7.0 MANAGEMENT PRACTICES

Chapter 7 contains design information and guidance for each management practice. The purpose of this section is to provide the design professional preparing the Stormwater Pollution Prevention Plan (SWPPP) and Erosion Prevention and Sediment Control (EPSC) Plan with detailed design and implementation guidelines for each management practice and to provide the inspector with installation and maintenance information. This information is intended to minimize the time required to design each management practice under general site conditions, but it is not intended to apply to all sites and all applications. Unusual site conditions may dictate that management practices be designed as a special case with corresponding construction specifications written specifically for the special case. In most cases, these management practices should be designed as a comprehensive system of controls rather than stand alone devices.

Each management practice presented herein contains a stated definition, purpose, application, additional considerations, design criteria, construction specifications, and maintenance and inspection information. Additional information and design examples may be found in the Appendices.

7.1 IDENTIFYING SENSITIVE AREAS OR CRITICAL AREAS

Definition Marking, flagging, or fencing areas in the field that should be protected from construction activities such as clearing, grading, mowing, staging activities, materials storage, and/or other related activities.

Purpose To protect sensitive areas from being disturbed or encroached upon by construction or construction-related activities.

Conditions Where Practice Applies Any site containing features considered to be sensitive to the impacts from construction, regardless of the project size. Areas that should be protected include tree preservation areas, Aquatic Resources Alteration Permit (ARAP) boundaries, streams, wetlands, endangered or protected species habitat, water quality buffers, mitigation or stream relocation boundaries, sinkholes, stormwater treatment areas, caves, and historic preservation areas. There may also be special cases in which the land owner or design professionals deem an area critical for preservation that should be clearly marked to prevent disturbance.

Planning Considerations Any sensitive or critical areas within the project boundaries should be identified in the SWPPP and on the EPSC plans. The design professional should clearly label all areas on construction plans and specify the type of marking materials to be used.

Design Criteria When a construction project contains wetlands or streams, additional permits are typically required (see Section 2 for more information on other permits that may be needed). Before any construction activity begins on a project in the vicinity of streams and wetlands, all permit boundaries should be identified on the project and marked in the field.

Temporary and permanent water quality buffers should also be identified. Maintenance and disturbance restrictions can vary, depending on the regulatory agency's requirements. For example, some portions of buffers can be disturbed and revegetated, while other buffers must remain completely undisturbed. Before staking the outer limits of the buffer, understand the local and state requirements relative to temporary and permanent water quality buffer zone disturbance and long term vegetation management. The SWPPP must clearly document these for the site.

In addition to streams and wetlands, other sensitive areas should be protected during construction. Any portions of the development that are designed as undisturbed natural areas should be clearly marked in the field to prevent disturbance. If these areas are disturbed, additional site design components may be needed to meet local or state requirements.

Areas that should be identified and clearly marked as sensitive areas in the field include the following:

- **Streams and wetland buffers**. Note that the buffer requirements in the Construction General Permit (See Appendix A) may not be the same as the locally required stream and wetland buffers. The more restrictive of the two must be followed.
- **ARAP boundaries**. If the ARAP allows a specific footage or acreage of stream or wetland encroachment, going beyond these boundaries can result in a violation. Clearly marking these boundaries in the field aids in maintaining compliance with the ARAP conditions.
- **Stream mitigation or relocation boundaries**. It is likely that a two step field marking process is necessary for stream relocations and/or mitigation. The first boundaries should identify the permitted impacts to the natural resource and should occur prior to work in the area. Once the relocation or mitigation has been installed and stabilized, these areas should be marked to show the outer limits and prevent disturbance or damage to plants.
- **Sinkholes**. Depending on the drainage patterns of the site, the only discharge point from a site may be a sinkhole. Sinkholes are a vital component of the drainage network and are subject to clogging by sediment and debris. Sinkhole basins should be protected from sediment from construction sites by using appropriate erosion prevention and sediment controls upgradient from the basin. Leaving sinkhole basins undisturbed provides an additional measure of protection. It should be noted that discharges to sinkholes may require a underground injection well permit from the TDEC Division of Water Supply.
- **Undisturbed areas**. Often, undisturbed open space requirements are established and enforced by the local jurisdiction. The amount of undisturbed open space per development is typically a percentage of the development. Disturbing these areas can lead to additional development restrictions or mitigation requirements. In addition, undisturbed areas of a site affect sediment control design. The less disturbed area on a site, the smaller the sediment storage required. If an area is shown on the SWPPP as undisturbed and is disturbed during construction, the sediment control measures can easily be overwhelmed, causing a failure and potential violation.
- **Threatened and/or Endangered species habitat**. Critical habitat for threatened or endangered species should be protected from land disturbing activities and

to avoid a potential "taking." These areas should be clearly identified on the plans and in the field to prevent inadvertent disturbance or encroachment.

- **Stormwater management areas**. Land disturbing activities destroy the infiltration capacity of soils by changing the soil structure, compacting the soils, and subjecting soil organic matter to a more rapid decay process. Many stormwater management practices, such as biorentention areas and water quality swales rely on the soil infiltration capacity. When the infiltration capacity of the in situ soils is substantially altered, the area may no longer be suitable for permanent stormwater management controls.

Construction Specifications

Many types of boundary markers are available. Flags, stakes, posts or fencing can be used as field boundary markers. Whatever type is used, it should be highly visible and installed along the outer perimeter of the feature's boundaries. Bright colors and highly distinguishable marking materials should be specified, such as orange fencing, neon or brightly colored flags, or highly visible signage. Some markers will be temporary (such as ARAP permit boundaries) while others may be more permanent (such as permanent water quality buffer boundaries). The decision about the type of marker to be used at the site may in part be dictated by the lifespan of the feature being marked.

Maintenance and Inspection Points

- Boundary markers should be maintained throughout the lifespan for the feature.
- Boundary markers should be inspected during each inspection, with inspections being performed as required by the CGP.
- Any markers that have been damaged, removed or degraded to the point that they are no longer visible should be replaced.
- Boundary markers should be removed at the end of construction, unless required by an agency or local government to be left in place.

References

TDOT Manual for Management of Stormwater Discharges Associated with Construction Activities

North Carolina Erosion and Sediment Control Planning and Design Manual

7.2 CONSTRUCTION SEQUENCING

Definition A work schedule specific to each project that coordinates the timing of land disturbing activities, installation of erosion prevention and sediment control measures, permanent stormwater management controls and stabilization.

Purpose To minimize the erosion and sedimentation by performing land disturbing activities, installing EPSC measures, installing permanent stormwater controls and stabilization in accordance with a planned schedule. Note that phasing is a site management technique within an overall construction schedule, but should not be mistaken for the construction schedule itself.

Conditions Where Practice Applies All construction sites disturbing one or more acres are required to have a construction schedule in their SWPPP. However, sites that affect less than one acre can benefit from a planned construction schedule as well.

Design Criteria The construction sequence should be designed and written so that it is easily understood and followed by contractors and subcontractors. The sequence should clearly state the order in which erosion prevention and sediment control devices are to be installed, including stating what measures should be in place before other activities are begun. See Table 5.2-1 in Chapter 5 for an example construction sequence.

An example of construction sequencing could be as follows:

- Install Construction entrance, mark sensitive areas, and designate equipment and chemical storage areas.
- Install sediment basins and traps, silt fencing, and other sediment barriers for Phase 1.
- Install runoff controls such as diversion structures, silt fence, wattles, and outlet protection for Phase 1.
- Perform land clearing and grading, installing EPSC components at the earliest possible time during grading activities for Phase 1. Maintain EPSC measures throughout the grading process.
- Stabilize surfaces immediately in areas where work is delayed or completed.
- Mark sensitive areas and install perimeter measures for Phase 2.
- Clear and grub Phase 2.
- Install sediment traps and other internal controls. Maintain controls.
- Install permanent stabilization measures in Phases 1 and 2, such as seeding and mulching, sodding, and riprap at earliest possible time following completion of grading and construction activities.
- Remove temporary controls and stabilize all disturbed areas.

As in the CGP, project sites exceeding 50 acres of disturbance require phasing. In some cases individual construction sequences may be provided for each individual planned phase, while in other cases the designer may find it necessary to provide an overall construction sequence which interconnects the phases and encompasses the project as a whole.

Construction Specifications

The construction sequence is a part of the SWPPP and therefore shall be maintained onsite and be available to all contractors and subcontactors at all times. Efforts to adhere to construction sequence should be a coordinated effort between all parties onsite.

