{.045}\left(\frac{2d}{2\sqrt{2^2+1}}\right)^{\frac{2}{3}}(.02)^{\frac{1}{2}}(2d^2)$$

where,

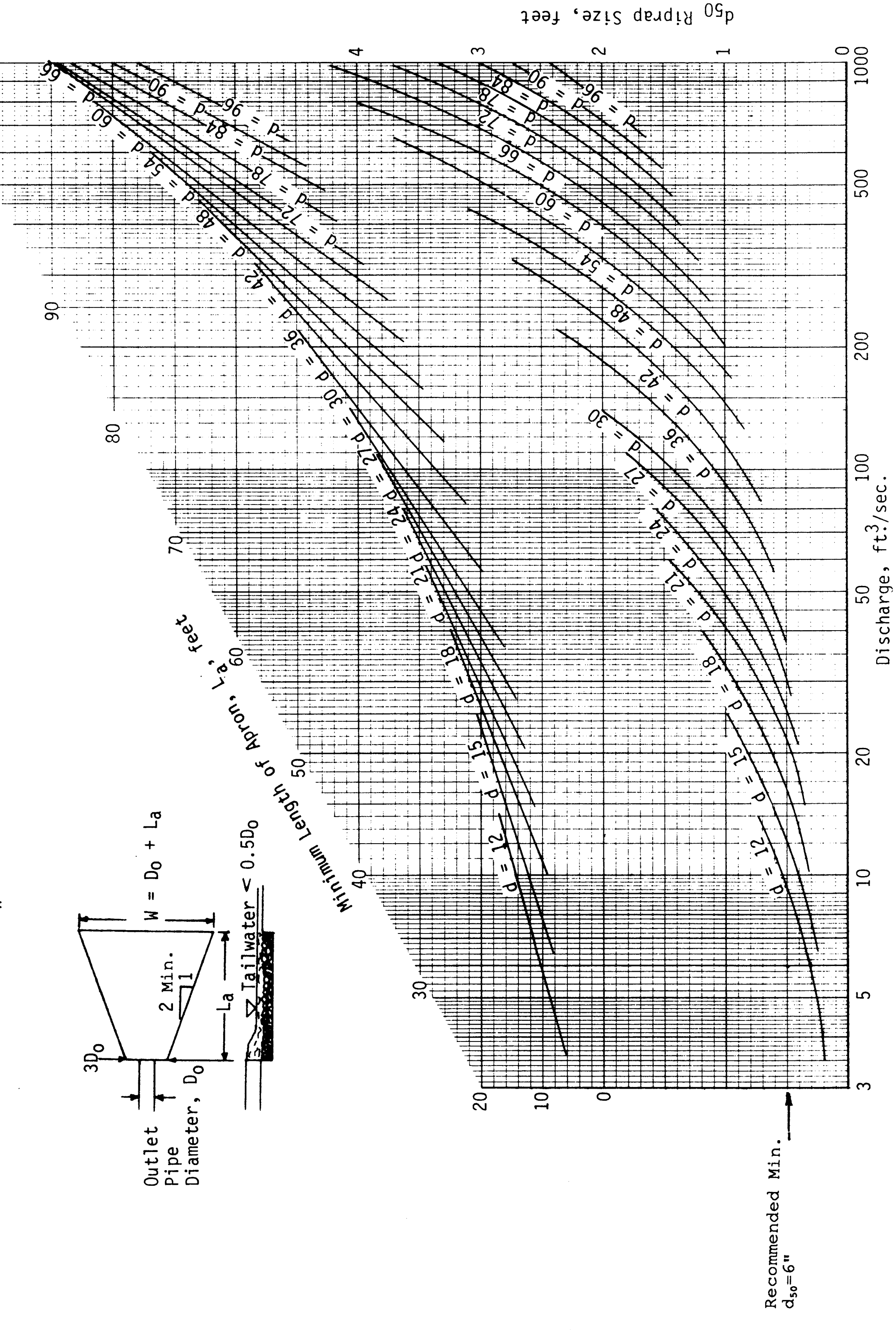
d = depth of tailwater
d = 1.74 ft. *

* since d is greater than half the pipe diameter, a Maximum Tailwater Condition exists.

2. From Plate 3.18-4, a median stone size (d_{50}) of 0.5 ft. and an apron length (L_a) of 41 ft. is determined.

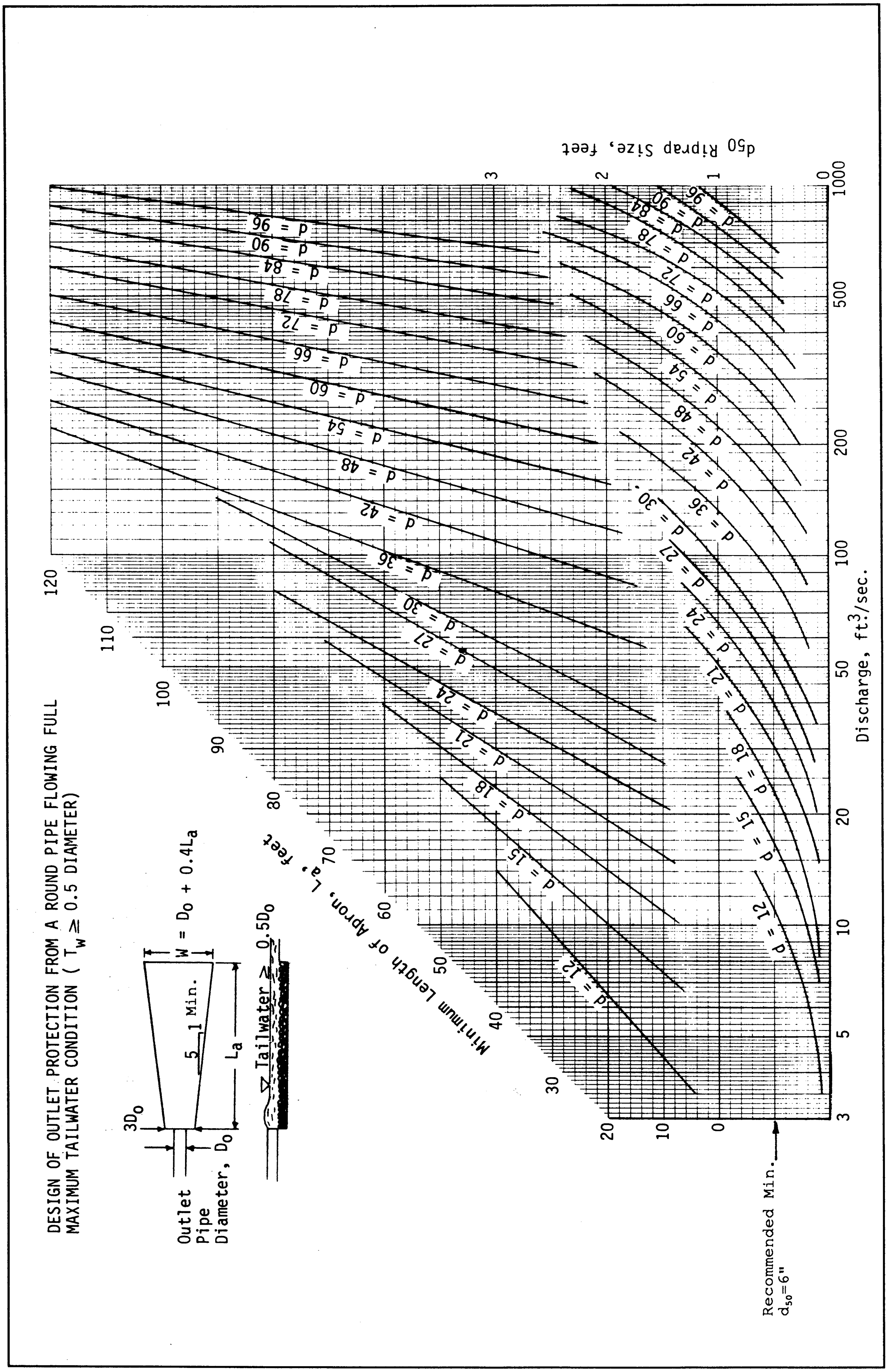
3. The entire channel cross-section should be lined since the maximum tailwater depth is within one foot of the top of the channel.

DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL
MINIMUM TAILWATER CONDITION (T_w < 0.5 DIAMETER)



Source: USDA-SCS

Plate 3.18-3



Source: USDA-SCS Plate 3.18-4

STD & SPEC 3.19

RIPRAP

RR

Definition

A permanent, erosion-resistant ground cover of large, loose, angular stone with filter fabric or granular underlining.

Purposes

1. To protect the soil from the erosive forces of concentrated runoff.

2. To slow the velocity of concentrated runoff while enhancing the potential for infiltration.

3. To stabilize slopes with seepage problems and/or non-cohesive soils.

Conditions Where Practice Applies

Wherever soil and water interface and the soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that the soil may erode under the design flow conditions. Riprap may be used, as appropriate, at stormdrain outlets, on channel banks and/or bottoms, roadside ditches, drop structures, at the toe of slopes, as transition from concrete channels to vegetated channels, etc.

Planning Considerations

Graded vs. Uniform Riprap

Riprap is classified as either graded or uniform. A sample of graded riprap would contain a mixture of stones which vary in size from small to large. A sample of uniform riprap would contain stones which are all fairly close in size.

For most applications, graded riprap is preferred to uniform riprap. Graded riprap forms a flexible self-healing cover, while uniform riprap is more rigid and cannot withstand movement of the stones. Graded riprap is cheaper to install, requiring only that the stones be dumped so that they remain in a well-graded mass. Hand or mechanical placement of individual stones is limited to that necessary to achieve the proper thickness and line. Uniform riprap requires placement in a more or less uniform pattern, requiring more hand or mechanical labor.

Riprap sizes can be designed by either the diameter or the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stones should be angular instead of spherical. However, it is simpler to specify the diameter of an equivalent size of spherical stone. Table 3.19-A lists some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon an assumed specific weight of 165 lbs./ft^3.

Since graded riprap consists of a variety of stone sizes, a method is needed to specify the size range of the mixture of stone. This is done by specifying a diameter of stone in the mixture for which some percentage, by weight, will be smaller. For example, d_{85} refers to a mixture of stones in which 85% of the stone by weight would be smaller than the diameter specified. Most designs are based on d_{50}. In other words, the design is based on the average size of stone in the mixture. Table 3.19-B lists VDOT standard graded riprap sizes by diameter the weight of the stone.

To ensure that stone of substantial weight is used when implementing riprap structures, specified weight ranges for individual stones and composition requirements should be followed. Such guidelines will help to prevent inadequate stone from being used in construction of the measures and will promote more consistent stone classification statewide. Table 3.19-C notes these requirements.

TABLE 3.19-A

SIZE OF RIPRAP STONES

Weight (lbs.)	Mean Spherical Diameter (ft.)	Angular Shape: Length (ft.)	Angular Shape: Width, Height (ft.)
50	0.8	1.4	0.5
100	1.1	1.75	0.6
150	1.3	2.0	0.67
300	1.6	2.6	0.9
500	1.9	3.0	1.0
1,000	2.2	3.7	1.25
1,500	2.6	4.7	1.5
2,000	2.75	5.4	1.8
4,000	3.6	6.0	2.0
6,000	4.0	6.9	2.3
8,000	4.5	7.6	2.5
20,000	6.1	10.0	3.3

Source: VDOT Drainage Manual

Sequence of Construction

Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

Design Criteria

Gradation

The riprap shall be composed of a well-graded mixture down to the one-inch size particle such that 50% of the mixture by weight shall be larger than the d_{50} size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1½ times the d_{50} size.

TABLE 3.19-B

GRADED RIPRAP - DESIGN VALUES

Riprap Class	D_{15} Weight (lbs.)	Mean D_{15} Spherical Diameter (ft.)	Mean D_{50} Spherical Diameter (ft.)
Class AI	25	0.7	0.9
Class I	50	0.8	1.1
Class II	150	1.3	1.6
Class III	500	1.9	2.2
Type I	1,500	2.6	2.8
Type II	6,000	4.0	4.5

Source: VDOT Drainage Manual

The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of damage by children shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.

Thickness

The minimum thickness of the riprap layer shall be 2 times the maximum stone diameter, but not less than 6 inches.

Quality of Stone

Stone for riprap shall consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirement of this standard and specification.

TABLE 3.19-C

GRADED RIPRAP - WEIGHT ANALYSIS

Riprap Class/Type	Weight Range* (lbs.)	Requirements for Stone Mixture
Class AI	25-75	Max. 10% > 75 lbs.
Class I	50-150	60% > 100 lbs.
Class II	150-500	50% > 300 lbs.
Class III	500-1,500	50% > 900 lbs.
Type I	1,500-4,000	Av. wt. = 2,000 lbs.
Type II	6,000-20,000	Av. wt. = 8,000 lbs.

* In all classes/types of riprap, a maximum 10% of the stone in the mixture may weigh less than the lower end of the range.

Source: Adapted from VDOT Road and Bridge Specifications

Filter Fabric Underlining

A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. Table 3.19-D notes the minimum physical properties of the filter fabric.

Filter fabric shall not be used on slopes greater than 1½:1 as slippage may occur and should be used in conjunction with a layer of course aggregate (granular filter blanket is described below) when the riprap to be placed is Class II or larger.

Granular Filter

Although the filter cloth underlining or bedding is the preferred method of installation, a granular (stone) bedding is a viable option when the following relationship exists:

$$\frac{d_{15}\ filter}{d_{85}\ base} < 5 < \frac{d_{15}\ filter}{d_{15}\ base} < 40$$

and,

$$\frac{d_{50}\ filter}{d_{50}\ base} < 40$$

In these relationships, filter refers to the overlying material and base refers to the underlying material. The relationships must hold between the filter material and the base material and between the riprap and the filter material. In some cases, more than one layer of filter material may be needed. Each layer of filter material should be approximately 6-inches thick.

TABLE 3.19-D

REQUIREMENTS FOR FILTER FABRIC USED WITH RIPRAP

Physical Property	Test Method	Requirements
Equivalent Opening Size	Corps of Engineers CWO 2215-77	Equal or greater than U.S. No. 50 sieve
Tensile Strength* @ 20% (maximum)	VTM-52	30 lbs./linear in. (minimum)
Puncture Strength	ASTM D751*	80 lbs. (minimum)

* Tension testing machine with ring clamp, steel ball replaced with 5/16 diameter solid steel cylinder with hemispherical tip centered within the ring clamp.

Seams shall be equal in strength to basic material.

Additional fabric material or non-corrosive steel wire may be incorporated into the fabric to increase overall strength.

Source: VDOT Road and Bridge Specifications

Riprap at Outlets

Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structure are contained in OUTLET PROTECTION (Std. & Spec. 3.18). A filter fabric underlining is required for riprap used as outlet protection.

Riprap for Channel Stabilization

Riprap for channel stabilization shall be designed to be stable for the condition of bank-full flow in the reach of channel being stabilized. The design procedure in Appendix 3.19-a, which is extracted from the Federal Highway Administration's Design of Stable Channels with Flexible Linings (82), shall be used. This method establishes the stability of the rock material relative to the forces exerted upon it.

Riprap shall extend up the banks of the channel to a height equal to the maximum depth of flow or to a point where vegetation can be established to adequately protect the channel.

The riprap size to be used in a channel bend shall extend upstream from the point of curvature and downstream from the bottom of the channel to a minimum depth equal to the thickness of the blanket and shall extend across the bottom of the channel the same distance (see Plate 3.19-1).

Freeboard and Height of Bank

For riprapped and other lined channels, the height of channel lining above the water surface should be based on the size of the channel, the flow velocity, the curvature, inflows, wind action, flow regulation, etc.

The height of the bank above the water surface varies in a similar manner, depending on the above factors plus the type of soil.

Plate 3.19-2 is based on information developed by the U.S. Bureau of Reclamation for average freeboard and bank height in relation to channel capacity. This chart should be used by the designer to obtain a minimum freeboard for placement of riprap and top of bank.

Riprap for Slope Stabilization

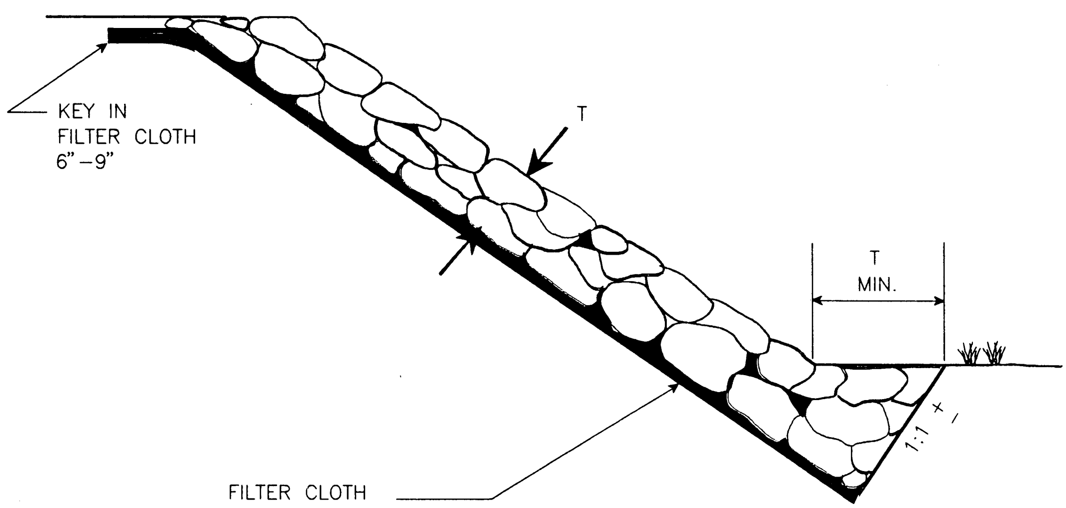
Riprap for slope stabilization shall be designed so that the natural angle of repose of the stone mixture is greater than the gradient of the slope being stabilized (see Plate 3.19-5).

Riprap for Lakes and Ponds Subject to Wave Action

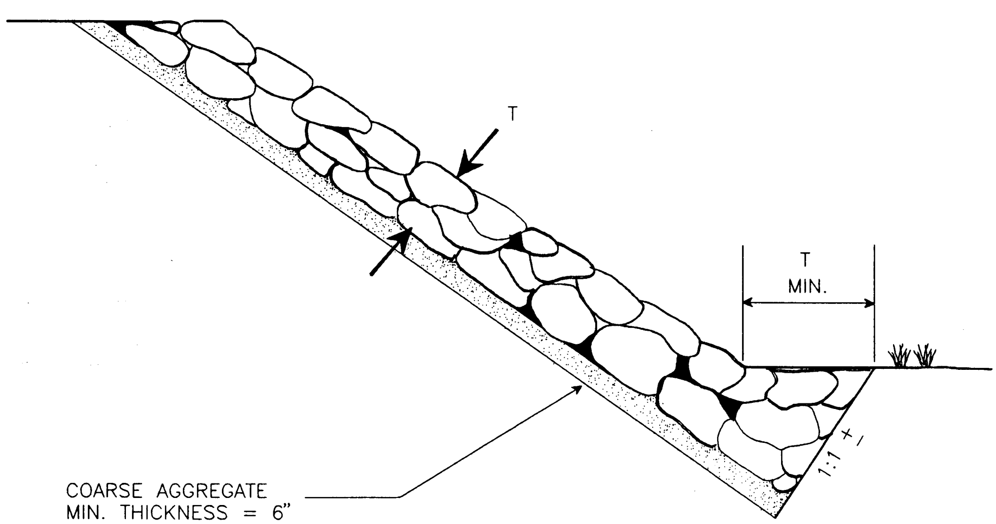
Riprap used for shoreline protection on lakes and ponds may be subject to wave action. The waves affecting the shoreline may be wind-driven or created by boat wakes. Consult

TOE REQUIREMENTS FOR BANK STABILIZATION

FILTER CLOTH UNDERLINER (PREFERRED)



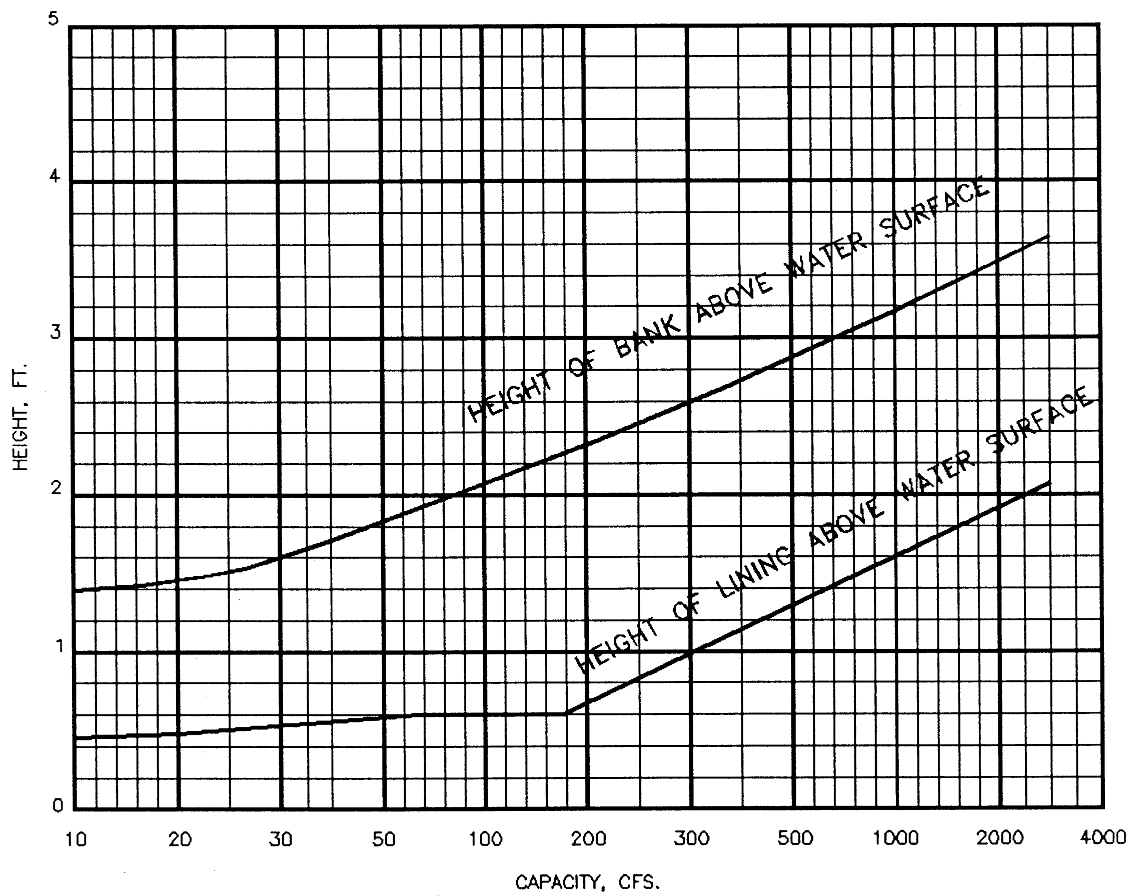
GRANULAR FILTER



Source: Adapted from VDOT Drainage Manual

Plate 3.19-1

RECOMMENDED FREEBOARD AND HEIGHT OF BANK OF LINED CHANNELS



Source: U. S. Bureau of Reclamation

Plate 3.19-2

the latest edition of the VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action") for specific design criteria in determining the required size of stones and the design wave height for such an installation. Use the equations in Appendix 3.19-b to calculate other pertinent design parameters. For more in-depth design criteria concerning these installations, see the U.S. Army Corps of Engineers' Shore Protection Manual (59).

Riprap for Abrupt Channel Contractions

Refer to latest edition of VDOT Drainage Manual.

Riprap for Installations Subject to Tidal and Wave Action

The design of riprap structures for tidal areas is beyond the scope of the VESCL and VESCR. The DSWC's Shoreline Programs Bureau provides advice regarding minimum design parameters for these installations. Notably, a riprap design for shoreline protection in tidal areas must meet all applicable state and federal requirements and should be carried out by a qualified professional.

Construction Specifications

Subgrade Preparation: The subgrade for the riprap or filter shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximately that of the surrounding undisturbed material. Brush, trees, stumps and other objectionable material shall be removed.

Filter Fabric or Granular Filter: Placement of the filter fabric should be done immediately after slope preparation. For granular filters, the stone should be spread in a uniform layer to the specified depth (normally 6 inches). Where more than one layer of filter material is used, the layer should be spread so that there is minimal mixing of the layers.

When installing geotextile filter cloths, the cloth should be placed directly on the prepared slope. The edges of the sheets should overlap by at least 12 inches. Anchor pins, 15 inches long, should be spaced every 3 feet along the overlap. The upper and lower ends of the cloth should be buried at least 12 inches. Care should be taken not to damage the cloth when placing the riprap. If damage occurs, that sheet should be removed and replaced. For large stone (Class II or greater), a 6-inch layer of granular filter will be necessary to prevent damage to the cloth.

Stone Placement: Placement of riprap should follow immediately after placement of the filter. The riprap should be placed so that it produces a dense well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry, controlled dumping of successive loads during final placing, or by a combination of these methods. The riprap should be placed to its full thickness in one operation. The riprap should not be placed in layers. The riprap should not be placed by dumping into chutes or similar methods which are likely to cause segregation of the various stone sizes. Care should be taken not to dislodge the underlying material when placing the stones.

The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve the required grades and a good distribution of stone sizes. Final thickness of the riprap blanket should be within plus or minus 1/4 of the specified thickness.

Maintenance

Once a riprap installation has been completed, it should require very little maintenance. It should, however, be inspected periodically to determine if high flows have caused scour beneath the riprap or filter fabric or dislodged any of the stone. Care must be taken to properly control sediment-laden construction runoff which may drain to the point of the new installation. If repairs are needed, they should be accomplished immediately.

APPENDIX 3.19-a

RIPRAP DESIGN IN CHANNEL

The design method described below is adapted from Hydraulic Engineering Circular No. 15 of the Federal Highway Administration. It is applicable to both straight and curved sections of channel where the flow is tangent to the bank of the channel.

Tangent Flow - Federal Highway Administration Method

This design method determines a stable rock size for straight and curved sections of channels. It is assumed that the shape, depth of flow, and slope of the channel are known. A stone size is chosen for the maximum depth of flow. If the sides of the channel are steeper than 3:1, the stone size must be modified accordingly. The final design size will be stable on both sides of the channel and the bottom.

1. Enter Plate 3.19-3 with the maximum depth of flow (feet) and channel slope (feet/foot). Where the two lines intersect, choose the d_{50} size of stone. (Select the d_{50} for the diagonal line above the point of intersection).

2. If channel side slopes are steeper than 3:1, continue with step 3; if not, the procedure is complete.

3. Enter Plate 3.19-4 with the side slope and the base width to maximum depth ratio (B/d). Where the two lines intersect, move horizontally left to read K_1.

4. Determine from Plate 3.19-5 the angle of repose for the d_{50} size of stone and the side slope of the channel. (Use 42° for d_{50} greater than 1.0. Do not use riprap on slopes steeper than the angle of repose for the size of stone).

5. Enter Plate 3.19-6 with the side slope of the channel and the angle of repose for the d_{50} size of stone. Where the two lines intersect, move vertically down to read k_2.

6. Compute $d_{50} \times K_1/K_2 = d'_{50}$ to determine the correct size stone for the bottom and side slopes of straight sections of channel.

For Curved Sections of Channel

1. Compute the radius of the curve (Ro), measured at the outside edge of the bottom.

2. Compute the ratio of the top width of the water surface (Bs) to the radius of the curve (Ro), Bs/Ro.

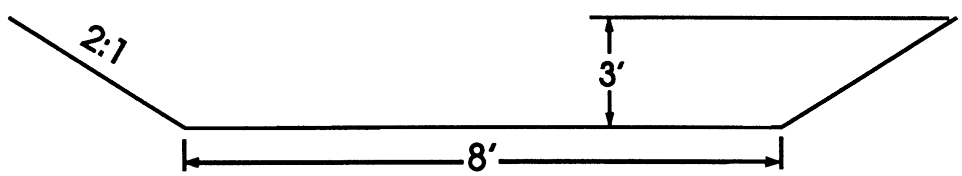
3. Enter Plate 3.19-7 with the radio Bs/Ro. Move vertically until the curve is intersected. Move horizontally left to read K_3.

4. Compute d'_{50} x K_3 = d_{50c} to determine the correct size stone for bottom and side slopes of the curved sections of channel.

Example Problem

Given:

A trapezoidal channel 3 feet deep, 8 foot bottom width, 2:1 side slopes, and a 2% slope.



Calculate:

A stable riprap size for the bottom and side slopes of the channel.

Solution:

1. From Plate 3.19-3, for a 3-foot-deep channel on a 2% grade, d_{50} = 0.75 feet or 9 inches.

2. Since the side slopes are steeper than 3:1, continue with step 3.

3. From Plate 3.19-4, B/d = 8/3 = 2.67, Z = 2, K_1 = 0.82.

4. From Plate 3.19-5, for d_{50} = 9 inches, = 41°.

5. From Plate 3.19-6, for Z = 2 and = 41°, K_2 = 0.73.

6. d_{50} x K_1/k_2 = d'_{50} = 0.75 x 0.82/0.73 = 0.84 feet.

$$0.84 \text{ feet} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 10.08.$$ Use d'_{50} = 10 inches.

Given:

The preceding channel has a curved section with a radius of 50 feet.

Calculate:

A stable riprap size for the bottom and side slopes of the curved section of channel.

Solution:

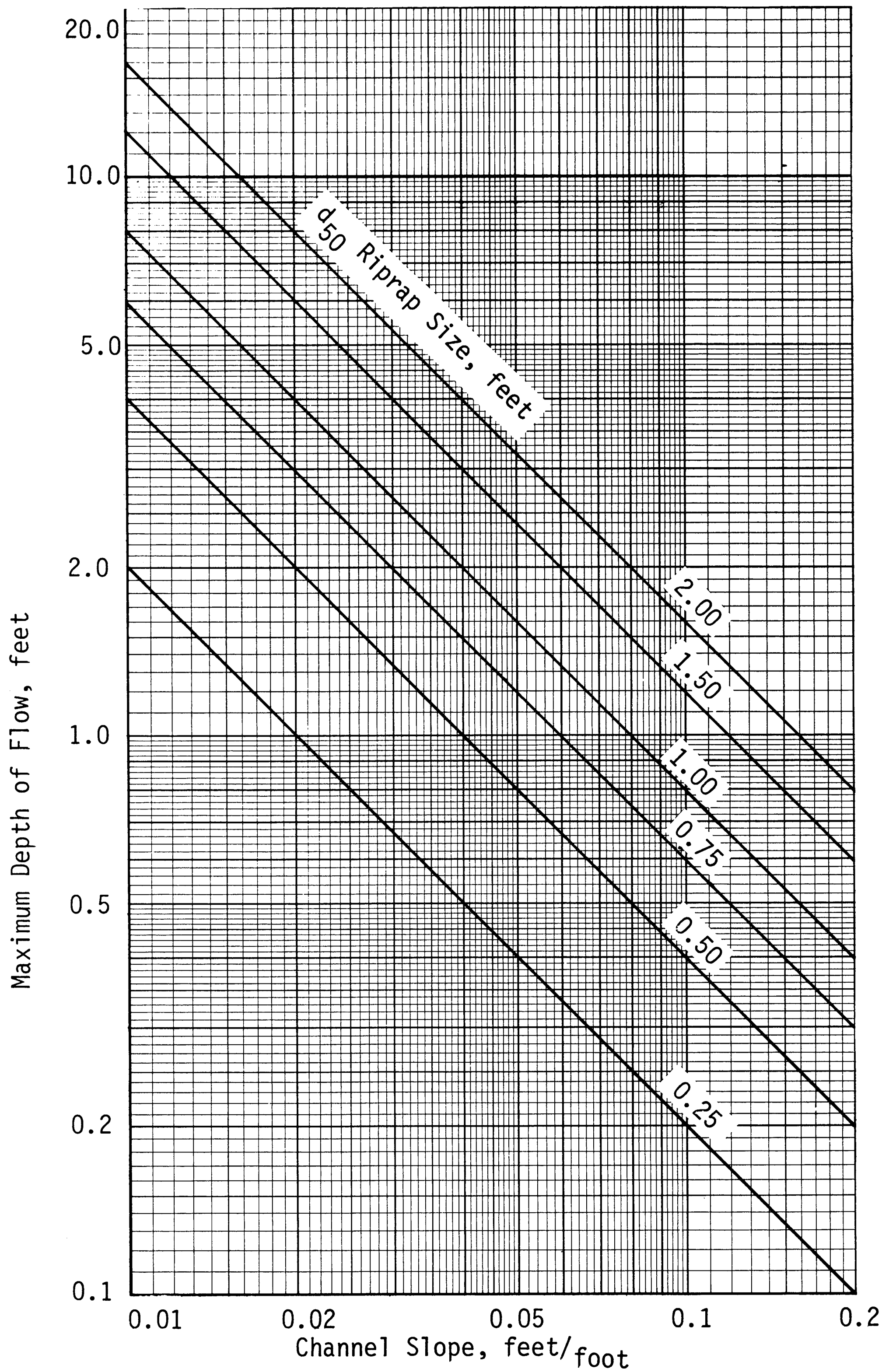
1. Ro = 50 feet

2. Bs/Ro = 20/50 = 0.40

3. From Plate 3.19-7, for Bs/Ro = 0.40, K_3 = 1.1

4. $d'_{50} \times K_3 = 0.84 \times 1.1 = 0.92$ feet

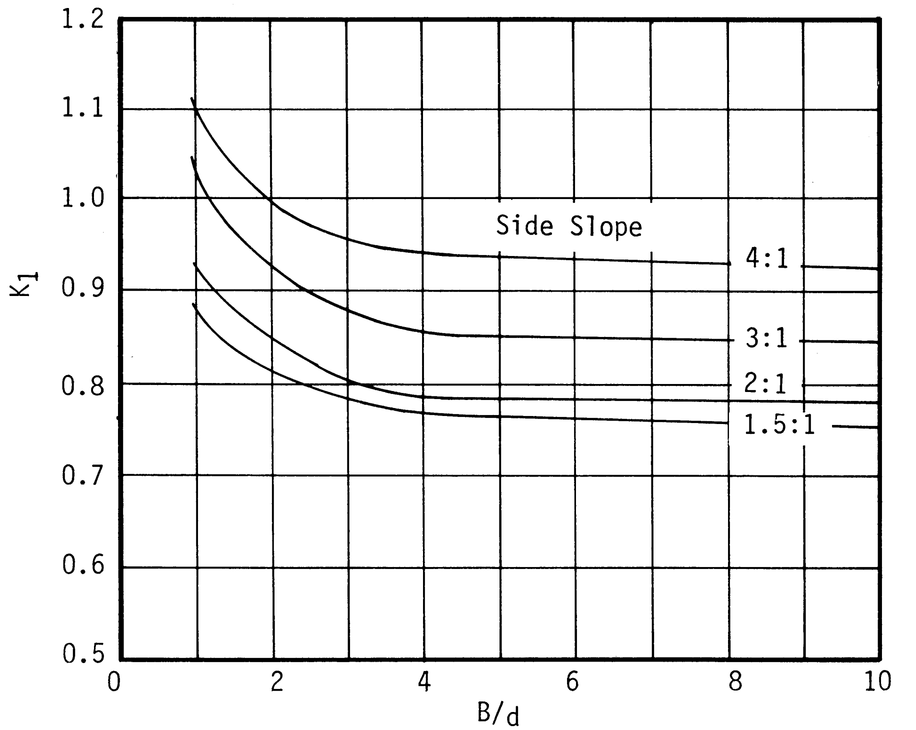
   $0.92 \text{ feet} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 11.0.$



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

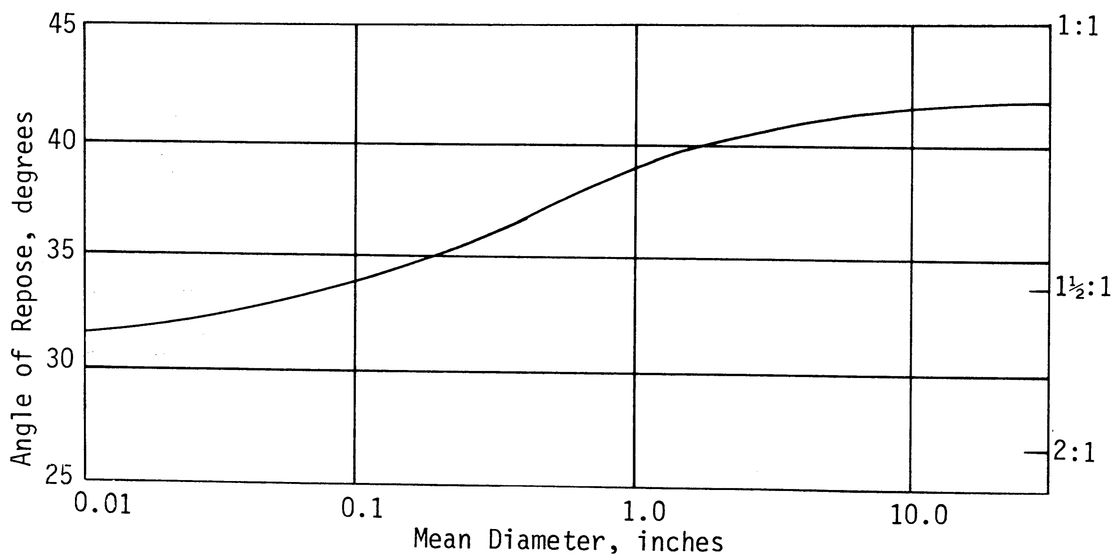
Source: VDOT Drainage Manual

Plate 3.19-3



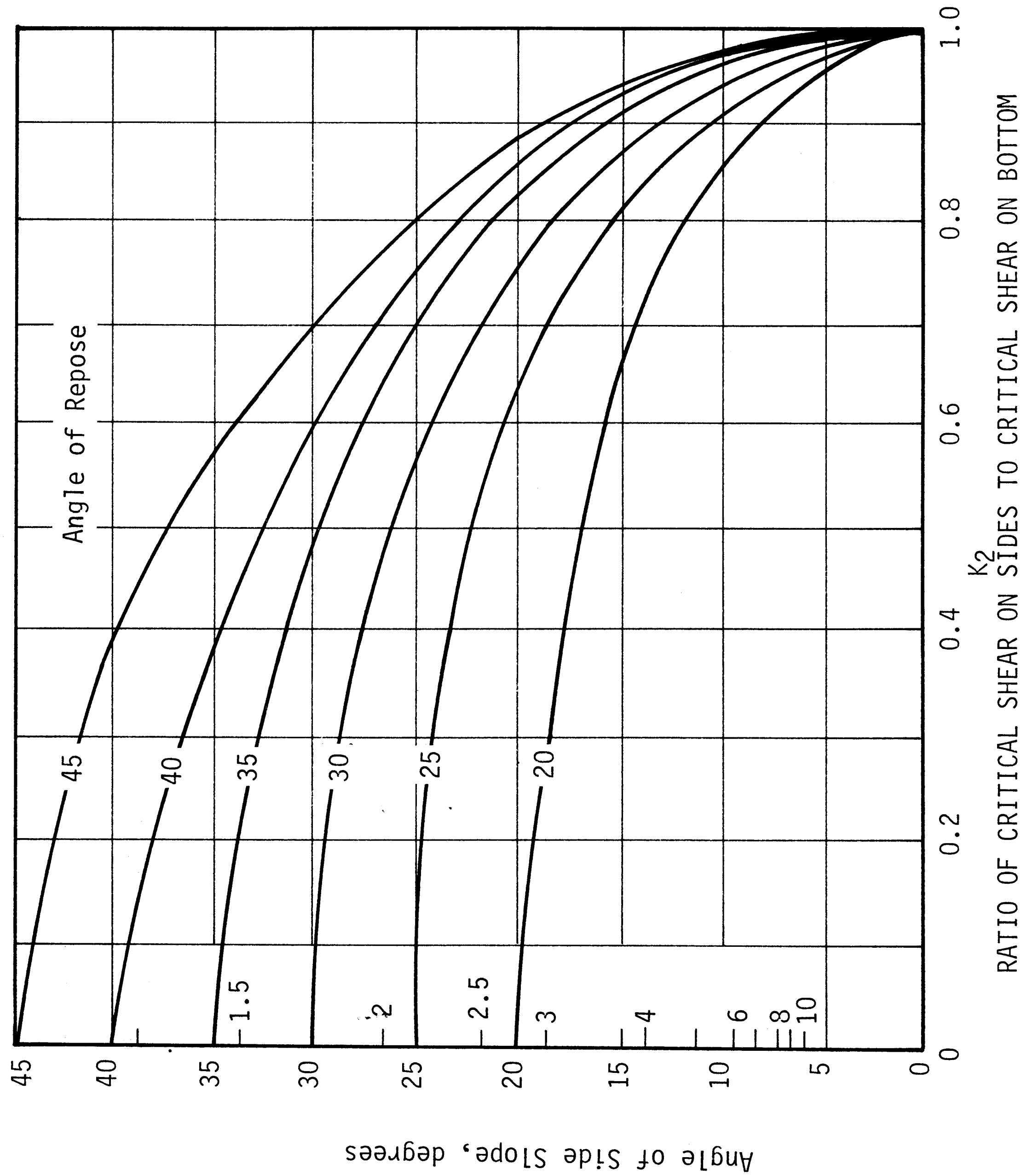
DISTRIBUTION OF BOUNDARY SHEAR AROUND WETTED PERIMETER OF TRAPEZOIDAL CHANNEL

Source: VDOT Drainage Manual Plate 3.19-4



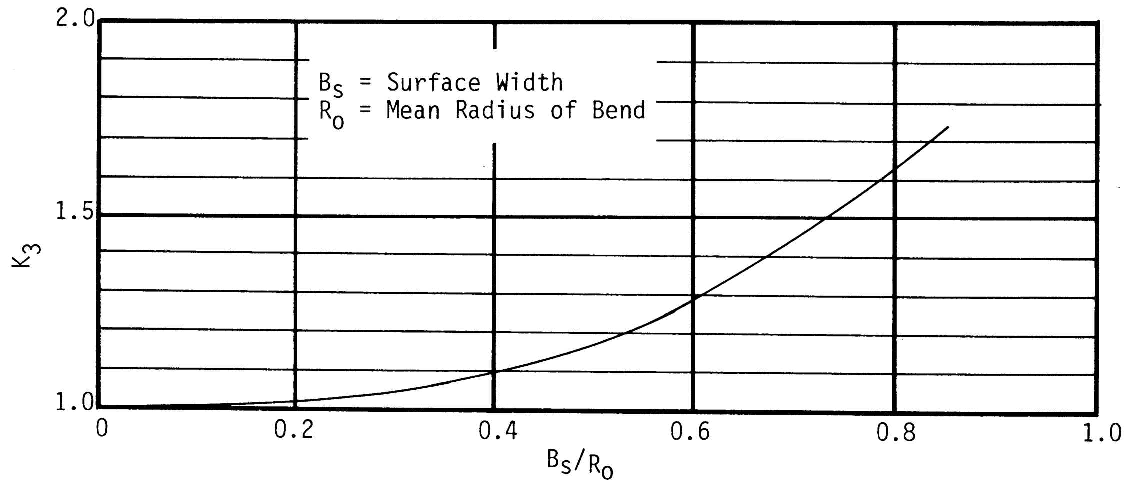
ANGLE OF REPOSE FOR RIPRAP STONES

Source: VDOT Drainage Manual Plate 3.19-5



Source: VDOT Drainage Manual

Plate 3.19-6



RATIO OF MAXIMUM BOUNDARY SHEAR IN BENDS TO MAXIMUM BOTTOM SHEAR IN STRAIGHT REACHES

Source: VDOT <u>Drainage Manual</u> Plate 3.19-7

APPENDIX 3.19-b

RIPRAP DESIGN EQUATIONS FOR LAKES AND PONDS SUBJECT TO WAVE ACTION

In many instances, riprap is installed along the shoreline of nontidal ponds and lakes in order to protect them from the continual scour of wind-driven waves. The following methods/equations will produce minimum design parameters for size of stone, depth of buried toe (or width of riprap apron) and height of structure above average water level.