Maintenance and Inspection Points

Follow the construction sequence throughout the entire project development. When changes in construction activities are needed, amend the sequence schedule in advance to maintain management control.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

TDOT Design Division Drainage Manual

7.3 TOPSOILING

Definition The act of scraping topsoil from a construction site and reserving it for use to aid final stabilization.

Purpose To provide a suitable soil medium to support vegetation growth.

Conditions Where Practice Applies Topsoiling should be utilized on all construction sites where topsoil is available at the surface of the soil. Preserving topsoil for use at final stabilization ensures a healthy stand of vegetation. Topsoil storage areas should have EPSC measures applied, such as stockpile perimeter controls and temporary cover. Topsoil should only be placed on slopes less than 2:1 unless additional engineered slope stabilization is applied to prevent slippage.

Planning Considerations Topsoil is the major zone of root development and biological activity. It is generally darker than the subsoils due to enrichment with organic matter, but not all darker soils are topsoils. Questionable soils available for topsoiling should be analyzed by a soils specialist or soil scientist to insure that the soils can in fact support vegetation growth.

Although topsoil may improve growth capabilities for vegetation, there are some disadvantages to topsoiling. Stripping, stockpiling, hauling, and spreading topsoil, or importing topsoil, may not be cost-effective for some projects. In addition, some topsoil contains weed seeds which compete with desirable vegetation species.

In planning for the final grading and vegetation of a site, the designer should compare the options of topsoiling with preparing a seedbed in the available subsoils.

Subgrade elevations and finished grade elevations should be considered when planning for topsoil thickness.

Topsoil stockpiling should be conducted early in the project as large disturbed areas are scheduled. Placement of topsoil should be completed at the end of construction just before permanent vegetation is to be installed.

Design Criteria

Topsoil should be stripped and stockpiled onsite before grading activities are commenced in any new area of the site. Stockpiled topsoil should be stabilized utilizing temporary vegetation practices *(refer to Sections 7.8 and 7.10 for more information).* Include a topsoil stockpile area on the EPSC Plan and in the construction sequence. Stockpile areas should be located where topsoil is less likely to discharge into streams and other sensitive areas if measures failed; where it does not block natural or artificial drainage ways; and where it does not interfere with work on the site.

Construction Specifications

The topsoil stockpile must be protected against erosion. Stabilize the stockpile with a temporary or permanent groundcover. In addition, perimeter measures should be provided around the stockpile area to prevent sediment migration.

Once grading on any portion of the site has reached final grade, topsoil should be spread prior to final stabilization. Topsoil placement should not be specified in areas where slopes are steeper than 2:1.

Good quality topsoil has the following characteristics:

General Characteristics – Topsoil should be friable and loamy, free of debris, objectionable weeds and stones, and contain no toxic substances that may be harmful to plant growth. Topsoil should be handled only when it is dry enough to work without damaging the soil structure.

Texture – Loam, sandy loam, and silt loam are best; sandy clay loam, silty clay loam, clay loam, and loamy sand are fair. Heavy clay and organics such as peat or muck should not be used as topsoil.

Organic Matter Content – Organic materials should be greater than 2% by weight.

Fertility and nutrients – pH range should be 5.5 to 7.0; liming may be specified if pH is less than 5.5. Soil test for nutrients as well, based upon the type of vegetation to be established.

Organic and inorganic soil amendments (see Chapter 7) may be applied to topsoil to achieve the desired characteristics.

The depth of topsoil to be applied should be 5 inches (unsettled).

STRIPPING
Strip topsoil only from areas that will be disturbed by excavation, filling, paving, or compaction by equipment. Stripping depth various and should be site-specific.

STOCKPILING
Topsoil stockpiles should be located to avoid slopes, natural and artificial drainage ways, and construction traffic. Multiple stockpiles near areas to be stripped may be specified on large sites so that re-spreading topsoil is more efficient and economical.

Sediment controls should be specified where necessary around stockpiles to prevent eroded topsoils from leaving the stockpile area. Temporary seeding practices should be performed no more than 15 days after the formation of the stockpile. Permanent groundcovers should be considered where topsoil stockpiles are to be inactive for longer periods of time.

TOPSOIL SPREADING
Topsoil should be spread only when grading activities have been completed and permanent vegetation is to be applied. Grades should be maintained according to the approved plan, and final grades should not be altered by adding topsoil. The subgrade surface should be roughened by disking or scarifying to a minimum depth of 4 inches prior to spreading topsoil to ensure bonding of the topsoil and subsoils. Apply lime or fertilizer to subgrade before roughening.

Topsoil should be uniformly distributed to a minimum depth of 5 inches and compacted. Do not spread topsoil while it is excessively wet or frozen. Uniformly moisten excessively dry soil that is not workable or too dusty. Correct any irregularities in the surface to prevent the formation of depressions or water pockets. After topsoil application, follow procedures for permanent vegetation.

Maintenance and Inspection Points

Topsoiled areas should be inspected for erosion, depressions or ridges, rocks, and other foreign materials prior to beginning permanent vegetation applications. These areas are subject to ongoing inspections and maintenance until final permanent stabilization has been achieved and a Notice of Termination has been submitted.

References

TDOT Design Division Drainage Manual

North Carolina Erosion and Sediment Control Planning and Design Manual

AIA Masterspec 95 Format, section 02920

7.4 TREE PRESERVATION

Definition Practices to preserve and protect desirable trees from damage during construction activities.

Purpose To preserve and protect trees that have present or future value for environmental or aesthetic benefits.

Conditions Where Practice Applies On construction sites to be developed or disturbed that contain desirable existing trees.

Planning Considerations Preserving and protecting trees and other natural plant groups often results in a more stable and aesthetically pleasing development. During the site evaluation, note where valuable trees and other natural landscape features should be preserved, then consider these trees and plants when determining the location of roads, buildings, or other structures.

Trees that are near construction zones should either be protected or removed because damage during construction activities may cause the death of the tree at a later time.

Trees should be considered for preservation for the following benefits:

- They stabilize the soil and prevent erosion.
- They moderate temperature changes, promote shade, and reduce the force of wind.

- They provide buffers and screens against noise and visual disturbance, providing a degree of privacy.
- They filter pollutants from the air, remove carbon dioxide from the air, and produce oxygen.
- They provide a habitat for animals and birds.
- They increase property values and improve site aesthetics.

Consider the following characteristics when selecting trees to be protected and saved:

- **Tree vigor** – Preserve healthy trees. A tree of low vigor is susceptible to damage by environmental changes that occur during site development. Healthy trees are less susceptible to insects and disease. Indications of poor vigor include dead tips of branches, small annual twig growth, stunted leaf size, sparse foliage, and pale foliage. Hollow or rotten trees, cracked, split or leaning trees, or trees with broken tips have less chance for survival.
- **Tree age** – Old, picturesque trees may be more aesthetically valuable than smaller, younger trees, but they may require more extensive protection.
- **Tree species** – Preserve those species that are the most suitable for site conditions and landscape design. Trees that are short-lived or brittle or are susceptible to attack by insects and disease may be poor choices for preservation.
- **Tree aesthetics** – Choose trees that are aesthetically pleasing, shapely, large, and colorful. Avoid trees that are leaner and in danger of falling. Occasionally, an odd-shaped tree or one of unusual form may add interest to the landscape if strategically located. However, be sure the tree is healthy.
- **Wildlife benefits** – Choose trees that are preferred by wildlife for food, cover, or nesting. A mixture of evergreens and hardwoods may be beneficial. Evergreen trees are important cover during winter months, whereas hardwoods are more valuable for food.

Construction activities can significantly injure or kill trees unless protective measures are taken. Although direct contact by equipment is an obvious means of damaging trees, most serious damage is caused by root zone stress from compacting, filling, or excavating too close to the tree. Clearly mark boundaries to maintain sufficient undisturbed area around the trees.

Design Criteria

The following general criteria should be considered when developing in a wooded area:

- Leave critical areas (such as floodplains, steep slopes, and wetlands) with desirable trees in their natural condition or only partially cleared.
- Locate roadways, storage areas, and parking pads away from valuable tree stands. Follow natural contours, where feasible, to minimize cutting and filling in the vicinity of trees.
- Select trees to be preserved before siting roads, buildings and other structures.
- Minimize trenching in areas with trees. Place several utilities in the same trench.
- Designate groups of trees and individual trees to be saved on the EPSC plan sheets and in the SWPPP.
- **Do not excavate, traverse, or fill closer than the drip line, or perimeter of the canopy, of trees to be preserved.**

Construction Specifications

1. Place barriers to prevent the approach of equipment within the drip line of the trees to be preserved.
2. Do not nail boards to trees during building operations.
3. Do not cut tree roots inside the drip line.
4. Do not place equipment, construction materials, topsoil, or fill dirt within the limit of the drip line of trees to be preserved.
5. If a tree marked for preservation is damaged, remove it and replace it with a tree of the same or similar species, 2-inch caliper or larger, from balled and burlaped nursery stock when activity in the area is complete.
6. During final site cleanup, remove barriers from around trees.