I. **Size of Riprap Required** - See VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action").

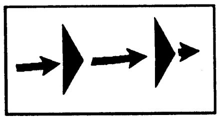
II. **DWH** (Design Wave Height) - See VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action") or U.S. Army Corps of Engineers' Shore Protection Manual.

III. **Depth of Buried Toe** = DWH at design wind speed.

IV. **Width of Riprap Apron** (Alternative to Buried Toe) = DWH x 2

V. **Height of Structure** (Above the Average Water Level) = DWH x 1.5

STD & SPEC 3.20



ROCK CHECK DAMS

CD

Definition

Small temporary stone dams constructed across a swale or drainage ditch.

Purpose

To reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. This practice also traps sediment generated from adjacent areas or the ditch itself, mainly by ponding of the stormwater runoff. Field experience has shown it to perform more effectively than silt fence or straw bales in the effort to stabilize "wet-weather" ditches.

Conditions Where Practice Applies

This practice, utilizing a combination of stone sizes, is limited to use in small open channels which drain 10 acres or less. It should not be used in a live stream as the objective should be to protect the live watercourse. Some specific applications include:

1. Temporary ditches or swales which, because of their short length of service, cannot receive a non-erodible lining but still need protection to reduce erosion.

2. Permanent ditches or swales which, for some reason, cannot receive a permanent non-erodible lining for an extended period of time.

3. Either temporary or permanent ditches or swales which need protection during the establishment of grass linings.

4. An aid in the sediment trapping strategy for a construction site. This practice is not a substitute for major perimeter trapping measures such as a SEDIMENT TRAP (Std. & Spec. 3.13) or a SEDIMENT BASIN (Std. & Spec. 3.14).

Planning Considerations

Check dams are effective in reducing flow velocity and thereby the potential for channel erosion. It is usually better to establish a protective vegetative lining before flow is confined or to install a structural channel lining than to install check dams. However, under circumstances where this is not feasible, check dams are useful.

Check dams installed in grass-lined channels may kill the vegetative lining if submergence after rains is too long and/or silting is excessive.

If check dams are used in grass-lined channels which will be mowed, care should be taken to remove all the stone when the dam is removed. This should include any stone which has washed downstream.

As previously mentioned, they have been found to be an effective aid in trapping sediment particles by virtue of their ability to pond runoff.

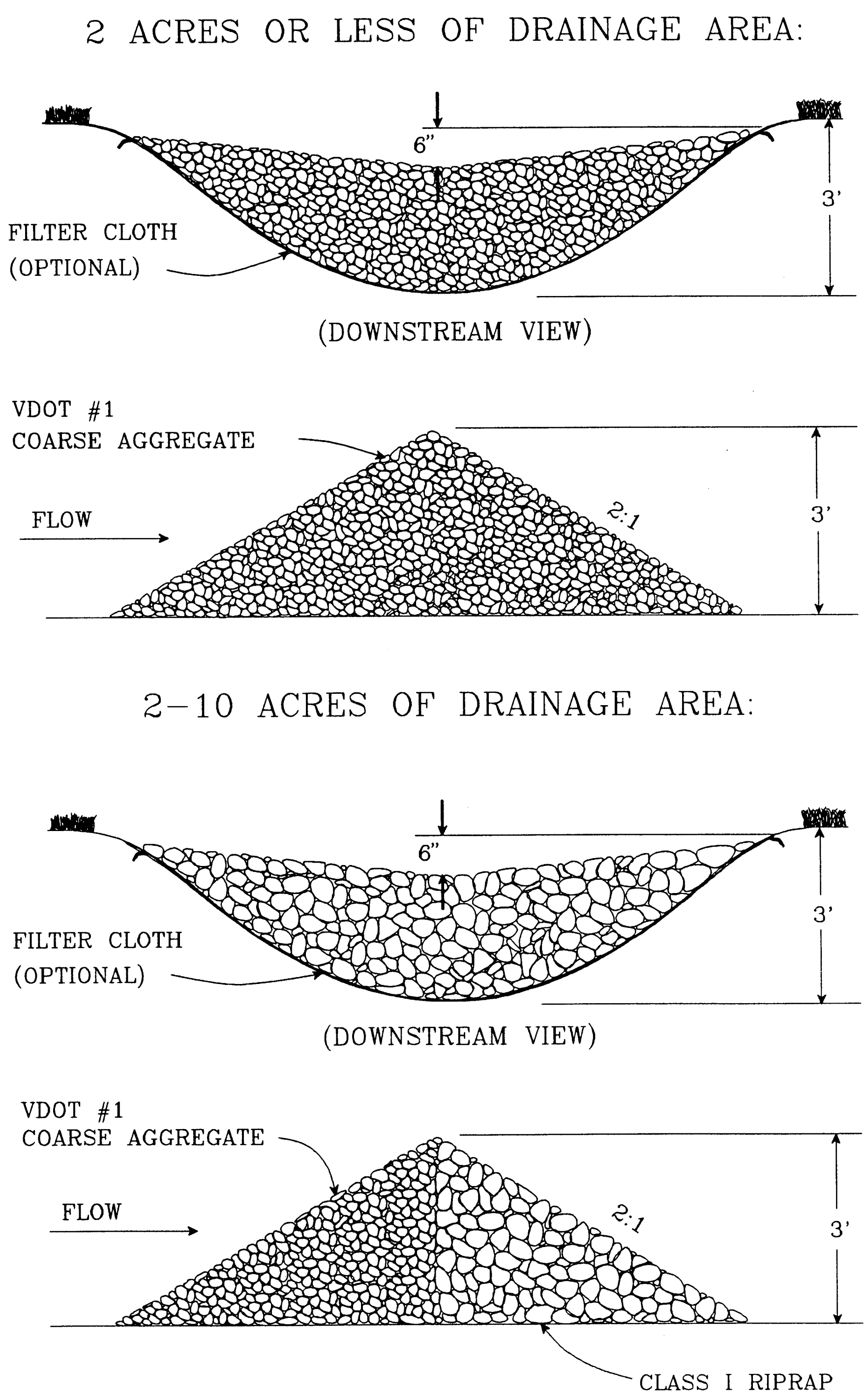
Specifications

No formal design is required for a check dam, however the following criteria should be adhered to when specifying check dams:

1. The drainage area of the ditch or swale being protected shall not exceed 2 acres when VDOT #1 Coarse Aggregate is used alone and shall not exceed 10 acres when a combination of Class I Riprap (added for stability) and VDOT #1 Coarse Aggregate is used. Refer to Plate 3.20-1 for orientation of stone and a cross-sectional view of the measure. An effort should be made to extend the stone to the top of channel banks.

2. However, the maximum height of the dam shall be 3.0 feet.

ROCK CHECK DAM



Source: Va. DSWC

Plate 3.20-1

3. The center of the check dam must be at least 6 inches lower than the outer edges. Field experience has shown that many dams are not constructed to promote this "weir" effect. Stormwater flows are then forced to the stone-soil interface, thereby promoting scour at that point and subsequent failure of the structure to perform its intended function.

4. For added stability, the base of the check dam can be keyed into the soil approximately 6 inches.

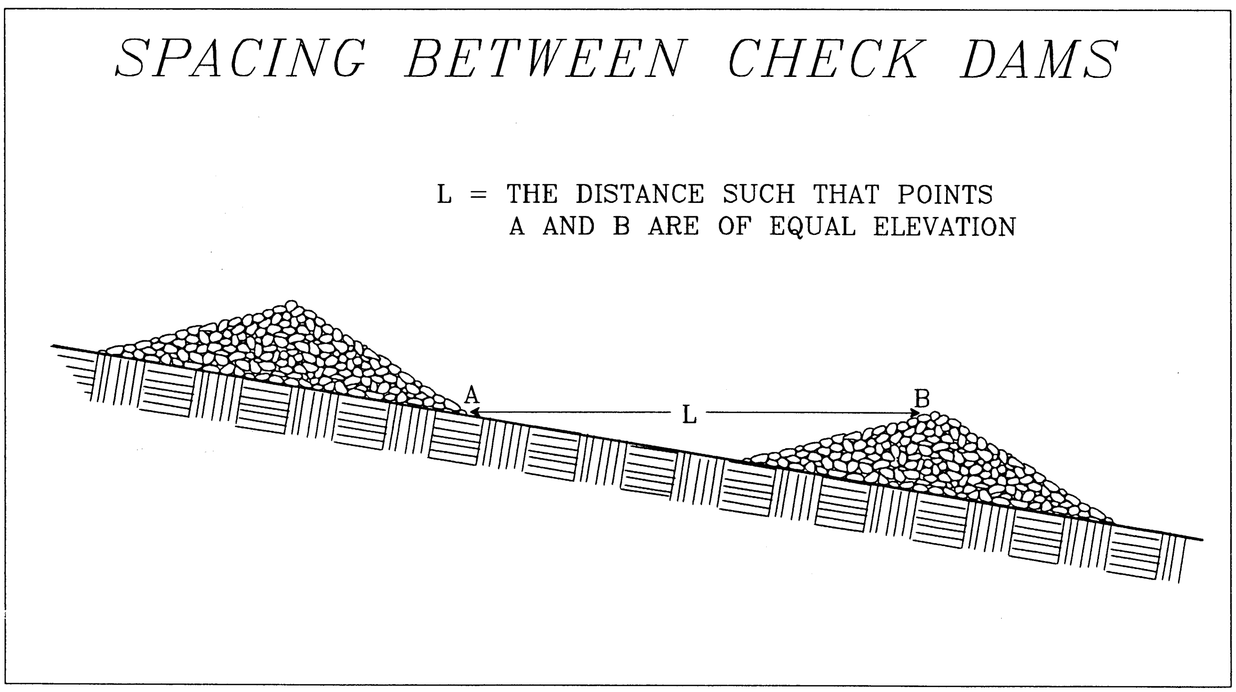
5. The maximum spacing between the dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam (see Plate 3.20-2).

6. Stone should be placed according to the configuration in Plate 3.20-1. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.

7. Filter cloth may be used under the stone to provide a stable foundation and to facilitate the removal of the stone. See Std. and Spec. 3.19, RIPRAP, for required physical properties of the filter cloth.

Sediment Removal

Sediment should be removed from behind the check dams when it has accumulated to one half of the original height of the dam.



Source: Va. DSWC

Plate 3.20-2

Removal of Practice

Unless they will be incorporated into a permanent stormwater management control, check dams must be removed when their useful life has been completed. In temporary ditches and swales, check dams should be removed and the ditch filled in when they are no longer needed. In permanent structures, check dams should be removed when a permanent lining can be installed. In the case of grass-lined ditches, check dams should be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams should be seeded and mulched immediately after they are removed. The use of filter cloth underneath the stone will make the removal of the stone easier.

Maintenance

Check dams should be checked for sediment accumulation after each runoff-producing storm event. Sediment should be removed when it reaches one half of the original height of the measure.

Regular inspections should be made to insure that the center of the dam is lower than the edges. Erosion caused by high flows around the edges of the dam should be corrected immediately.

STD & SPEC 3.21

LEVEL SPREADER

LS

Definition

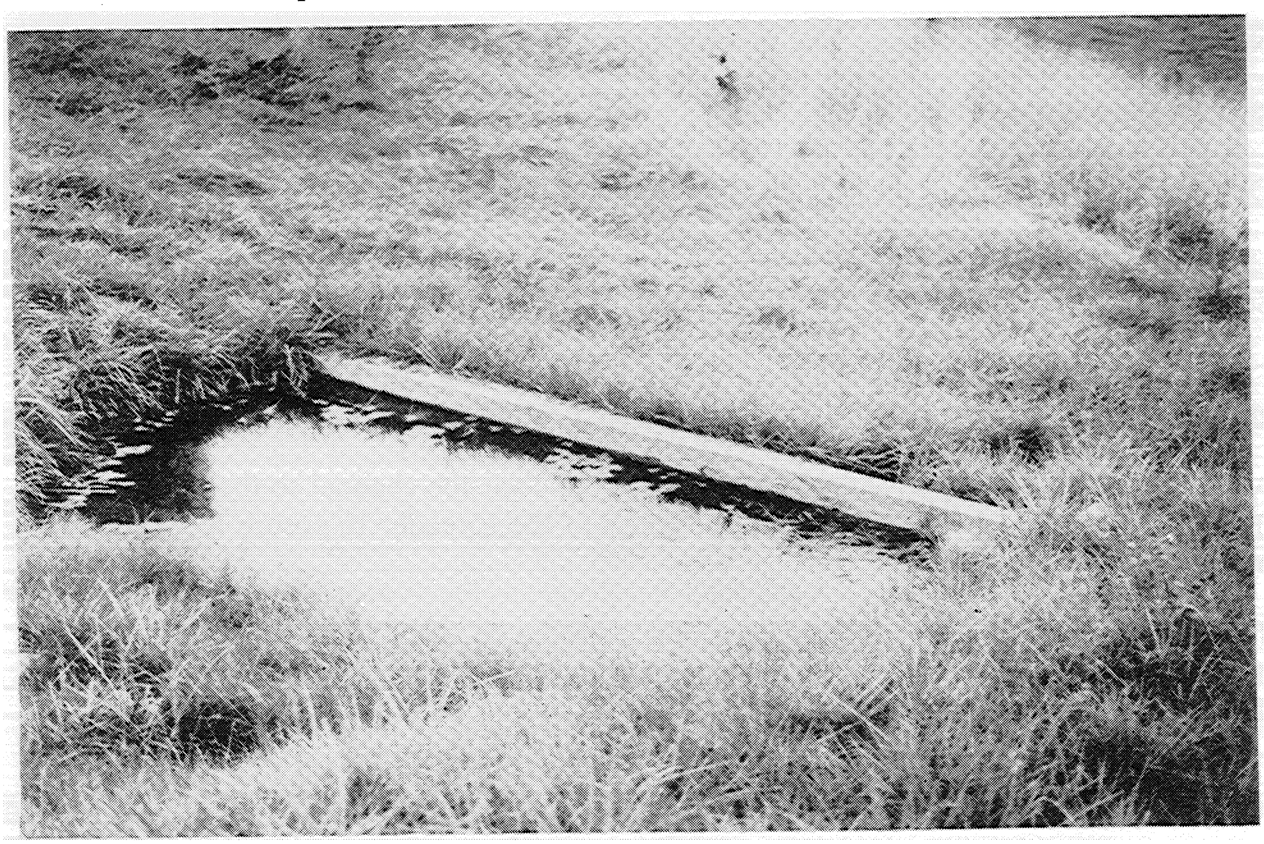
An outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.

Purpose

To convert concentrated runoff to sheet flow and release it uniformly onto areas stabilized by existing vegetation.

Conditions Where Practice Applies

Where there is a need to divert stormwater away from disturbed areas to avoid overstressing erosion control measures; where sediment-free storm runoff can be released in sheet flow down a stabilized slope without causing erosion.



This practice applies only in those situations where the spreader can be constructed on undisturbed soil and the area below the level lip is uniform with a slope of 10% or less and is stabilized by natural vegetation. The runoff water should not be allowed to reconcentrate after release unless it occurs during interception by another measure (such as a permanent pond or detention basin) located below the level spreader.

Planning Considerations

The TEMPORARY DIVERSION DIKE, (Std.& Spec. 3.09) and the TEMPORARY RIGHT-OF-WAY DIVERSION, (Std. & Spec. 3.11) each call for a stable outlet for concentrated stormwater flows. The level spreader is a relatively low-cost structure to release small volumes of concentrated flow where site conditions are suitable (see Plate 3.21-1).

The outlet area must be uniform and well-vegetated with slopes 10% or less. Particular care must be taken to construct the outlet lip completely level in a stable, undisturbed soil. Any depressions in the lip will concentrate the flow, resulting in erosion. Under higher design flow conditions, a rigid outlet lip design should be used to create the desired sheet flow conditions. Runoff water containing high sediment loads must be treated in a sediment trapping device before being released to a level spreader.

Design Criteria

No formal design is required. The following criteria must be met:

Spreader Dimensions

Determine the capacity of the spreader by estimating the peak flow expected from a 10-year storm (Q_{10}).

Select the appropriate length, width and depth of the spreader from Table 3.21-A.

For design flows greater than 20 cfs, the measure should be designed by a qualified engineer.

A 20-foot transition section should be formed in the diversion channel so that the width of the diversion will smoothly tie in with the width of the spreader to ensure more uniform outflow.

The depth of the level spreader, as measured from the lip, shall be at least 6 inches. The depth may be made greater to increase temporary storage capacity, improve trapping of debris and to enhance settling of any suspended solids.

TABLE 3.21-A

MINIMUM DIMENSIONS FOR LEVEL SPREADER

Design Flow, Q_{10} (cfs)	Depth (ft.)	Width of Lower Side Slope of Spreader (ft.)	Length (ft.)
0-10	0.5	6	10
10-20	0.6	6	20

Source: Va. DSWC

Grade

1. The grade of the channel for the last 20 feet of the dike or diversion entering the level spreader shall be less than or equal to 1% (see Plate 3.21-1).

2. The grade of the level spreader channel shall be 0%.

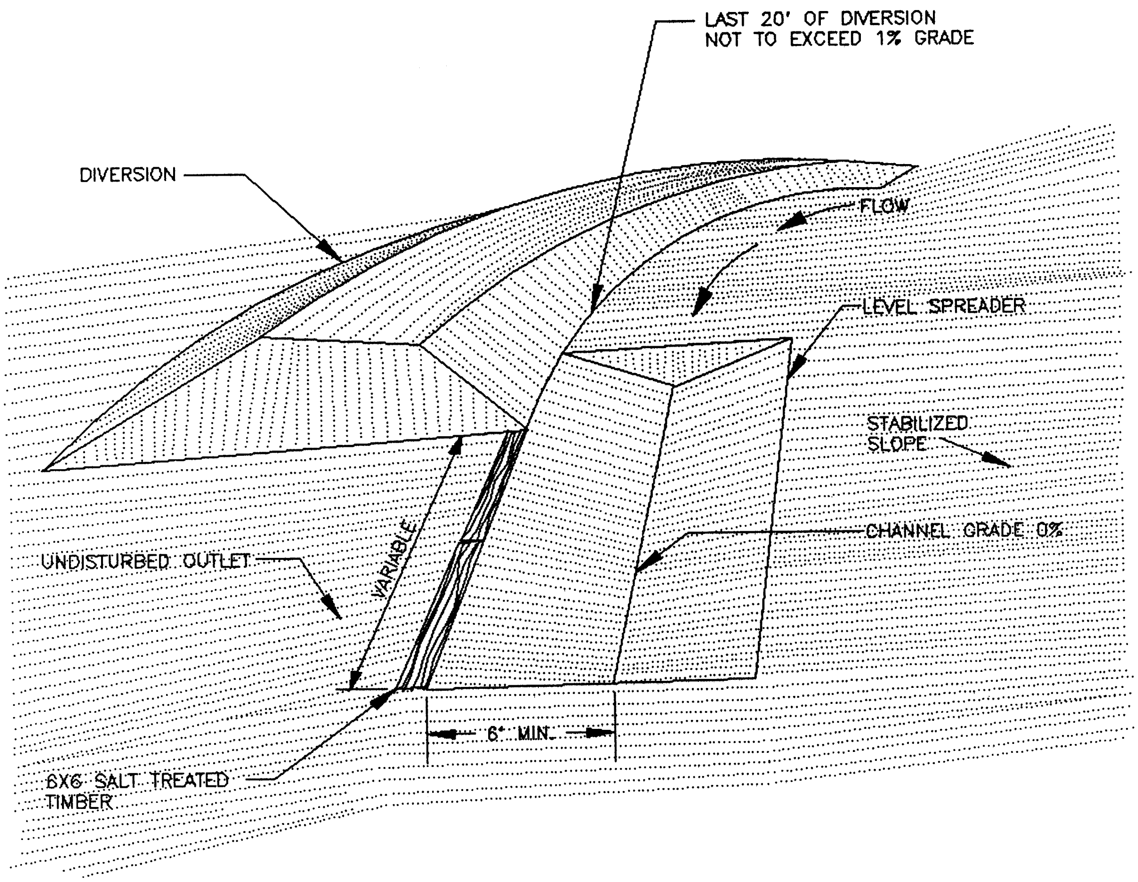
Spreader Lip

The release of the stormwater will be over the level lip onto an undisturbed well-vegetated area with a maximum slope of 10%. The level lip should be of uniform height and zero grade over the length of the spreader.

The level spreader lip may be stabilized by vegetation or may be of a rigid non-erodible material depending on the expected design flow:

Spreader Lip	Design Flow (cfs)
Vegetated	0 - 4
Rigid	5 - 20

LEVEL SPREADER



PERSPECTIVE VIEW

NOTE: ALL TEMPORARY BERMS, SWALES AND LEVEL SPREADER DITCH MUST RECEIVE TEMPORARY SEEDING IMMEDIATELY AFTER INSTALLATION

Source: Adapted from N.C. Erosion and Sediment Control Planning and Design Manual

Plate 3.21-1

A vegetated level lip must be constructed with an erosion-resistant material, such as jute or excelsior blankets, to inhibit erosion and allow vegetation to become established (see Plate 3.21-2).

For higher design flows and permanent installations, a rigid lip of non-erodible material, such as pressure-treated timbers or concrete curbing, should be used (see Plate 3.21-2).

Construction Specifications

1. Level spreaders must be constructed on undisturbed soil (not fill material).

2. The entrance to the spreader must be shaped in such a manner as to insure that runoff enters directly onto the 0% channel.

3. Construct a 20-ft. transition section from the diversion channel to blend smoothly to the width and depth of the spreader.

4. The level lip shall be constructed at 0% grade to insure uniform spreading of stormwater runoff.

5. Protective covering for vegetated lip should be a minimum of 4 feet wide extending 6 inches over the lip and buried 6 inches deep in a vertical trench on the lower edge. The upper edge should butt against smoothly cut sod and be securely held in place with closely spaced heavy duty wire staples (see Plate 3.21-2).

6. Rigid level lip should be entrenched at least 2 inches below existing ground and securely anchored to prevent displacement. An apron of VDOT #1, #2 or #3 Coarse Aggregate should be placed to top of level lip and extended downslope at least 3 feet. Place filter fabric under stone and use galvanized wire mesh to hold stone securely in place (see Plate 3.21-2).

7. The released runoff must outlet onto undisturbed stabilized areas with slope not exceeding 10%. Slope must be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.

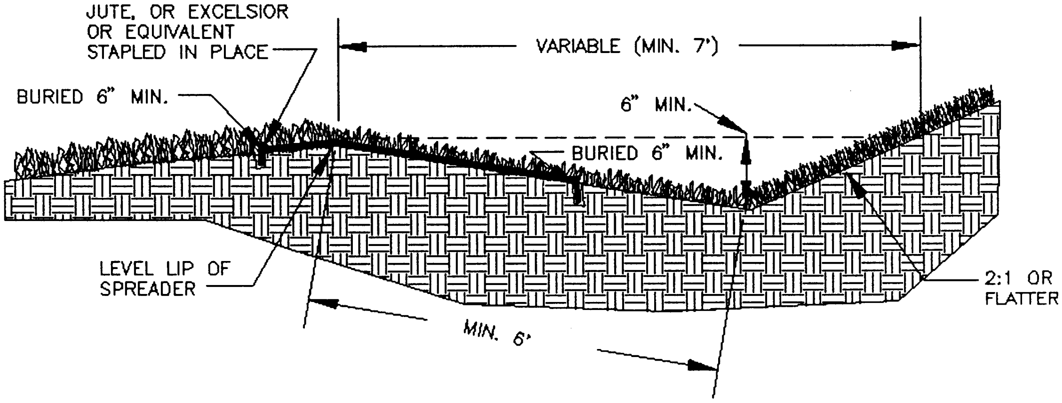
8. Immediately after its construction, appropriately seed and mulch the entire disturbed area of the spreader.

Maintenance

The measure shall be inspected after every rainfall and repairs made, if required. Level spreader lip must remain at 0% slope to allow proper function of measure. The contractor should avoid the placement of any material on and prevent construction traffic across the structure. If the measure is damaged by construction traffic, it shall be repaired immediately.

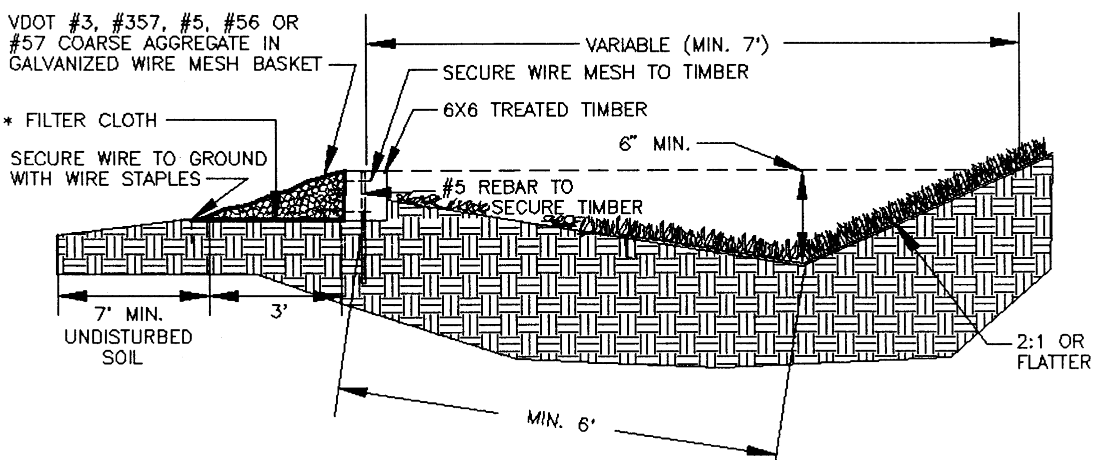
LEVEL SPREADER

CROSS SECTION



LEVEL SPREADER WITH VEGETATED LIP

CROSS SECTION



LEVEL SPREADER WITH RIGID LIP

* MIN. PHYSICAL REQUIREMENTS OF FILTER CLOTH NOTED IN STD. & SPEC. 3.19, RIPRAP

Source: Va. DSWC and N.C. Erosion and Sediment Control Planning and Design Manual

Plate 3.21-2

STD & SPEC 3.22

VEGETATIVE STREAMBANK STABILIZATION

(VSS)

Definition

The use of vegetation in stabilizing streambanks.

Purpose

To protect streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies

Along banks in creeks, streams and rivers subject to erosion from excess runoff. This practice is generally applicable where bankfull flow velocity does not exceed 5 ft./sec. and soils are erosion resistant. Above 5 ft./sec., structural measures are generally required. This practice does not apply where tidal conditions exist.

Planning Considerations

A primary cause of stream channel erosion is the increased frequency of bank-full flows which often result from upstream development. Most natural stream channels are formed with a bank-full capacity to pass the runoff from a storm with a 1½ to 2-year recurrence interval. However, in a typical urbanizing watershed, stream channels are subject to a 3- to 5-fold increase in the frequency of bank-full flows. As a result, stream channels that were once parabolic in shape and covered with vegetation are often transformed into wide rectangular channels with barren banks.

In recent years, a number of structural measures have evolved to strengthen and protect the banks of rivers and streams. These methods, if employed correctly, immediately insure a satisfactory protection of the banks. However, many such structures are expensive to build and to maintain and frequently cause downstream velocity problems. Without constant upkeep, they are exposed to progressive deterioration by natural agents. The materials used often prevent the re-establishment of native plants and animals, especially when the design is executed according to standard cross-sections which ignore natural variations of the stream system. Very often these structural measures destroy the appearance of the site.

In contrast, the utilization of living plants instead of or in conjunction with structures has many advantages. The degree of protection, which may be low to start with, increases as the plants grow and spread. The repair and maintenance of structures is unnecessary where self-maintaining streambank plants are established. The protection provided by natural vegetation is more reliable and effective where the cover consists of natural plant communities which are native to the site. Planting vegetation is less damaging to the environment than installing structures. Vegetation also provides habitat for fish and wildlife and is aesthetically pleasing. Plants provide erosion protection to streambanks by reducing stream velocity, binding soil in place with a root mat and covering the soil surface when high flows tend to flatten vegetation against the banks. For these reasons, vegetation should always be considered first.

One disadvantage of vegetation is that it lowers the carrying capacity of the channel, which may promote flooding. Therefore, maintenance needs and the consequences of flooding should be considered. The erosion potential for the stream needs to be evaluated to determine the best solutions. The following items should be considered in the evaluation:

1. The frequency of bankfull flow based on anticipated watershed development.

2. The channel slope and flow velocity, by design reaches.

3. The antecedent soil conditions.

4. Present and anticipated channel roughness ("n") values.

5. The location of channel bends along with bank conditions.

6. The location of unstable areas and trouble spots. Steep channel reaches, high erosive banks and sharp bends may require structural stabilization measures such as riprap, while the remainder of the streambank may require only vegetation.

Where streambank stabilization is required and velocities appear too high for the use of vegetation, one should consider structural measures (see Std. & Spec. 3.23, STRUCTURAL STREAMBANK STABILIZATION) or the use of permanent erosion control matting (see Std. & Spec. 3.36, SOIL STABILIZATION MATTING). Notably, any applicable approval or permits from other state or federal agencies must be obtained prior to working in such areas.

Vegetation Zones Along Watercourses

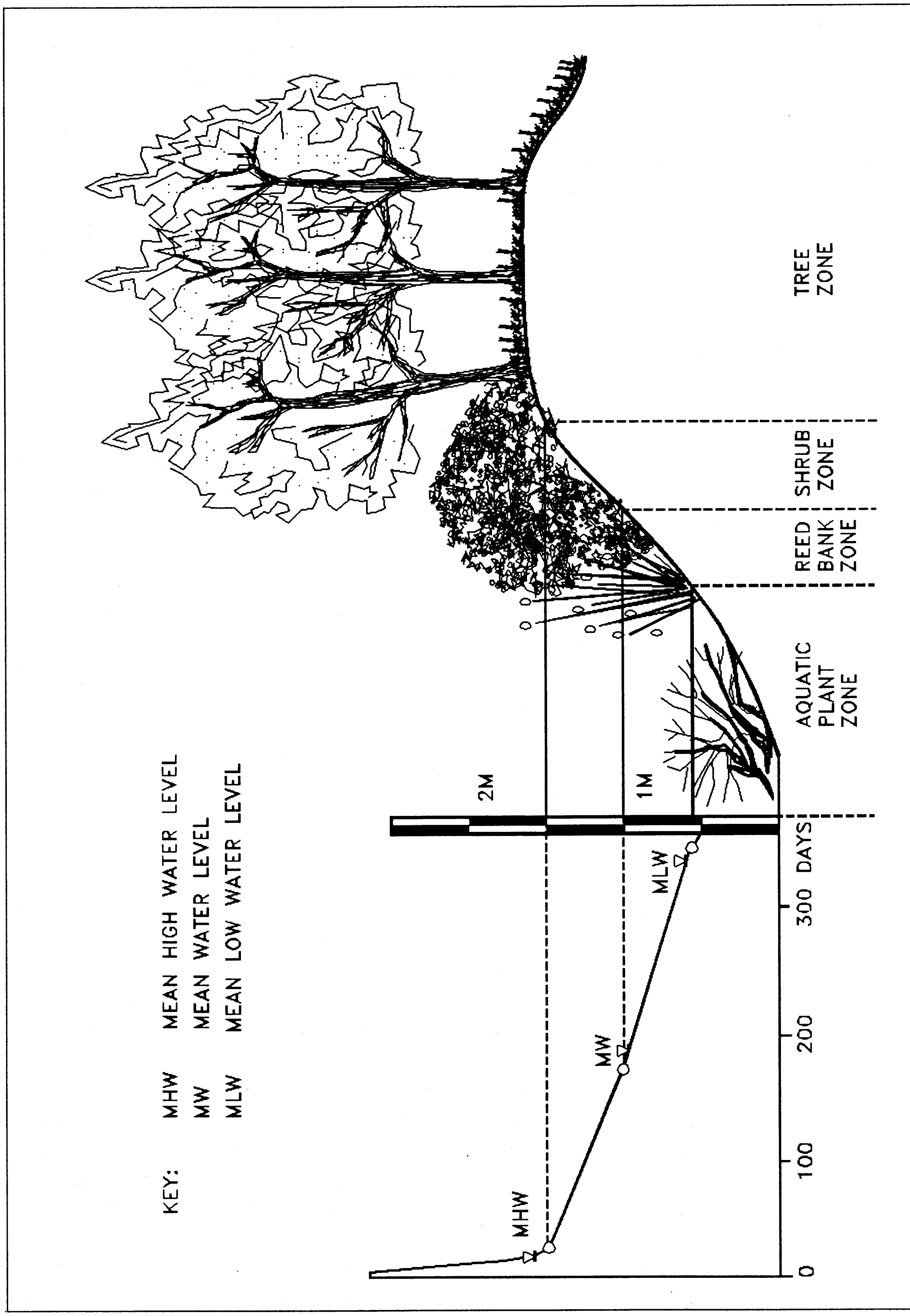
At the edge of all natural watercourses, plant communities exist in a characteristic succession of vegetative zones, the boundaries of which are dependent upon site conditions such as the steepness and shape of the bank and the seasonal and local variations in water depth and flow rate. Streambanks commonly exhibit the following zonation (see Plate 3.22-1):

1. Aquatic Plant Zone - This zone is normally permanently submerged. In Virginia, this zone is inhabited by plants such as pondweeds and water lilies, which reduce the water's flow rate by friction. The roots of these plants help to bind the soil, and they further protect the channel from erosion because the water flow tends to flatten them against the banks and bed of the stream.

2. Reed-Bank Zone - The lower part of this zone is normally submerged for only about half the year. In Virginia, this zone is inhabited by rushes, reed grasses, cattails, and other plants which bind the soil with their roots, rhizomes and shoots and slow the water's flow rate by friction.

3. Shrub Zone - This zone is flooded only during periods of average high water. In Virginia, the shrub zone is inhabited by trees and shrubs--such as willow, alder, dogwood and viburnum--with a high regenerative capacity. These plants hold the soil with their root systems and slow water speed by friction. They also protect tree trunks from damage caused by breaking ice and help to prevent the formation of strong eddies around large trees during flood flows. Shrub zone vegetation is particularly beneficial along the impact bank of a stream meander, where maximum scouring tends to occur. Infringement of shrub vegetation into the channel tends to reduce the channel width, increasing probability of floods. However, brief flooding of riverside woods and undeveloped bottomlands does no significant damage, and the silt deposits in these wooded areas are less of a problem than failed banks.

4. Tree Zone - This zone is flooded only during periods of very high water (i.e., the 2-year bank-full flow or greater flows). Typical plants in Virginia are trees in the ash-elm, alder-ash, and oak-horn-beam associations. These trees hold soil in place with their root systems.



TYPICAL ANNUAL CURVE OF WATER LEVELS CORRELATED WITH TYPICAL VEGETATIVE ZONES

Source: <u>Importance of Natural Vegetation for the Protection of the Banks of Streams, Rivers and Canals</u>, Seibert

Plate 3.22-1

Design Criteria

Table 3.22-A provides general guidelines for maximum allowable velocities in streams to be protected by vegetation.

1. Ensure that channel bottoms are stable before stabilizing channel banks.

2. Keep velocities at bankfull flow non-erosive for the site conditions.

3. Provide mechanical protection such as rip-rap on the outside of channel bends if bankfull stream velocities approach the maximum allowable for site conditions.

4. Be sure that requirements of other state or federal agencies are met in the design in the case that other approvals or permits are necessary.

TABLE 3.22-A

CONDITIONS WHERE VEGETATIVE STREAMBANK STABILIZATION IS ACCEPTABLE

Frequency of Bankfull Flow	Max. Allowable Velocity for Highly Erodible Soil	Maximum Allowable Velocity (Erosion Resistant Soil)
> 4 times/yr.	4 ft./sec.	5 ft./sec.
1 to 4 times/yr.	5 ft./sec.	6 ft./sec.
< 1 time/yr.	6 ft./sec.	6 ft./sec.

Source: Va. DSWC

Planting Guidelines

Guidelines will be presented only for the reed-bank and shrub zones. The aquatic plant zone is difficult to implant and establish naturally when reed-bank vegetation is present. There are presently many experts in this field at the federal, state, and private sector levels who can be consulted concerning successful establishment of plants in the aquatic zone. The tree zone is least significant in terms of protecting banks from more frequent erosion-force flows, since this zone is seldom flooded. Also, shade from trees in this zone can prevent adequate establishment of vegetation in other zones.

1. Establishing Reed-Bank Vegetation

There are various ways of planting reed-bank vegetation. The following plants are considered suitable:

Common Reed	(Phragmites communis)
Reed Canary Grass	(Phalaris arundinacae)
Great Bulrush	(Scirpus lacustris)
Common Cattail	(Typha latifolia)

The greatest protection seems to be provided by the Common Reed. It is a very robust plant whose stems become woody in the autumn, resulting in continued protection during the winter. Because the shoots and rhizomes are deeply and strongly rooted and densely intertwined, they bind the soil more firmly than any other reed. The stems and roots have dormant buds at the nodes and are capable of sprouting when planted. However, the Common Reed does grow high and thick, and periodic maintenance may be needed in order to achieve a neat appearance.

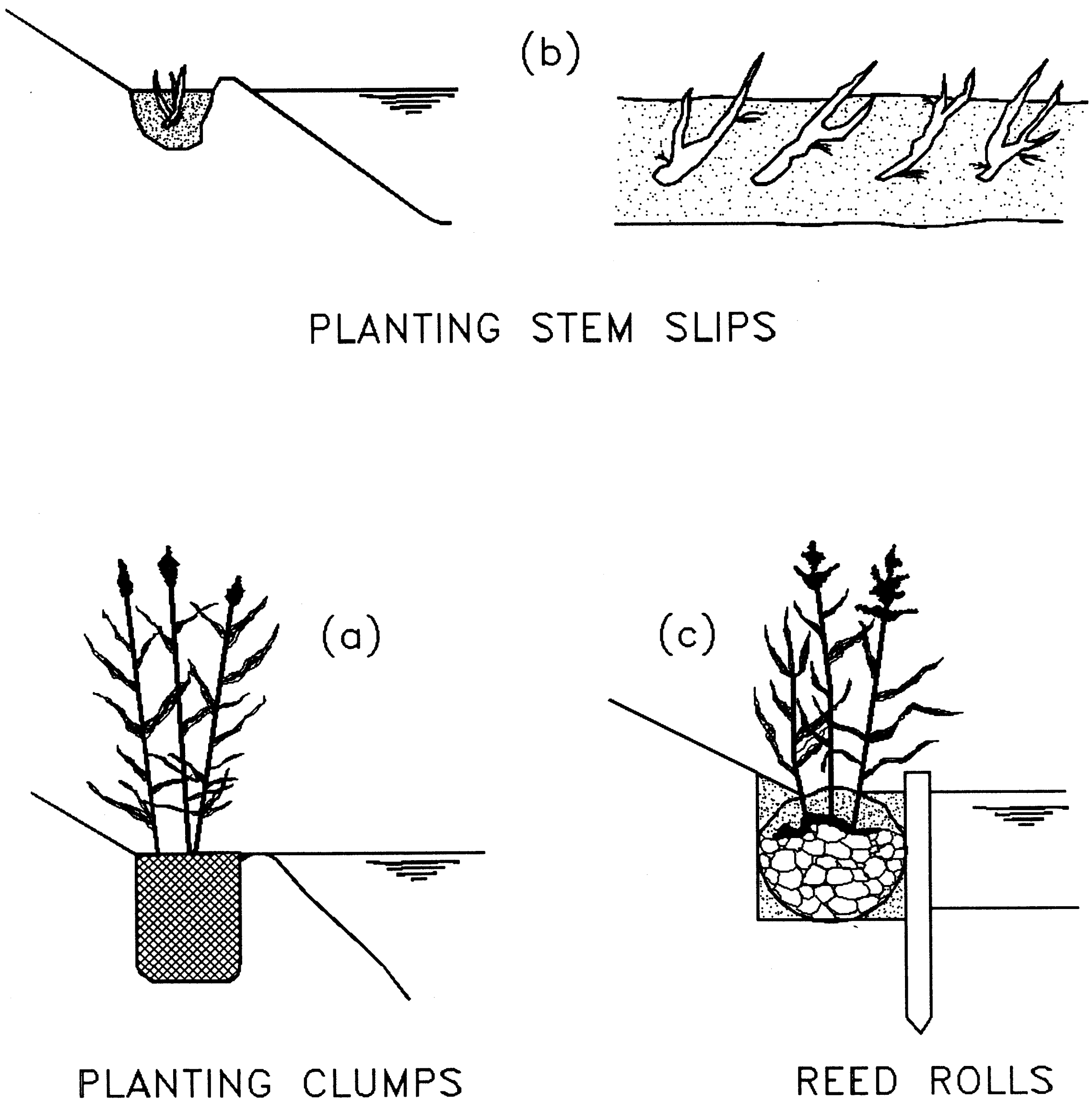
a. Planting in Clumps: The oldest and most common method of planting reeds is planting in clumps (see Plate 3.22-2 (a)). The stems of the reed colony are scythed. Then square clumps are cut out of the ground and placed in pits prepared in advance on the chosen site. The clumps are planted at a depth where they will be submerged to a maximum of two-thirds of their height.

b. Planting Rhizomes and Shoots: Less material is needed for the planting of rhizomes and shoots, a procedure which can be used to establish the Common Reed, Reed Grass, Bulrush, Cattail and other plants. Slips are taken from existing beds during the dormant season, after the stems have been cut. Rhizomes and shoots are carefully removed from the earth without bruising the buds or the tips of the sprouts. They are placed in holes or narrow trenches, along the line of the average summer water level, so that only the stem sprouts are showing above the soil.

c. Planting Stem Slips: It is possible to plant stem slips of the Common Reed along slow-moving streams (see Plate 3.22-2 (b)). Usually, three slips are set in a pit 12 to 20 inches deep. If the soil is packed or strong, the holes must be made with a dibble bar or some other metal planting tool. The pits should be located approximately 1 foot apart.

d. Reed Rolls: In many cases, the previously described methods do not consolidate the banks sufficiently during the period immediately after planting. Combined structures have therefore been designed, in which protection of the bank is at first insured by structural materials. Along slow to fairly fast

METHODS OF ESTABLISHING REED BANK VEGETATION



Source: Importance of Natural Vegetation for the Protection of the Banks of Streams, Rivers and Canals, Seibert

Plate 3.22-2

streams, the most effective method of establishing reed-bank vegetation has been found to be the use of Reed Rolls (see Plate 3.22-2 (c)). A trench 18 inches wide and deep is dug behind a row of stakes. Wire netting, such as ½-inch hardware cloth, is then stretched from both sides of the trench between upright planks. Onto this netting is dumped fill material such as coarse gravel, sod, or soil and other organic material. This material is then covered by reed clumps until the two edges of the wire netting can just be held together with wire. The upper edge of the roll should be no more than 2 inches above the level of the water. Finally, the planks are taken out, and any gaps along the sides of the roll are filled in with earth. This method provides greater protection from the possibility of a heavy flow washing away the vegetative materials before they have a chance to become established.

e. Seeding: Reed Canary Grass can be sown 1/2-inch deep on very damp bank soil, provided that the seeded surface is not covered by water for six months after sowing. Seed at a rate of 12-15 lbs./acre. Reed Canary Grass is a cool season grass and should not be seeded in the summer.

f. Vegetation and Stone Facing: Reed-bank and other types of vegetation can be planted in conjunction with rip-rap or other stone facing by planting clumps, rhizomes or
shoots in the crevices and gaps along the line of the average summer water level.

2. Establishing Shrub Zone Vegetation: Stands of full-grown trees are of little use for protecting streambanks apart from the binding of soil with their roots. Shrubwood provides much better protection; and in fact, riverside stands of willow trees are often replaced naturally by colonies of shrub-like willows. Plants should be used which can easily adapt to the stream and site conditions.

a. Seeding and Sodding: Frequently, if the stream is small and a good seedbed can be prepared, grasses can be used alone to stabilize the streambanks. To seed the shrub zone, first grade eroded or steep streambanks to a maximum slope of 2:1 (3:1 preferred). Existing trees greater than 4 inches in diameter should be retained whenever possible. Topsoil should be conserved for re-use. Seeding mixtures should be selected and operations performed according to Std. & Spec. 3.32, PERMANENT SEEDING. Some type of erosion control blanket, such as jute netting, excelsior blankets, or equivalent should be installed according to Std. & Spec. 3.36, SOIL STABILIZATION BLANKETS & MATTING. Sod can also be placed in areas where grass is suitable. Sod should be selected and installed according to Std. & Spec. 3.33, SODDING. Turf should only be used where the grass will provide adequate protection, necessary maintenance can be provided, and establishment of other streambank vegetation is not practical or possible.

b. Planting Cuttings and Seedlings: Shrub willows, shrub dogwoods and alders can be put into the soil as cuttings, slips or stems. In dense shade, shrubs such as the Blue Arctic Willow (Salix purpurea nana) and the Silky Dogwood (Cornus amomum) or evergreen ground covers such as Lily Turf (Liriope Muscari) or Hall's Honeysuckle (Linicera hallsiana) are appropriate. The Silky Dogwood also works well in sunny areas. On larger streams, "Streamco" Purpleosier Willow (Salix purpurea "Streamco") and Bankers' Dwarf Willow (Salix x Cotteti) have been widely used with success. Two native river alders (Alnus serrulata and Alnus rugosa), which occur throughout the northeast, also show great promise for streambank stabilization, although they have not been fully tested. Again, the first step in the planting process is to grade eroded or steep slopes to a maximum slope of 2:1 (3:1 preferred), removing overhanging bank edges.

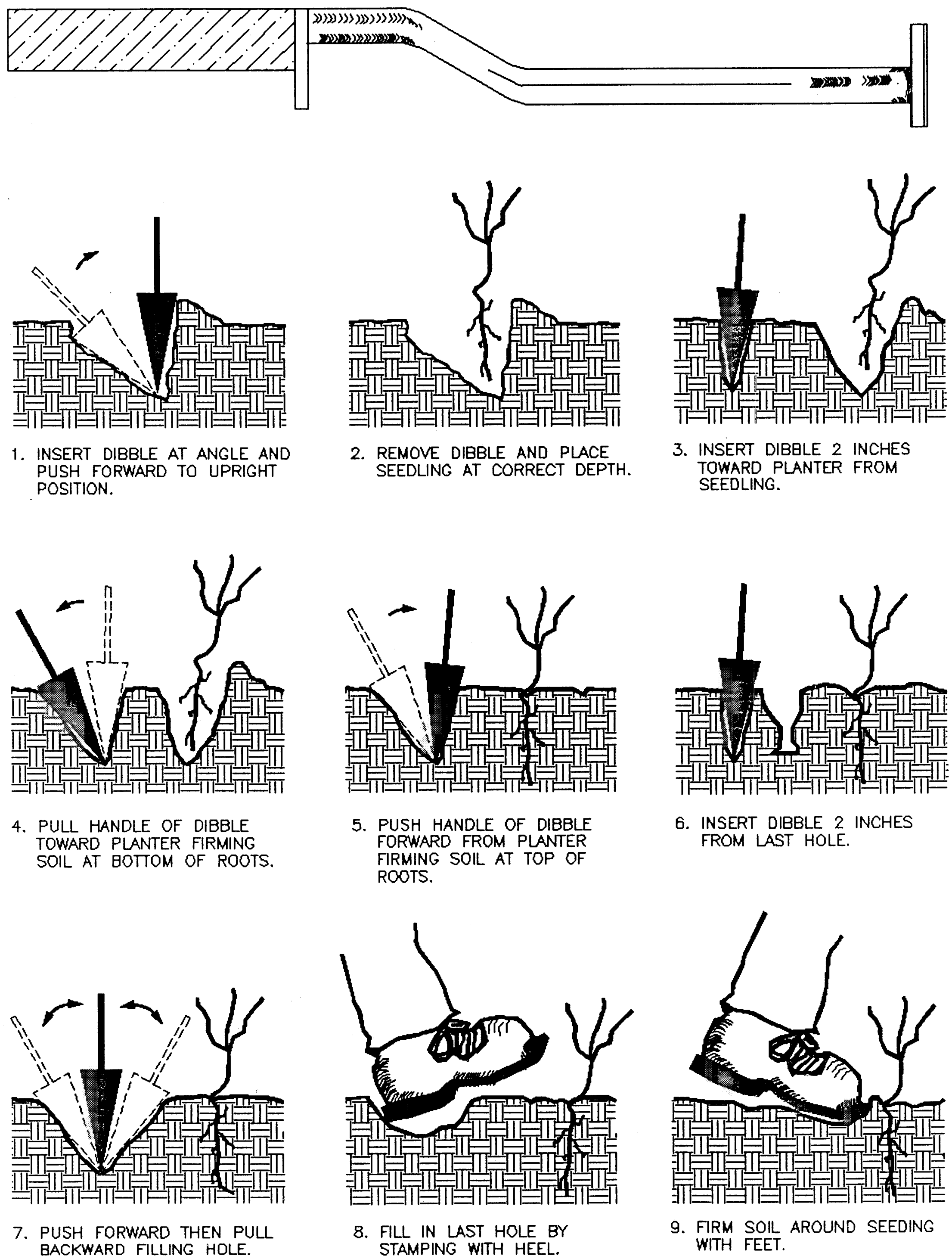
Willows can be planted as 1-year old, nursery-grown, rooted cuttings or as fresh hardwood cuttings gathered from local mother-stock plantings. Silky Dogwood and the alders should be nursery-grown seedlings 1 or 2 years old. Fresh cuttings should be 3/8- to 1/2-inch thick and 12 to 18 inches long. They should be kept moist. If not used at once, they should be stored in cool moist sand.

Streambanks are often difficult to plant, even when they are well-sloped. This is especially true in gravelly or strong banks. Where mattocks or shovels are unsatisfactory tools, a stiff steel bar, such as a crowbar, is better. The best tool for this purpose is a dibble bar, a heavy metal tool with a blade and a foot pedal. It is thrust into the ground to make a hole for the plant (see Plate 3.22-3).

Rooted cuttings should be planted vertically in the bank with 1 or 2 inches of wood protruding above the ground surface. They should be stuck in a hole large enough to accommodate the root system when well spread. The plant roots must be maneuvered into the bottom of the hole so they will grow down instead of up. The roots should not be twisted, nor should they be exposed above the ground surface. After the plant is placed, the dibble bar can be installed a few inches away from the plant to close the hole. Slow-release fertilizer should be applied on the surface, not in the hole. The soil should be tamped adequately to provide complete contact between the soil and the cutting. Cuttings should be planted 1 foot on center in at least 3 rows located at the top, middle and bottom of the shrub zone.

Plant seedings of the river alders vertically in the bank to the depth they were growing in the nursery. Use the same procedure described previously. Plant one row of alders at 2-foot intervals at the base of the shrub zone, not more than 1.5 to 3 feet from the average summer water level or from the reeds. A greater distance is of no use unless a belt of tall perennial herb colonies is established between the reeds and the alders. Plant the next row 2 feet up

DIBBLE PLANTING



Source: A Guide For Vegetating Surface-Mined Lands For Wildlife in Eastern Kentucky and West Virginia, USDI-Fish and Wildlife Service

Plate 3.22-3

the slope, with a third row 4 feet up the slope. Plant at least 3 rows. Locate the plants in a diamond pattern.

Since these plants are generally not effective for the first two years, grasses can be seeded immediately following their planting to provide initial streambank protection. The seed mixtures noted in Table 3.22-B are appropriate plantings.

TABLE 3.22-B

INITIAL STREAMBANK PLANTINGS: SEED MIXTURES BY REGION*

Appalachian Region	Piedmont Region	Coastal Plain
Kentucky-31 Tall Fescue: 65 lbs./acre Creeping Red Fescue: 15 lbs./acre Redtop Grass: 5 lbs./acre	Kentucky-31 Tall Fescue: 80 lbs./acre. Redtop Grass: 5 lbs./acre	Kentucky-31 Tall Fescue: 65 lbs./acre Bermudagrass: 15 lbs./acre Redtop Grass: 5 lbs./acre
* Physiographic Regions are described in Std. & Spec. 3.32, PERMANENT SEEDING.		

Source: Va. DSWC

The seedbed should be roughened with rakes and fertilized with 500 to 1000 pounds per acre of 10-10-10, adjusted to meet the needs of the site. Special care should be used when fertilizing next to water sources to avoid any unnecessary introduction of nitrogen/phosphorus into the water. Seed should be broadcast, covered lightly and mulched with 2 tons of straw per acre (2-3 bales per 1000 square feet) or a minimum of 1500 pounds of wood fiber mulch per acre (2000 pounds per acre preferred). If straw is used, it should be properly anchored with netting or an effective tackifier. Erosion control blankets/mats are often very effective aids in the establishment of grasses or plant material along streambanks (see Std. & Spec. 3.36, SOIL STABILIZATION BLANKETS & MATTING).

Willows and other softwoods can also be bound together in various ways in order to insure immediate protection of the streambank.

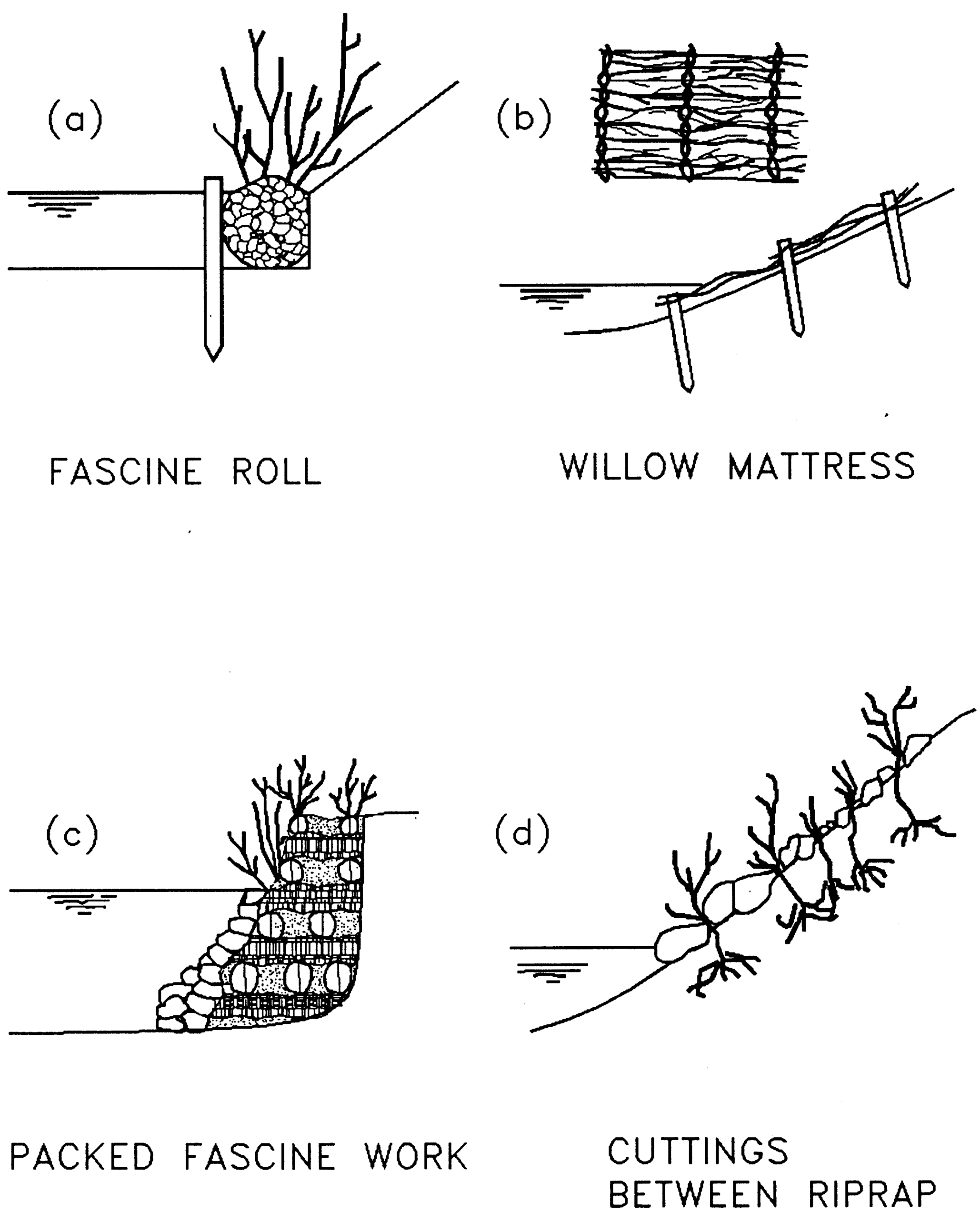
c. Fascine Rolls: Fascine rolls are bundles of brushwood and sticks, without branches if possible, that are filled with coarse gravel and rubble and wired tightly around the outside. They are 4 to 20 yards long and 4 to 16 inches in diameter. They are set against the bank so that the parts which are to take root touch the ground above the water level and are able to get sufficient moisture. Covering with earth improves the contact with the ground and retards the loss of moisture from the wood (see Plate 3.22-4 (a)).

d. Willow Mattresses: The degree of streambank protection can be increased by using willow mattresses or packed fascine work. Willow mattresses consist of 4- to 8-inch thick layers of growing branches set perpendicular to the direction of the current or sloping downstream. with the broad ends of the branches oriented downwards. The branches are held together with interweaving wire or other branches at intervals of 24 to 32 inches, set parallel to the direction of the current or at an angle of 30 degrees. If several layers of mattress are necessary, the tops of the lower layers should cover the bases of the upper layers. The bottom layer is fixed at the base in a trench previously dug at the base of the softwood zone. The whole mattress structure should be covered with 2 to 10 inches of earth or fine gravel (Plate 3.22-4 (b)).

e. Packed Fascine-Work: Packed fascine-work [Plate 3.22-4 (c)] consists essentially of layers of branches laid one across the other to a depth of 8 to 12 inches and covered with fascine rolls. The spaces between the fascine rolls are filled with gravel, stones and soil so that no gaps remain; and a layer of soil and gravel 8 to 12 inches thick is added on top. Packed fascine-work is particularly suitable for repairing large breaches in the banks of streams with high water levels.

f. Combination with Stone Facing: In many places, the bank is not adequately protected by vegetation until the roots are fully developed, and temporary protection must be provided by inanimate materials. There is a wide choice of methods, including the planting of woody plants in the crevices of stone facing (Plate 3.22-4 (d)). For structural protection measures, see Std. & Spec. 3.23, STRUCTURAL STREAMBANK PROTECTION.

METHODS OF ESTABLISHING SHRUB ZONE VEGETATION



Source: Importance of Natural Vegetation for the Protection of the Banks of Streams, Rivers and Canals, Seibert

Plate 3.22-4

Maintenance

Streambanks are always vulnerable to new damage. Repairs are needed periodically. Banks should be checked after every high-water event is over. Gaps in the vegetative cover should be fixed at once with new plants, and mulched if necessary. Fresh cuttings from other plants on the bank can be used, or they can be taken from mother-stock plantings if they are available. Trees that become established on the bank should be removed at once.

STD & SPEC 3.23

STRUCTURAL STREAMBANK STABILIZATION

SSS

Definition

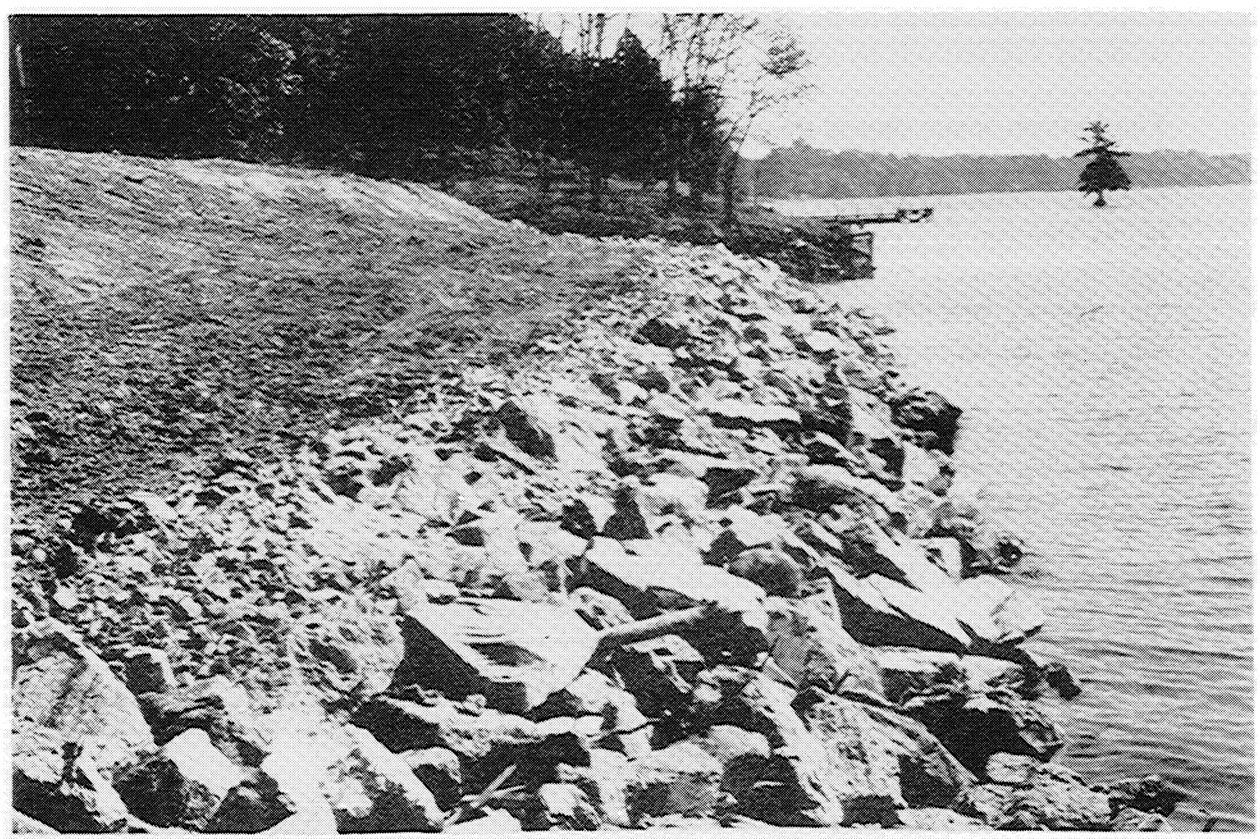
Methods of stabilizing the banks of live streams with permanent structural measures.

Purpose

To protect streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies

Applicable to streambank sections which are subject to excessive erosion due to increased flows or disturbance during construction. Generally applicable where flow velocities exceed 5 ft./sec. or where vegetative streambank protection is inappropriate.



Planning Considerations

Stream channel erosion problems vary widely in type and scale and there are many different structural stabilization techniques which have been employed with varying degrees of effectiveness. The purpose of this specification is merely to point out some of the practices which are available and to establish some broad guidelines for their selection and design. Such structures should be planned and designed in advance by an engineer or some other qualified individual with appropriate experience. Many of the practices referenced here involve the use of manufactured products and should be designed and installed in accordance with the manufacturers' specifications.

Before selecting a structural stabilization technique, the designer should carefully evaluate the possibility of using vegetative stabilization (Std. & Spec. 3.22) alone or in conjunction with structural measures, to achieve the desired protection. Vegetative techniques are generally less costly and more compatible with natural stream characteristics.

General Guidelines

Since each reach of channel requiring protection is unique, measures for streambank protection should be installed according to a plan and adapted to the specific site. Designs should be developed according to the following principles:

1. Protective measures to be applied shall be compatible with improvements planned or being carried out by others.

2. The bottom scour should be controlled, by either natural or artificial means, before any permanent type of bank protection can be considered feasible. This is not necessary if the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.

3. Streambank protection should be started and ended at a stabilized or controlled point on the stream.

4. Changes in channel alignment shall be made only after an evaluation of the effect upon land use, interdependent waste water systems, hydraulic characteristics and existing structures.

5. Special attention should be given to maintaining and improving habitat for fish and wildlife.

6. The design velocity should be that of the peak discharge of the 10-year storm. Structural measures must be effective for this design flow and must be capable of withstanding greater flows without serious damage.

7. All requirements of state law and permit requirements of local, state and federal agencies must be met.

8. Stabilize all areas disturbed by construction as soon as the structural measures are complete.

Streambank Protection Measures

Riprap - heavy angular stone placed (preferably) or dumped onto the streambank to provide armor protection against erosion. Riprap shall be designed and installed according to the practice entitled RIPRAP (Std. & Spec. 3.19).

Gabions - rectangular, rock-filled wire baskets are pervious, semi-flexible building blocks which can be used to armor the bed and/or banks of channels or to divert flow away from eroding channel sections. Gabions should be designed and installed in accordance with manufacturer's standards and specifications (see Plate 3.23-1). At a minimum, they should be constructed of a hexagonal triple twist mesh of heavily galvanized steel wire (galvanized wire may also receive a poly-vinyl chloride coating). The design water velocity for channels utilizing gabions should not exceed that given below:

Gabion Thickness (feet)	Maximum Velocity (feet per second)
1/2	6
3/4	11
1	14

Deflectors (groins or jetties) - Structural barriers which project into the stream to divert flow away from eroding streambank sections. Plate 3.23-2 contains general guidelines for designing and installing deflectors.

Installation of Structures Under Wave and/or Tidal Action

The installation of riprap, gabions or deflectors under significant wave action or under tidal conditions requires special design considerations to ensure stability of the measure and the area it protects. The design/installation of these measures for tidal areas is beyond the scope of the Virginia Erosion and Sediment Control Law and Virginia Erosion and Sediment Control Regulations. The DSWC's Shoreline Programs Bureau can be consulted in regard to minimum design parameters for tidal installations. For situations where there is significant wave action affecting the shoreline of a nontidal lake or pond, the design parameters presented in Std. & Spec. 3.19, RIPRAP, should be used. Notably, there are many other site specific factors which should be incorporated into a design; hence, it is recommended that the design parameters presented only be used as minimum requirements and that a qualified professional be consulted when the installation of such a structure is contemplated.

Reinforced Concrete - may be used to armor eroding sections of the streambank by constructing retaining walls or bulk heads. Positive drainage behind these structures must be provided. Reinforced concrete may also be used as a channel lining (see Std. & Spec. 3.17, STORMWATER CONVEYANCE CHANNEL).

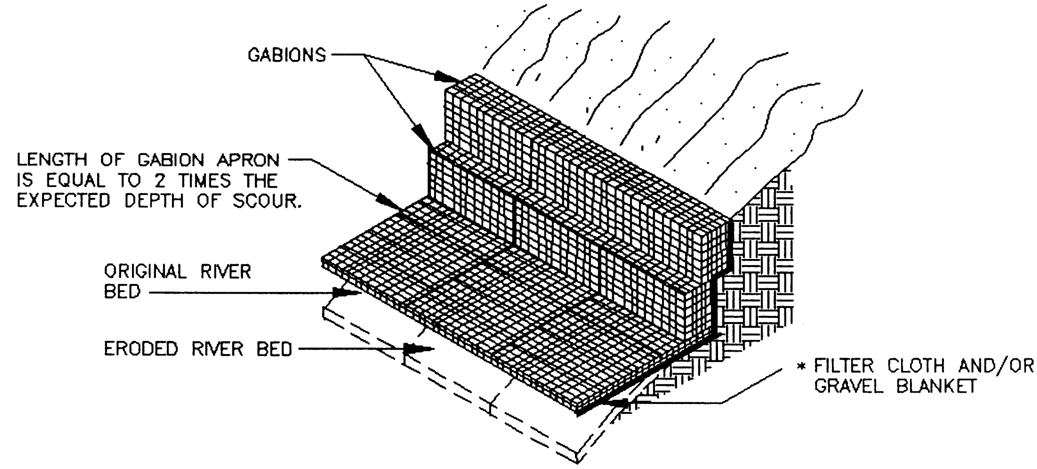
Log Cribbing - a retaining structure built of logs to protect streambanks from erosion. Log cribbing is normally built on the outside of stream bends to protect the streambank from the impinging flow of the stream (see Plate 3.23-3).

Grid Pavers - modular concrete units with interspersed void areas which can be used to armor the streambank while maintaining porosity and allowing the establishment of vegetation. These structures may be obtained in pre-cast blocks or mats, or they may be formed and poured in place. Design and installation should be in accordance with manufacturer's instructions (see Plate 3.23-4).

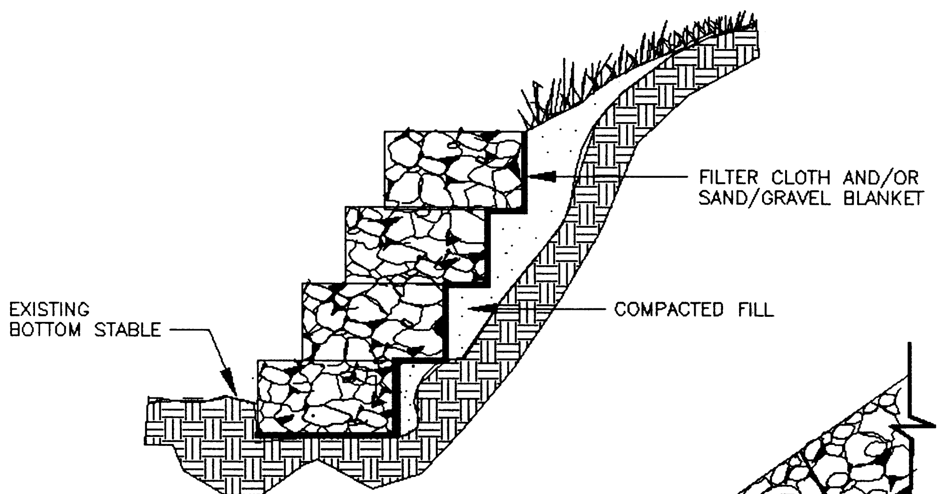
Maintenance

All structures should be maintained in an "as built" condition. Structural damage caused by storm events should be repaired as soon as possible to prevent further damage to the structure or erosion of the streambank.