Maintenance and Inspection Points

In spite of precautions, some damage to protected trees may occur. In such cases, repair any damage to the crown, trunk or root system immediately.

- Repair roots by cutting off the damaged. Spread peat moss or moist topsoil over exposed roots.
- Repair damage to bark by trimming around the damaged area, taper the cut to provide drainage, and paint with tree paint.
- Cut off all damaged tree limbs above the tree collar at the trunk or main branch. Use three separate cuts to avoid peeling bark from healthy areas of the tree.

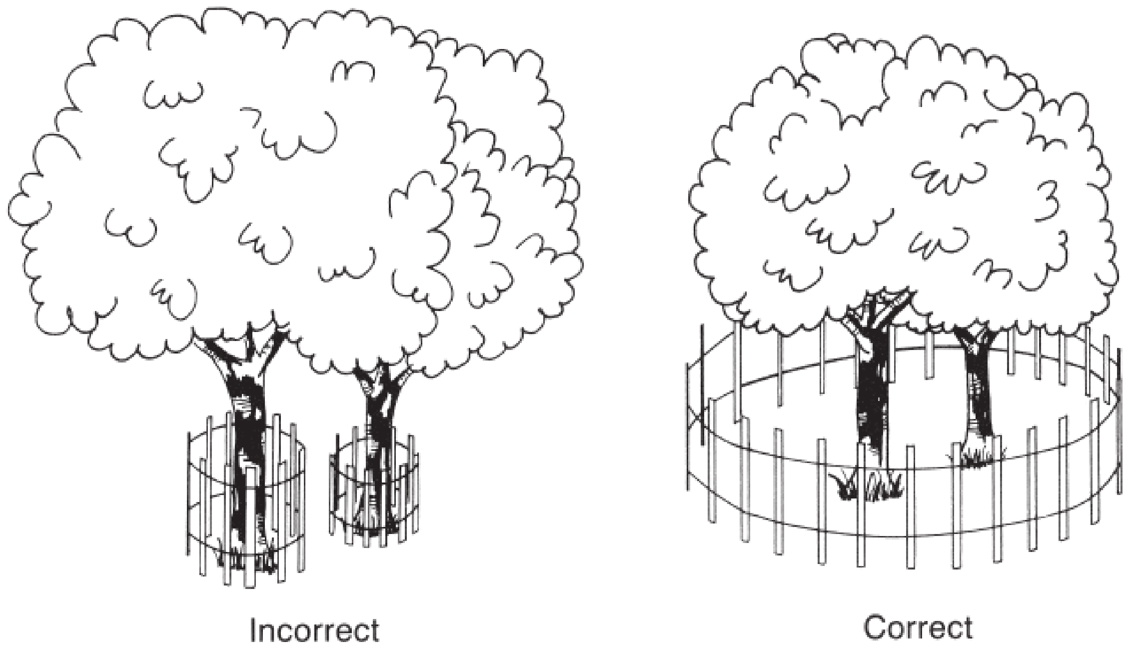


Figure 7-1 Construction barriers should be installed at the drip line of the tree branches.

References *North Carolina Erosion and Sediment Control Planning and Design Manual*

7.5 SURFACE ROUGHENING AND TRACKING

Definition Roughening a bare soil surface with horizontal grooves running across the slope, stair stepping, or tracking with construction equipment.

Purpose To aid the establishment of vegetative cover from seed, to reduce runoff velocity and increase infiltration, and to reduce erosion and provide for sediment trapping.

Conditions Where Practice Applies All construction slopes require surface roughening to facilitate stabilization with vegetation, particularly slopes steeper than 3:1. Slopes to be covered with rolled erosion control products need not be roughened.

Planning Considerations Rough slope surfaces are preferred because they aid the establishment of vegetation, improve water infiltration, and decrease runoff velocity. Graded areas with smooth, hard surfaces may be initially attractive, but such surfaces increase the potential for erosion. A rough, loose soil surface gives a mulching effect that protects lime, fertilizer, and seed. Nicks in the surface are cooler and provide more favorable moisture conditions than hard, smooth 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 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.

Design Criteria No formal design is required.

Construction Specifications

CUT SLOPE ROUGHENING FOR AREAS NOT TO BE MOWED

- Stair-step grade slopes with a gradient steeper than 3:1.
- Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in toward the vertical wall.
- Do not make individual vertical cuts more than 2 feet in soft materials or more than 3 feet in rocky materials.

FILL SLOPE ROUGHENING FOR AREAS NOT TO BE MOWED

- Place fill slopes with a gradient steeper than 3:1 in lifts not to exceed 9 inches, and make sure each lift is properly compacted. Ensure that the face of the slope consists of loose, uncompacted fill 4 to 6 inches deep.
- Do not blade or scrape the final slope.

CUTS, FILLS AND GRADED AREAS THAT WILL BE MOWED

- Make mowed slopes **no steeper than 3:1.**
- Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use of cultipacker-seeder. Make the final pass of any such tillage implement on the contour.
- Make grooves, formed by such implements, close together (less than 10 inches) and not less than 1 inch deep.
- Excessive roughness is undesirable where mowing is planned.

ROUGHENING WITH TRACKED MACHINERY

- Limit roughening with tracked machinery to sandy soils to avoid undue compaction of the soil surface. Tracking is generally not as effective as the other roughening methods described.
- Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back-blade during the final grading operation.
- **Seeding** – Immediately seed and mulch roughened areas to obtain optimum seed germination and growth.

Maintenance and Inspection Points

Periodically check the seeded slopes for rills and washes. Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

If a storm event occurs, it is likely that the surface roughening will have to be redone. Surface roughening is a temporary measure. If roughening is washed away in a heavy storm, the surface will have to be re-roughened and new seed laid.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

STABILIZATION PRACTICES

7.6 STABILIZATION WITH STRAW MULCH

MU STABILIZATION WITH STRAW MULCH

Definition Application of a temporary protective blanket of straw to the soil surface.

Purpose To protect the soil surface from the forces of raindrop impact and overland flow. Mulch reduces runoff and erosion, conserves soil moisture, promotes seed germination, insulates soil, suppresses weed growth, and prevents surface crusting.

Conditions Where Practice Applies Mulch seeded areas immediately. Areas that cannot be seeded because of the season should be mulched to provide temporary protection of the soil surface.

Planning Considerations A surface mulch is considered the most effective, practical means of controlling runoff and erosion on disturbed land prior to vegetative establishment. Mulch reduces soil moisture loss by evaporation, prevents crusting and sealing of the soil surface, moderates soil temperatures, provides a suitable microclimate for seed germination, and may increase the infiltration rate of soil.

Straw mulch is the most common type of mulch used in conjunction with seeding or providing a temporary groundcover. The straw should come from wheat or oats (“small grains”), and may be spread by hand or with a mulch blower. Note that straw may be lost to wind and must be tacked down. The recommended application rate for straw mulch is 2 tons per acre, dry unchopped, unweathered.

Note that the goal is 70% uniform coverage over 100% of the site. Straw mulch is often used in conjunction with some channel liners.

Design Criteria No formal design is required.

Construction Specifications

Before applying mulch, complete the required grading, install sediment control practices, and, if applying seed, prepare the seed bed. When applying seed in combination with mulch, apply the seed before mulch except in the following cases:

- Seed is applied as a part of a hydroseeder slurry containing mulch.
- A hydroseeder slurry is applied over straw.

Application:

Spread mulch uniformly by hand or with a mulch blower. When spreading mulch by hand, divide the area to be mulched into sections of approximately 1000 ft^2 and place 70-90 lbs of straw (1.5 to 2 bales) in each section to facilitate uniform distribution. After spreading mulch, no more than 25% of the soil surface should be visible. In hydroseeding applications a green dye added to the slurry assures a uniform application.

Anchoring:

Straw mulch must be anchored immediately after spreading. The following methods may be used.

Mulch Anchoring Tool: Straw mulch may be pressed into the soil immediately after the mulch is spread. A special crimper or disk harrow with the discs set straight may be used. Serrated discs are preferred and should be 20 inches or more in diameter and 8 to 12 inches apart. The edges of the discs shall be dull enough to press the mulch into the ground without cutting it. Mulch should not be plowed into the soil. This method is limited on slopes no steeper than 3:1, where equipment can operate safely. Operate machinery on the contour.