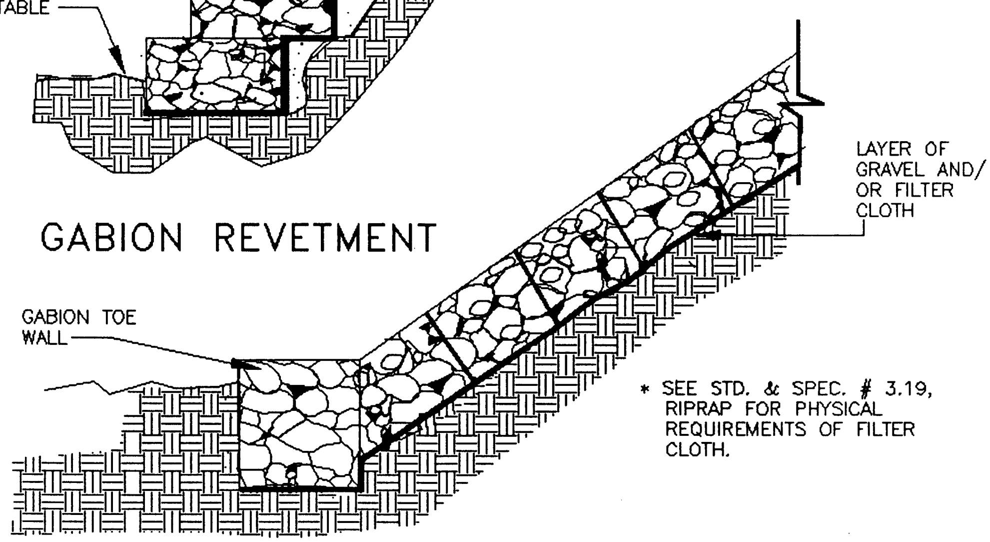
GABIONS



GABION TOE WALL



GABION REVETMENT

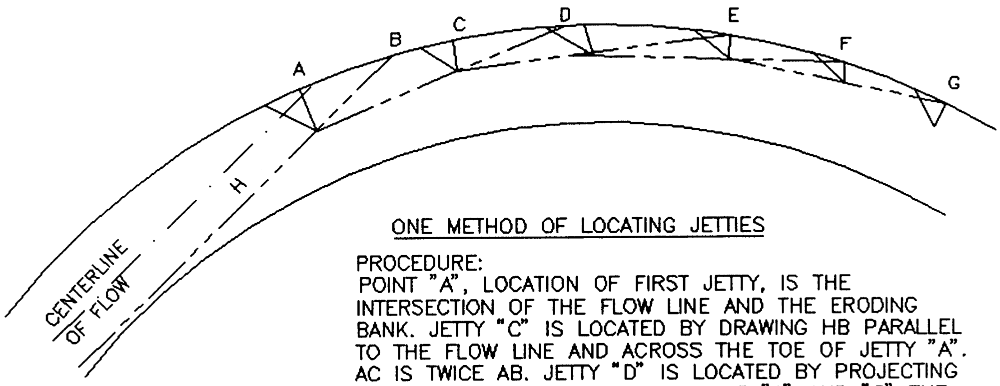


REVETMATTRESS / RENOMATTRESS

Source: Adapted from product literature of Bekaert Gabions

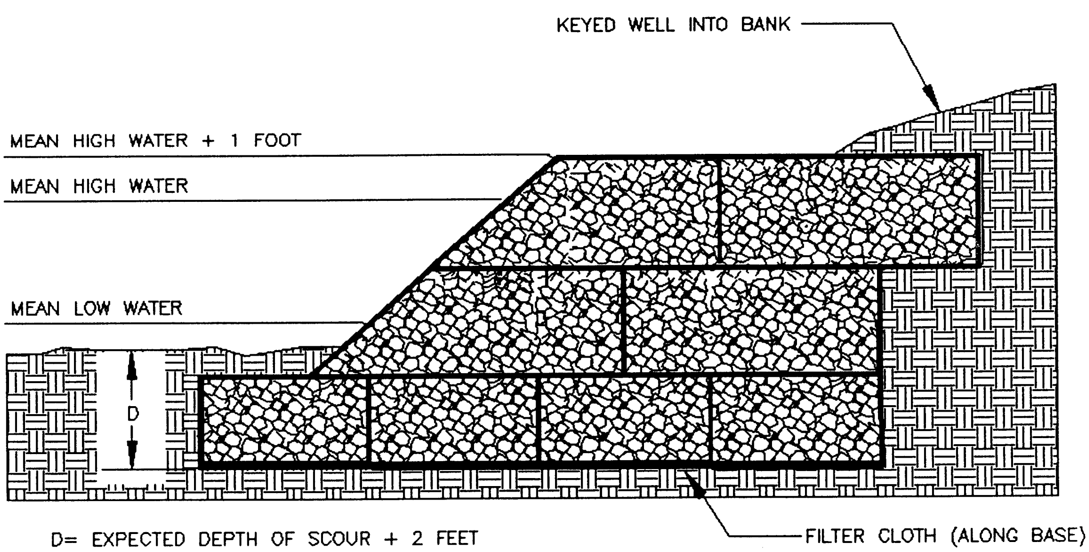
Plate 3.23-1

DEFLECTORS



ONE METHOD OF LOCATING JETTIES

PROCEDURE:
POINT "A", LOCATION OF FIRST JETTY, IS THE INTERSECTION OF THE FLOW LINE AND THE ERODING BANK. JETTY "C" IS LOCATED BY DRAWING HB PARALLEL TO THE FLOW LINE AND ACROSS THE TOE OF JETTY "A". AC IS TWICE AB. JETTY "D" IS LOCATED BY PROJECTING A LINE ACROSS THE TOE OF JETTIES "A" AND "C". THE REMAINING JETTIES ARE LOCATED THE SAME AS "D". SUPPLEMENTARY JETTY "K" IS LOCATED AC DISTANCE UPSTREAM FROM "A".

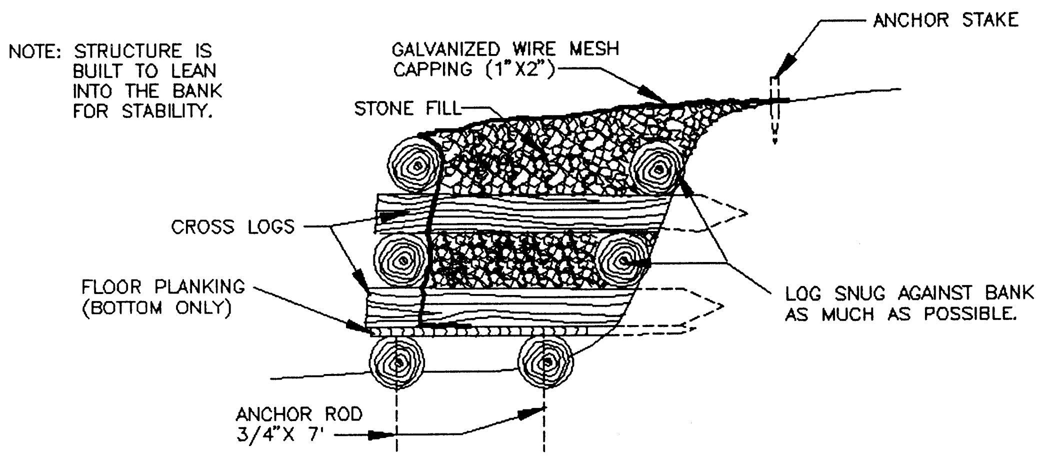


TYPICAL GABION DEFLECTOR

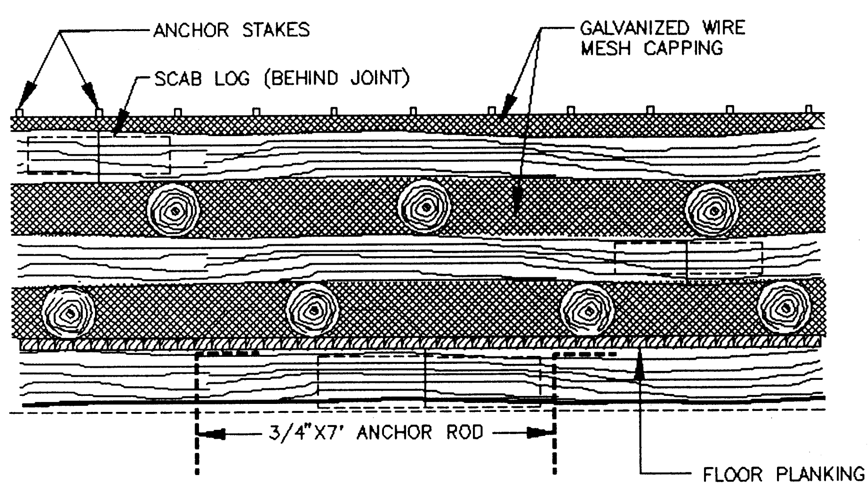
Source: Adapted from product literature of Bekaert Gabions

Plate 3.23-2

LOG CRIBBING



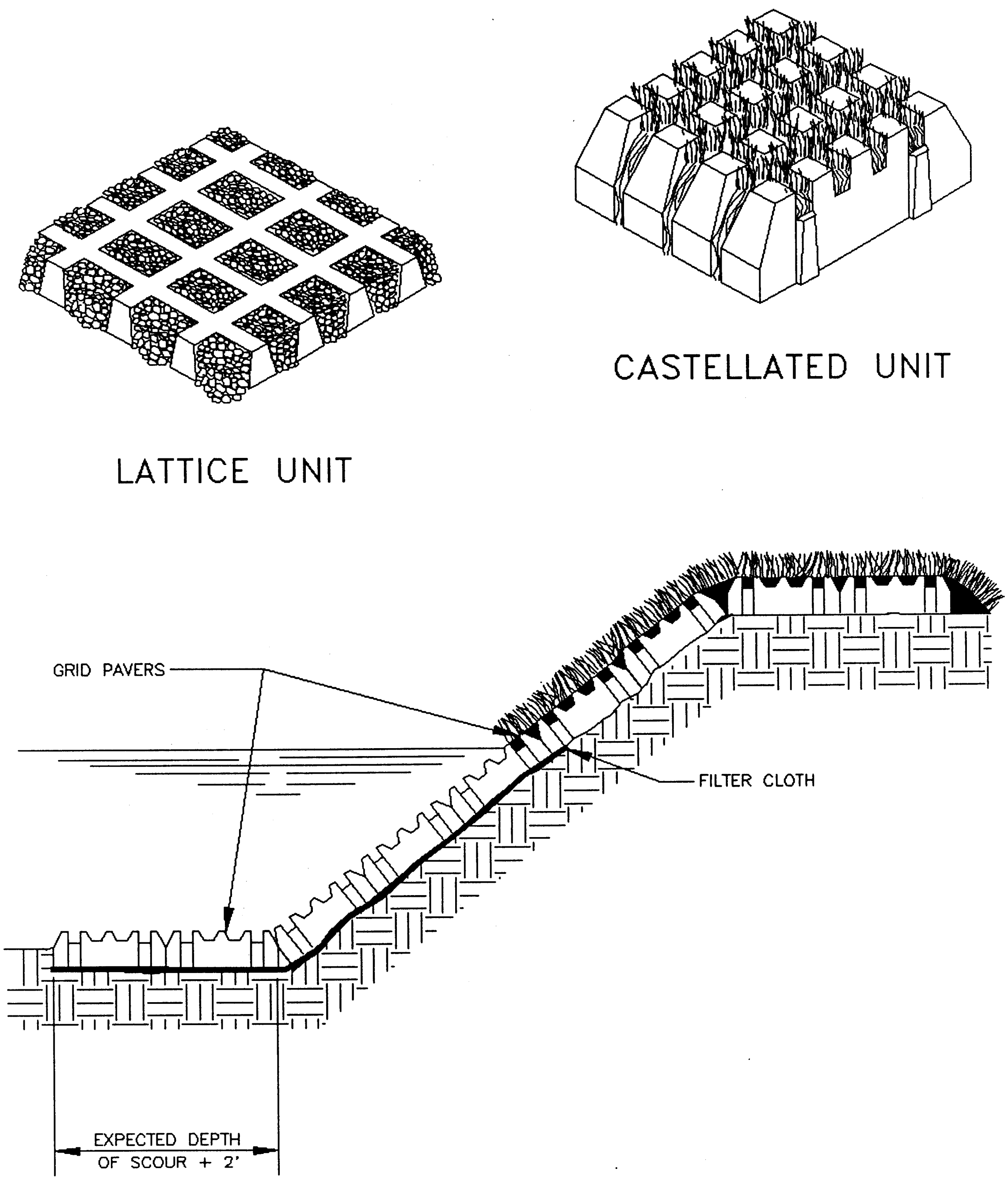
SIDE VIEW



FRONT VIEW

Source: Introductory Guide to Stream Improvement Plate 3.23-3

GRID PAVERS



Source: Va. DSWC

Plate 3.23-4

STD & SPEC 3.24

TEMPORARY VEHICULAR STREAM CROSSING

SC

Definition

A temporary structural span installed across a flowing watercourse for use by construction traffic. Structures may include bridges, round pipes, pipe arches, or oval pipes.

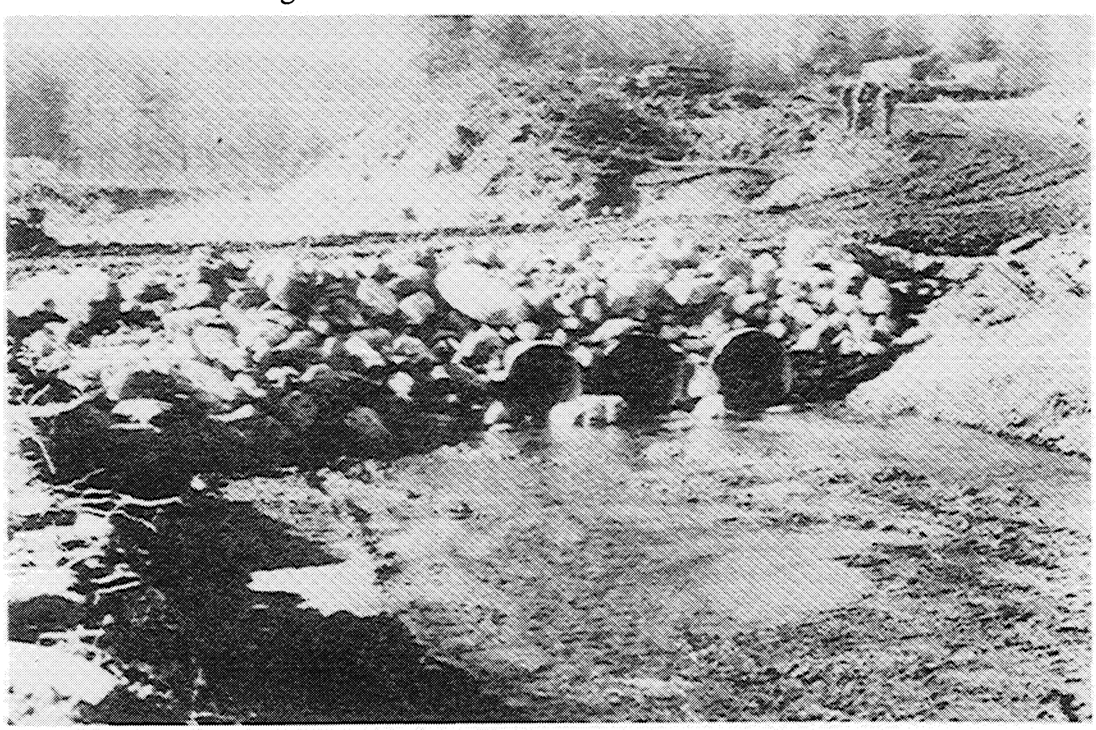
Purposes

1. To provide a means for construction traffic to cross flowing streams without damaging the channel or banks.

2. To keep sediment generated by construction traffic out of the stream.

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than 1 square mile. Structures which must handle flow from larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.



Planning Considerations

Temporary stream crossings are necessary to prevent construction vehicles from damaging streambanks and continually tracking sediment and other pollutants into the flow regime. These structures are, however, also undesirable in that they represent a channel constriction which can cause flow backups or washouts during periods of high flow. For this reason, the temporary nature of stream crossings is stressed. They should be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed.

The specifications contained in this section pertain primarily to flow capacity and resistance to washout of the structure. From a safety and utility standpoint, the designer must also be sure that the span is capable of withstanding the expected loads from heavy construction equipment which will cross the structure. The designer must also be aware that such structures are subject to the rules and regulations of the U. S. Army Corps of Engineers for in-stream modifications (404 permits).

A temporary bridge crossing is a structure made of wood, metal, or other materials which provides access across a stream or waterway. It is the preferred method for temporary waterway crossings. Normally, bridge construction causes the least amount of disturbance to the stream bed and banks when compared to the other types of crossings. They can also be quickly removed and reused. In addition, temporary bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings. A temporary culvert crossing is a structure consisting of stone and a section(s) of circular pipe, pipe arches, or oval pipes of reinforced concrete, corrugated metal, or structural plate, which is used to convey flowing water through the crossings. Temporary culverts are used where the channel is too wide for normal bridge construction or the anticipated loading of construction vehicles may prove unsafe for single span bridges. There is some disturbance within the stream during construction and removal of the temporary culvert crossing. The stone, along with the temporary culverts, can be salvaged and reused.

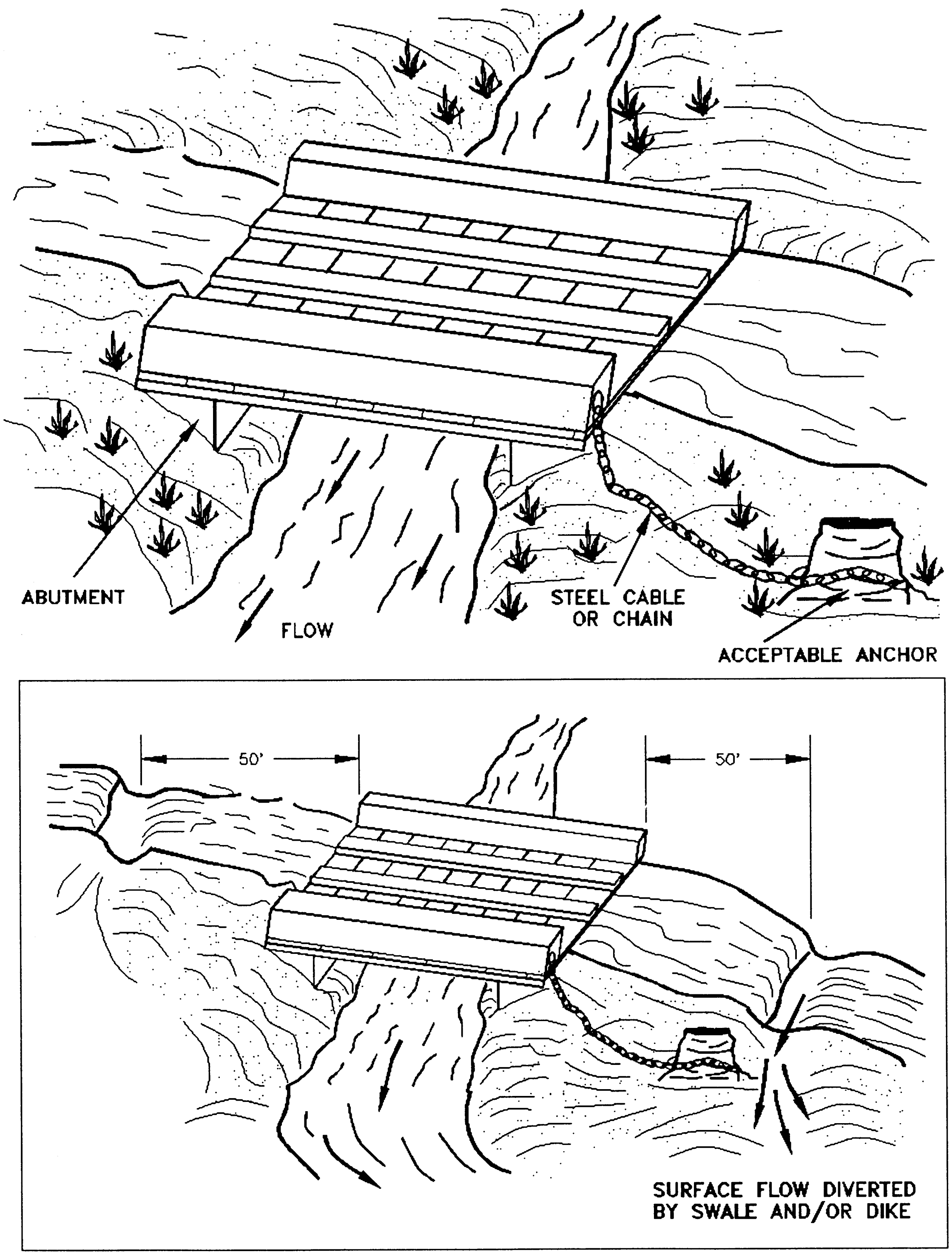
Design Criteria

1. Temporary Bridge Crossing

   a. Structures may be designed in various configurations. However, the materials used to construct the bridge must be able to withstand the anticipated loading of the construction traffic. Plate 3.24-1 shows on example of such a crossing.

   b. Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15° from a line drawn perpendicular to the center line of the stream at the intended crossing location.

TEMPORARY BRIDGE CROSSING



Source: 1983 Maryland Standards and Specifications for Soil Erosion and Sediment Control

Plate 3.24-1

c. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.

d. A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with Std. & Spec. 3.11, TEMPORARY RIGHT OF WAY DIVERSION or Std. & Spec. 3.09, TEMPORARY DIVERSION DIKE. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

e. Appropriate perimeter controls such as SILT FENCE (Std. & Spec. 3.05) or TURBIDITY CURTAIN (Std. & Spec. 3.27) must be employed when necessary along banks of stream parallel to the same.

f. All crossings shall have one traffic lane. The minimum width shall be 12 feet with a maximum width of 20 feet.

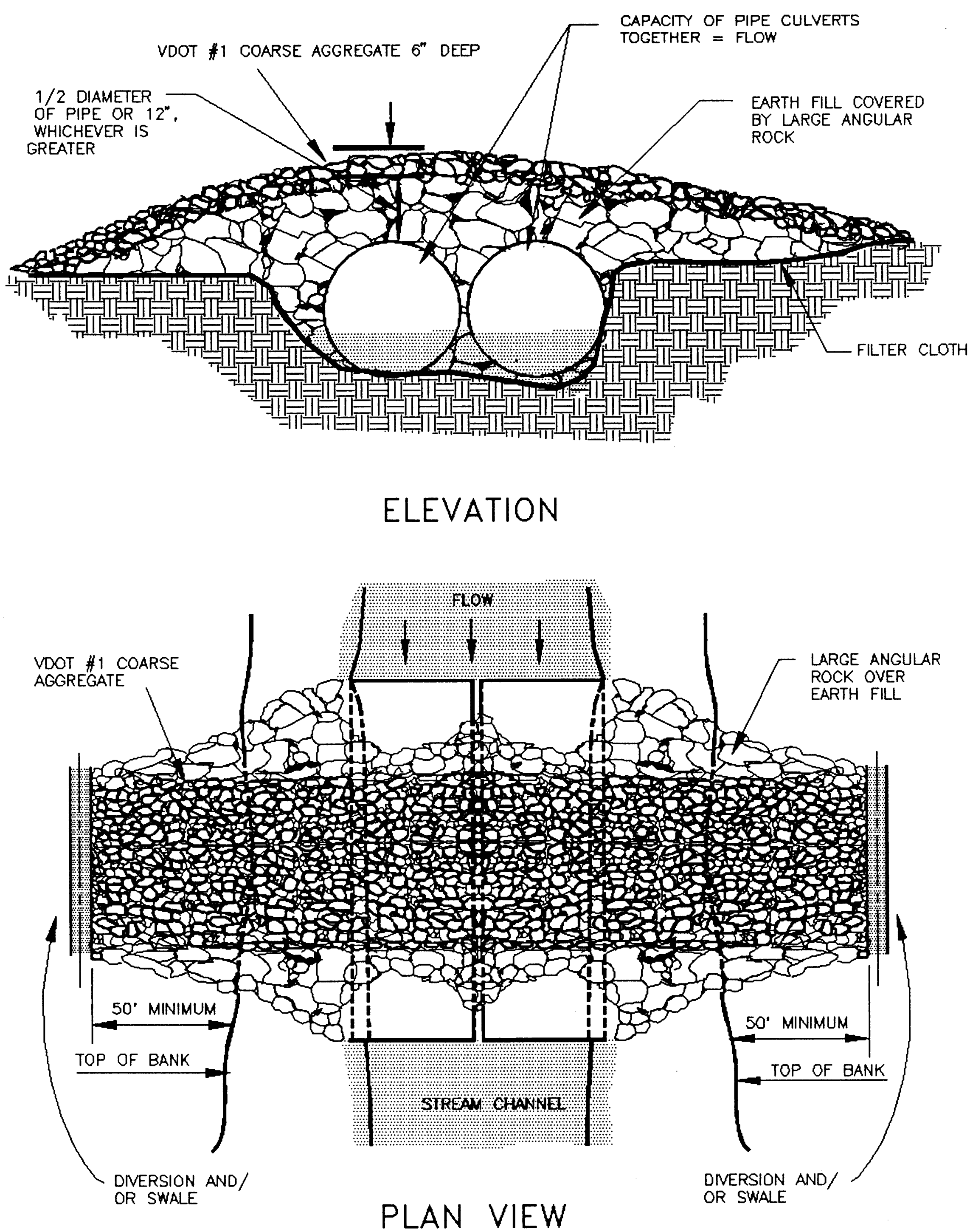
g. Further design/construction recommendations for temporary bridge construction may be found in Construction Specifications.

2. <u>Temporary Culvert Crossing</u>

a. Where culverts are installed, VDOT #1 Coarse Aggregate <u>or larger</u> will be used to form the crossing. The depth of stone cover over the culvert shall be equal to one-half the diameter of the culvert or 12 inches, whichever is greater. To protect the sides of the stone from erosion, riprap shall be used and designed in accordance with Std. & Spec. 3.19, RIPRAP (see Plate 3.24-2).

b. If the structure will remain in place for <u>up to 14 days</u>, the culvert shall be large enough to convey the flow from a 2-year frequency storm without appreciably altering the stream flow characteristics. See Table 3.24-A for aid in selecting an appropriate culvert size (note all assumptions). If the structure will remain in place <u>14 days to 1 year</u>, the culvert shall be large enough to convey the flow from a 10-year frequency storm. In this case, the hydrologic calculation and subsequent culvert size must be done for the specific watershed characteristics. If the structure must remain in place over 1 year, it must be designed as a permanent measure by a qualified professional.

TEMPORARY CULVERT CROSSING



Source: Va. DSWC

Plate 3.24-2

c. Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert that may be used is 18 inches.

d. All culverts shall be strong enough to support their cross-sectioned area under maximum expected loads.

e. The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.

f. The slope of the culvert shall be at least 0.25 inch per foot.

g. Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15° from a line drawn perpendicular to the centerline of the stream at the intended crossing location.

h. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.

i. The approaches to the structure shall consist of stone pads meeting the following specifications:

1) Stone: VDOT #1
2) Minimum thickness: 6 inches
3) Minimum width: equal to the width of the structure

j. A water diverting structure such as a swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with Std. & Spec. 3.11, TEMPORARY RIGHT OF WAY DIVERSION or Std. & Spec. 3.09, TEMPORARY DIVERSION DIKE. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

TABLE 3.24-A
PIPE DIAMETER (INCHES) FOR STREAM CROSSINGS[a]

Drainage Area (Acres)	Average Slope of Watershed			
	1%	4%	8%	16%
1 - 25	24	24	30	30
26 - 50	24	30	36	36
51 - 100	30	36	42	48
101 - 150	30	42	48	48
151 - 200	36	42	48	54
301 - 350	42	48	60	60
351 - 400	42	54	60	60
451 - 500	42	54	60	72
501 - 550	48	60	60	72
551 - 600	48	60	60	72
601 - 640	48	60	72	72

[a] Note: Table is based on USDA-SCS Graphical Peak Discharge Method for 2-year frequency storm event, CN = 65; Rainfall depth = 3.5 inches (average for Virginia).

Source: Va. DSWC

Construction Specifications

1. Temporary Bridge Crossing (see Plate 3.24-1)

   a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.

b. The temporary bridge structure shall be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.

c. Abutments shall be placed parallel to and on stable banks.

d. Bridges shall be constructed to span the entire channel. If the channel width exceeds 8 feet (as measured from top-of-bank to top-of-bank), then a footing, pier or bridge support may be constructed within the waterway. One additional footing, pier or bridge support will be permitted for each additional 8-foot width of the channel. No footing, pier or bridge support, however, will be permitted within the channel for waterways which are less than 8 feet wide.

e. Stringers shall either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.

f. Decking materials shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.

g. Run planking (optional) shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.

h. Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option which will provide additional safety.

i. Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.

j. All areas disturbed during installation shall be stabilized within 7 calendar days of that disturbance in accordance with MS #1.

k. When the temporary bridge is no longer needed, all structures including abutments and other bridging materials should be removed immediately.

l. Final clean-up shall consist of removal of the temporary bridge from the waterway, protection of banks from erosion, and removal of all construction materials. All removed materials shall be stored outside flood plain of the stream. Removal of the bridge and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.

2. Temporary Culvert Crossing

a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.

b. The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration.

c. Filter cloth shall be placed on the streambed and streambanks prior to placement of the pipe culvert(s) and aggregate. The filter cloth shall cover the streambed and extend a minimum of six inches and a maximum of one foot beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability. See Std. & Spec. 3.19, RIPRAP, for required physical qualities of the filter cloth.

d. The culvert(s) shall extend a minimum of one foot beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case shall the culvert exceed 40 feet in length.

e. The culvert(s) shall be covered with a minimum of one foot of aggregate. If multiple culverts are used, they shall be separated by at least 12 inches of compacted aggregate fill. At a minimum, the bedding and fill material used in the construction of the temporary access culvert crossings shall conform with the aggregate requirements cited in part "i" under "Temporary Culvert Crossing."

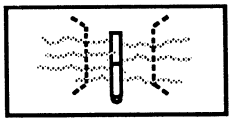
f. When the crossing has served its purpose, all structures including culverts, bedding and filter cloth materials shall be removed. Removal of the structure and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.

g. Upon removal of the structure, the stream shall immediately be shaped to its original cross-section and properly stabilized.

Maintenance

Both structures shall be inspected after every rainfall and at least once a week, whether it has rained or not, and all damages repaired immediately.

STD & SPEC 3.25



UTILITY STREAM CROSSING

USC

Definition

A strategy for crossing small waterways when in-stream utility construction is involved.

Purposes

1. To help protect sediment from entering the stream from construction within approach areas.

2. To minimize the amount of disturbance within the stream itself.

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than one square mile. Structures or methodology for crossing streams with larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.

A *Diversion Channel* may be utilized to allow "work in the dry".

Planning Considerations

Utility construction, by virtue of its sprawling, linear nature, frequently crosses and impacts live streams. There is a potential for excessive sediment loss into a stream by both the disturbance of the approach areas and by the work with the stream-bed and banks.

It is often a difficult task to decide what type of control to use as a utility stream crossing. A method such as the "boring and jacking" of pipe below a streambed, which would prevent disturbance within the watercourse, is a preferred method if it is practical. However, in cases where in-stream work is unavoidable, consideration must be given to providing adequate mitigation of sediment loss while minimizing the amount of encroachment (MS #12) and time spent working in the channel. There is some "give and take" as far as the installation of controls - sometimes there is less damage to the environment created by providing substantial controls for the approach areas and refraining from installing extensive measures in the stream itself. However, when the installation of the utility line within streambed and banks will take an extended period of construction time, consideration should be given to substantial in-stream controls or stream diversion in order to prevent excessive sedimentation damage.

As a result of the difficulty in choosing the right method for a utility stream crossing, designers and plan reviewers should always make site visits of proposed crossing to ensure that the most appropriate method is chosen. The designer and plan reviewer should also be aware that such modifications are subject to other state and federal construction permits.

The following are several methods for dealing with utility stream crossings (with varying construction time and stream size scenarios) which allow for "work in the dry" to prevent excessive sedimentation damage. By no means are these methods all-inclusive. As with other control measures, site-specific design and innovative variations are encouraged.

Design Criteria (All methods)

1. The drainage area should be no greater than one square mile (640 acres).

2. All filter cloth used in the construction of the utility crossing must conform to physical requirements noted in Std. & Spec. 3.19, RIPRAP.

3. Water diverting structures should be used at all trenching and/or construction road approaches (50 feet on either side of the crossing) as per Std. & Spec. 3.24, VEHICULAR STREAM CROSSING.

4. Design criteria more specific to each particular crossing can be found in Plates 3.25-1 through 3.25-4.

Construction Specifications

1. Diversion Channel Crossing - Preferred method if construction will remain in area of stream for an extended period (longer than 72 hours) and site conditions (such as width of stream) make diversion practical.

   a. The diversion channel crossing must be operational before work is done in the stream (construction will be performed "in the dry").

   b. Minimum width of bottom shall be six feet or equal to bottom width of existing streambed, whichever is less. Refer to Plates 3.25-1 and 3.25-2.

   c. Maximum steepness of side slopes shall be 2:1. Depth and grade may be variable, dependent on site conditions, but shall be sufficient to ensure continuous flow of water in the diversion.

   d. There are three types of diversion channel linings which can be used, based upon expected velocity of bankfull flow. Refer to Plate 3.25-2 and the following table:

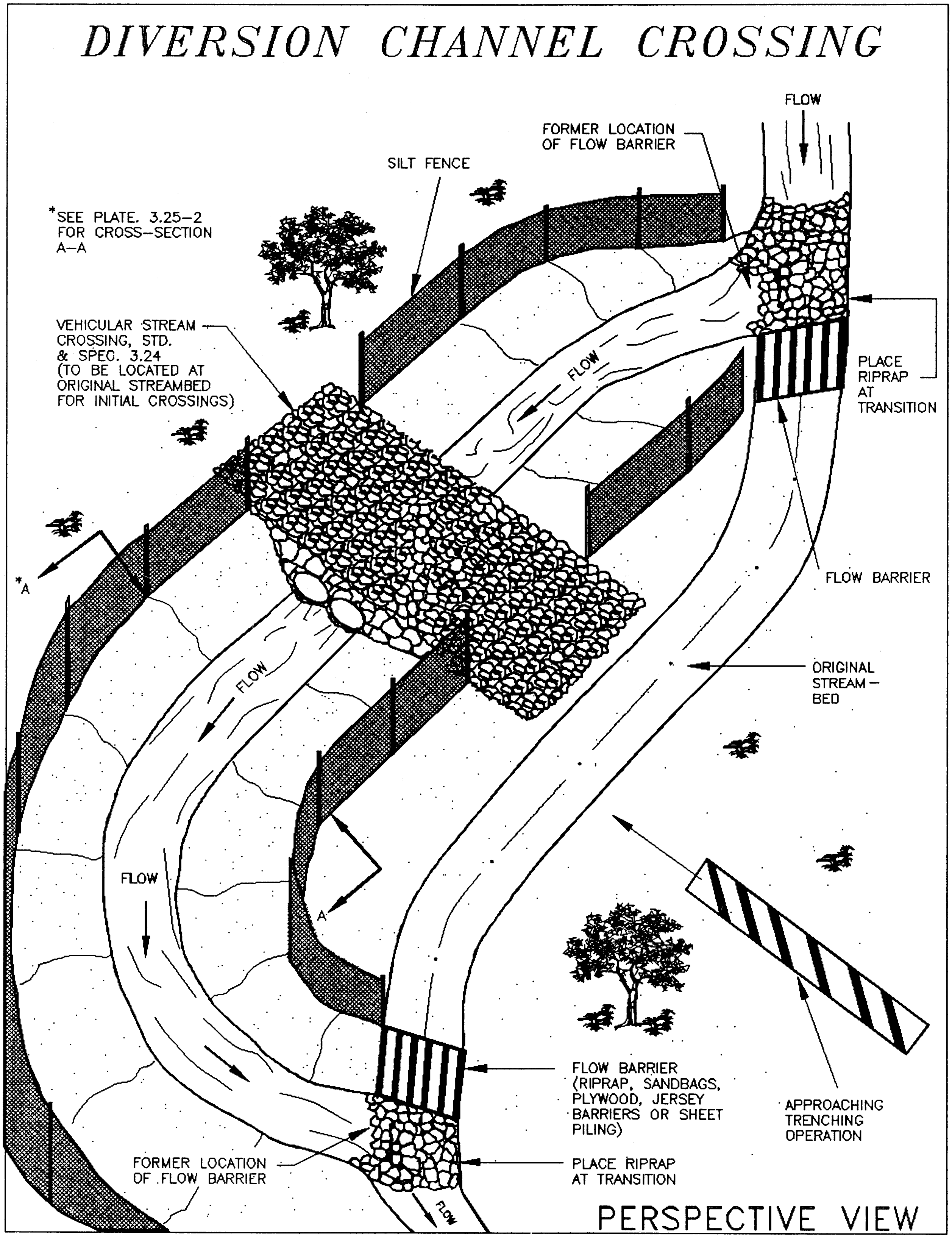
TABLE 3.25-A

DIVERSION CHANNEL LININGS

Lining Material	Classification	Acceptable Velocity Range
Filter Cloth*, Polyethylene or Grass	TYPE A	0 - 2.5 f.p.s.
Filter Cloth*	TYPE B	2.5 - 9.0 f.p.s.
Class I Riprap and Filter Cloth*	TYPE C	9.0 - 13.0 f.p.s.

* Filter Cloth must meet the minimum physical requirements noted in Std. & Spec. 3.19, RIPRAP.

Source: VDOT Standard Sheets

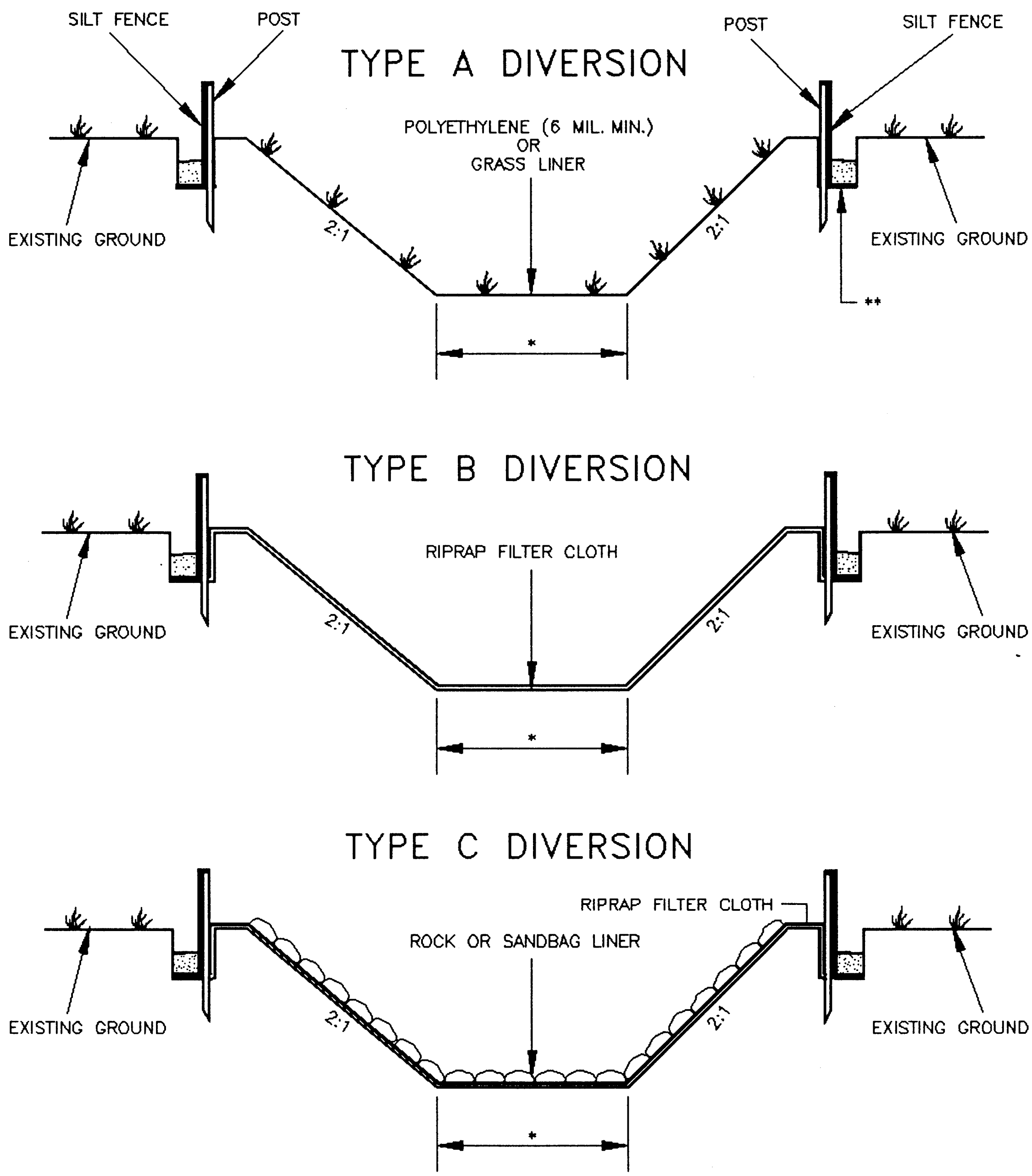


Source: Va. DSWC

Plate 3.25-1

DIVERSION CHANNEL CROSSING

ACCEPTABLE LININGS (CROSS SECTION A-A OF PLATE 3.25-1)



* 6' MINIMUM OR WIDTH OF EXISTING STREAM WHICHEVER IS LESS

** ENTRENCH SILT FENCE AND FILTER CLOTH IN SAME TRENCH

Source: Adapted from VDOT Standard Sheets

Plate 3.25-2

e. Type A stream diversions may be seeded with a standard seed mix for the type of soils encountered and the time of year seed is sown. An average growth of two inches in height shall be achieved throughout the diversion with an 85% cover before water is turned through it.

f. Stream diversion liners shall be secured at the upstream and downstream sides with non-erodible weights such as riprap. These weights shall allow normal flow of the stream. Soil shall not be mixed in with stream diversion weights. Weights may also be needed along the stream diversion's length to secure liner.

g. Stream diversion liners should be overlapped when a single or continuous liner is not available or is impractical. Overlaps should be such that continuous flow of the steam is maintained. An upstream section should overlap a downstream section by a <u>minimum of 18 inches</u>. Overlaps along the cross-section should be made such that a liner is placed in the steam diversion bottom first and additional pieces of liner on the slopes overlap the bottom piece by a minimum of 18 inches.

h. Stream diversion liners shall be entrenched at the top of the diversion slopes (slopes breaks) along with a line of silt fence. Silt fence may be excluded if the diversion liner is extended to such a point that siltation of the stream will not occur. If silt fence is excluded, the diversion liner must be secured. Liners shall extend from slope break to slope break as shown in Plate 3.25-2.

i. Staples used in securing SOIL STABILIZATION BLANKETS AND MATTING (see Std. & Spec. 3.36) or non-erodible weights (riprap) shall be used as necessary to anchor stream diversion liners to the side slopes of the diversion. Wooden stakes should not be used on the diversion's bottom or side slopes.

j. Non-erodible materials such as riprap, jersey barriers, sandbags, plywood, or sheet piling, shall be used as flow barriers to divert the stream away from its original channel and to prevent or reduce water backup into a construction area.

k. The downstream flow barrier is to be removed prior to the upstream barrier when opening a stream diversion for the transport of water.

l. Streams should be rediverted upon completion of the utility crossing for which the diversion was built. Prior to rediversion, any materials (flow barrier) used to prevent water backup into the downstream end of the original streambed shall be removed. This material should not be placed in the downstream end of the diversion until after water has been rediverted to the original waterway. The stream should then be rediverted by removing all of the materials damming the upstream end of the original streambed and then placing it in the upstream end of the stream diversion. The diversion should be sealed off at the downstream end and then backfilled.