Liquid Mulch Binders: Application of liquid mulch binders and tackifiers should be heaviest at the edges, crests of ridges, and banks to resist wind. Binders should be applied uniformly to the remaining area. Binders must be applied after the mulch is spread, or may be sprayed into the mulch as it is being applied. Applying the straw and binder together is the most effective method. Liquid binders include emulsified asphalt and an array of commercially available synthetic binders.

Emulsified asphalt is the most commonly used mulch binder. Any type thin enough to be blown from spray equipment is satisfactory. Asphalt is classified according to the time it takes to cure. Rapid setting (RS or CRS designation) is formulated for curing in less than 24 hours, even during periods of high humidity. It is best used in fall and spring. Medium setting (MS or CMS) is formulated for curing in 24 to 48 hours, and slow setting (SS or CSS) is formulated for use during hot, dry weather, requiring 48 hours or more curing time.

Apply asphalt at 0.10 gallons per square yard (10 gal/1000 ft^2). Heavier applications cause straw to “perch” over rills.

In traffic areas, uncured asphalt can be picked up on shoes and cause damage to rugs, clothing, etc. Use types RS or CRS to minimize such problems. Synthetic binders may be used to anchor mulch. Follow the manufacturer’s recommended application method and rate. Most synthetic binders are expensive and are therefore used mostly in small areas or in residential areas where asphalt may be a problem.

Mulch Nettings: Lightweight plastic, cotton, jute, wire, or paper nets may be stapled over the mulch according to manufacturer's recommendations. Note that single net RECPs with integrated mulch may be used instead of separate mulch with netting.

Maintenance and Inspection Points

Inspect all mulches periodically, and after rainstorms to check for rill erosion, dislocation or failure. Where erosion is observed, apply additional mulch. If washout occurs, repair the slope grade, reseed and reinstall mulch. Continue inspecting mulched areas until vegetation has firmly established or until construction activities resume in the area.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

STABILIZATION PRACTICES

7.7 STABILIZATION WITH OTHER MULCH MATERIALS

MO STABILIZATION WITH OTHER MULCHES

Ground trees were used to stabilize the flat portion of the site above.

Definition Application of a protective blanket of plant residues, wood chips, or other organic material, produced on the site if possible, to the soil surface.

Purpose To protect the soil surface from the forces of raindrop impact and overland flow. Mulch reduces runoff and erosion, conserves soil moisture, promotes seed germination, insulates soil, suppresses weed growth, and prevents surface crusting.

Conditions Where Practice Applies This practice is applicable for areas that require temporary stabilization until permanent vegetation can establish. These mulches should be applied on areas that are not to be mowed. In addition, do not use in drainages or areas of concentrated flow. Specific applications include:

- Exposed areas that cannot be seeded due to seasonal conditions.
- On areas that are not to be mowed, such as trees, shrubs, or ground covers to stabilize the soil between plants.

Planning Considerations Woody plant residue, wood chips and mulches that cannot be anchored down are susceptible to floating and movement by water. These materials should not be used in areas of concentrated flow or high sheet flow.

Design Criteria The choice of materials for mulching should be based on soil conditions, season, type of vegetation, and size of the area.

Wood Chips:
Wood chips are suitable for areas that will not be closely mowed, and around ornamental plantings. Chips do not require tacking. Because they decompose slowly they must be treated with 12 lbs of nitrogen per ton to prevent nutrient deficiency in plants. This can be an inexpensive mulch if chips are obtained from trees cleared on the site.

Bark Chips and Shredded Bark:
Bark chips and shredded bark are byproducts of timber processing that are often used in landscape plantings. Bark is also suitable mulch for areas planted to grasses and not closely mowed. It may be applied by hand or with a mulch blower; do not use a tackifier. Unlike the use of wood chips, bark does not require additional nitrogen fertilizer.

Wood Fiber:
Wood fiber refers to short cellulose fibers applied as a slurry in hydroseeding operations. Wood fiber does not require tacking, although tacking agents or soil binders could be easily added to the slurry. Wood fiber hydroseeder slurries may be used to tack straw mulch on steep slopes, critical areas, and where harsh climatic conditions exist. Wood fiber does not provide sufficient erosion protection to be used alone.

Construction Specifications

Before applying mulch, complete the required grading and install sediment control practices. Woody plant residue mulch should not be used where seed is being or has been applied.

Materials: Organic mulch such as wood chips or bark shall be applied at a rate that provides 70% or greater soil coverage. Organic material from the clearing stage of development should remain on site, be chipped, and applied as mulch. This method of mulching greatly reduces erosion control costs. This method however, should not be used in conjunction with seeding due to soil acidification and nitrogen reduction problems that the decomposition of the “green” material will produce.

Maintenance and Inspection Points

Inspect all mulches periodically, and after rainstorms to check for rill erosion, dislocation or failure. Where erosion is observed, apply additional mulch. If washout occurs, repair the slope grade, reseed and reinstall mulch. Continue inspections until vegetation has firmly established.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

CALTRANS Roadside Management Toolbox

STABILIZATION PRACTICES

7.8 TEMPORARY VEGETATION

TS STABILIZATION WITH TEMPORARY VEGETATION

Definition

The establishment of temporary vegetative cover with fast growing species for seasonal protection on disturbed or denuded areas.

Purpose

To temporarily stabilize denuded areas that will not be brought to final grade for a period of more than 14 days.

Temporary seeding controls runoff and erosion until permanent vegetation or other erosion control measures can be established. Seeding with a temporary groundcover provides temporary stabilization until permanent stabilization can be achieved. In addition, it provides residue for soil protection and seedbed preparation, and reduces problems of mud and dust production from bare soil surfaces during construction.

Conditions Where Practice Applies

On any cleared, unvegetated, or sparsely vegetated soil surface where vegetative cover is needed for less than 1 year.

For permanent seeding specifications, see Section 7.9.

Planning Considerations

Annual plants that sprout and grow rapidly and survive for only one season are suitable for establishing initial or temporary vegetative cover. Temporary seeding preserves the integrity of earthen sediment control structures such as dikes, diversions, and the banks of dams and sediment basins. It can also reduce the amount of maintenance associated with these devices. For example, the frequency of sediment basin cleanouts will be reduced if the watershed areas outside the active construction zone are stabilized.

Proper seedbed preparation, selection of appropriate species, and the use of quality seed are important. Failure to follow established guidelines and recommendations carefully may result in an inadequate or short-lived stand of vegetation that will not control erosion. Temporary seeding provides protection for no more than 1 year, during which time permanent stabilization should be initiated.

Design Criteria

Complete grading before preparing seedbeds, and install all necessary erosion control practices such as dikes, waterways, and basins. Minimize steep slopes because they make seedbed preparation difficult and increase the erosion hazard. If soils become compacted during grading, loosen them to a depth of 6-8 inches using a ripper, harrow, or chisel plow.

Construction Specifications

Grading and Shaping: Excessive water runoff shall be reduced by properly designed and installed erosion control practices such as ditches, dikes, diversions, and sediment basins. No shaping or grading is required if slopes can be stabilized by hand-seeded vegetation or if hydraulic seeding equipment is to be used.

Seedbed Preparation: Good seedbed preparation is essential to successful plant establishment. A good seedbed is well pulverized, loose and uniform. Where hydroseeding methods are used, the surface may be left with a more irregular surface of large clods and stones.

Liming: Apply lime according to soil test recommendations. If the pH (acidity) of the soil is not known, an application of ground agricultural limestone at the rate to 1 to 1½ tons/acre on coarse textured soils and 2-3 tons/acre on fine textured soils is usually sufficient. Apply limestone uniformly and incorporate into the top 4-6 inches of soil. Soils with a pH of 6 or higher do not need to be limed.

Fertilizer: Base application rates on soil tests. When soil tests are not possible, apply a 10-10-10 grade fertilizer at 700-1000lb/acre. Both fertilizer and lime should be incorporated into the top 4-6 inches of soil. If a hydraulic seeder is used, do not mix seed and fertilizer more than 30 minutes before the application.

Surface Roughening: If recent tillage operations have resulted in a loose surface, additional roughening may not be necessary, except to break up large clods. If rainfall caused the surface to become sealed or crusted, loosen it just prior to seeding by disking, raking, harrowing, or other suitable methods. Groove or furrow slopes steeper than 3:1 on the contour before seeding.

Seeding: Select a non-invasive grass or grass-legume mixture suitable to the area and season of the year. See Figures 7.8-1 to 7.8-3 for suggestions of temporary seeding species. Although native plants are preferred, there are currently no available native species that are not cost prohibitive. Non-invasive annual plants are preferred. Seed shall be applied uniformly by hand, cyclone seeder, drill, cultipacker seeder, or hydraulic seeder. Drill or cultipacker seeders should normally place seed ¼ to ½ inches deep. Appropriate depth of planting is 10 times the seed diameter. Soil should be raked lightly to cover seed with soil if seeded by hand.

Mulching: The use of mulch will help ensure establishment under normal conditions, and is essential to seeding success under harsh site conditions. Harsh site conditions include:

- Seeding in fall for winter cover
- Slopes steeper than 3:1
- Excessively hot or dry weather
- Adverse soils (shallow, rocky, or high in clay or sand), and
- Areas receiving concentrated flow.

Irrigation: During times of drought, water shall be applied at a rate not causing runoff and erosion. The soil shall be thoroughly wetted to a depth that will ensure germination of the seed. Subsequent applications should be made as needed. Newly seeded areas require more water than more mature plants.

Species	Rate (lb/acre)
Rye	120

Seeding dates

East ....Above 2500 feet: Feb. 15 - May 15
Below 2500 feet: Feb. 1- May 1
Middle .... Jan. 1 - May 1
West .... Dec. 1 - Apr. 15

Soil amendments

Follow recommendations of soil tests or apply 2,000 lb/acre ground agricultural limestone and 750 lb/acre 10-10-10 fertilizer.

Mulch

Apply 4,000 lb/acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

Maintenance

Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

Figure 7.8-1 Temporary Seeding Recommendation for Late Winter and Early Spring

Species	Rate (lb/acre)
Oats	60
Brown top millet	30

Seeding dates

East .... May 15 - Aug. 15
Middle .... May 1 - Aug. 15
West .... Apr. 15 - Aug. 15

Soil amendments

Follow recommendations of soil tests or apply 2,000 lb/acre ground agricultural limestone and 750 lb/acre 10-10-10 fertilizer.

Mulch

Apply 4,000 lb/acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

Maintenance

Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

Figure 7.8-2 Temporary Seeding Recommendation for Summer

Species **Rate (lb/acre)**

Species	Rate (lb/acre)
Oats	30
Winter wheat	30

Seeding dates

East .... Aug 15 – Dec 15
Middle .... Aug. 15 – Dec 30
West .... Aug. 15 – Dec 30

Soil amendments

Follow recommendations of soil tests or apply 2,000 lb/acre ground agricultural limestone and 750 lb/acre 10-10-10 fertilizer.

Mulch

Apply 4,000 lb/acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

Maintenance

Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage. If necessary to extend temporary cover beyond June 15, overseed with 50 lb/ac crimson clover in late February or early March.

Figure 7.8-3 Temporary Seeding Recommendations for Fall

Maintenance and Inspection Points

Reseed and mulch areas where seedling emergence is poor or where erosion occurs, as soon as possible. Do not mow.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

STABILIZATION PRACTICES

7.9 PERMANENT VEGETATION

PS STABILIZATION WITH PERMANENT VEGETATION

Definition The planting of native perennial vegetation such as ground covers, shrubs, vines, trees, and/or flowering plants (forbs) on exposed areas for erosion control and final stabilization. Permanent perennial vegetation is required to achieve final stabilization. Native perennial plants are preferred for erosion control because of the following reasons:

- In appropriate habitats, native plants are better adapted to environmental and site conditions, resulting in lower maintenance costs
- Natives are not typically aggressive and do not allow the site to become a source of exotic invasive plants that can spread to other locations and become costly to remove
- Unlike most non-natives, native plants support native insect, bird, and other wildlife for pollinations, food sources, and nesting
- Using native plants provides opportunities to educate and demonstrate various sustainable approaches for the public
- The Tennessee Exotic Pest Plant (TNEPPC) council has ranked non-native plants in Tennessee based on their invasiveness and threats to the natural environment. The following plants that have been used for erosion control ty TDEC and TDOT are listed in TNEPPC's publication **"Invasive Exotic Pest Plants in Tennessee – 2009"**:
  - Korean (and Kobe) lespedeza – "Severe Threat" Category (Kobe is not ranked but has same invasive characteristics as Korean)
  - Tall fescue – "Significant Threat" Category

- Foxtail millet – “Significant Threat” Category
- Crown vetch – “Alert” Category

We are providing native and non-invasive alternative species as the preferred choice for erosion control and soil stabilization for TDEC projects. (Table 7.9-1)

Purpose

To reduce stormwater runoff velocity, maintain sheet flow, protect the soil surface from erosion, promote infiltration of runoff into the soil, and improve aesthetics and provide diversity. Many native grasses have very deep and fibrous roots, a minimum of one foot and up to fifteen feet, and provide long-term erosion control.

Conditions Where Practice Applies

Apply to fine-graded areas on which permanent, long-lived vegetative cover is the most practical or most effective method of stabilizing the soil. Permanent seeding may also be used on rough-graded areas that will not be brought to final grade for a year or more. Areas to be seeded with permanent vegetation must be seeded or planted within 14 days after the construction activity in that portion of the site has permanently ceased.

Planning Considerations

The most common and economical means of stabilizing disturbed soils is by seeding a mixture of grasses and forbs. The advantages of seeding over other means of establishing plants include the smaller initial cost, lower labor input, and greater flexibility of method. The disadvantages of seeding include the potential for erosion during the establishment stage, the need to reseed areas that fail to establish, seasonal limitations on suitable seeding dates, and a need for water and appropriate temperatures during germination and early growth. The probability of successful plant establishment can be maximized through good planning, knowledge of the soil characteristics, selection of suitable plant materials for the site, good seedbed preparation, adequate liming and fertilization, and timely planting and maintenance.

Native grasses can be planted by drilling or seeding. The ground should be prepared by discing or rotovating prior to seeding in the spring or summer. Annual grains such as rye or oats can be planted prior to sowing the grass seed for erosion control. Grass seed can be planted in the dormant season as well.

Permanent perennial vegetation is used to provide a protective cover for exposed areas including cuts, fill, and other denuded areas that will not be regraded. Permanent stabilization should be applied where topsoil was never stripped, or has been returned and incorporated into the soil surface.

- When stripping a site, topsoil should be stockpiled for later use.
- Stockpiled topsoil should be stabilized using temporary vegetation.
- Where a suitable planting medium is not present, topsoil shall be imported and incorporated into the site.
- Block sod provides immediate cover; it is especially effective in controlling erosion adjacent to concrete flumes and other structures. .
- When mixed plantings are done during marginal planting periods, companion crops shall be used.
- No-till planting can be effective when planting is done following a summer or winter annual cover crop.
- Irrigation should be used when the soil is dry or when summer plantings are done.

- Native species are low maintenance plants and are preferred to ensure long-lasting erosion control.
- Wildlife plantings of native species should be included when applicable.

Wildlife Plantings: Commercially available plants beneficial to wildlife species include the following:

- Mast Bearing Trees: Beech, Black Cherry, Blackgum, Chestnut, Oak, Hackberry, Hickory, Honey Locust, Black Locust, and Persimmon.
- Shrubs and Small Trees: Serviceberry, Crabapple, Pawpaw, Spicebush, Hazelnut, Dogwood, Highbush and Lowbush Blueberries, native Holly, Red Cedar, Red Mulberry, Sumac, Wild Plum, Blackhaw and Blackberry. Plant shrubs in patches without tall trees to develop stable shrub communities. All produce fruit used by many kinds of wildlife.

Design Criteria

The state is divided into three planting regions designated I, II and III as shown in the figure below. Native seed mixes are preferred and the recommendations are shown in Table 7-9.1. Note that the rates are based upon Pure Live Seed (PLS).