Once started, any work to relocate a stream shall not be discontinued until it is completed.

m. Stream should be rediverted only after backfilling and restabilization of original streambed and banks is completed. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of its utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by the Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.

n. Any dewatering discharge from this operation shall be placed into an approved DEWATERING STRUCTURE (see Std. & Spec. 3.26).

2. Flume Pipe Crossing - To be used when in-stream construction will last less than 72 hours and stream is narrow (less than 10 feet wide), making "cofferdam" construction impractical.

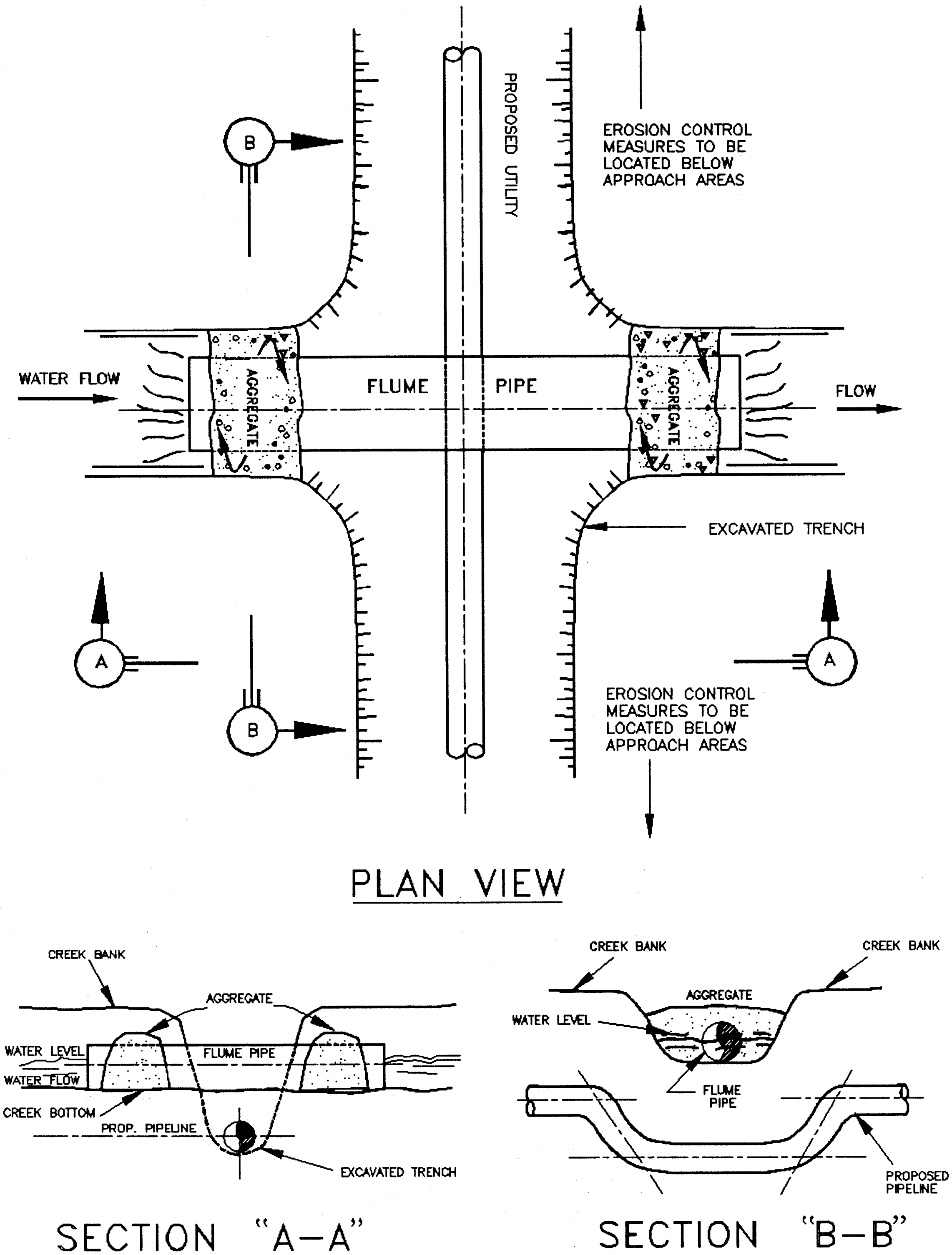
a. The flume pipe crossing must be made operational prior to the start of construction in the stream.

b. The materials used (culvert(s), stone and filter fabric) must meet the physical constraints of those used in VEHICULAR STREAM CROSSING, Std. & Spec. 3.24.

c. A large flume pipe (or culvert) of an adequate size to support normal water channel flow (see Table 3.24-A) shall then be installed in the stream bed across the proposed pipeline trench centerline. VDOT #1 Coarse Aggregate (minimum size) or riprap shall be placed close to each end of the flume pipe so as to dam off the creek forcing the water to flow through the flume pipe (see Plate 3.25-3).

d. The entrapped water can then be pumped from the creek within the dammed-off area and in the proposed trench centerline into an approved DEWATERING STRUCTURE (see Std. & Spec. 3.26). The trench can then be dug under the flume pipe. The pipe sections will then be installed to the proper depth under the flume pipe. After pipe sections are installed, the ditch will be backfilled and restabilization shall be carried out.

FLUME PIPE CROSSING



Source: Va. DSWC

Plate 3.25-3

e. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of the utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by the Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.

f. After completion of backfilling operation and restoration of stream/creek banks and leveling of stream bed, the flume pipe can then be removed. The gravel can be removed or spread in the stream bed depending on permit requirements. Sediment control in approach areas shall not be removed until all construction is completed in stream/creek crossing area. All ground contours shall be returned to their original condition.

3. Cofferdam Utility Crossing - To be used when stream diversion is not practical and stream is wide enough (10 feet or wider) to make cofferdam installation practical.

a. Construction is to be performed in low flow periods.

b. Crossing shall be accomplished in a manner that will not prohibit the flow of the stream. (See Plate 3.25-4).

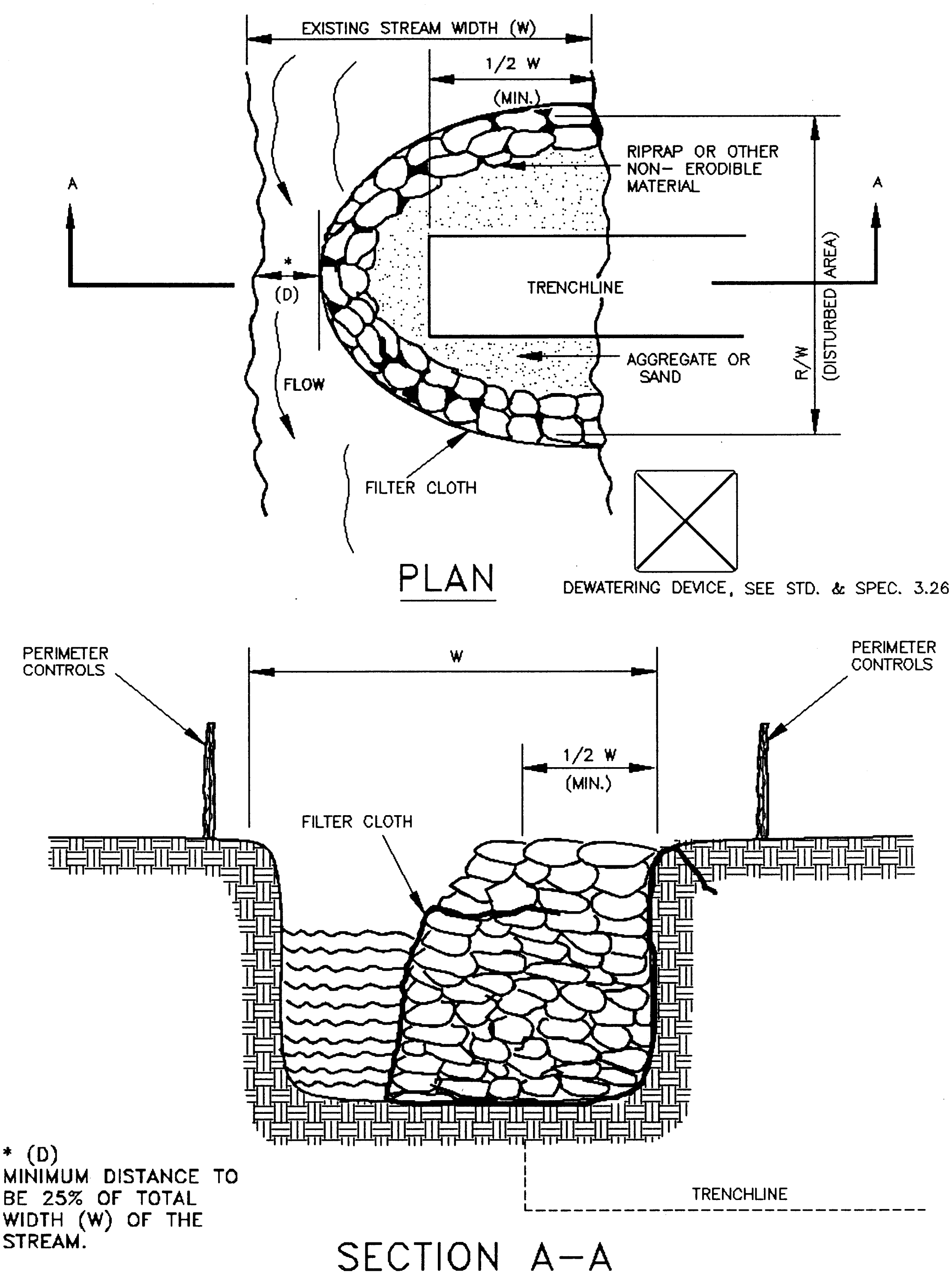
c. As with all utility line crossings, approach areas must be controlled with perimeter measures such as silt fence or straw bales.

d. Remove large rocks, woody vegetation, or other material from the streambed and banks that may get in the way of placing the riprap, sandbags, sheet metal, or wood planks or installing the utility pipe or line.

e. Form a cofferdam by placing the riprap (or other non-erodible materials) in a semicircle along the side of the stream in which the utility installation will begin. It must be surrounded and underlain with filter cloth as shown in Plate 3.25-4. The height of and area within the dam will depend upon the size of the work area and the amount of steam flow. Stack materials as high as will be necessary to keep water from overtopping the dam and flooding the work area. When the stream flow is successfully diverted by the cofferdam, dewater the work area and stabilize it with aggregate (VDOT #57 or #68 Coarse Aggregate) or sand. Make sure to discharge the water into a sediment trapping device (see DEWATERING STRUCTURE, Std. & Spec. 3.26).

g. Install the utility pipe or line in half the streambed as noted in Plate 3.25-4. Remove the riprap or other materials and begin placing them on the other side of the stream.

COFFERDAM CROSSING



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

Source: Va. DSWC

Plate 3.25-4

h. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of its utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.

Maintenance

Care must be taken to inspect any steam crossing area at the end of each day to make sure that the construction materials are positioned securely. This will ensure that the work area stays dry and that no construction materials float downstream.

STD & SPEC 3.26

DEWATERING STRUCTURE

DS

Definition

A temporary settling and filtering device for water which is discharged from dewatering activities.

Purpose

To filter sediment-laden water prior to the water being discharged off-site.

Conditions Where Practice Applies

Wherever sediment-laden water must be removed from a construction site by means of pumping.

Planning Considerations

Water which is pumped from a construction site usually contains a large amount of sediment. A dewatering structure is designed to remove the sediment before water is released off-site.

This practice includes several types of dewatering structures which have different applications dependent upon site conditions and types of operation. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the Plan-Approving Authority.

A dewatering structure may not be needed if there is a well- stabilized, vegetated area on-site to which water may be discharged. The area must be stabilized so that it can filter sediment and at the same time withstand the velocity of the discharged water without eroding. A minimum filtering length of 75 feet must be available in order for such a method to be feasible.

Design Criteria

1. A dewatering structure must be sized (and operated) to allow pumped water to flow through the filtering device without overtopping the structure.

2. Material from any required excavation shall be stored in an area and protected in a manner that will prevent sediments from eroding and moving off-site.

3. An excavated basin (applicable to "Straw Bale/Silt Fence Pit") may be lined with filter fabric to help reduce scour and to prevent the inclusion of soil from within the structure.

4. Design criteria more specific to each particular dewatering device can be found in Plates 3.26-1 through 3.26-3.

Construction Specifications

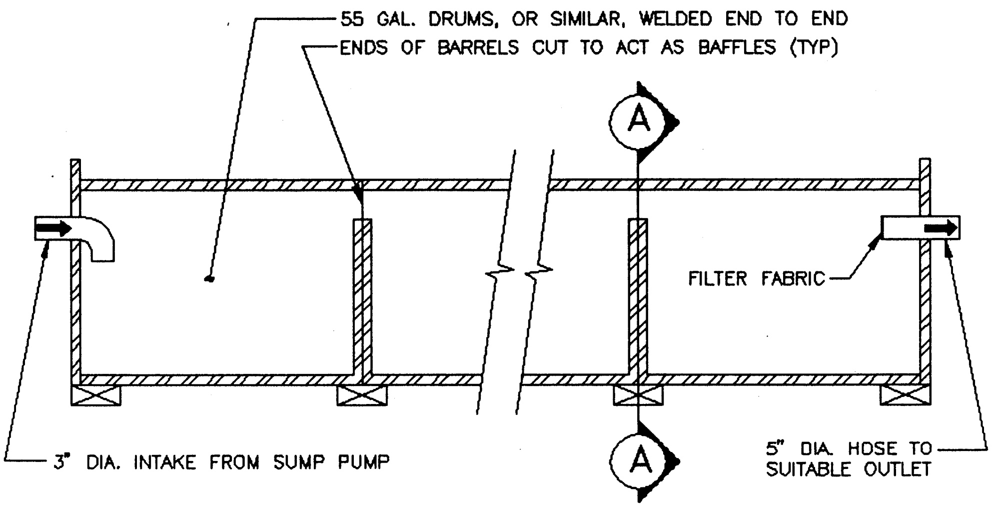
1. Portable Sediment Tank (see Plate 3.26-1)

    a. The structure may be constructed with steel drums, sturdy wood or other material suitable for handling the pressure exerted by the volume of water.

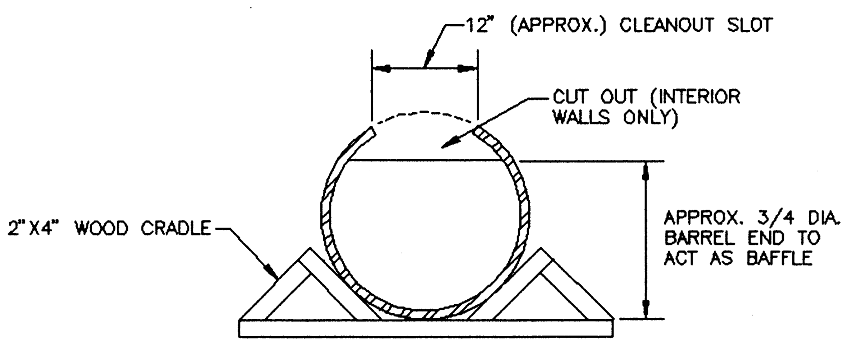
    b. Sediment tanks will have a minimum depth of two feet.

    c. The sediment tank shall be located for easy clean-out and disposal of the trapped sediment and to minimize the interference with construction activities.

PORTABLE SEDIMENT TANK



ELEVATION



CROSS-SECTION A-A

Source: USDA-SCS

Plate 3.26-1

d. The following formula shall be used to determine the storage volume of the sediment tank:

Pump discharge (g.p.m.) x 16 = *cubic feet of storage required*

e. Once the water level nears the top of the tank, the pump must be shut off while the tank drains and additional capacity is made available.

f. The tank shall be designed to allow for emergency flow over top of the tank.

g. Clean-out of the tank is required once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the clean-out point.

2. Filter Box (see Plate 3.26-2)

a. The box selected should be made of steel, sturdy wood or other materials suitable to handle the pressure requirements imposed by the volume of water. Fifty-five gallon drums welded top to bottom are normally readily available and, in most cases, will suffice.

b. Bottom of the box shall be made porous by drilling holes (or some other method).

c. VDOT #3 Coarse Aggregate shall be placed over the holes at a minimum depth of 12 inches (metal "hardware" cloth may need to be placed between the aggregate and the holes if holes are drilled larger than the majority of the stone).

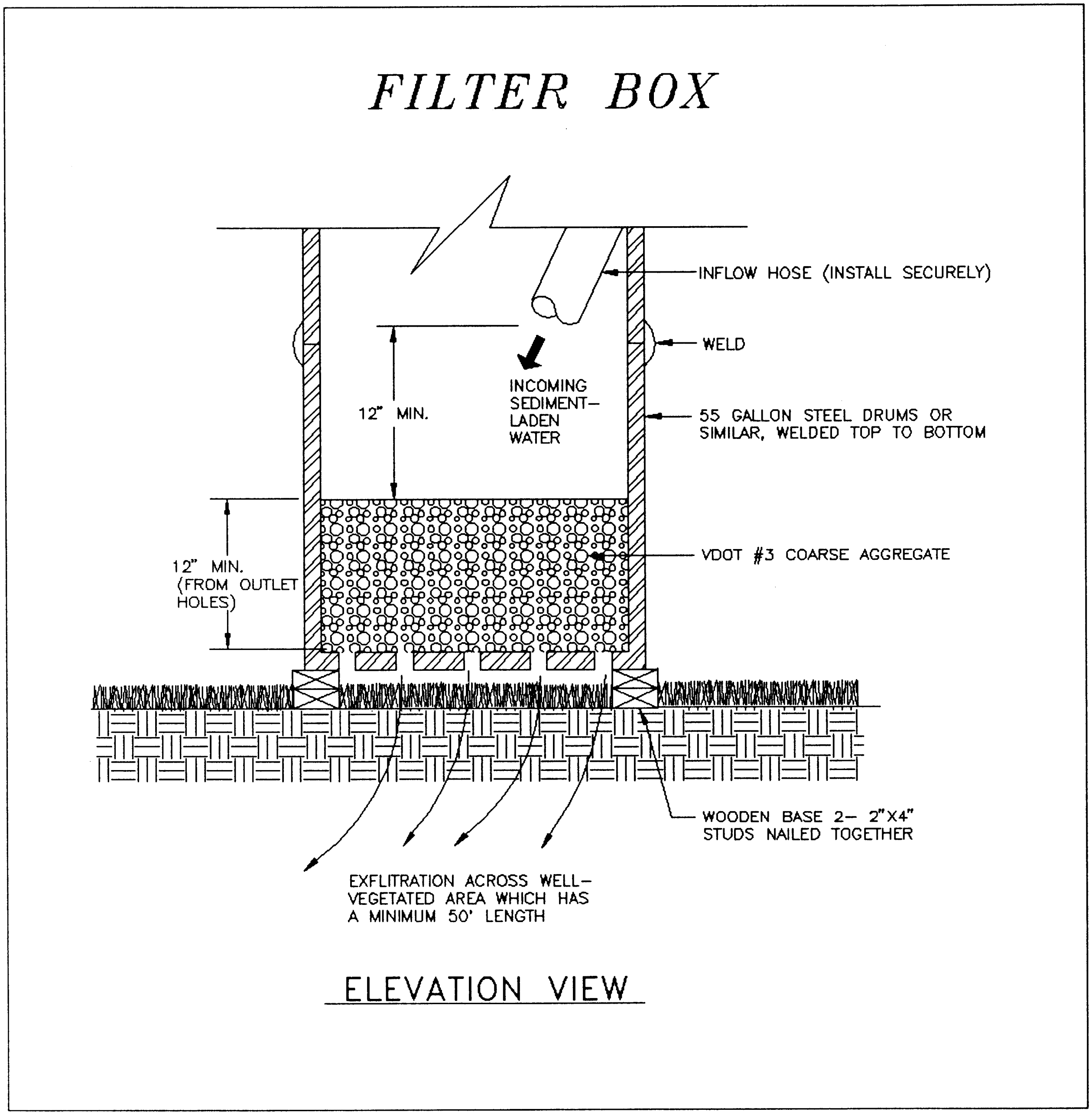
d. As a result of the fast rate of flow of sediment-laden water through the aggregate, the effluent must be directed over a well-vegetated strip of at least 50 feet after leaving the base of the filter box.

e. The box shall be sized as follows:

Pump discharge (g.p.m.) x 16 = *cubic feet of storage required*

f. Once the water level nears the top of the box, the pump must be shut off while the box drains and additional capacity is made available.

g. The box shall be designed/constructed to allow for emergency flow over the top of this box.



Source: Va. DSWC Plate 3.26-2

h. Clean-out of the box is required once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the clean-out point.

i. If the stone filter does become clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned and replaced.

<u>Note</u>: Using a filter box only allows for minimal settling time for sediment particles; therefore, it should only be used when site conditions restrict the use of the other methods.

3. <u>Straw Bale/Silt Fence Pit</u> (see Plate 3.26-3)

   a. Measure shall consist of straw bales, silt fence, a stone outlet (a combination of VDOT Class AI Riprap and VDOT #25 or #26 Aggregate) and a wet storage pit oriented as shown in Plate 3.26-3.

   b. The structure must have a capacity which is dictated by the following formula:

   Pump discharge (g.p.m.) x 16 = *cubic feet of storage required*

   In calculating the capacity, one should include the volume available from the floor of the excavation to the crest of the stone weir.

   c. In any case, the excavated area should be a minimum of 3 feet below the base of the perimeter measures (straw bales or silt fence).

   d. The perimeter measures must be installed as per the guidelines found in Std. & Spec. 3.04, STRAW BALE BARRIER and Std. & Spec. 3.05, SILT FENCE.

   e. Once the water level nears the crest of the stone weir (emergency overflow), the pump must be shut off while the structure drains down to the elevation of the wet storage.

   f. The wet storage pit may be dewatered <u>only after a minimum of 6 hours</u> of sediment settling time. This effluent should be pumped across a well-vegetated area or through a silt fence prior to entering a watercourse.

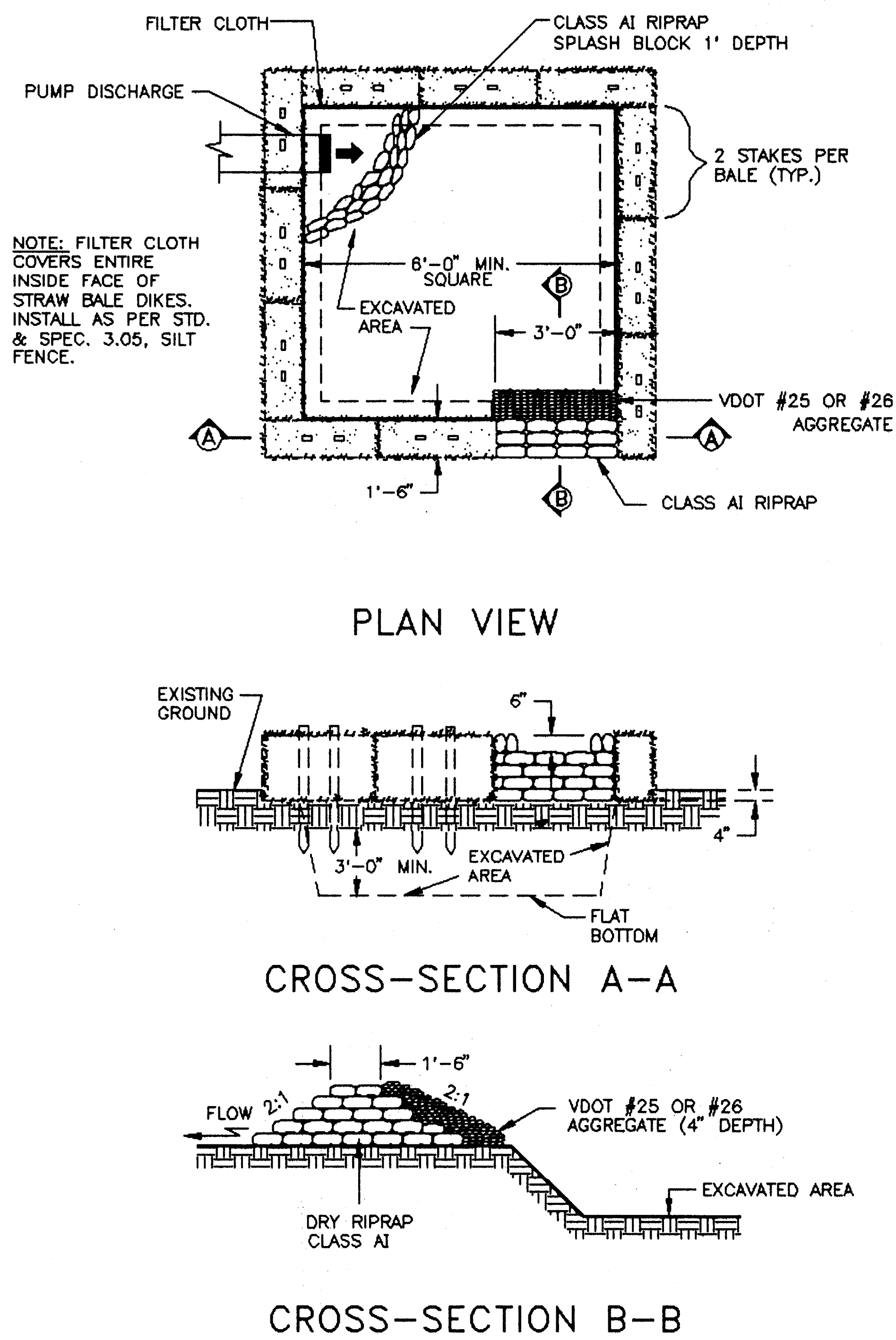
   g. Once the wet storage area becomes filled to one-half of the excavated depth, accumulated sediment shall be removed and properly disposed of.

   h. Once the device has been removed, ground contours will be returned to original condition.

<u>Maintenance</u>
(All dewatering structures)

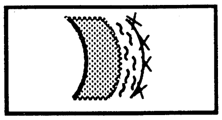
1. The filtering devices must be inspected frequently and repaired or replaced once the sediment build-up prevents the structure from functioning as designed.

STRAW BALE/SILT FENCE PIT



Source: Va. DSWC Plate 3.26-3

2. The accumulated sediment which is removed from a dewatering device must be spread on-site and stabilized or disposed of at an approved disposal site as per approved plan.



STD & SPEC 3.27

TURBIDITY CURTAIN

(TC)

Definition

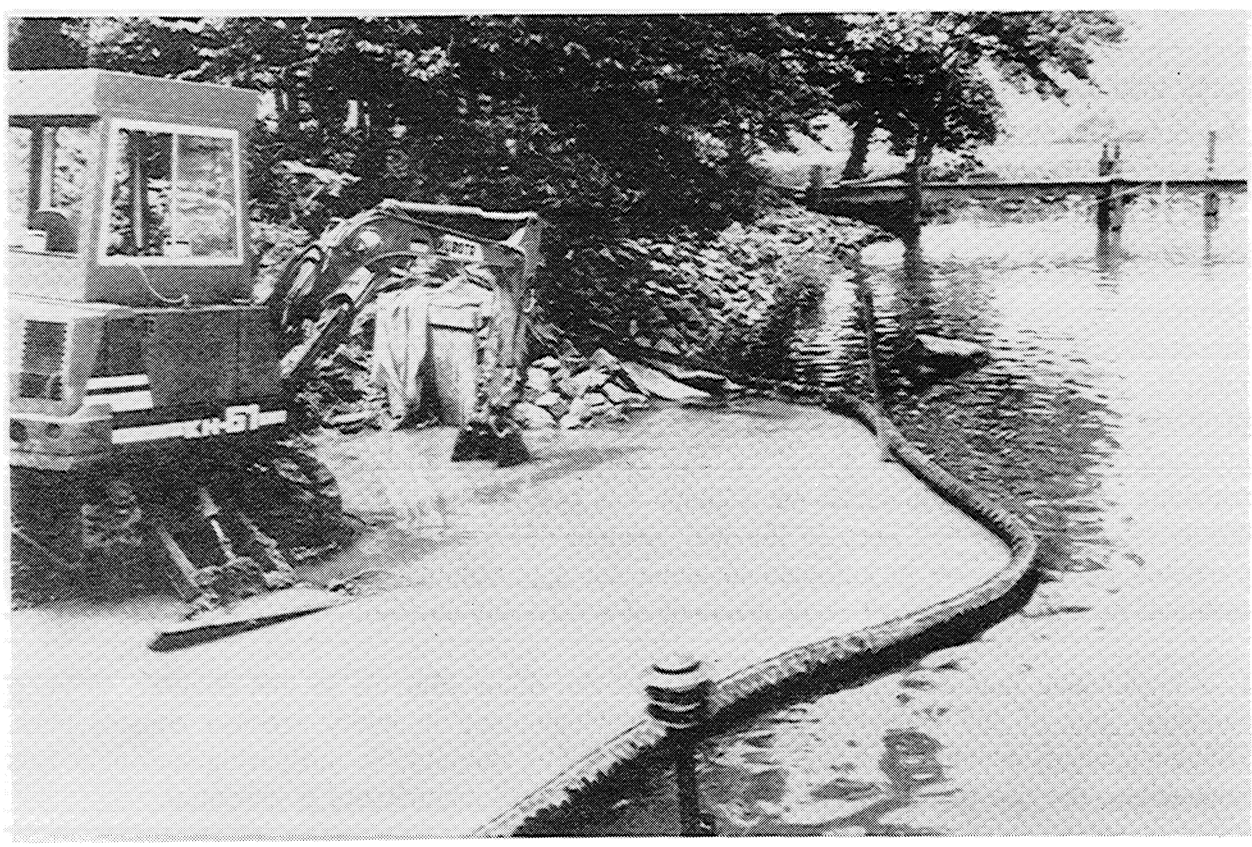
A floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water.

Purpose

To provide sedimentation protection for a watercourse from up-slope land disturbance or from dredging or filling within the watercourse.

Conditions Where Practice Applies

Applicable to non-tidal and tidal watercourses where intrusion into the watercourse by construction activities and subsequent sediment movement is unavoidable.



Planning Considerations

Soil loss into a watercourse results in long-term suspension of sediment. In time, the suspended sediment may travel large distances and affect wide-spread areas. A turbidity curtain is designed to deflect and contain sediment within a limited area and provide enough residence time so that soil particles will fall out of suspension and not travel to other areas.

Turbidity curtain types must be selected based on the flow conditions within the water body - whether it be a flowing channel, lake, pond, or a tidal watercourse. The specifications contained within this practice pertain to minimal and moderate flow conditions where the velocity of flow may reach 5 feet per second (or a current of approximately 3 knots). For situations where there are greater flow velocities or currents, a qualified engineer and product manufacturer should be consulted.

Consideration must also be given to the direction of water movement in channel flow situations. Turbidity curtains are not designed to act as water impoundment dams and can not be expected to stop the flow of a significant volume of water. They are designed and installed to trap sediment, not to halt the movement of the water itself. In most situations, turbidity curtains should not be installed across channel flows.

In tidal or moving water conditions, provisions must be made to allow the volume of water contained within the curtain to change. Since the bottom of the curtain is weighted and external anchors are frequently added, the volume of water contained within the curtain will be much greater at high tide verses low tide and measures must be taken to prevent the curtain from submerging. In addition to allowing for slack in the curtain to rise and fall, water must be allowed to flow through the curtain if the curtain is to remain in roughly the same spot and to maintain the same shape. Normally, this is achieved by constructing part of the curtain from a heavy woven filter fabric. The fabric allows the water to pass through the curtain, but retains the sediment pollutants. Consideration should be given to the volume of water that must pass through the fabric and sediment particle size when specifying fabric permeability.

Sediment which has been deflected and settled out by the curtain may be removed if so directed by the on-site inspector or the Plan-Approving Authority. However, consideration must be given to the probable outcome of the procedure - will it create more of a sediment problem by resuspension of particles and by accidental dumping of the material by the equipment involved? It is, therefore, recommended that the soil particles trapped by a turbidity curtain only be removed if there has been a significant change in the original contours of the affected area in the watercourse. Regardless of the decision made, soil particles should always be allowed to settle for a minimum of 6-12 hours prior to their removal by equipment or prior to removal of a turbidity curtain.

It is imperative that the intended function of the other controls in this chapter, to keep sediment out of the watercourse, be the strategy used in every erosion control plan. However, when proximity to the watercourse makes successfully mitigating sediment loss impossible, the use of the turbidity curtain during land disturbance is essential.

Design Criteria

1. Type I configuration (see Plate 3.27-1) should be used in protected areas where there is no current and the area is sheltered from wind and waves.

2. Type II configuration (see Plate 3.27-1) should be used in areas where there may be small to moderate current running (up to 2 knots or 3.5 feet per second) and/or wind and wave action can effect the curtain.

3. Type III configuration (see Plate 3.27-2) should be used in areas where considerable current (up to 3 knots or 5 feet per second) may be present, where tidal action may be present and/or where the curtain is potentially subject to wind and wave action.

4. Turbidity curtains should extend the entire depth of the watercourse whenever the watercourse in question is not subject to tidal action and/or significant wind and wave forces.

5. In tidal and/or wind and wave action situations, the curtain should never be so long as to touch the bottom. A minimum 1-foot "gap" should exist between the weighted lower end of the skirt and the bottom at "mean" low water. Movement of the lower skirt over the bottom due to tidal reverses or wind and wave action on the flotation system may fan and stir sediments already settled out.

6. In tidal and/or wind and wave action situations, it is seldom practical to extend a turbidity curtain depth lower than 10 to 12 feet below the surface, even in deep water. Curtains which are installed deeper than this will be subject to very large loads with consequent strain on curtain materials and the mooring system. In addition, a curtain installed in such a manner can "billow up" towards the surface under the pressure of the moving water, which will result in an effective depth which is significantly less than the skirt depth.

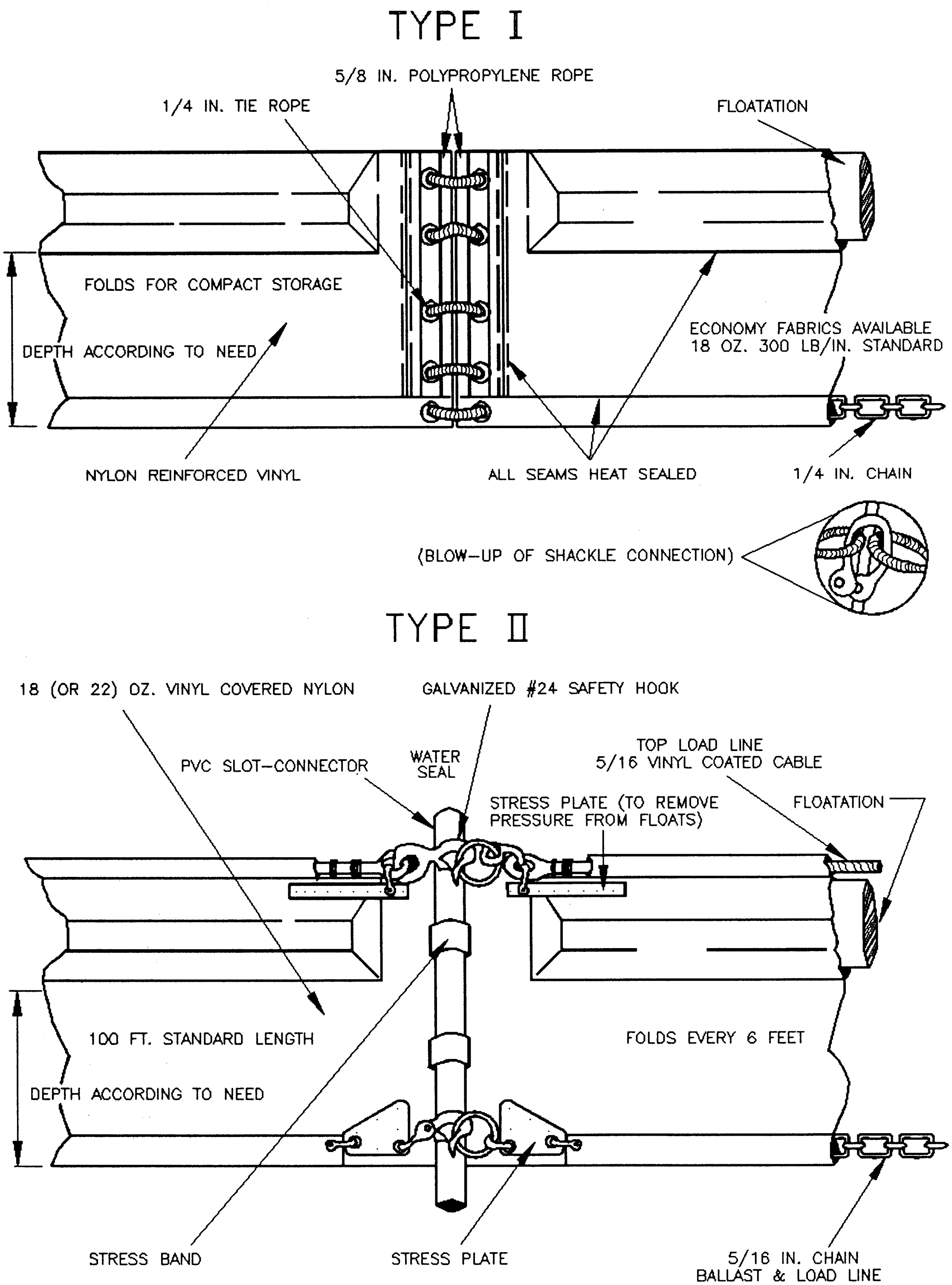
7. Turbidity curtains should be located parallel to the direction of flow of a moving body of water. Turbidity Curtain should not be placed across the main flow of a significant body of moving water.