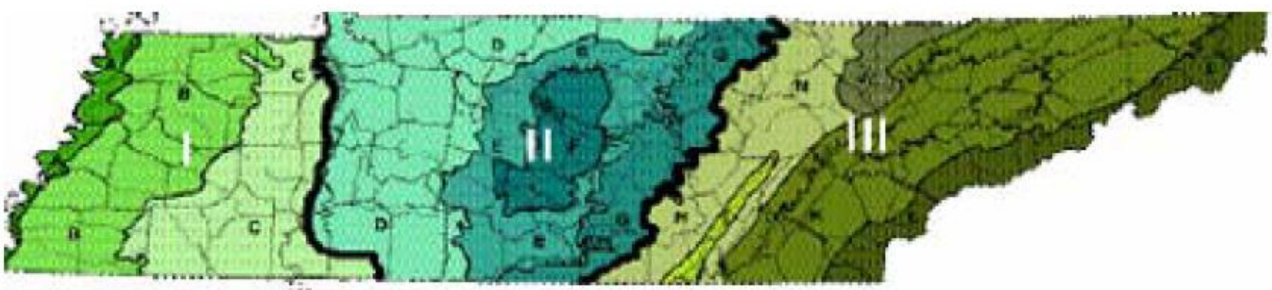


Figure 7.9-1: TN Planting Regions

Table 7.9-1 Preferred seed mixes using natives or naturalized plants and planting dates.
**non-native but do not spread.*

Zone		Best	Marginal	Preferred Rate/Mix (lb/ac PLS)
Region I	Poorly drained soils	Feb 1 – Mar 20 Sept 1 – Sept 30	Mar 20 – Apr 30 Sept 30 – Oct 31	15 Browntop millet* (nurse crop) 2 switch grass 4 little bluestem 4 Virginia wild rye 4 purpletop 2 partridge pea 2 black-eyed susan
	Well drained soils	Apr 1 – July 15		15 Browntop millet* (nurse crop) 4 little blue stem 4 purpletop 2 sideoats gramma 2 partridge pea 2 black-eyed susan
	High maintenance	Apr 1 – July 15		15 Browntop millet* (nurse crop) 2 partridge pea 45 Red fescue* 45 hard fescue* 25 chewing fescue*
Region II	Low maintenance; Slopes and Poor, shallow soils	Aug 25 – Sept 15 **Feb 15 – May 30**	Sept 15 – Oct 25 Mar 21 – May 30	15 Browntop millet* (nurse crop) 5 little bluestem 2 switch grass 2 tall dropseed 5 sideoats gramma 2 black-eyed susan 2 partridge pea 1 greyheaded coneflower
	Low maintenance; Moderate slopes; soils >6 in. depth	Aug 25 – Sept 15 **Feb 15 – May 30**	Sept 15 – Oct 25 Mar 21 – Apr 15	15 Browntop millet* (nurse crop) 5 purpletop 5 little bluestem 5 Virginia wild rye 2 black-eyed susan 2 partridge pea 1 greyheaded coneflower
	High maintenance	Aug 30 – Oct 15	Feb 15 – Apr 15	15 Browntop millet* (nurse crop) 2 partridge pea 45 Red fescue* 45 hard fescue* 25 chewing fescue*
Region III	>2500 ft elevation; steep slopes	Mar 20 – Apr 30	Aug 15 – Aug 30 Mar 1 – Mar 20 Apr 20 – June 15	15 Browntop millet* (nurse crop) 5 purpletop 10 little bluestem 10 Indian grass 2 black-eyed susan 0.5 monarda (bergamot) 4 Maryland senna
	<2500 ft elevation; steep slopes	Aug 15 – Sept 1 **Mar 1 – Apr 1**	Sept 1 – Sept 15 Apr 1 – June 10	

Region III *cont'd*	>2500 ft elev.; Shallow soils	Mar 20 – Apr 20	Aug 15 – Aug 30 Mar 5 – Mar 20 April 20 – June 15	15 Browntop millet* (nurse crop) 4 purpletop 10 little bluestem 10 broomsedge 2 partridge pea 2 black-eyed susan 0.5 monarda (bergamot)
	<2500 ft elev.; Shallow soils	Aug 15 – Sept 1 **Mar 1 – Apr 1**	Sept 1 – Sept 15 Apr 1 – June 10	
	>2500 ft. elev.; Moderate slopes	Mar 20 – Apr 20	Aug 15 – Aug 30 Mar 5 – Mar 20 Apr 20 – June 15	15 Browntop millet* (nurse crop) 4 purpletop 10 little bluestem 10 Indian grass 2 black-eyed susan 0.5 monarda (bergamot) 4 Maryland senna
	<2500 ft. elev.; Moderate slopes	Aug 15 – Sept 1 **Mar 1 – Apr 1**	Sept 1 – Sept 15 Apr 1 – June 10	
	>2500 ft elev.; High maintenance	**Mar 20 – Apr 20**	Aug 15 – Aug 30 Mar 5 – Mar 20 Apr 20 – June 15	15 Browntop millet* (nurse crop) 45 Red fescue* 45 hard fescue* 25 chewing fescue*
	<2500 ft elev.; High maintenance	Aug 15 – Sept 1 **Mar 1 – Apr 1**	Sept 1 – Sept 15 Apr 1 – June 10	

In Table 7.9-1, the bold dates are the preferred dates for seeding. Also, high maintenance areas include lawns and other grassed areas that will be maintained for aesthetics.

Table 7.9-2 Allowable seed mixes and planting dates.

	Zone	Best	Marginal	Rate/Mix (lb/ac PLS)
Region I	Poorly drained soils	Feb 1 – Mar 20 Sept 1 – Sept 30	Mar 20 – Apr 30 Sept 30 – Oct 31	80 Pensacola bahiagrass 30 Bermudagrass (hulled) 20 Korean lespedeza** 10 Kobe lespedeza**
	Well drained soils	Apr 1 – July 15		50 Pensacola bahiagrass 15 Bermudagrass (hulled) 30 Korean lespedeza** 15 Foxtail millet**
	High maintenance	Apr 1 – July 15		40 Bermudagrass (hulled)
Region II	Low maintenance; Slopes and Poor, shallow soils	Aug 25 – Sept 15 **Feb 15 – Mar 21**	Sept 15 – Oct 25 Mar 21 – Apr 15	100 Pensacola bahiagrass 40 Bermudagrass (hulled) 20 Korean lespedeza** 10 Kobe lespedeza**
	Low maintenance; Moderate slopes; soils >6 in. depth	Aug 25 – Sept 15 **Feb 15 – Mar 21**	Sept 15 – Oct 25 Mar 21 – Apr 15	80 Pensacola bahiagrass 30 Bermudagrass (hulled) 20 Korean lespedeza** 10 Kobe lespedeza**
	High maintenance	Aug 15 – Oct 15	Feb 15 – Apr 15	200 KY 31 fescue**

Region III	>2500 ft elevation; steep slopes	July 25 - Aug 15 **Mar 20 – Apr 20**	July 15 – July 25 Aug 15 – Aug 30 Mar 1- Mar 20 Apr 20 – May 15	100 KY 31 fescue** 20 Kobe lespedeza** 10 Korean lespedeza** 5 Redtop
	<2500 ft elevation; steep slopes	Aug 15 – Sept 1 **Mar 1 – Apr 1**	July 25 – Aug 15 Sept 1 – Sept 15 Apr 1 – May 10	
	>2500 ft elev.; Shallow soils	July 25 - Aug 15 **Mar 20 – Apr 20**	July 15 – July 25 Aug 15 – Aug 30 Mar 5 – Mar 20 Apr 20 – May 15	40 KY 31 Fescue** 10 Korean lespedeza** 10 Redtop 10 Crown vetch**
	<2500 ft elev.; Shallow soils	Aug 15 – Sept 1 **Mar 1 – Apr 1**	July 25 – Aug 15 Sept 1 – Sept 15 Apr 1 – May 10	
	>2500 ft. elev.; Moderate slopes	July 25- Aug 15 **Mar 20 – Apr 20**	July 15 – July 25 Aug 15 – Aug 30 Mar 5 – Mar 20 Apr 20 – May 15	60 KY 31 fescue** 15 Korean lespedeza** 15 Kobe lespedeza**
	<2500 ft. elev.; Moderate slopes	Aug 15 – Sept 1 **Mar 1 – Apr 1**	July 25 – Aug 15 Sept 1 – Sept 15 Apr 1 – May 10	
	>2500 ft elev.; High maintenance	July 25 - Aug 15 **Mar 20 – Apr 20**	July 15 – July 25 Aug 15 – Aug 30 Mar 5 – Mar 20 Apr 20 – May 15	200 KY 31 fescue**
	<2500 ft elev.; High maintenance	Aug 15 – Sept 1 **Mar 1 – Apr 1**	July 25 – Aug 15 Sept 1 – Sept 15 Apr 1 – May 10	

ROUNDSTONE Native Seed LLC

Roundstone Native Seed, LLC
9764 Raider Hollow Road, Upton, KY 42784

Kind: Switchgrass		*Lot No: 11074*	
Variety:	*Cave-in-Rock*	*Inert Matter:*	*1.78*
Origin:	*KY*	*Weed Seeds:*	*0.00*
Test Date:	*02/12*	*Crop Seeds:*	*0.00*
Pure Seed:	*98.22*	*Hard Seed:*	*0.00*
Total Germ:	*95.32*	*Germ:*	*95.32*
Pure Live Seed:	*93.62*	*Noxious:*	*0.00*

Figure 7.9-2 Typical Seed

Seeding rates: *Seed rates in Table 7.9-1 are based upon Pure Live Seed (PLS), which is the product of the purity shown on the seed tag multiplied by the germination. The PLS for the seed tag shown in Figure 7.9-2 would be 0.9362 X 0.95 = 0.89 Thus only 89% of the seed are considered live. If the plan calls for a seed rate of 2 lb/acre of switchgrass find the actual seed rate for the conditions shown on the tag. Actual seed rate required is 2 lb/ac / 0.95 PLS = 2.15 lb/acre. In other words, to get an actual rate of 2 lb. per acre it will require 2.15 lb. of seed.*

Temporary seed may be required when seeding outside of the preferred seeding dates. See Section 7.8 for more information on temporary seeding.