8. When sizing the length of the floating curtain, allow an additional 10-20% variance in the straight line measurements. This will allow for measuring errors, make installing easier and reduce stress from potential wave action during high winds.

9. An attempt should be made to avoid an excessive amount of joints in the curtain; a minimum continuous span of 50 feet between joints is a good "rule of thumb."

10. For stability reasons, a maximum span of 100 feet between joints (anchor or stake locations) is also a good rule to follow.

TURBIDITY CURTAIN

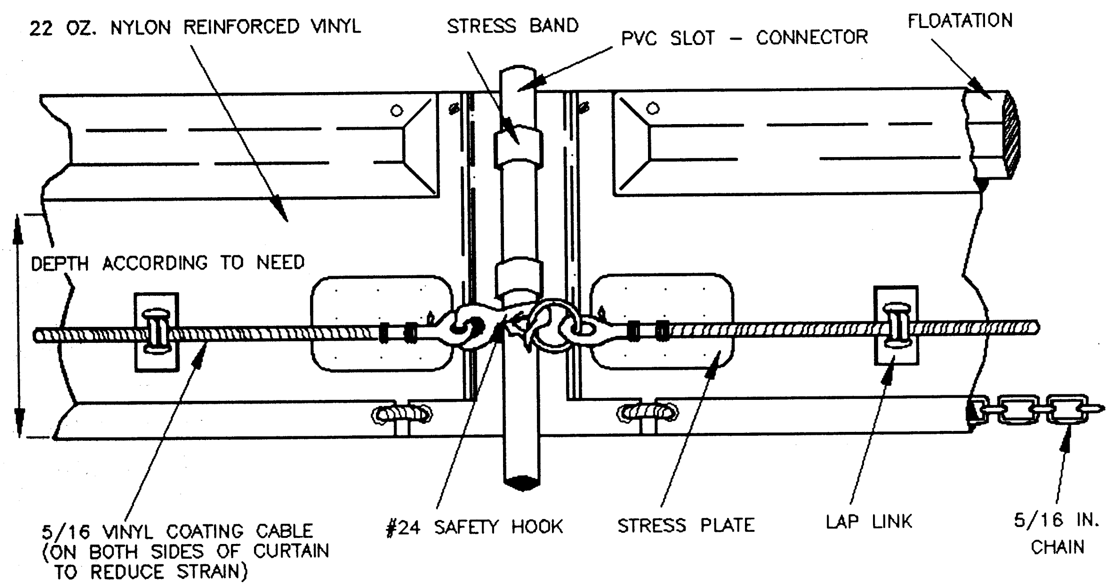


Source: American Boom and Barrier Corp. product literature

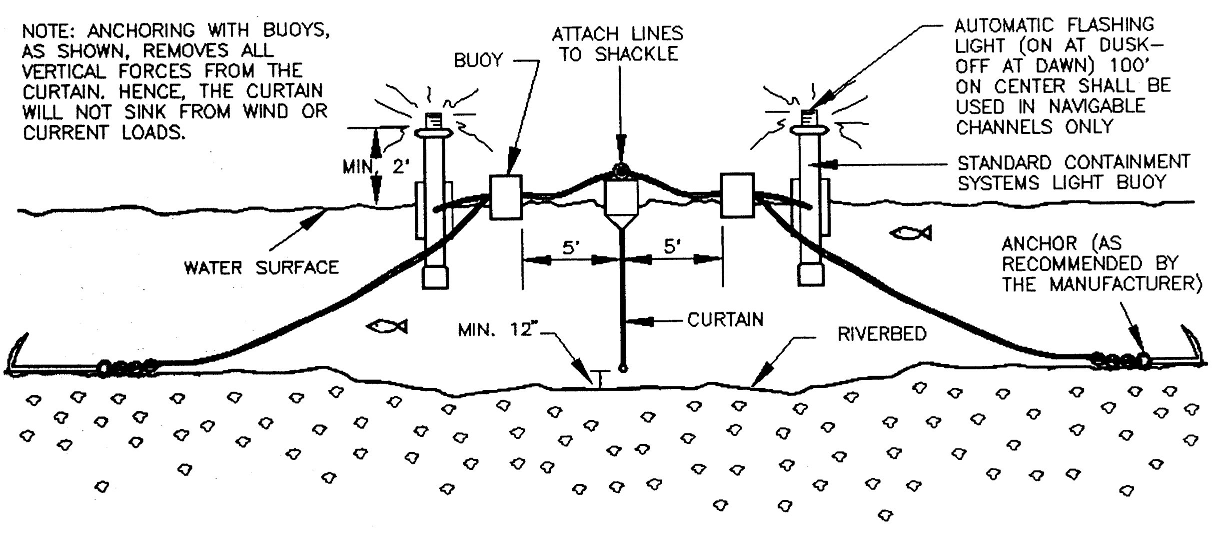
Plate 3.27-1

TURBIDITY CURTAIN

TYPE III



ORIENTATION WHEN INSTALLED (TIDAL SITUATION – TYPE III)



Source: Adapted from American Boom and Barrier Corp. and VDOT Standard Sheets

Plate 3.27-2

11. The ends of the curtain, both floating upper and weighted lower, should extend well up into the shoreline, especially if high water conditions are expected. The ends should be secured firmly to the shoreline (preferably to rigid bodies such as trees or piles) to fully enclose the area where sediment may enter the water.

12. When there is a specific need to extend the curtain to the bottom of the watercourse in tidal or moving water conditions, a heavy woven pervious filter fabric may be substituted for the normally recommended impervious geotextile. This creates a "flow-through" medium which significantly reduces the pressure on the curtain and will help to keep it in the same relative location and shape during the rise and fall of tidal waters.

13. Typical alignments of turbidity curtains can be seen in Plate 3.27-3. The number and spacing of external anchors may vary depending on current velocities and potential wind and wave action; manufacturer's recommendations should be followed.

Construction Specifications

Materials

1. Barriers should be a bright color (yellow or "international" orange are recommended) that will attract the attention of nearby boaters.

2. The curtain fabric must meet the minimum requirements noted in Table 3.27-A.

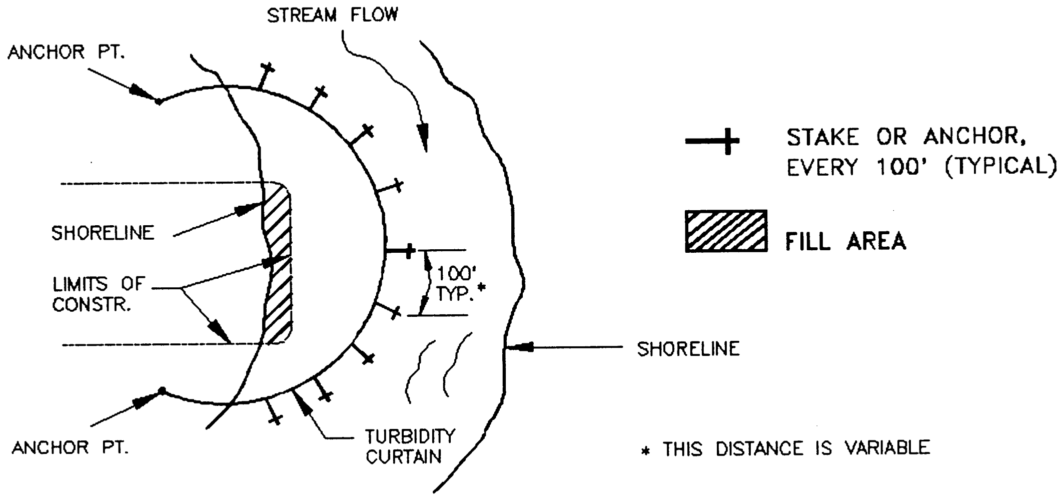
3. Seams in the fabric shall be either vulcanized welded or sewn, and shall develop the full strength of the fabric.

4. Floatation devices shall be flexible, buoyant units contained in an individual floatation sleeve or collar attached to the curtain. Buoyancy provided by the floatation units shall be sufficient to support the weight of the curtain and maintain a freeboard of at least 3 inches above the water surface level (see Plate 3.27-2).

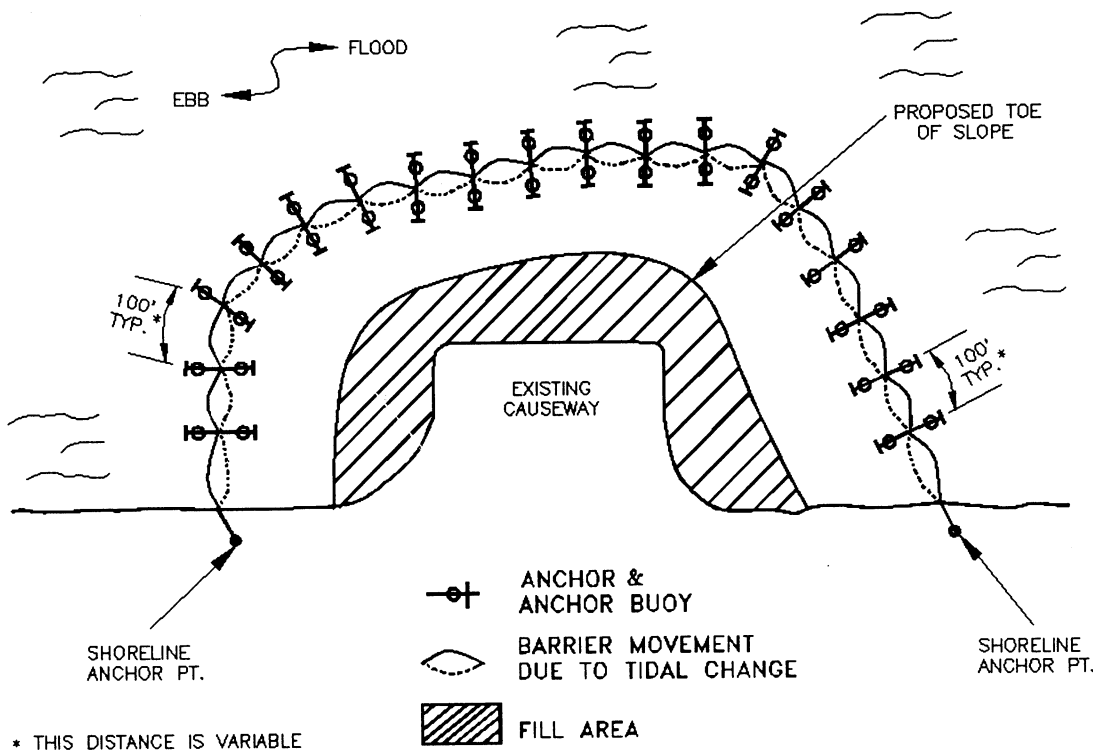
5. Load lines must be fabricated into the bottom of all floating turbidity curtains. Type II and Type III must have load lines also fabricated into the top of the fabric. The top load line shall consist of woven webbing or vinyl-sheathed steel cable and shall have a break strength in excess of 10,000 pounds. The supplemental (bottom) load-line shall consist of a chain incorporated into the bottom hem of the curtain of sufficient weight to serve as ballast to hold the curtain in a vertical position. Additional anchorage shall be provided as necessary. The load lines shall have suitable connecting devices which develop the full breaking strength for connecting to load lines in adjacent sections (see Plates 3.27-1 and 3.27-2 which portray this orientation).

TURBIDITY CURTAIN

TYPICAL LAYOUTS:
STREAMS, PONDS & LAKES (PROTECTED & NON-TIDAL)



TIDAL WATERS AND/OR HEAVY WIND & WAVE ACTION



Source: Adapted from Florida Department of Transportation Road and Design Specifications

Plate 3.27-3

TABLE 3.27-A

PHYSICAL PROPERTIES OF TURBIDITY CURTAIN FABRIC

Physical Property	Requirement
Thickness, mils	45
Weight/oz./sq. yd.:	
Type I	18
Type II	18 or 22
Type III	22
Grab Tensile Strength, lbs.	300
UV Inhibitor	Must be included

Source: Adapted from The Ralph Lemon Company product literature

6. External anchors may consist of wooden or metal stakes (2- x 4-inch or 2½-inch minimum diameter wood or 1.33 pounds/linear foot steel) when Type I installation is used; when Type II or Type III installations are used, bottom anchors should be used.

7. Bottom anchors must be sufficient to hold the curtain in the same position relative to the bottom of the watercourse without interfering with the action of the curtain. The anchor may dig into the bottom (grappling hook, plow or fluke-type) or may be weighted (mushroom type) and should be attached to a floating anchor buoy via an anchor line. The anchor line would then run from the buoy to the top load line of the curtain. When used with Type III installations, these lines must contain enough slack to allow the buoy and curtain to float freely with tidal changes without pulling the buoy or curtain down and must be checked regularly to make sure they do not become entangled with debris. As previously noted, anchor spacing will vary with current velocity and potential wind and wave action; manufacturer's recommendations should be followed. See orientation of external anchors and anchor buoys for tidal installation in Plate 3.27-2.

Installation

1. In the calm water of lakes or ponds (Type I installation) it is usually sufficient to merely set the curtain end stakes or anchor points (using anchor buoys if bottom anchors are employed), then tow the curtain in the furled condition out and attach it to these stakes or anchor points. Following this, any additional stakes or buoyed anchors required to maintain the desired location of the curtain may be set and these anchor points made fast to the curtain. Only then, the furling lines should be cut to let the curtain skirt drop.

2. In rivers or in other moving water (Type II and Type III installations) it is important to set all the curtain anchor points. Care must be taken to ensure that anchor points are of sufficient holding power to retain the curtain under the existing current conditions, prior to putting the furled curtain into the water. Again, anchor buoys should be employed on all anchors to prevent the current from submerging the flotation at the anchor points. If the moving water into which the curtain is being installed is tidal and will subject the curtain to currents in both directions as the tide changes, it is important to provide anchors on both sides of the curtain for two reasons:

   a) Curtain movement will be minimized during tidal current reversals.

   b) The curtain will not overrun the anchors and pull them out when the tide reverses.

   When the anchors are secure, the furled curtain should be secured to the upstream anchor point and then sequentially attached to each next downstream anchor point until the entire curtain is in position. At this point, and before unfurling, the "lay" of the curtain should be assessed and any necessary adjustments made to the anchors. Finally, when the location is ascertained to be as desired, the furling lines should be cut to allow the skirt to drop.

3. Always attach anchor lines to the flotation device, not to the bottom of the curtain. The anchoring line attached to the floatation device on the downstream side will provide support for the curtain. Attaching the anchors to the bottom of the curtain could cause premature failure of the curtain due to the stresses imparted on the middle section of the curtain.

4. There is an exception to the rule that turbidity curtains should not be installed across channel flows; it occurs when there is a danger of creating a silt build-up in the middle of a watercourse, thereby blocking access or creating a sand bar. Curtains have been used effectively in large areas of moving water by forming a very long-sided, sharp "V" to deflect clean water around a work site, confine a large part of the silt-laden water to the work area inside the "V" and direct much of the silt toward the shoreline. Care must be taken, however, not to install the curtain perpendicular to the water current.

5. See Plate 3.27-3 for typical installation layouts.

Removal

1. Care should be taken to protect the skirt from damage as the turbidity curtain is dragged from the water.

2. The site selected to bring the curtain ashore should be free of sharp rocks, broken cement, debris, etc. so as to minimize damage when hauling the curtain over the area.

3. If the curtain has a deep skirt, it can be further protected by running a small boat along its length with a crew installing furling lines before attempting to remove the curtain from the water.

Maintenance

1. The developer/owner shall be responsible for maintenance of the filter curtain for the duration of the project in order to ensure the continuous protection of the watercourse.

2. Should repairs to the geotextile fabric become necessary, there are normally repair kits available from the manufacturers; manufacturer's instructions must be followed to ensure the adequacy of the repair.

3. When the curtain is no longer required as determined by the inspector, the curtain and related components shall be removed in such a manner as to minimize turbidity. Remaining sediment shall be sufficiently settled before removing the curtain. Sediment may be removed and the original depth (or plan elevation) restored. Any spoils must be taken to upland area and be stabilized.

STD & SPEC 3.28

SUBSURFACE DRAIN

SD

Definition

A perforated conduit such as pipe, tubing or tile installed beneath the ground to intercept and convey ground water.

Purposes

1. To prevent sloping soils from becoming excessively wet and subject to sloughing.
2. To improve the quality of the growth medium in excessively wet areas by lowering the water table.
3. To drain stormwater detention areas or structures.

Conditions Where Practice Applies

Wherever excess water must be removed from the soil. The soil must be deep and permeable enough to allow an effective system to be installed. Either a gravity outlet must be available or pumping must be provided. These standards do no apply to foundation drains.

Planning Considerations

Subsurface drainage systems are of two types, relief drains and interceptor drains. Relief drains are used either to lower the water table in order to improve the growth of vegetation, or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random pattern (see Plate 3.28-1).

Interceptor drains are used to remove water as it seeps down a slope to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout (see Plate 3.28-2).

Design Criteria

Location

Tree roots can often clog subsurface drain systems. Consequently, sub-surface drains should be located such that there are no trees within 50 feet of the drain.

Relief Drains - Relief drains should be located through the center of wet areas. They should drain in the same direction as the slope.

Interceptor drains - Interceptor drains should be located on the uphill side of wet areas . They should be installed across the slope and drain to the side of the slope.

Capacity of Drains

The required capacity of a subsurface drain depends upon its use.

Relief drains- Relief drains installed in a uniform pattern should remove a minimum of 1 inch of groundwater in 24 hours (0.042 cfs/acre). The design capacity must be increased accordingly to accommodate any surface water which enters directly into the system (see Plate 3.28-4).

Interceptor drains or relief drains in a random pattern- Interceptor drains or relief drains installed in a random pattern should remove a minimum of 1.5 cfs/1000 feet of length. This value should be increased for sloping land according to the values in Table 3.28-A. In addition, if a flowing spring or surface water enters directly into the system, this flow must be accommodated and the design capacity must be increased accordingly to take care of this flow (see Plate 3.28-4).

TABLE 3.28-A

WATER REMOVAL RATES FOR SLOPING LAND*

Land Slope	Water Removal Rates
2 - 5%	1.65 cfs/1000 ft.
6 - 12%	1.80 cfs/1000 ft.
> 12%	1.95 cfs/1000 ft.

* These rates depend on the soil types where the drains are installed. Heavier soils may result in slower water removal rates.

Source: Va. DSWC

Size of Drains

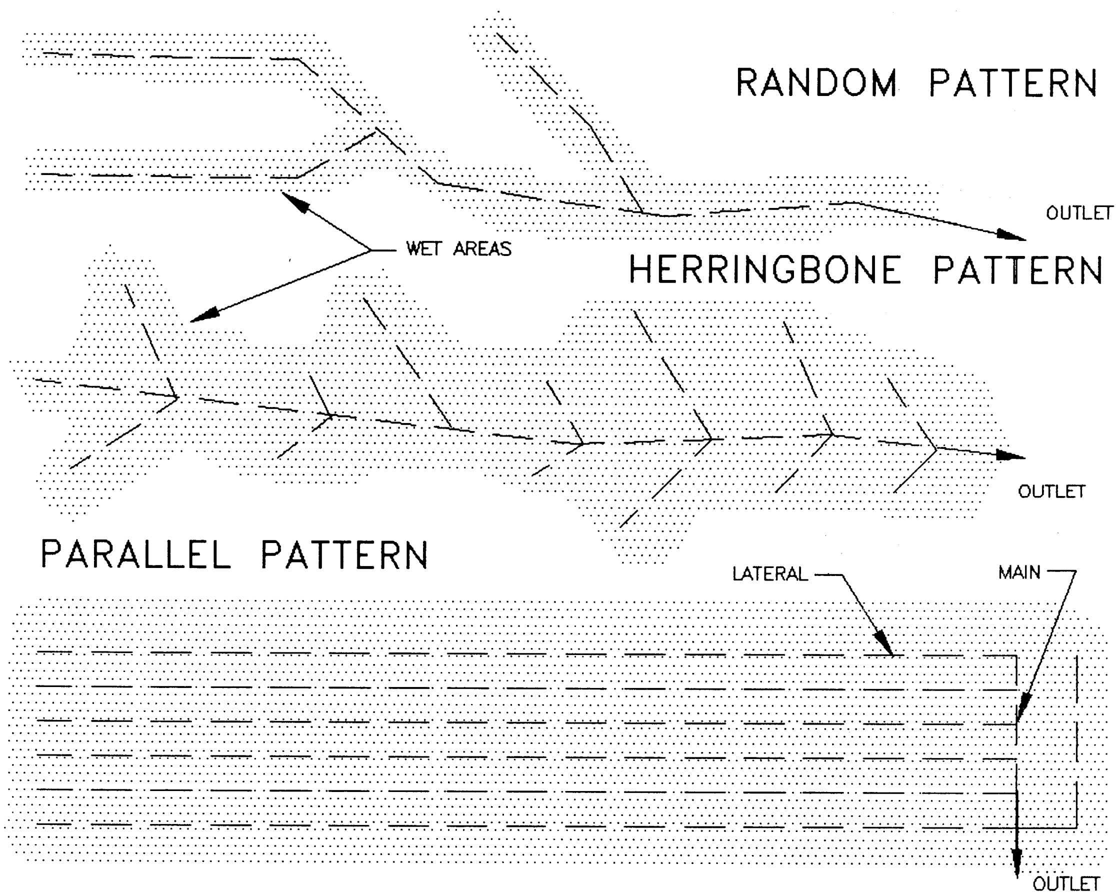
Subsurface drains should be sized for the required capacity using Plates 3.28-6 and 3.28-7 in Appendix 3.28-a. The minimum diameter for a subsurface drain shall be 4 inches.

Depth and Spacing

Relief Drains - Relief drains installed in a uniform pattern should have equal spacing between drains and the drains should be at the same depth. Maximum depth is limited by the allowable load on the pipe, depth to impermeable layers in the soil, and outlet requirements. The minimum depth is 24 inches under normal conditions. Twelve inches is acceptable where the drain will not be subject to equipment loading or frost action. Spacing between drains is dependent on soil permeability and the depth of the drain. In general, however, a depth of 3 feet and a spacing of 50 feet will be adequate. A more economical system may be designed., if the necessary information is available, by using the equations found in Appendix 3.28-a.

Interceptor drain - The depth of installation of an interceptor drain is influenced mainly by the depth to which the water table is to be lowered. The maximum depth is limited by the allowable load on the pipe and the depth to an impermeable layer. Minimum depth should be the same as for relief drains.

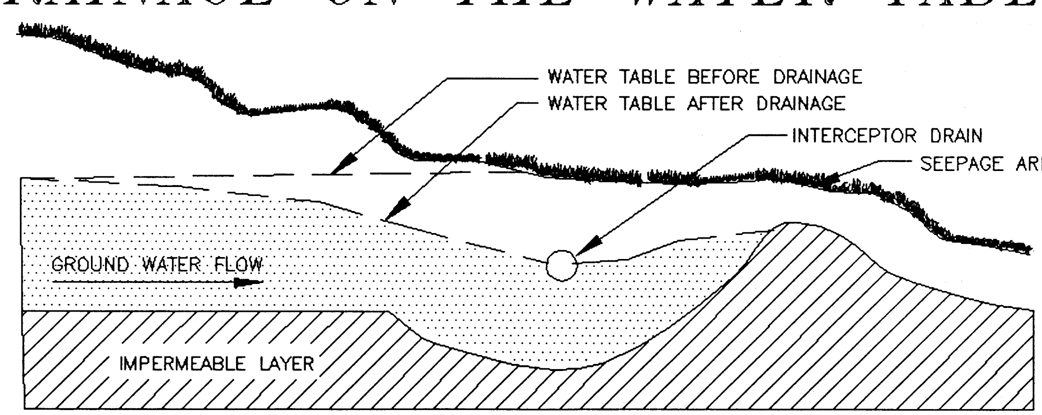
SUBSURFACE DRAIN LAYOUT



Source: USDA-SCS

Plate 3.28-1

EFFECT OF SUBSURFACE DRAINAGE ON THE WATER TABLE



Source: USDA-SCS

Plate 3.28-2

One interceptor drain is usually sufficient. However, if multiple drains are to be used, determining the required spacing can be difficult. The best approach is to install the first drain - then if seepage or high water table problems occur downslope, install an additional drain a suitable distance downslope. This distance can be calculated from equations found in Appendix 3.28-a.

Velocity and Grade

The minimum velocity required to prevent silting is 1.4 ft./sec. The line should be graded to achieve at least this velocity. Steep grades should be avoided, however. Table 3.28-B lists maximum velocities for various soil textures.

TABLE 3.28-B

MAXIMUM VELOCITIES FOR VARIOUS SOIL TEXTURES

Soil Texture	Maximum Velocity (ft./sec.)
Sandy and Sandy Loam	3.5
Silt and Silt Loam	5.0
Silty Clay Loam	6.0
Clay and Clay Loam	7.0
Coarse Sand or Gravel	9.0

Source: Va. DSWC

Envelopes

Envelopes shall be used around all drains for proper bedding and improved flow of groundwater into the drain. The envelope shall consist of 3 inches of VDOT #68 aggregate placed completely around the drain. The stone shall be encompassed by a filter cloth separator in order to prevent the migration of surrounding soil particles into the drain (see Plate 3.28-3). Filter cloth must meet the physical requirements noted in Std. & Spec. 3.19, RIPRAP.

Surface Water

Plate 3.28-4 shows two types of surface water inlets. The grated inlet should not be used where excessive sedimentation might be a problem.

Outlet

The outlet of the subsurface drain shall empty into a channel or some other watercourse which will remove the water from the outlet. It shall be above the mean water level in the receiving channel. It shall be protected from erosion, undermining, damage from periods of submergence, and the entry of small animals into the drain.

The outlet shall consist of a 10-foot section of corrugated metal, cast iron, steel or schedule 40 PVC pipe without perforations. No envelope material shall be used around the pipe. At least two-thirds of the outlet pipe length shall be buried.

Materials

Acceptable materials for subsurface drains include perforated, continuous closed-joint conduits of corrugated plastic, concrete, corrugated metal, asbestos cement, and bituminous fiber. The strength and durability of the pipe shall meet the requirements of the site in accordance with the manufacturer's specifications.

Construction Specifications

1. The trench shall be constructed on a continuous grade with no reverse grades or low spots.
2. Soft or yielding soils under the drain shall be stabilized with gravel or other suitable material.
3. Deformed, warped, or otherwise unsuitable pipe shall not be used.
4. Envelopes or filter material shall be placed as specified with at least 3 inches of material on all sides of the pipe.
5. Backfilling shall be done immediately after placement of the pipe. No sections of pipe should remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.
6. The outlet section of the drain shall consist of at least 10 feet of non-perforated corrugated metal, cast iron, steel or schedule 40 PVC pipe. At least two-thirds of its length shall be buried.

Maintenance

1. Subsurface drains should be checked periodically to ensure that they are free-flowing and not clogged with sediment.

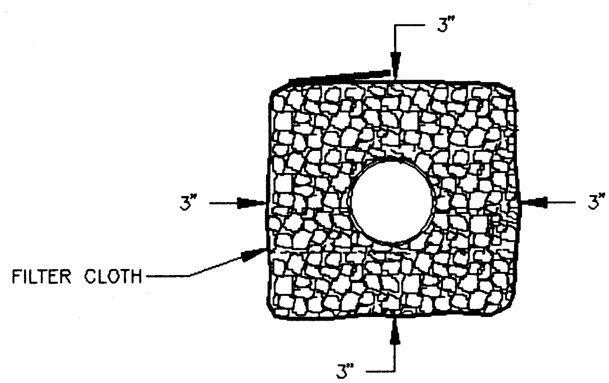
2. The outlet should be kept clean and free of debris.

3. Surface inlets should be kept open and free of sediment and other debris.

4. Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees.

5. Where drains are crossed by heavy vehicles, the line should be checked to ensure that it is not crushed.

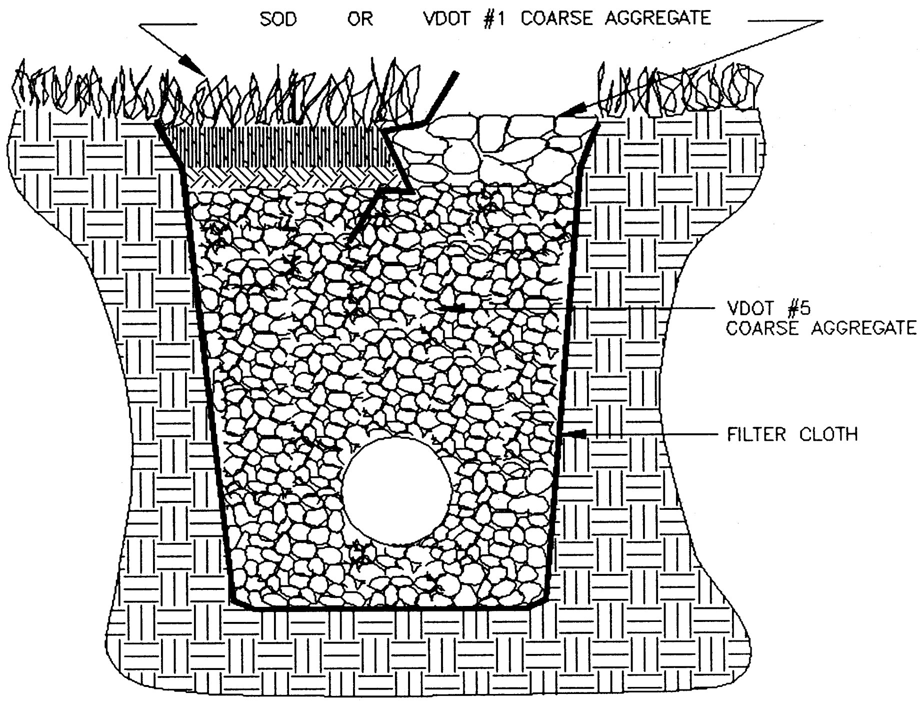
DRAINAGE ENVELOPE



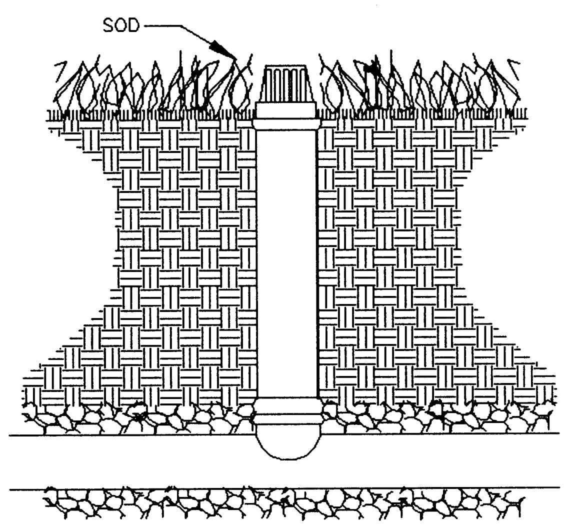
Source: USDA-SCS

Plate 3.28-3

SURFACE INLETS



NATURAL INLET



GRATED INLET

Source: USDA-SCS

Plate 3.28-4

APPENDIX 3.28-a

Subsurface drains are not generally designed to flow under pressure and the hydraulic gradient is parallel with the grade line. Consequently, the flow is considered to be open channel and Manning's Equation can be used. The required drain size can be determined by the following procedure:

1. Determine the flow the drain must carry.

2. Determine the gradient of the drain

3. From Table 3.28-C, determine "n" for the type of drain pipe to be used. Choose the correct Plate (3.28-5 through 3.28-7) for the "n" just determined.

4. Enter the appropriate plate with the gradient of the pipe and the flow in the pipe. The intersection of the two lines must be to the right of the line for 1.4 ft./sec. If it is not, increase the gradient or flow capacity or both.

Example 1

Given:

A random subsurface drain is to be installed on a 1.0% grade, 700 feet in length, and using corrugated plastic pipe.

Calculate:

The required size of the drain pipe.

Solution:

From the Std. & Spec., the required capacity of the pipe is:

$$1.5\ ft.^3/\text{sec.}/1000\ ft.$$

$$Capacity = \frac{700}{1000}\ x\ 1.5\ ft.^3/\text{sec.} = 1.05\ ft.^3/\text{sec.}$$

* From Table 3.28-C, n = 0.015 for corrugated plastic pipe.

* From Plate 3.28-6, choose an 8-inch pipe.

Example 2

Given:

A relief drain installed in a gridiron pattern of 8 laterals, 500 feet long, 0.5% grade, and 50 feet on centers. A main 400 feet in length on a 0.5% grade will connect to the laterals. Use bituminized fiber pipe for the main and laterals.

Calculate:

The required size of the drain pipe.

Solution:

The drainage area for each lateral is 25 feet on either side of the pipe times the length. Therefore:

$$\frac{50\ ft. \times 500\ ft.}{43{,}560\ ft.^2/acre} = 0.57\ acre$$

From the Std. & Spec., the drains must remove 1 inch of water in 24 hours or 0.042 $ft.^3$/sec./acre.

$$0.042\ ft.^3/\text{sec.}/acre \times 0.57\ acre = 0.02\ ft.^3/\text{sec.}$$

From Table 3.28-C, n = 0.013 for bituminized fiber pipe.

From Plate 3.28-5, a 4-inch pipe must be used for the laterals.

The first 25 feet of the main will drain 25 feet on either side of the pipe. The remaining 375 feet will drain only 25 feet on the side opposite from the laterals. In addition, the main will drain the laterals.

Drainage from main:

$$\frac{25\ ft. \times 50\ ft.}{43{,}560\ ft.^2/acre} + \frac{375\ ft. \times 25\ ft.}{43{,}560\ ft.^2/acre} = 0.24\ acre$$

Drainage from laterals:

$$8 \quad x \quad 0.57 \; acre \quad = \quad 4.56 \; acre$$

$$Total \quad = \quad 0.24 \quad + \quad 4.56 \quad = \quad 4.8 \; acre$$

Required capacity:

$$0.042 \; ft.^3/\text{sec.}/acre \quad x \quad 4.8 \; acre \quad = \quad 0.20 \; ft.^3/\text{sec.}$$

From Plate 3.28-5, choose a 5-inch pipe for the main.