Construction Specifications

Grading and Shaping: Grading and shaping may not be required where hydraulic seeding and fertilizing equipment is to be used. Vertical banks shall be sloped to enable plant establishment.

When conventional seeding and fertilizing are to be done, grade and shape the slope, where feasible and practical, so that equipment can be used safely and efficiently during seedbed preparation, seeding, mulching, and maintenance of vegetation.

Concentrations of water that could cause excessive soil erosion should be diverted to a safe outlet. Diversions and other treatment practices must conform to the appropriate standards and specifications.

Plant Selection: Only certified seed shall be used. Refer to Table 7.9-1 for suggested species. Grass type should be selected on the basis of species characteristics; site and soil conditions; planned use and maintenance of the area; time of year of planting, method of planting; and the needs and desires of the land user.

Plant selection may also include annual companion crops. Annual companion crops should be used only when the perennial species are not planted during their optimum planting period. Care should be taken in selecting companion crop species and seeding rates because annual crops will compete with perennial species for water, nutrients, and growing space. A high seeding rate of the companion crop may prevent the establishment of perennial species.

Ryegrass shall not be used in any seeding mixtures containing permanent, perennial species due to its ability to out-compete desired species chosen for permanent perennial cover. However, crimson, clover, oats and winter wheat can be planted any time of the year and are recommended as a cover crop with native perennial species.

Topsoil: Topsoil should be replaced on all areas to be seeded. See Practice 7.3 for more information on the removal, storage and reapplication of topsoil.

Seedbed Preparation: When conventional seeding is to be used, topsoil should be applied to any area where the disturbance results in subsoil at the final grade surface. Figure 7.9-3 provides guidance on the volume of topsoil required to provide specific topsoil depths. Soil pH should be above 5 – preferably between 6.0 and 6.5. Soil on the site should be tested to determine lime and fertilizer rates. Soil should be submitted to a soils specialist or County Agricultural Extension agent for testing and soil amendment recommendations. In the absence of soil test results, the following application rates can be used:

- **Ground agricultural limestone:**
  Light-textured, sandy soils: 1- 1 1/2 tons/acre
  Heavy-textured, clayey soils: 2-3 tons/acre
- **Fertilizer:**
  Grasses: 800-1200 lb/acre of 10-10-10 (or the equivalent)
  Grass-legume mixtures: 800-1200 lb/acre of 5-10-10 (or the equivalent)

Broadcast Seeding:

- Seedbed preparation may not be required where hydraulic seeding equipment is to be used.
- Tillage, at a minimum, shall adequately loosen the soil to a depth of 4 to 6 inches; alleviate compaction; incorporate topsoil, lime, and fertilizer; smooth and firm the soil; allow for the proper placement of seed, sprigs, or plants; and allow for the anchoring of straw or hay mulch if a crimper is to be used.
- Tillage may be done with any suitable equipment.
- Tillage should be done parallel to the contour where feasible.
- On slopes too steep for the safe operation of tillage equipment, the soil surface shall be pitted or trenched across the slope with appropriate hand tools to provide consecutive beds, 6 to 8 inches apart, in which seed may lodge and germinate. Hydraulic seeding may also be used.

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

7.9-3 Cubic yards of topsoil required to attain various soil depths

Inoculants: Native legume seeds do not need to be inoculated. All non-native legume seed shall be inoculated with appropriate nitrogen fixing bacteria. The inoculants shall be pure culture prepared specifically for the seed species and used within the dates on the container. A mixing medium recommended by the manufacturer shall be used to bond the inoculants to the seed. For conventional seeding, use twice the amount of inoculants recommended by the manufacturer.

No-Till Seeding: No-till seeding is permissible into annual cover crops when planting is done following maturity of the cover crop or if the temporary cover stand is sparse enough to allow adequate growth of the permanent (perennial) species. No-till seeding shall be done with appropriate no-till seeding equipment. The seed must be uniformly distributed and planted at the proper depth. Native grasses respond very well to drill seeding at a depth of one-fourth inch.

Mulch: Straw mulch is required for all permanent vegetation applications and must be applied immediately after the application of seed. The application rate for mulch is 2 tons per acre with overall uniform soil coverage of 70%. All mulch must be anchored. See Practice 7.6 for more information on straw mulch.

Maintenance and Inspection Points

Any areas that have washed out due to high stormwater flows, areas that have been disturbed by blowing wind, and areas that do not show good germination should be retreated.

Inspect seeded areas for failure and make necessary repairs and reseedings within the same season, if possible.

Reseeding: If a stand has inadequate cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or over-seed the stand. Consider seeding temporary, annual species if the time of year is not appropriate for permanent seeding.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

STABILIZATION PRACTICES

7.10 SOD

SO STABILIZATION WITH SOD

Definition Permanently stabilizing areas by laying a continuous cover of grass sod.

Purpose To prevent erosion and damage from sediment and runoff by stabilizing the soil surface with permanent vegetation where specific goals might be:

- to establish immediate ground cover,
- protect the soil surface from erosion,
- reduce stormwater runoff,
- to stabilize disturbed areas with a suitable plant material that cannot be established by seed, or
- to stabilize drainageways, channels, and other areas of concentrated flow where flow velocities will not exceed that specified for a grass lining.

Conditions Where Practice Applies This practice is applicable for areas that require immediate and permanent vegetative cover, or where sodding is preferred over other means of grass establishment. Specific applications include:

- Grass swales or waterways carrying intermittent flow.
- Areas around drop inlets.
- Steep critical areas where vegetative cover may be hard to establish.

Planning Considerations Quality turf can be established with either seed or sod; site preparation for the two methods is similar. The practice of sodding for soil stabilization eliminates both the seeding and mulching operations, and is a much more reliable method of producing adequate cover and sediment control. However, compared to seed, sod is more expensive, difficult to obtain, transport, and store.

Advantages of properly installed sod include:

- immediate erosion and dust control,

- nearly year-round establishment capability,
- less chance of failure than with seedings,
- less weeds, and
- rapid stabilization of surfaces for traffic areas, channel linings, or critical areas.

Sod can be laid during times of the year when seeded grasses may fail, provided there is adequate water available for irrigation in the early weeks. Irrigation is essential, at all times of the year, to install sod. It is initially more costly to install sod than to plant seed. However, the higher cost may be justified for specific applications where sod performs better than seed.

In waterways and channels that carry concentrated flow, properly pinned sod is preferable to seed because it provides immediate protection. For channel design, refer to Section 7.27. Drop inlets placed in areas to be grassed can be protected from sediment by placing permanent sod strips around the inlet. Sod also maintains the necessary grade around the inlet.

Because sod is composed of living plants that must receive adequate care, final grading and soil preparation should be completed before sod is delivered. If left rolled or stacked, heat can build up inside the sod, causing severe damage and loss of costly plant material.

Design Criteria

Choosing appropriate types of sod: The type of sod selected should be composed of plants adapted to both the site and the intended purpose. A complete and current listing of sod recommendations can be obtained from suppliers or the State Agricultural Extension office. Sod composed of a mixture of varieties may be preferred because of its broader range of adaptability. Sod that consists of native species is preferred if available.

In general, warm season grasses such as bermudagrass sod should be used in West TN and cool season grasses such as fescue sod should be used in East TN. Both can be used in Middle TN, with warmer season grasses in southern Middle TN and cooler season grasses in northern Middle TN.

Construction Specifications

Quality of sod: Use only high-quality sod of known genetic origin, free of noxious weeds, disease, and insect problems. It should appear healthy and vigorous, and conform to the following specifications:

- Sod should be machine cut and contain ¾” of soil, not including shoots or thatch.
- Sod should not have been cut in excessively wet or dry weather.
- Sod should be cut to the desired size. Torn or uneven pads should be rejected.
- Harvest, delivery, and installation of sod should take place within a period 36 hours.
- Sections of sod should be strong enough to support their own weight and retain their size and shape when lifted by one end.
- Avoid planting when subject to frost heave or hot weather if irrigation is not available.