TABLE 3.28-C

"n" VALUES FOR SUBSURFACE DRAIN PIPES

Composition of Pipe or Tubing	"n" Values
Asbestos Cement	0.013
Bituminized Fiber	0.013
Concrete	0.015
Corrugated Plastic	0.015
Corrugated Metal	0.025

Source: Va. DSWC

Spacing of Relief Drains

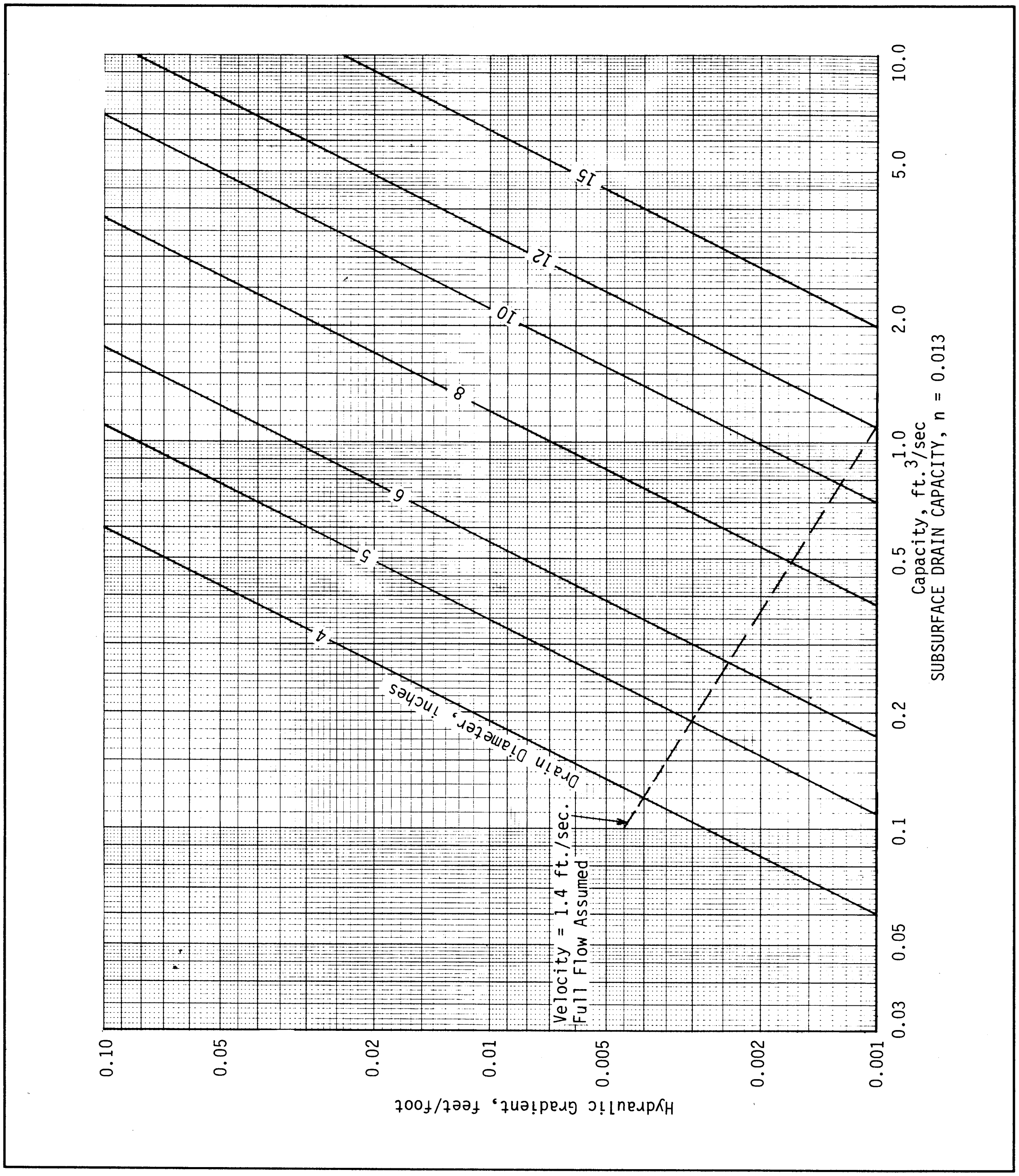
If the necessary information is known, the following equation can be used to calculate drain spacing in lieu of the recommended standard:

$$S \quad = \quad \sqrt{\frac{4k \; (M^2 \; + \; 2 \; AM)}{q}}$$

Where,

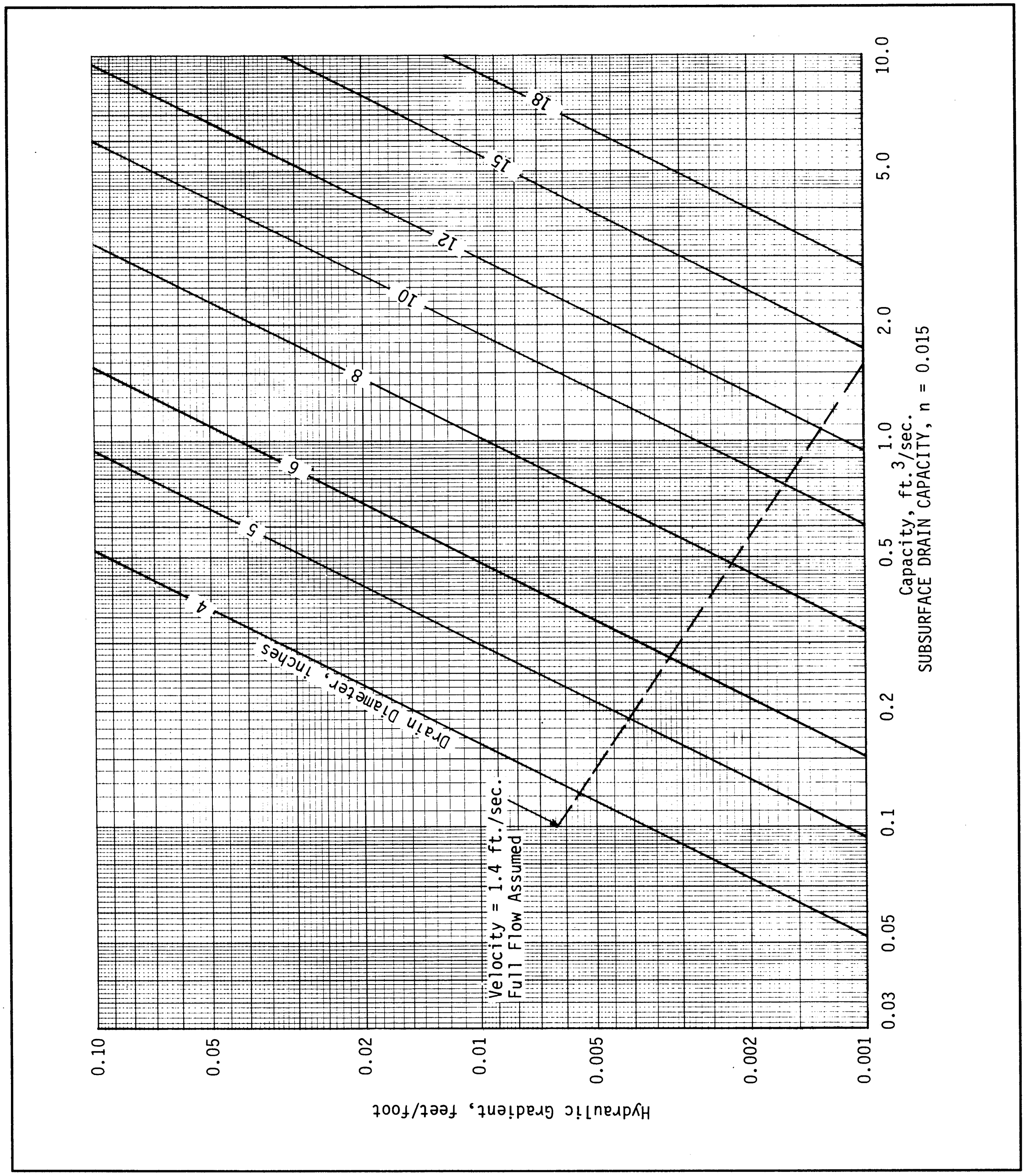
S = drain spacing, feet

k = average hydraulic conductivity, in./hr. (for practical purposes, hydraulic conductivity is equal to permeability).



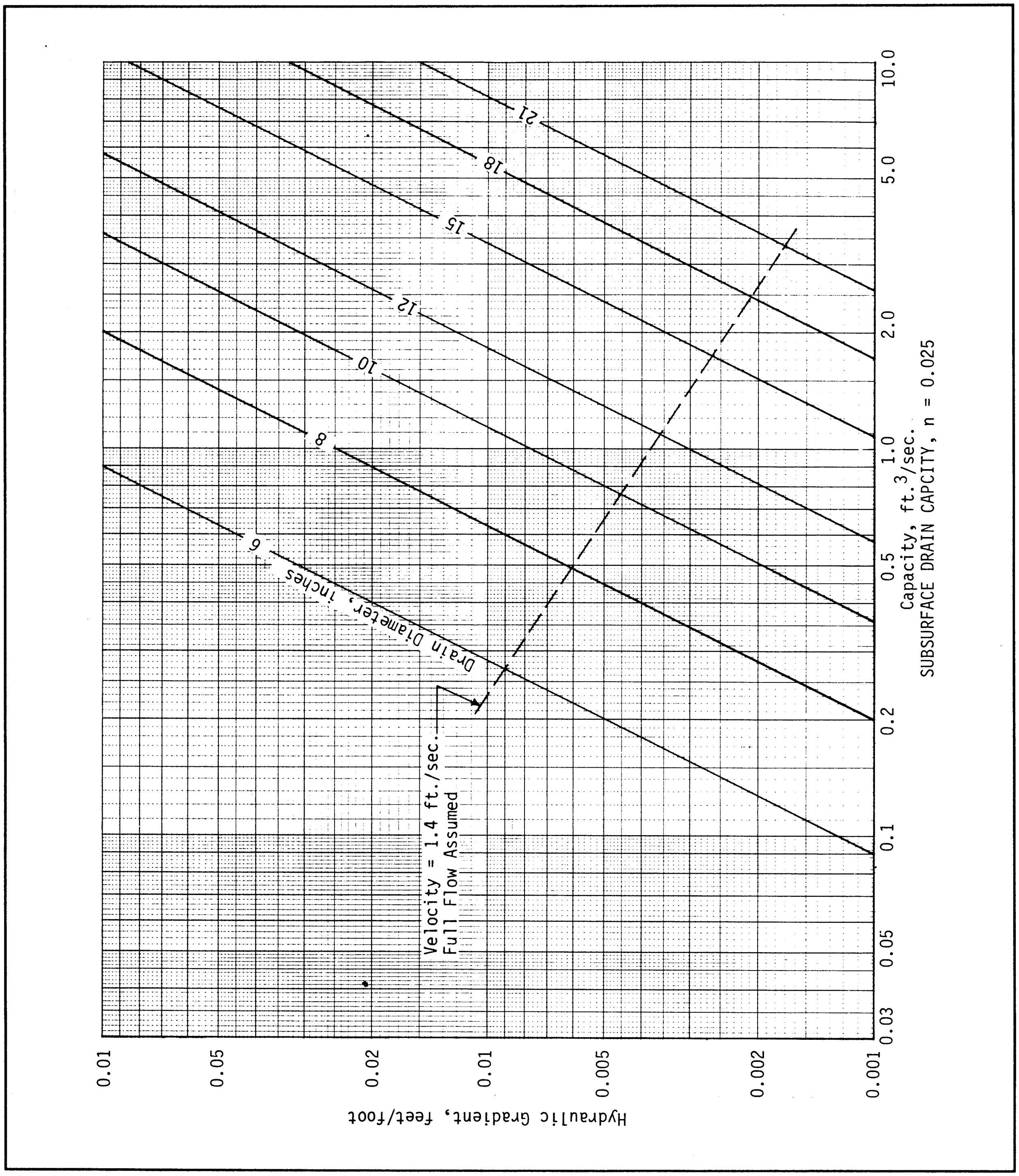
Source: USDA-SCS

Plate 3.28-5



Source: USDA-SCS

Plate 3.28-6



Source: USDA-SCS

Plate 3.28-7

M = vertical distance, after drawdown, of water table above drain at mid-point between lines, feet.

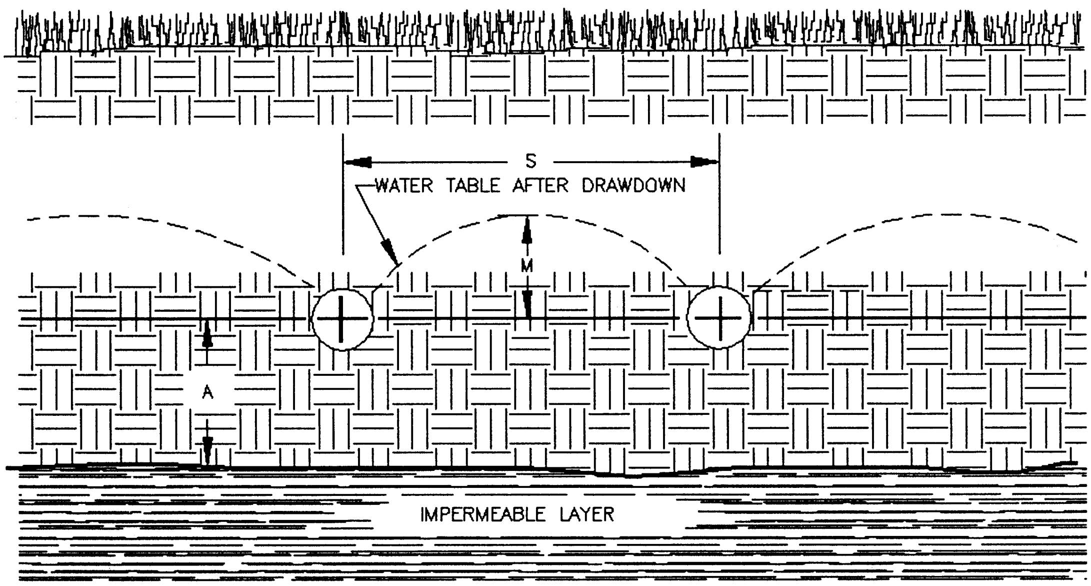
A = depth of barrier below drain, feet.

q = drainage coefficient, rate of water removal, inch/hr.

Also, see Plate 3.28-8.

This equation is applicable to most areas in Virginia. Limitations of the equation are listed in the SCS National Engineering Handbook, Section 16, Drainage of Agricultural Land (66).

RELIEF DRAIN SPACING



Source: USDA-SCS

Plate 3.28-8

Spacing of Interceptor Drains

If one interceptor drain is not sufficient, the spacing of multiple drains can be calculated by the following equation:

$$Le = \frac{k\,i}{q}(de - dw + W_2)$$

Where,

Le = the distance downslope from the drain to the point where the water table is at the desired depth after drainage, feet. The second drain should be located at this point.

k = the average hydraulic conductivity of the subsurface profile to the depth of the drain, in./hr.

q = drainage coefficient, rate of water removal, in./hr.

i = the hydraulic gradient of the water table before drainage, feet/foot.

de = the effective depth of the drain, feet.

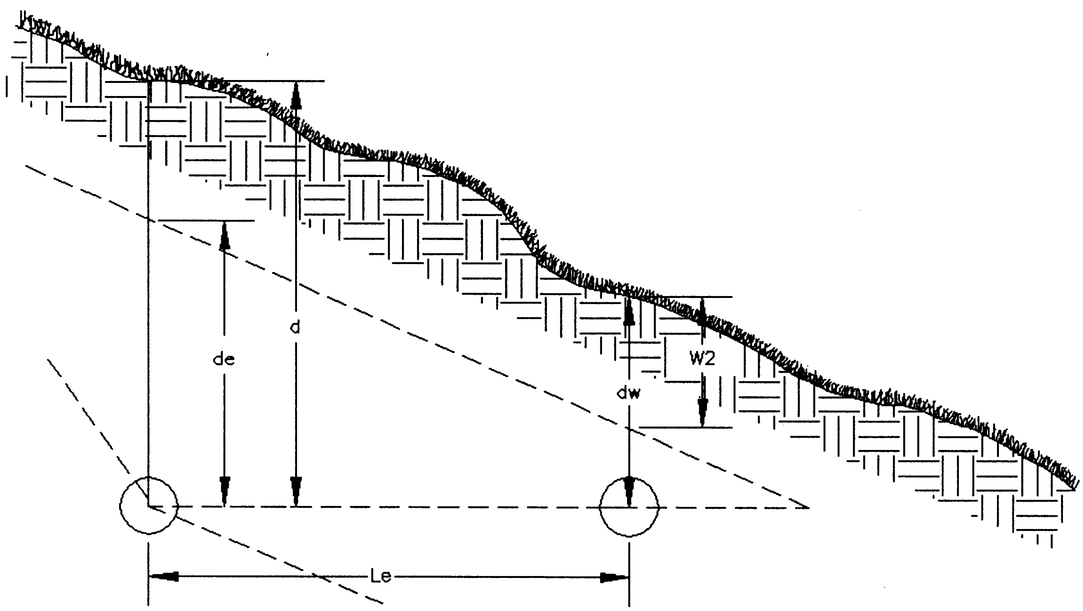
dw = the desired minimum depth to water table after drainage, feet.

W_2 = the distance from the ground surface to the water table, before drainage, at the distance (Le) downslope from the drain, feet.

Also, see Plate 3.28-9.

Further information on the equation can be obtained from the SCS National Engineering Handbook, Section 16, Drainage of Agricultural Land (66).

INTERCEPTOR DRAIN SPACING



Source: USDA-SCS

Plate 3.28-9

STD & SPEC 3.29

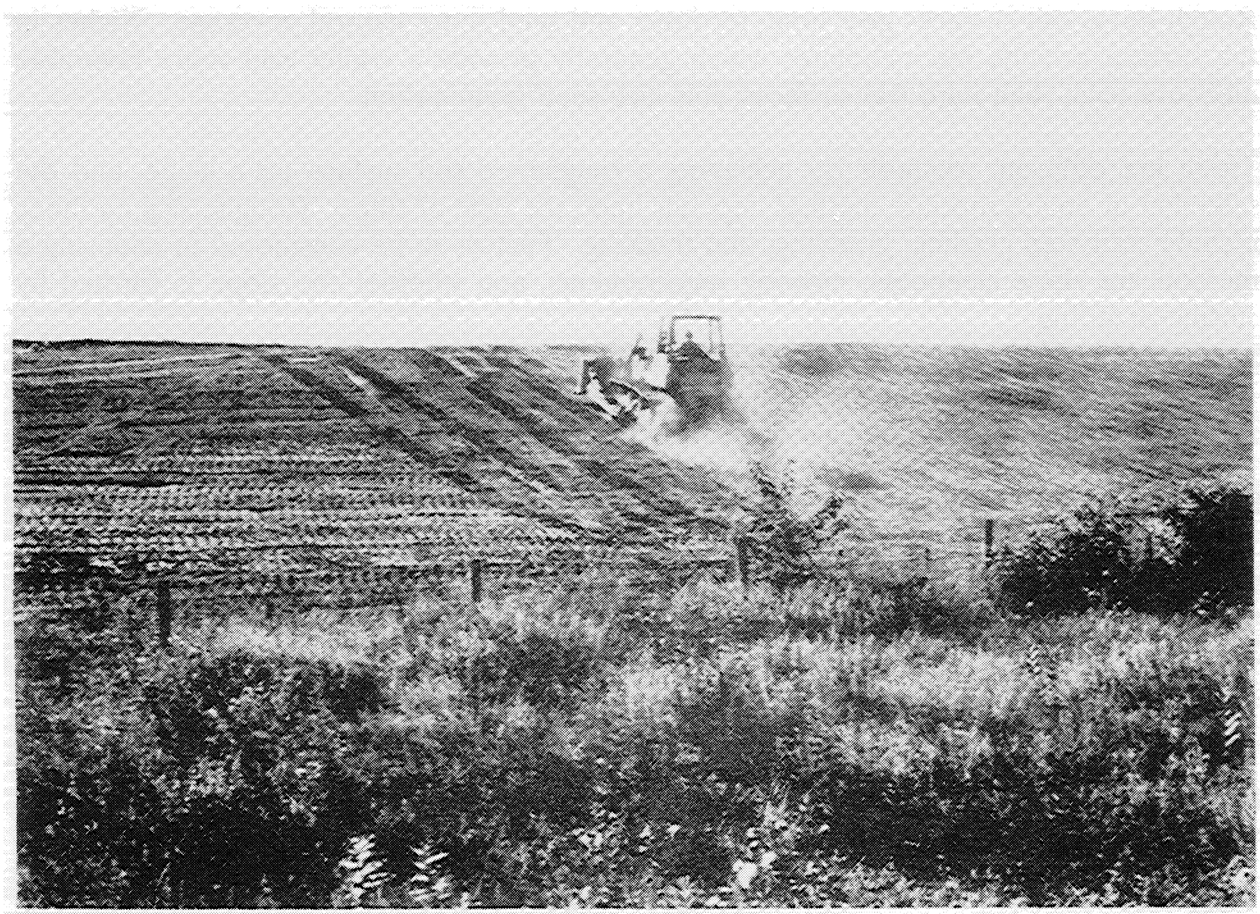
SURFACE ROUGHENING

Definition

Providing a rough soil surface with horizontal depressions created by operating a tillage or other suitable implement on the contour, or by leaving slopes in a roughened condition by not fine-grading them.

Purposes

1. To aid in establishment of vegetative cover with seed.
2. To reduce runoff velocity and increase infiltration.
3. To reduce erosion and provide for sediment trapping.



Conditions Where Practice Applies

1. All slopes steeper than 3:1 require surface roughening, either stair-step grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation.

2. Areas with grades less steep than 3:1 should have the soil surface lightly roughened and loose to a depth of 2 to 4 inches prior to seeding.

3. Areas which have been graded and will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.

4. Slopes with a stable rock face do not require roughening or stabilization.

Planning Considerations

Graded areas with smooth, hard surfaces give a false impression of "finished grading" and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, but encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity.

Rough loose soil surfaces give lime, fertilizer and seed some natural coverage. Niches in the surface provide microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

1. Disturbed areas which will not require mowing may be stair-step graded, grooved, or left rough after filling.

2. Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material which sloughs from above, and provides a level site where vegetation can become established.

3. Areas which will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by discing, harrowing, raking, or seed-planting machinery operated on the contour.

4. It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all, but is not as

effective as other forms of roughening, as the soil surface is severely compacted and runoff is increased.

Specifications

Cut Slope Applications For Areas Which Will Not Be Mowed

Cut slopes with a gradient steeper than 3:1 shall be stair-step graded or grooved (Plates 3.29-1 and 3.29-2).

1. Stair-step grading may be carried out on any material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.

   The ratio of the vertical cut distance to the horizontal distance shall be less than 1:1 and the horizontal portion of the "step" shall slope toward the vertical wall.

   Individual vertical cuts shall not be more than 30 inches on soft soil materials and not more than 40 inches in rocky materials.

2. Grooving consists of using machinery to create a series of ridges and depressions which run perpendicular to the slope (on the contour).

   Grooves may be made with any appropriate implement which can be safely operated on the slope and which will not cause undue compaction. Suggested implements include discs, tillers, spring harrows, and the teeth on a front-end loader bucket. Such grooves shall not be less than 3 inches deep nor further than 15 inches apart.

Fill Slope Applications For Areas Which Will Not Be Mowed

Fill slopes with a gradient steeper than 3:1 shall be grooved or allowed to remain rough as they are constructed. Method (1) or (2) below may be used.

1. Groove according to #2 above.

2. As lifts of the fill are constructed, soil and rock materials may be allowed to fall naturally onto the slope surface (see Plate 3.29-3).

Colluvial materials (soil deposits at the base of slopes or from old stream beds) shall not be used in fills as they flow when saturated.

At no time shall slopes be bladed or scraped to produce a smooth, hard surface.

Cuts, Fills, and Graded Areas Which Will Be Mowed

Mowed slopes should not be steeper than 3:1. Excessive roughness is undesirable where mowing is planned. These areas may be roughened with shallow grooves such as remain after tilling, discing, harrowing, raking, or use of a cultipacker-seeder. The final pass of any such tillage implement shall be on the contour (perpendicular to the slope).

Grooves formed by such implements shall be not less than 1-inch deep and not further than 12-inches apart. Fill slopes which are left rough as constructed may be smoothed with a dragline or pickchain to facilitate mowing.

Roughening With Tracked Machinery (see Plate 3.29-4)

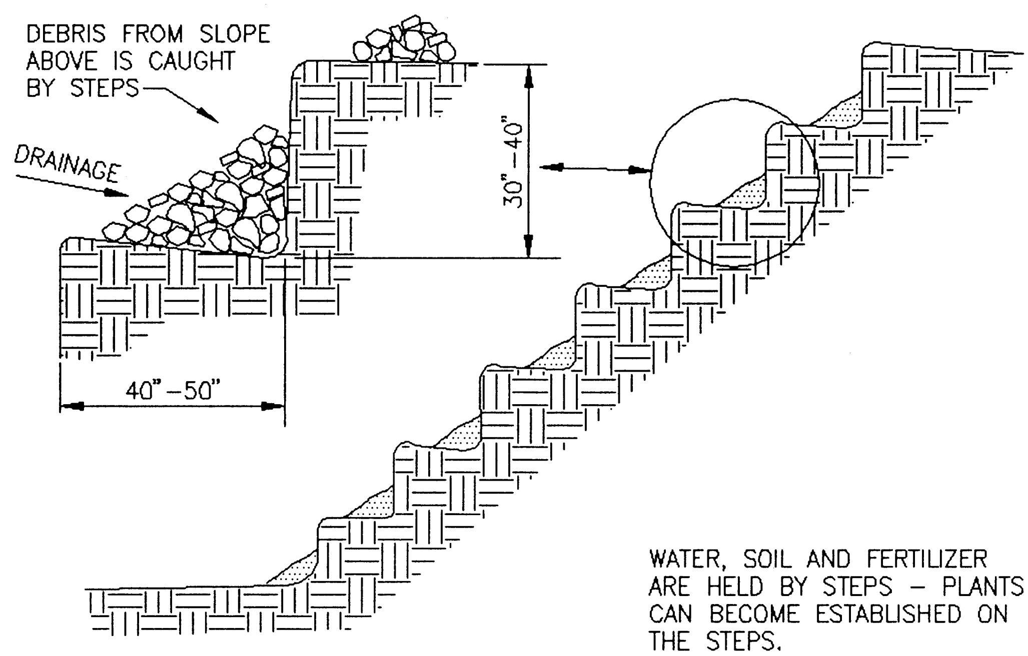
Roughening with tracked machinery on clayey soils is not recommended unless no alternatives are available. Undue compaction of surface soil results from this practice. Sandy soils do not compact severely, and may be tracked. In no case is tracking as effective as the other roughening methods described.

When tracking is the chosen surface roughening technique, it shall be done by operating tracked machinery up and down the slope to leave horizontal depressions in the soil. As few passes of the machinery should be made as possible to minimize compaction.

Seeding

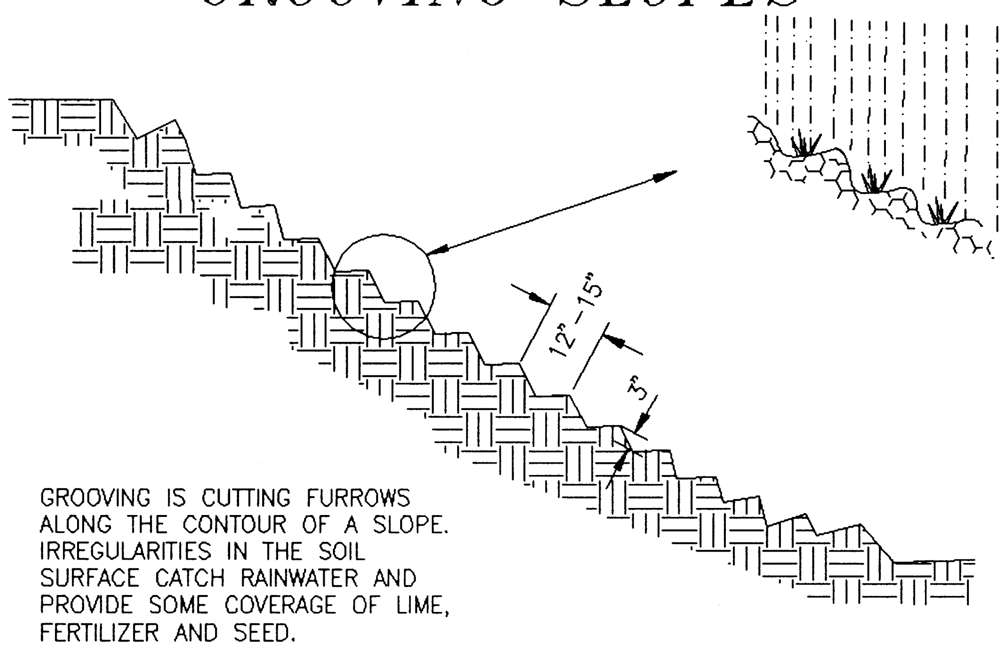
Roughened areas shall be seeded and mulched as soon as possible to obtain optimum seed germination and seedling growth.

STAIR STEPPING CUT SLOPES

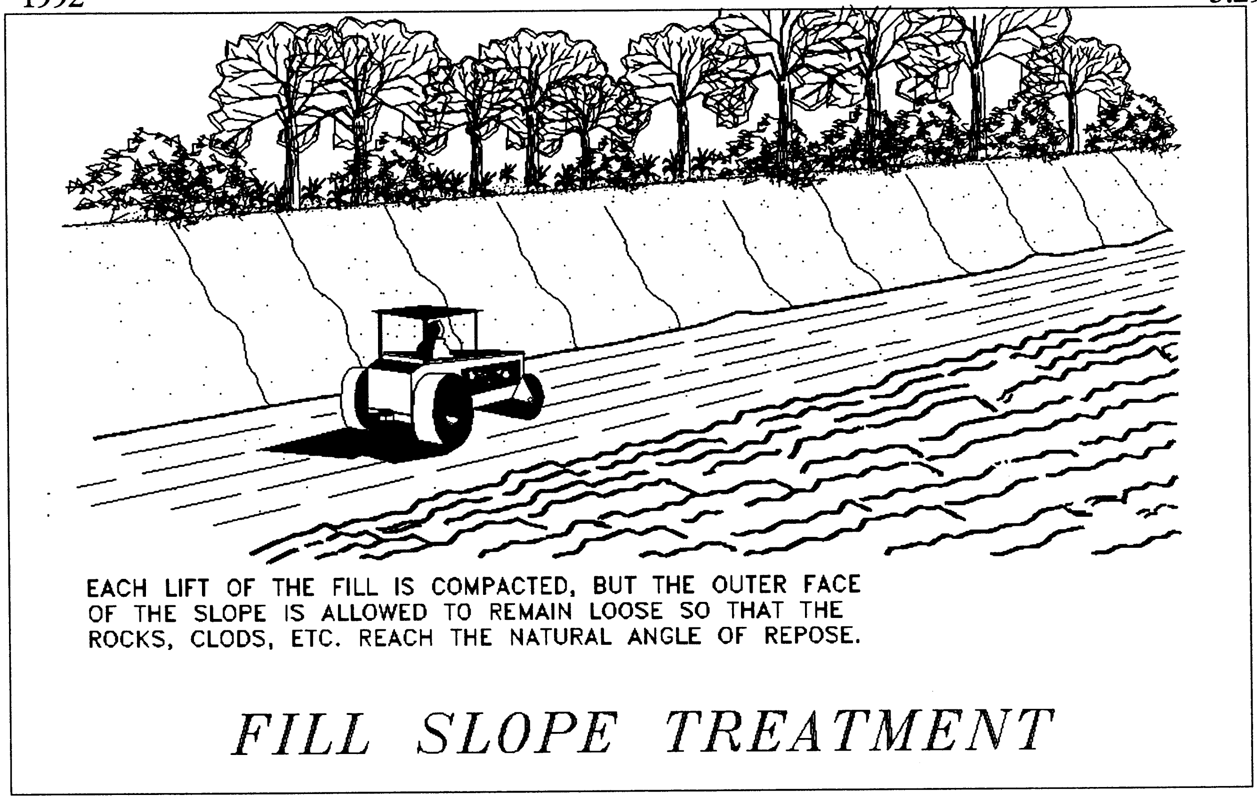


Source: Va. DSWC Plate 3.29-1

GROOVING SLOPES

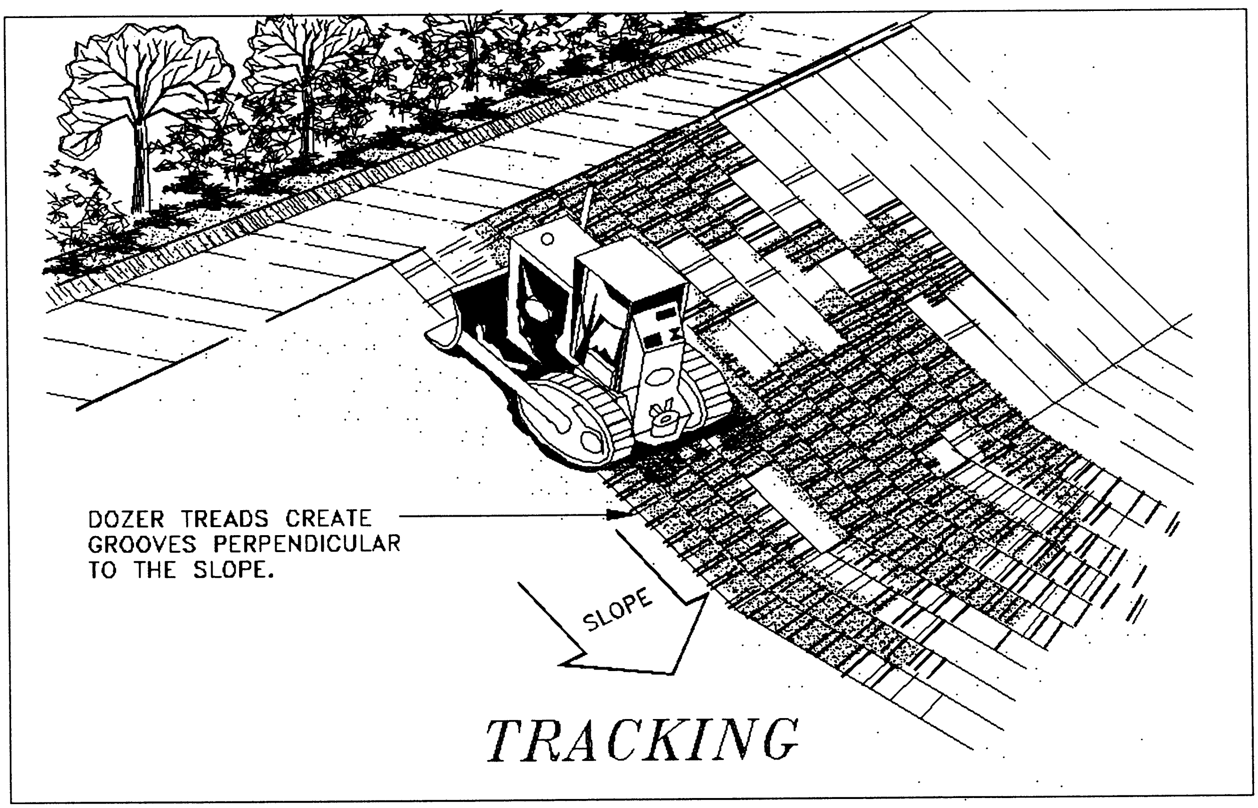


Source: Va. DSWC Plate 3.29-2



Source: Va. DSWC

Plate 3.29-3



Source: Michigan Soil Erosion and Sedimentation Guide

Plate 3.29-4

STD & SPEC 3.30

TOPSOILING

Definition

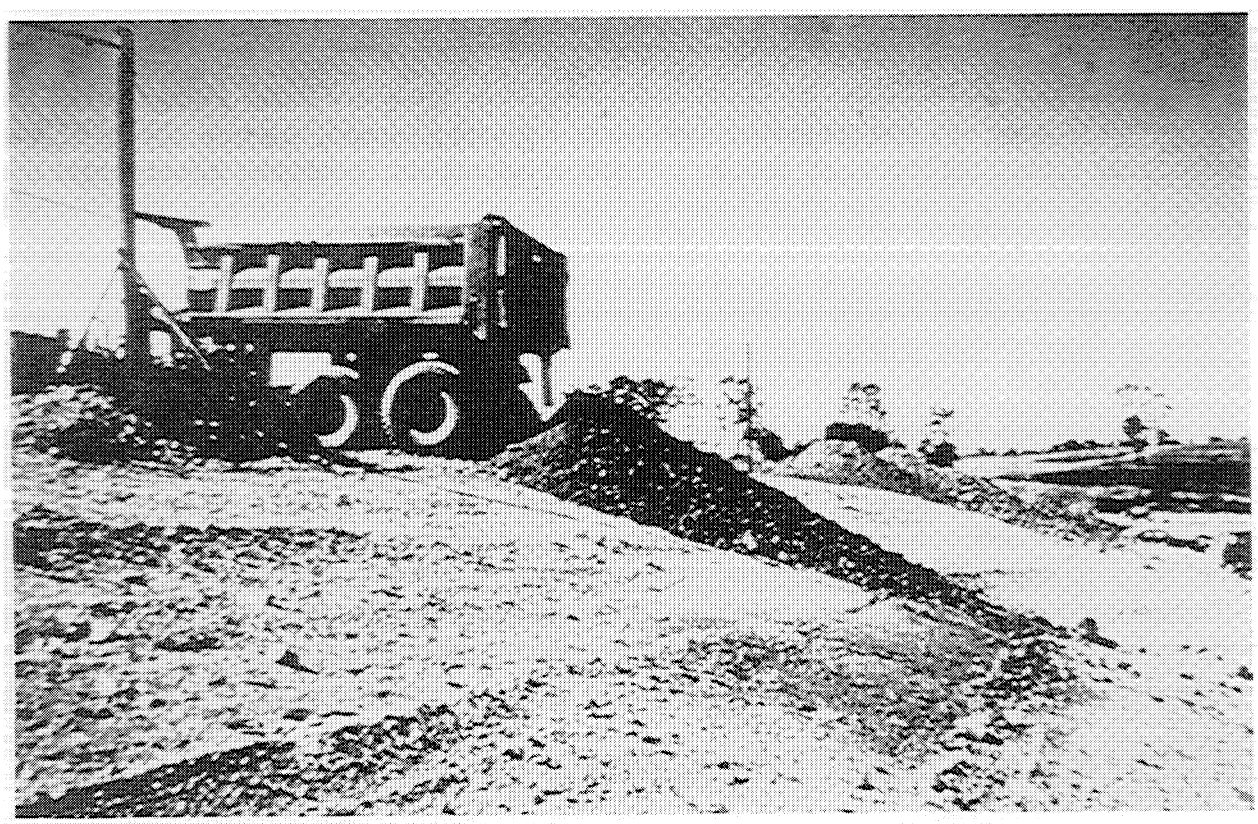
Methods of preserving and using the surface layer of undisturbed soil, often enriched in organic matter, in order to obtain a more desirable planting and growth medium.

Purpose

To provide a suitable growth medium for final site stabilization with vegetation.

Conditions Where Practice Applies

1. Where the preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium.



2. Where the subsoil or existing soil presents the following problems:

    a. The texture, pH, or nutrient balance of the available soil cannot be modified by reasonable means to provide an adequate growth medium.

    b. The soil material is too shallow to provide an adequate root zone and to supply necessary moisture and nutrients for plant growth.

    c. The soil contains substances potentially toxic to plant growth.

3. Where high-quality turf is desirable to withstand intense use or meet aesthetic requirements.

4. Where ornamental plants will be established.

5. Only on slopes that are 2:1 or flatter unless other measures are taken to prevent erosion and sloughing.

Planning Considerations

Topsoil is the surface layer of the soil profile, generally characterized as being darker than the subsoil due to the presence of organic matter. It is the major zone of root development, carrying much of the nutrients available to plants, and supplying a large share of the water used by plants.

Although topsoil provides an excellent growth medium, there are disadvantages to its use. Stripping, stockpiling, and reapplying topsoil, or importing topsoil, may not always be cost-effective. Topsoiling can delay seeding or sodding operations, increasing the exposure time of denuded areas. Most topsoil contains weed seeds, and weeds may compete with desirable species.

Advantages of topsoil include its high organic matter content and friable consistence, water-holding capacity, and nutrient content.

In site planning, the option of topsoiling should be compared with that of preparing a seedbed in subsoil. The clay content of subsoils does provide high moisture availability and deter leaching of nutrients and, when properly limed and fertilized, subsoils may provide a good growth medium which is generally free of weed seeds. In many cases topsoiling may not be required for the establishment of less demanding, lower maintenance plant material. Topsoiling is strongly recommended where ornamental plants or high-maintenance turf will be grown. Topsoiling is a required procedure when establishing vegetation on shallow soils, soils containing potentially toxic materials, and soils of critically low pH (high acid) levels.

If topsoiling is to be done, the following items should be considered:

1. Whether an adequate volume of topsoil exists on the site. Topsoil will be spread at a compacted depth of 2 to 4 inches (depths closer to 4 inches are preferred).

2. Location of the topsoil stockpile so that it meets specifications and does not interfere with work on the site.

3. Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding, or planting.

4. Care must be taken not to apply topsoil to subsoil if the two soils have contrasting textures. Clayey topsoil over sandy subsoil is a particularly poor combination, as water may creep along the junction between the soil layers, causing the topsoil to slough. Sandy topsoil over a clay subsoil is equally as likely to fail.

5. If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. Topsoiling of steep slopes should be discouraged unless good bonding of soils can be achieved.

Specifications

Materials

Field exploration of the site shall be made to determine if there is sufficient surface soil of good quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). It shall be free of debris, trash, stumps, rocks, roots, and noxious weeds, and shall give evidence of being able to support healthy vegetation. It shall contain no substance that is potentially toxic to plant growth.

All topsoil shall be tested by a recognized laboratory for the following criteria:

Organic matter content shall be not less than 1.5% by weight.

pH range shall be from 6.0-7.5. If pH is less than 6.0, lime shall be added in accordance with soil test results or in accordance with the recommendations of the vegetative establishment practice being used.

Soluble salts shall not exceed 500 ppm.

If additional off-site topsoil is needed, it must meet the standards stated above.

Stripping

Topsoil operations should not be performed when the soil is wet or frozen. Stripping shall be confined to the immediate construction area. A 4-to 6-inch stripping depth is common, but depth may vary depending on the particular soil. All perimeter dikes, basins, and other sediment controls shall be in place prior to stripping.

Stockpiling

Topsoil shall be stockpiled in such a manner that natural drainage is not obstructed and no off-site sediment damage shall result. Stabilize or protect stockpiles in accordance with MS #2.

Side slopes of the stockpile shall not exceed 2:1.

Perimeter controls must be placed around the stockpile immediately; seeding of stockpiles shall be completed within 7 days of the formation of the stockpile, in accordance with Std. & Spec. 3.31, TEMPORARY SEEDING if it is to remain dormant for longer than 30 days (refer to MS #1 and MS #2).

Site Preparation Prior to and Maintenance During Topsoiling

Before topsoiling, establish needed erosion and sediment control practices such as diversions, grade stabilization structures, berms, dikes, level spreaders, waterways, sediment basins, etc. These practices must be maintained during topsoiling.

Grading: Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.

Liming: Where the pH of the subsoil is 6.0 or less, or the soil is composed of heavy clays, agricultural limestone shall be spread in accordance with the soil test or the vegetative establishment practice being used.

Bonding: After the areas to be topsoiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by discing or scarifying to a depth of at least 2 inches to ensure bonding of the topsoil and subsoil.

Applying Topsoil

Topsoil shall not be placed while in a frozen or muddy condition, when topsoil or subgrade is excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed sodding or seeding. The topsoil shall be uniformly distributed to a minimum compacted depth of 2 inches on 3:1 or steeper slopes and 4 inches on flatter slopes. (See Table 3.30-A to determine volume of topsoil required for application to various depths). Any irregularities in the surface, resulting from topsoiling or other operations, shall be corrected in order to prevent the formation of depressions or water pockets.

It is necessary to compact the topsoil enough to ensure good contact with the underlying soil and to obtain a level seedbed for the establishment of high maintenance turf. However, undue compaction is to be avoided as it increases runoff velocity and volume, and deters seed germination. Special consideration should be given to the types of equipment used to place topsoil in areas to receive fine turf. Avoid unnecessary compaction by heavy machinery whenever possible. In areas which are not going to be mowed, the surface should be left rough in accordance with SURFACE ROUGHENING (Std. & Spec. 3.29).

Soil Sterilants

No sod or seed shall be placed on soil which has been treated with soil sterilants until sufficient time has elapsed to permit dissipation of toxic materials.

TABLE 3.30-A

CUBIC YARDS OF TOPSOIL REQUIRED FOR APPLICATION TO VARIOUS DEPTHS

Depth (inches)	Per 1,000 Square Feet	Per Acre
1	3.1	134
2	6.2	268
3	9.3	403
4	12.4	537
5	15.5	672
6	18.6	806

Source: Va. DSWC

STD & SPEC 3.31

TEMPORARY SEEDING

TS

Definition

The establishment of a temporary vegetative cover on disturbed areas by seeding with appropriate rapidly growing annual plants.

Purposes

1. To reduce erosion and sedimentation by stabilizing disturbed areas that will not be brought to final grade for a period of more than ~~30~~ 14 days. RWE; DEQ-OTS 3-12-14

2. To reduce damage from sediment and runoff to downstream or off-site areas, and to provide protection to bare soils exposed during construction until permanent vegetation or other erosion control measures can be established.

Conditions Where Practice Applies

Where exposed soil surfaces ~~are not to be fine-graded for periods longer than 30~~ will not be at final grade for more than 14 days. Such areas include denuded areas, soil stockpiles, dikes, dams, sides of sediment basins, temporary roadbanks, etc. (see MS #1 and MS #2). A permanent vegetative cover shall be applied to areas that will be left dormant for a period of more than 1 year.

Planning Considerations

Sheet erosion, caused by the impact of rain on bare soil, is the source of most fine particles in sediment. To reduce this sediment load in runoff, the soil surface itself should be protected. The most efficient and economical means of controlling sheet and rill erosion is to establish vegetative cover. Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover. Temporary seeding is encouraged whenever possible to aid in "controlling" construction sites.

Temporary seeding also prevents costly maintenance operations on other erosion control systems. For example, sediment basin clean-outs will be reduced if the drainage area of the basin is seeded where grading and construction are not taking place. Perimeter dikes will be more effective if not choked with sediment.

Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

Proper seedbed preparation and the use of quality seed are important in this practice just as in permanent seeding. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

Specifications

Prior to seeding, install necessary erosion control practices such as dikes, waterways, and basins.

Plant Selection

Select plants appropriate to the season and site conditions from Tables 3.31-B and 3.31-C. Note that Table 3.31-B presents plants which can be used without extensive evaluation of site conditions; Table 3.31-C presents more in-depth information on the plant materials.

Seedbed Preparation

To control erosion on bare soil surfaces, plants must be able to germinate and grow. Seedbed preparation is essential.

1. Liming: An evaluation should be conducted to determine if lime is necessary for temporary seeding. In most soils, it takes up to 6 months for a pH adjustment to occur following the application of lime. Therefore, it may be difficult to justify the cost of liming a temporary site, especially when the soil will later be moved and regraded. The following table may be used to determine the actual need along with suggested application rates.

TABLE 3.31-A

LIMING REQUIREMENTS FOR TEMPORARY SITES

pH Test	Recommended Application of Agricultural Limestone
below 4.2	3 tons per acre
4.2 to 5.2	2 tons per acre
5.2 to 6	1 ton per acre

Source: Va. DSWC

2. Fertilizer: Shall be applied as 600 lbs./acre of 10-20-10 (14 lbs./1,000 sq. ft.) or equivalent nutrients. Lime and fertilizer shall be incorporated into the top 2 to 4 inches of the soil if possible.

3. Surface Roughening: If the area has been recently loosened or disturbed, no further roughening is required. When the area is compacted, crusted, or hardened, the soil surface shall be loosened by discing, raking, harrowing, or other acceptable means (see SURFACE ROUGHENING, Std. & Spec. 3.29).

4. Tracking: Tracking with bulldozer cleats is most effective on sandy soils. This practice often causes undue compaction of the soil surface, especially in clayey soils, and does not aid plant growth as effectively as other methods of surface roughening.

Seeding

Seed shall be evenly applied with a broadcast seeder, drill, cultipacker seeder or hydroseeder. Small grains shall be planted no more than 1½ inches deep. Small seeds, such as Kentucky Bluegrass, should be planted no more than 1/4 inch deep. Other Grasses and Legumes should be planted from 1/4 inch to 1/2 inch deep.

Mulching

1. Seedings made in fall for winter cover and during hot and dry summer months shall be mulched according to MULCHING, Std. & Spec. 3.35, except that hydromulches (fiber mulch) will not be considered adequate. Straw mulch should be used during these periods.

2. Temporary seedings made under favorable soil and site conditions during optimum spring and fall seeding dates may not require mulch.

Re-seeding

Areas which fail to establish vegetative cover adequate to prevent rill erosion will be re-seeded as soon as such areas are identified.

TABLE 3.31-B

ACCEPTABLE TEMPORARY SEEDING PLANT MATERIALS

"QUICK REFERENCE FOR ALL REGIONS"

Planting Dates	Species	Rate (lbs./acre)
Sept. 1 - Feb. 15	50/50 Mix of Annual Ryegrass (Lolium multi-florum) & Cereal (Winter) Rye (Secale cereale)	50 - 100
Feb. 16 - Apr. 30	Annual Ryegrass (Lolium multi-florum)	60 - 100
May 1 - Aug 31	German Millet (Setaria italica)	50

Source: Va. DSWC

TABLE 3.31-C

TEMPORARY SEEDING PLANT MATERIALS, SEEDING RATES, AND DATES

SPECIES	SEEDING RATE		NORTH[a]			SOUTH[b]			PLANT CHARACTERISTICS
	Acre	1000 ft^2	3/1 to 4/30	5/1 to 8/15	8/15 to 11/1	2/15 to 4/30	5/1 to 9/1	9/1 to 11/15	
OATS (Avena sativa)	3 bu. (up to 100 lbs., not less than 50 lbs.)	2 lbs.	X	-	-	X	-	-	Use spring varieties (e.g., Noble).
RYE[d] (Secale cereale)	2 bu. (up to 110 lbs., not less than 50 lbs.)	2.5 lbs.	X	-	X	X	-	X	Use for late fall seedings, winter cover. Tolerates cold and low moisture.
GERMAN MILLET (Setaria italica)	50 lbs.	approx. 1 lb.	-	X	-	-	X	-	Warm-season annual. Dies at first frost. May be added to summer mixes.
ANNUAL RYEGRASS[c] (Lolium multi-florum)	60 lbs.	1½ lbs.	X	-	X	X	-	X	May be added in mixes. Will mow out of most stands.
WEEPING LOVEGRASS (Eragrostis curvula)	15 lbs.	5½ ozs.	-	X	-	-	X	-	Warm-season perennial. May bunch. Tolerates hot, dry slopes and acid, infertile soils. May be added to mixes.
KOREAN LESPEDEZA[c] (Lespedeza stipulacea)	25 lbs.	approx. 1½ lbs.	X	X	-	X	X	-	Warm season annual legume. Tolerates acid soils. May be added to mixes.

[a] Northern Piedmont and Mountain region. See Plates 3.22-1 and 3.22-2.
[b] Southern Piedmont and Coastal Plain.
[c] May be used as a cover crop with spring seeding.
[d] May be used as a cover crop with fall seeding.
X May be planted between these dates.
\- May not be planted between these dates.

STD & SPEC 3.32

PERMANENT SEEDING

PS

Definition

The establishment of perennial vegetative cover on disturbed areas by planting seed.

Purposes

1. To reduce erosion and decrease sediment yield from disturbed areas.

2. To permanently stabilize disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials.

3. To improve wildlife habitat.

4. To enhance natural beauty.

Conditions Where Practice Applies

1. Disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil.

2. Rough-graded areas which will not be brought to final grade for a year or more.

Planning Considerations

Vegetation controls erosion by reducing the velocity and the volume of overland flow and protecting the bare soil surface from raindrop impact.

Areas which must be stabilized after the land has been disturbed require vegetative cover. The most common and economical means of establishing this cover is by seeding grasses and legumes. Permanent vegetative covers must meet the requirements of Minimum Standard #3.

Advantages of seeding over other means of establishing plants include the small initial establishment cost, the wide variety of grasses and legumes available, low labor requirement, and ease of establishment in difficult areas.

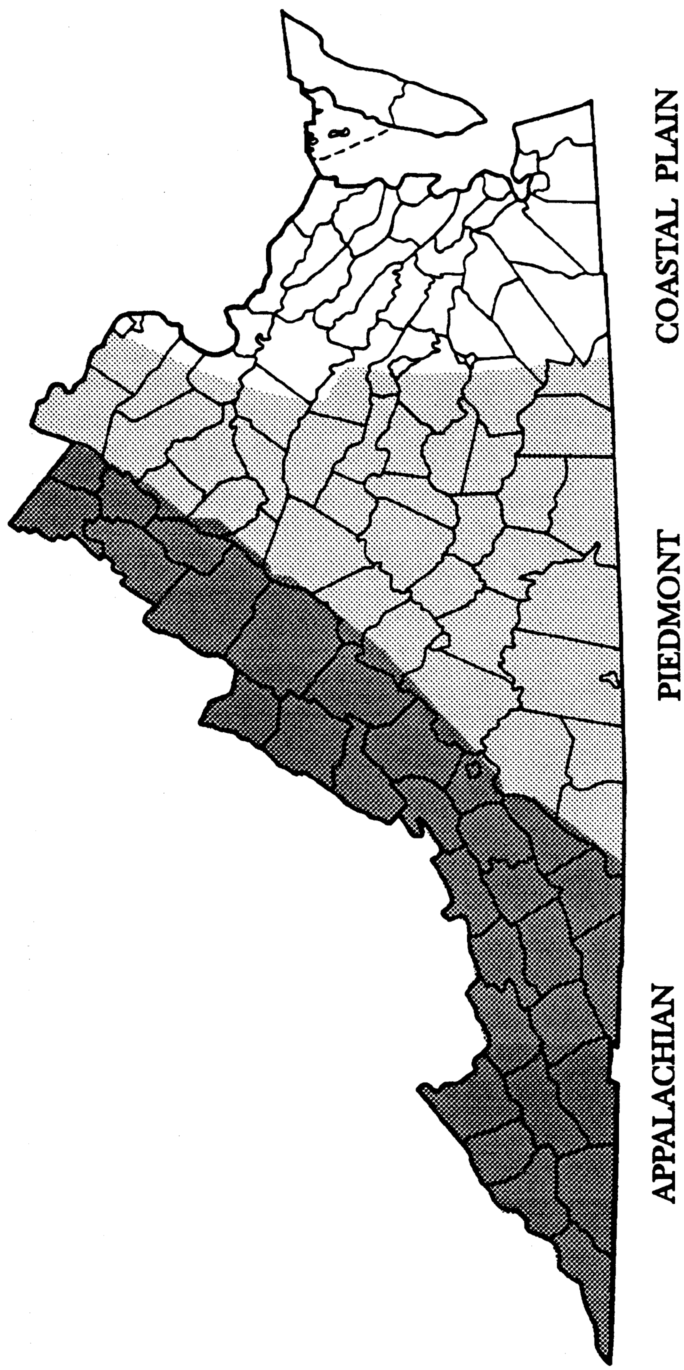
Disadvantages which must be dealt with are the potential for erosion during the establishment stage, a need to reseed areas that fail to establish, limited periods during the year suitable for seeding, the potential need for weed control during the establishment phase, and a need for water and appropriate climatic conditions during germination.

There are so many variables in plant growth that an end product cannot be guaranteed. Much can be done in the planning stages to increase the chances for successful seeding. Selection of the right plant materials for the site, good seedbed preparation, and conscientious maintenance are important.

SELECTING PLANT MATERIALS: The factors affecting plant growth are climate, soils, and topography. In Virginia, there are three major physiographic regions that reflect changes in soil and topography. In selecting appropriate plant materials, one should take into account the characteristics of the physiographic region in which the project is located (see Plate 3.32-1).

PHYSIOGRAPHIC REGIONS:

Coastal Plain - Soils on the Coastal Plain are deeply weathered, stratified deposits of sand and clay. They are generally acidic and low in plant nutrients. The sandy soils are hot and droughty in summer. This region receives more rain and is warmer than the other regions of the state. The land is fairly level, and many areas are poorly drained. Warm season grasses traditionally perform well in these areas.



PHYSIOGRAPHIC PROVINCES IN VIRGINIA

Source: Va. DSWC

Plate 3.32-1

Piedmont - Soils on the Piedmont plateau are highly variable. They tend to be shallow, with clayey subsoils. Piedmont soils are low in phosphorus. Soils derived from mica schist are highly erodible. Topography is rolling and hilly. The southern Piedmont has much the same climate as the Coastal Plain. Often referred to as the "transition zone" in planting. Contains areas that will support both warm or cool season grasses.

Appalachian and Blue Ridge Region - This region is divided into plateaus, mountains, and narrow valleys. Soils tend to be shallow and acid, and may erode rapidly on steep slopes. Shaley slopes are often unstable and droughty. This area is colder and drier than the rest of the State. The rugged topography makes plant establishment difficult. Cool season grasses are normally specified in this region.

SOILS: On the whole, soils in Virginia always require some nitrogen (N) fertilization to establish plants. Phosphorus (P) and potassium (K) are usually needed. Except for some small pockets of shallow limestone soils, lime is universally needed.

Soils can be modified with lime and fertilizer, but climate cannot be controlled. For this reason, the State has been divided into two major climatic regions, referred to as the Northern Piedmont and Mountain Region and the Southern Piedmont and Coastal Plain Region, for grass and legume selection (see map, Plate 3.32-2).

Microclimate, or localized climate conditions, can affect plant growth. A south-facing slope is drier and hotter than a north-facing slope, and may require drought-tolerant plants. Shaded areas require shade-tolerant plants; the windward side of a ridge will be drier than the leeward, etc.

LAND USE: A prime consideration in selecting which plants to establish is the intended use of the land. All of these uses - residential, industrial, commercial, recreational - can be separated into two major categories: high-maintenance and low-maintenance.

High-maintenance areas will be mowed frequently, limed and fertilized regularly, and will either receive intense use (e.g., athletics) or require maintaining to an aesthetic standard (home lawns). Grasses used for these situations must be fine-leaved and attractive in appearance, able to form tight sod, and be long-lived perennials. They must be well-adapted to the geographic area where they are planted, because constant mowing puts turf under great stress. Sites where high-maintenance vegetative cover is desirable include homes, industrial parks, schools, churches, athletic playing surfaces as well as some recreational areas.

Low-maintenance areas will be mowed infrequently or not at all; lime and fertilizer may not be applied on a regular basis; the areas will not be subjected to intense use, nor required to have a uniform appearance. These plants must be able to persist with little maintenance over long periods of time. Grass and legume mixtures are favored for these sites because legumes are capable of fixing nitrogen from the air for their own use, and the use of the plants around them. Such mixed stands are better able to withstand adverse conditions.

Sites that would be suitable for low-maintenance vegetation include steep slopes, stream or channel banks, some commercial properties, and "utility turf" areas such as roadbanks.

Seedbed Preparation - The soil on a disturbed site must be modified to provide an optimum environment for seed germination and seedling growth. The surface soil must be loose enough for water infiltration and root penetration. The pH (acidity and alkalinity) of the soil must be such that it is not toxic and nutrients are available, usually between pH 6.0-7.0. Sufficient nutrients (added as fertilizer) must be present. After seed is in place, it must be protected with a mulch to hold moisture and modify temperature extremes, and to prevent erosion while seedlings are growing.

The addition of lime is equally as important as applying fertilizer. Lime is best known as a pH, or acidity, modifier, but it also supplies calcium and magnesium which are plant nutrients. Its effect on pH makes other nutrients more available to the plant. It can also prevent aluminum toxicity by making aluminum less soluble in the soil. Many soils in Virginia are high in aluminum, which stunts the growth of plant roots.

MAINTENANCE: Even with careful, well-planned seeding operations, failures can occur. When it is clear that plants have not germinated on an area or have died, these areas must be reseeded immediately to prevent erosion damage. However, it is extremely important to determine for what reason germination did not take place and make any corrective action necessary prior to reseeding the area. Healthy vegetation is the most effective erosion control available.

Specifications

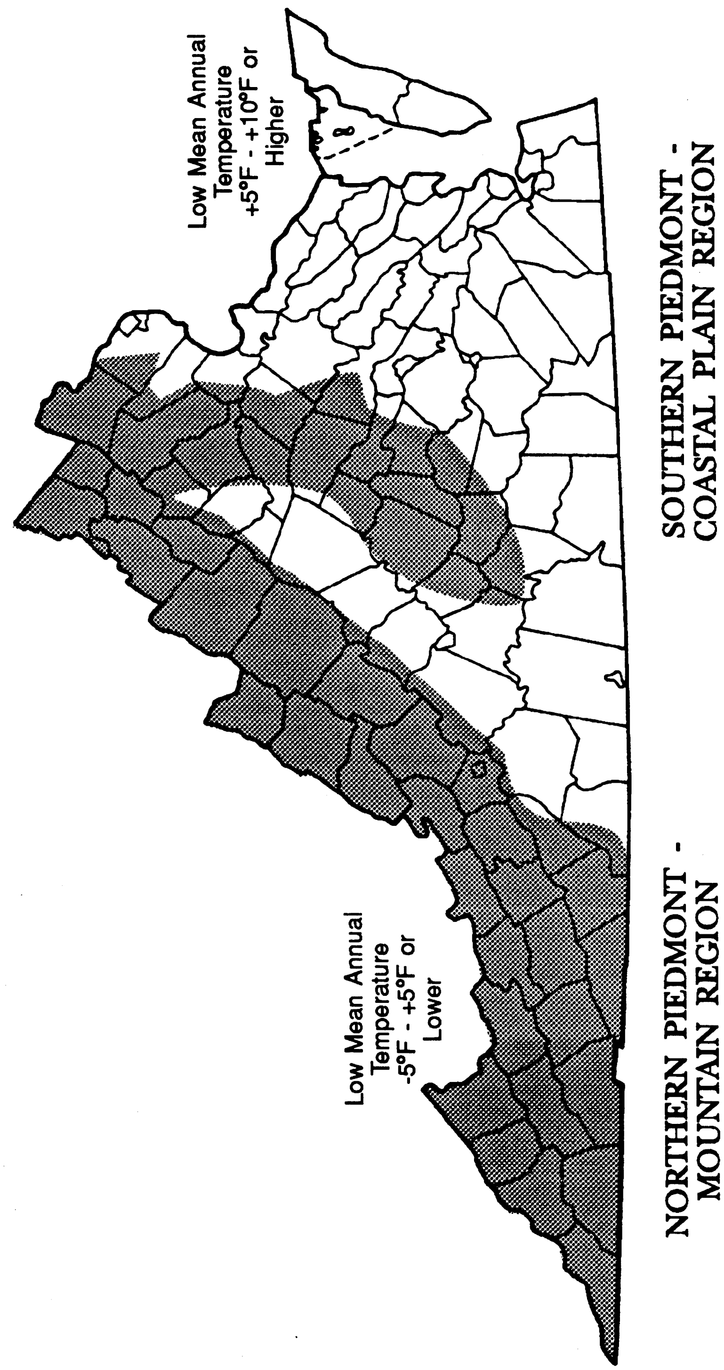
Selection of Plant Materials

1. Selection of plant materials is based on climate, topography, soils, land use, and planting season. To determine which plant materials are best adapted to a specific site, use Tables 3.32-A and 3.22-B which describe plant characteristics and list recommended varieties.

2. Appropriate seeding mixtures for various site conditions in Virginia are given in Tables 3.32-C, 3.32-D and 3.32-E. These mixtures are designed for general use, and are known to perform well on the sites described. Check Tables 3.32-A and 3.32-B for recommended varieties.

3. A more extensive description of plant materials (grasses and legumes), their usage and pictorial representation can be found in Appendix 3.32-c.

4. When using some varieties of turfgrasses, the Virginia Crop Improvement Association (VCIA) recommended turfgrass mixtures may also be used. Consumer protection programs have been devised to identify quality seed of the varieties recommended by the Virginia Cooperative Extension Service. These will bear a label indicating



PLANT HARDINESS ZONES IN VIRGINIA FOR GRASSES AND LEGUMES

Source: Adapted from Virginia Climate Advisory, 1979. Plate 3.32-2 that they are approved by the Association. Mixtures may be designed for a specific physiographic region or based on intended use. Special consideration is given to plant characteristics, performance, etc.

TABLE 3.32-A
CHARACTERISTICS OF COMMONLY SELECTED GRASSES

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
TALL FESCUE (Festuca arundinacea)	P	C	5.5-6.2	10-14	60-85	F	F	M	SPD	225K	Low when used for erosion control; high when used in lawn	Better suited for erosion control and rough turf application.	Ky 31
TALL FESCUES (Improved)	P	C	5.5-6.2	10-14	60-85	F	G	M	SPD	220K	Responds well to high maintenance.	Excellent for lawn and fine turf.	See current VCIA list.
KENTUCKY BLUEGRASS (Poa pratense)	P	C	6.0-6.5	14	60-75	G	P	M	SPD	2.2m	Needs fertile soil, favorable moisture. Requires several years to become well established.	Excellent for fine turfs-takes traffic, mowing. Poor drought/heat tolerance.	See current VCIA list.
PERENNIAL RYEGRASS (Lolium perenne)	P	C	5.8-6.2	7-10	60-75	F	F	M-H	SPD	227K	Will tolerate traffic.	May be added to mixes. * Improved varieties will perform well all year.	See current VCIA list.

KEY

A = Annual P = Perennial C = Cool Season Plant W = Warm Season Plant G = Good F = Fair P = Poor VP = Very Poor H = High
M = Medium L = Low SPD = Somewhat Poorly Drained MPD = Moderately Poorly Drained PD = Poorly Drained VPD = Very Poorly Drained

TABLE 3.32-A (Continued)
CHARACTERISTICS OF COMMONLY SELECTED GRASSES

COMMON NAME (Botanical Name)		Life Cycle	Season	pH Range	Germination Time, In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
FINE FESCUES	HARD FESCUE (Festuca Longifolia)	P	C	5.0-6.2	10-14	60-80	VG	G	L	MWD	400K	Grows well in sun or shade and will tolerate infertile soils; improved disease resistance.	Exceeds all fine fescues in most tests. Excellent for low-maintenance situations.	Reliant, Spartan, Aurora
	CHEWINGS FESCUE	P	C	5.0-6.2	10-14	60-80	VG	G	L	MWD	400K	Tolerates shade, dry infertile soils.	Poor traffic tolerance, less thatch than other fine fescues.	Flyer
	RED FESCUE (Festuca Rubra)	P	C	5.0-6.2	10-14	60-80	VG	G	L	MWD	400K	Low to medium fertility requirements. Requires well-drained soil.	Spreads by rhizomes, tillers and stolons. Will not take traffic - very shade tolerant.	Long-fellow, Victory
REED CANARYGRASS (Phalaris arundinacea)		P	C	5.8-6.2	21	70-85	G	G	M-H	VPD	530K	Do not mow closely or often.	Conservation cover in wet areas.	No named varieties

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TABLE 3.32-A (Continued)
CHARACTERISTICS OF COMMONLY SELECTED GRASSES

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time, In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
REDTOP (Agrostis alba)	P	C	5.8-6.2	10	65-85	G	F	L	PD	5m	Will tolerate poor, infertile soils; deep rooted.	Does well in erosion control mixes - not for lawns.	No named varieties.
WEEPING LOVEGRASS (Evagrostis curvula)	P	W	4.5-6.2	14	65-85	F-P	G	L-M	SPD	1.5m	Low-fertility requirements; excellent drought tolerance.	Fast-growing, warm-season bunch grass. Excellent cover for erosion control.	No named varieties.
BERMUDAGRASS (Cynodon dactylon)	P	W	5.8-6.2	21	70-95	P	G	M-H	SPD	1.8m hulled	High nitrogen utilization, excellent drought tolerance. Some varieties adapted to western VA.	Common varieties used for erosion control. Hybrids used for fine turf.	See current VCIA list.
ORCHARDGRASS (Dactylis glomerata)	P	C	5.8-6.2	18	60-75	F	F	M	SPD	625K	Does best on well-drained, loamy soil.	Good pasture selection - may be grazed.	Virginia origin or Potomac

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TABLE 3.32-A (Continued)
CHARACTERISTICS OF COMMONLY SELECTED GRASSES

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
ANNUAL RYEGRASS (Lolium multiflorum)	A	C	5.8-6.2	7	60-70	G	P	M-H	SPD	227K	Will grow on most Virginia Soils. Do not use in fine-turf areas.	May be added into mixes or established alone as temporary cover in spring and fall.	No named varieties.
RYE (Secale cereale)	A	C	5.8-6.2	7	55-70	VG	G	L-M	SPD	18K	Will establish in most all Virginia soils. Do not use in fine-turf areas.	May be added into mixes or established alone for late fall/winter cover.	Abruzzi, Balboa
FOXTAIL MILLET (Setaria italica)	A	W	5.8-6.2	10	65-85	VP	G	M	MWD	220K	Establishes well during summer. Very low moisture requirements.	May be added to erosion-control mixes or established alone.	Common, German

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TABLE 3.32-B
CHARACTERISTICS OF LEGUMES APPROPRIATE FOR EROSION CONTROL

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
CROWNVETCH (Coronilla varia)	P	C	6.0-6.5	14-21	70	G	VG	M	MWD	110K	Does best on well-drained soils. Minimum maintenance when established. May need phosphorus. Inoculation is essential.	Excellent for steep, rocky slopes. Produces colorful blooms in May/June. Slow to establish. Does best when seeded in spring.	Penngift Chemung Emerald
SERICEA LESPEDEZA (Lespedeza cuneata)	P	W	5.8-6.2	21-28	70-85	F	VG	L	MWD	335K	Grows in most well-drained soils. Low fertility requirements. Inoculation is essential.	Use hulled seed in spring; unhulled in fall. Very deep-rooted legume. Excellent choice for eastern Va.	Serecia Interstate
FLATPEA (Lathyrus silvestrus)	P	C	5.0-7.0	14-28	65-75	G	G	L	PD	15K	Needs lime and high phosphorus. Good shade tolerance.	Tolerates acidic and wetter soils better than other legumes.	Lathco
BIRDSFOOT TREFOIL (Lotus corniculatus)	P	C	6.0-6.5	7	65-70	G	F	M	SPD	375K	Inoculation is essential. Grows in medium-fertile, slightly acid soils.	Grows better on poorly drained soils than most legumes. Poor drought/heat tolerance.	No named varieties.

KEY

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TABLE 3.32-B (Continued)
CHARACTERISTICS OF LEGUMES APPROPRIATE FOR EROSION CONTROL

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
ANNUAL LESPEDEZAS (Lespedeza striata, L. stipulacea)	A	W	5.8-6.2	14	70-85	F	VG	L	MWD	200K	Will grow on almost any well-drained soil.	Choose Kobe for southeastern Va.; needs almost no nitrogen to survive.	Kobe, Korean
RED CLOVER (Trifolium pratense)	P	C	6.0-6.5	7-14	70	G	F	M	SPD	275K	Needs high levels of phosphorus and potassium.	Acts as a biennial. Can be added to low-maintenance mixes.	Kenstar, Kenland
WHITE CLOVER (Trifolium repens)	P	C	6.0-6.5	10	70	G	P	M	PD	700K	Requires favorable moisture, fertile soils, high pH.	Spreads by soil surface stolons, white flowers.	Common, White Dutch

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M = Medium L = Low SPD = Somewhat Poorly Drained MPD = Moderately Poorly Drained PD = Poorly Drained VPD = Very Poorly Drained

TABLE 3.32-C
SITE SPECIFIC SEEDING MIXTURES
FOR APPALACHIAN/MOUNTAIN AREA

	Total Lbs. Per Acre
Minimum Care Lawn	
- Commercial or Residential	200-250 lbs.
- Kentucky 31 or Turf-Type Tall Fescue	90-100%
- Improved Perennial Ryegrass *	0-10%
- Kentucky Bluegrass	0-10%
High-Maintenance Lawn	
Minimum of three (3) up to five (5) varieties of bluegrass from approved list for use in Virginia.	125 lbs.
General Slope (3:1 or less)	
- Kentucky 31 Fescue	128 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop **	20 lbs.
	150 lbs.
Low-Maintenance Slope (Steeper than 3:1)	
- Kentucky 31 Fescue	108 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop **	20 lbs.
- Crownvetch ***	20 lbs.
	150 lbs.

* Perennial Ryegrass will germinate faster and at lower soil temperatures than fescue, thereby providing cover and erosion resistance for seedbed.

** Use seasonal nurse crop in accordance with seeding dates as stated below:

March, April through May 15th	Annual Rye
May 16th through August 15th	Foxtail Millet
August 16th through September, October	Annual Rye
November through February	Winter Rye

*** If Flatpea is used, increase to 30 lbs./acre. All legume seed must be properly inoculated. Weeping Lovegrass may also be included in any slope or low-maintenance mixture during warmer seeding periods; add 10-20 lbs/acre in mixes.

TABLE 3.32-D
SITE SPECIFIC SEEDING MIXTURES FOR PIEDMONT AREA

	Total Lbs. Per Acre
Minimum Care Lawn	
- Commercial or Residential	175-200 lbs.
- Kentucky 31 or Turf-Type Tall Fescue	95-100%
- Improved Perennial Ryegrass	0-5%
- Kentucky Bluegrass	0-5%
High-Maintenance Lawn	200-250 lbs.
- Kentucky 31 or Turf-Type Tall Fescue	100%
General Slope (3:1 or less)	
- Kentucky 31 Fescue	128 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
	150 lbs.
Low-Maintenance Slope (Steeper than 3:1)	
- Kentucky 31 Fescue	108 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
- Crownvetch **	20 lbs.
	150 lbs.

* Use seasonal nurse crop in accordance with seeding dates as stated below:

February 16th through April . . . . Annual Rye
May 1st through August 15th . . . . Foxtail Millet
August 16th through October . . . . Annual Rye
November through February 15th . . . . Winter Rye

** Substitute Sericea lespedeza for Crownvetch east of Farmville, Va. (May through September use hulled Sericea, all other periods, use unhulled Sericea). If Flatpea is used in lieu of Crownvetch, increase rate to 30 lbs./acre. All legume seed must be properly inoculated. Weeping Lovegrass may be added to any slope or low-maintenance mix during warmer seeding periods; add 10-20 lbs./acre in mixes.

TABLE 3.32-D

SITE SPECIFIC SEEDING MIXTURES FOR COASTAL PLAIN AREA

	Total Lbs. Per Acre
Minimum Care Lawn	
- Commercial or Residential	
- Kentucky 31 or Turf-Type Tall Fescue	175-200 lbs.
or	
- Common Bermudagrass **	75 lbs.
High-Maintenance Lawn	
- Kentucky 31 or Turf-Type Tall Fescue	200-250 lbs.
or	
- Hybrid Bermudagrass (seed) **	40 lbs. (unhulled)
or	30 lbs. (hulled)
- Hybrid Bermudagrass (by other vegetative establishment method, see Std. & Spec. 3.34)	
General Slope (3:1 or less)	
- Kentucky 31 Fescue	128 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
	150 lbs.
Low Maintenance Slope (Steeper than 3:1)	
- Kentucky 31 Tall Fescue	93-108 lbs.
- Common Bermudagrass **	0-15 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
- Sericea Lespedeza **	20 lbs.
	150 lbs.

* Use seasonal nurse crop in accordance with seeding dates as stated below:

February, March through April .... Annual Rye
May 1st through August .... Foxtail Millet
September, October through November 15th ..... Annual Rye
November 16th through January .... Winter Rye

** May through October, use hulled seed. All other seeding periods, use unhulled seed. Weeping Lovegrass may be added to any slope or low-maintenance mix during warmer seeding periods; add 10-20 lbs./acre in mixes.

Seedbed Requirements

Vegetation should not be established on slopes that are unsuitable due to inappropriate soil texture, poor internal structure or internal drainage, volume of overland flow, or excessive steepness, until measures have been taken to correct these problems.

To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. The existing soil must have these characteristics:

1. Enough fine-grained material to maintain adequate moisture and nutrient supply.

2. Sufficient pore space to permit root penetration. A bulk density of 1.2 to 1.5 indicates that sufficient pore space is present. A fine granular or crumb-like structure is also favorable.

3. Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans shall be 12 inches or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.

4. A favorable pH range for plant growth. If the soil is so acidic that a pH range of 6.0-7.0 cannot be attained by addition of pH-modifying materials, then the soil is considered an unsuitable environment for plant roots and further soil modification would be required.

5. Freedom from toxic amounts of materials harmful to plant growth.

6. Freedom from excessive quantities of roots, branches, large stones, large clods of earth, or trash of any kind. Clods and stones may be left on slopes steeper than 3:1 if they do not significantly impede good seed soil contact.

If any of the above criteria cannot be met, i.e., if the existing soil is too coarse, dense, shallow, acidic, or contaminated to foster vegetation, then topsoil shall be applied in accordance with TOPSOILING, Std. & Spec. 3.30.

Necessary structural erosion and sediment control practices will be installed prior to seeding. Grading will be carried out according to the approved plan.

Surfaces will be roughened in accordance with SURFACE ROUGHENING, Std. & Spec. 3.29.

Soil Conditioners

In order to modify the texture, structure, or drainage characteristics of a soil, the following materials may be added to the soil:

1. Peat is a very costly conditioner, but works well. If added, it shall be sphagnum moss peat, hypnum moss peat, reed-sedge peat or peat humus, from fresh-water sources. Peat shall be shredded and conditioned in storage piles for at least six months after excavation.

2. Sand shall be clean and free of toxic materials. Sand modification is ineffective unless you are adding 80 to 90% sand on a volume basis. This is extremely difficult to do on-site. If this practice is considered, consult a professional authority to ensure that it is done properly.

3. Vermiculite shall be horticultural grade and free of toxic substances. It is an impractical modifier for larger acreage due to expense.

4. Raw manure is more commonly used in agricultural applications. However, when stored properly and allowed to compost, it will stabilize nitrogen and other nutrients. Manure, in its composted form, is a viable soil conditioner; however, its use should be based on site-specific recommendations offered by a professional in this field.

5. Thoroughly rotted sawdust shall have 6 pounds of nitrogen added to each cubic yard and shall be free of stones, sticks, and toxic substances.

6. The use of treated sewage sludge has benefitted from continuing advancements in its applications in the agricultural community. When composted, it offers an alternative soil amendment. Limitations include a potentially undesirable pH (because of lime added during the treatment process) and the possible presence of heavy metals. This practice should be thoroughly evaluated by a professional and be used in accordance with any local, state, and federal regulations.

Lime and Fertilizer

Lime and fertilizer needs should be determined by soil tests. Soil tests may be performed by the Cooperative Extension Service Soil Testing Laboratory at VPI&SU, or by a reputable commercial laboratory. Information concerning the State Soil Testing Laboratory is available from county extension agents. Reference Appendix 3.32-d for liming applications (in lbs.) needed to correct undesirable pH for various soil types.

Under unusual conditions where it is not possible to obtain a soil test, the following soil amendments will be applied:

Lime

Coastal Plain: 2 tons/acre pulverized agricultural grade limestone (90 lbs./1000 $ft.^2$).

Piedmont and Appalachian Region: 2 tons/acre pulverized agricultural grade limestone (90 lbs./1000 $ft.^2$).

Note: An agricultural grade of limestone should always be used.

Fertilizer

Mixed grasses and legumes: 1000 lbs./acre 10-20-10 or equivalent nutrients (23 lbs./1000 $ft.^2$).

Legume stands only: 1000 lbs./acre 5-20-10 (23 lbs./ 1000 $ft.^2$) is preferred; however, 1000 lbs./acre of 10-20-10 or equivalent may be used.

Grass stands only: 1000 lbs./acre 10-20-10 or equivalent nutrients, (23 lbs./1000 $ft.^2$).

Other fertilizer formulations, including slow-release sources of nitrogen (preferred from a water quality standpoint), may be used provided they can supply the same amounts and proportions of plant nutrients.

Incorporation - Lime and fertilizer shall be incorporated into the top 4-6 inches of the soil by discing or other means whenever possible. For erosion control, when applying lime and fertilizer with a hydroseeder, apply to a rough, loose surface.

Seeding

1. Certified seed will be used for all permanent seeding whenever possible. Certified seed is inspected by the Virginia Crop Improvement Association or the certifying agency in other states. The seed must meet published state standards and bear an official "Certified Seed" label (see Appendix 3.32-a).

Kentucky Bluegrass Seed Mixtures

Kentucky Bluegrass Seed Blends