Soil Preparation: Bring the soil surface to final grade. Clear surface of trash, woody debris, stones and clods larger than 1”. Fill or level low spots in order to avoid standing water. Mix fertilizer and/or lime into soil surface where necessary. See Section 7.9 for more information on soil amendments.

Installation:

- Moistening the sod after it is unrolled helps maintain its viability. Store it in the shade during installation.
- Rake the soil surface to break the crust just before laying sod. During the summer, lightly irrigate the soil, immediately to cool the soil, reduce root burning, and dieback.
- Ensure that the sod is in good contact with the prepared soil surface.
- Do not stretch the sod strips. Instead, maintain the shape of the sod and cut pieces to fit rather than stretching sections.
- Do not install sod on gravel, frozen soils, or soils that have been treated recently with sterilants or herbicides.
- Lay the first row of sod in a straight line with subsequent rows placed parallel to and butting tightly against each other. Stagger strips in a brick-like pattern (see Figure 7-7.10-1). Be sure that the sod is not stretched or overlapped and that all joints are butted tightly to prevent voids.
- Install strips of sod with their longest dimension perpendicular to the slope. On slopes 3:1 or steeper, or wherever erosion may be a problem, secure with pegs or staples.
- As sodding of clearly defined areas is complete, roll sod to provide firm contact between roots and soil.
- After rolling irrigate until the soil is wet 4” below the sod.
- Keep sodded area moist to a depth of 4” until the grass takes root. This can be determined by gently tugging on the sod.
- Mowing should not be attempted until the sod is firmly rooted, usually 2-3 weeks.

Sodded Waterways: The sod must be able to withstand the flow velocity specified in the channel design. Lay sod strips perpendicular to the direction of flows, with the lateral joints staggered in a brick-like pattern. Edges should be butted tightly together.

1. Sodded slopes may require pinning to prevent sod from sliding while it is getting established.

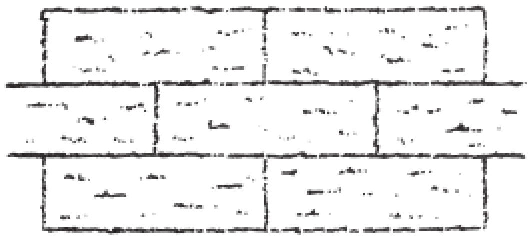


Figure 7-7.10-1. Correct sod placement

Maintenance and Inspection Points

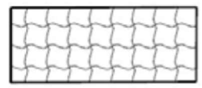
After the first week, water as necessary to maintain adequate moisture in the root zone and prevent the sod from going dormant. Grass height should not be cut to less than 2” to 3”. Re-sod areas where an adequate stand of sod is not obtained.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

STABILIZATION PRACTICES

7.11 ROLLED EROSION CONTROL PRODUCTS



ROLLED EROSION CONTROL PRODUCT

Definition

Rolled erosion control products (RECPs) are manufactured sheets of mulch materials (e.g., straw, coir, wood fibers, curled wood, etc.) that are bound into netting composed of either photodegradable synthetic or natural materials. They are usually delivered to a construction site in rolls which are then installed as a protective covering designed to protect soil and hold seed and mulch in place on slopes and in channels so that vegetation can become well established. **This section only addresses RECPs applied to slopes. RECPs as channel linings are covered in Section 7.27 Channels.**

Purpose

To reduce soil erosion and assist in the growth, establishment and protection of temporary or permanent vegetation on steep slopes.

Conditions Where Practice Applies

RECPs can be applied to steep slopes where erosion hazards are high and conventional seeding is likely to be too slow in providing adequate protective cover. RECPs shall be applied to cut or fill slopes of 2.5:1 or steeper with a height of 10 feet or greater in need of protection during establishment of temporary or permanent ground cover.

Planning Considerations

There are many types of erosion control nets and blankets on the market that may be appropriate in certain circumstances. In general, most nets require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.

Good ground contact is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion. It is preferred that loose woven netting made with natural fibers be used.

Most netting used with blankets is photodegradable, meaning they break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation has established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after the installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.

Biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a fiber mesh and stitching which may last up to one year.

Design Criteria

Formal design of RECPs applied to slopes is not required. However, for each location erosion control blankets are used, the type of blanket should be indicated in the EPSC Plans.

The use of erosion control blankets on cut or fill slopes may be considered for the following conditions:

- In flat or rolling terrain, on 2H:1V or 3H:1V fill slopes and/or 2H:1V or 3H:1V cut slopes (in soils) that are 20 feet or greater in height;
- In mountainous or hilly terrain, 2H:1V or 3H:1V fill slopes and/or 2H:1V or 3H:1V cut slopes (in soils) that are 30 feet or greater in height;
- On slopes built of highly erodible soils such as sandy/loess soils in West Tennessee;
- On slopes running adjacent to a stream or adjacent to a large ditch or channel that empties directly into high-quality or sediment-impaired waters near the roadway construction;
- At point of stormwater runoff concentration where off-site runoff threatens stability of cut slopes.

On sites with flat slopes or short slope lengths, it may be possible to substitute mulch control netting or open weave textiles for erosion control blanket, based on economic considerations.

In addition to the above criteria, the designer should consider the design life of the erosion control blanket. The designer should ensure that it is possible for the permanent vegetation to become well established before the degradable portions of the blanket have degraded to the point that their resistance to erosion is significantly reduced.

Construction Specifications

Even if properly designed, if not properly installed, erosion control blankets will likely not function as desired. Proper installation is imperative. Even if properly installed, if not properly timed and nourished, vegetation will likely not grow as desired. Proper seed/vegetation selection is also imperative.

Grade the surface of installation areas so that the ground is smooth and soil loose. When seeding prior to installation, follow the steps for seed bed preparation, soil amendments, and seeding. All gullies, rills, and any other disturbed areas must be fine graded prior to installation. Spread seed before blanket installation. (**Important**: Remove all large rocks, dirt clods, stumps, roots, grass clumps, trash, and other obstructions from the soil surface to allow for direct contact between the soil surface and the blanket.) Terminal anchor trenches are required at blanket end. Terminal anchor trenches should be a minimum of 12 inches in depth and 6 inches in width.

Installation for Slopes: Place the blanket 2-3 feet over the top of the slope and into an excavated end trench measuring approximately 12 inches deep by 6 inches wide. Pin the blanket at 1 foot intervals along the bottom of the trench, backfill, and compact. Unroll the blanket down (or along) the slope maintaining direct contact between the soil and the blanket. Overlap adjacent rolls a minimum of 3 inches. Pin the blanket to the ground using staples or pins in a 3 foot center-to-center pattern or as recommended by manufacturer.

Anchoring Devices: 11 gauge, at least 6 inches length by 1 inch width, staples or 12 inch minimum length wooden stakes are recommended for anchoring the blanket to the ground.

Drive staples or pins so that the top of the staple or pin is flush with the ground surface. Anchor each blanket every 3 feet along its center. Longitudinal overlaps must be sufficient to accommodate a row of anchors and uniform along the entire length of overlap and anchored every 3 feet along the overlap length. Roll ends may be spliced by overlapping 1 foot (in the direction of water flow), with the upstream/upslope mat placed on top of the downstream/downslope blanket. This overlap should be anchored at 1 foot spacing across the blanket. When installing multiple width mats heat seamed in the factory, all factory seams and field overlaps should be similarly anchored.

Maintenance and Inspection Points

Good contact with the ground must be maintained, and erosion must not occur beneath the blanket.

Any areas of the blanket that are damaged or not in close contact with the ground shall be repaired and stapled.

If erosion occurs due to poorly controlled drainage, the problem shall be fixed and the eroded area repaired.

Monitor and repair the blanket as necessary until ground cover is established. Inspections should include walking across the slope to check for erosion gullies that can be felt rather than seen.

References

TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-34

North Carolina Erosion and Sediment Control Planning and Design Manual

STABILIZATION PRACTICES

7.12 HYDRO APPLICATIONS

HYD

HYDRO APPLICATIONS

Definition A hydraulically applied mixture containing mulch, tackifiers, soil amendments and/or seed in a water based slurry, applied to slopes to establish of vegetation. Hydro applications include hydroseeding, hydromulching, and bonded fiber matrix applications.

Purpose To provide a method of stabilization to slopes that are often difficult to otherwise vegetate.

Conditions Where Practice Applies This practice is applicable on cut or fill slopes and stockpiles where surface protection is needed. Specific applications include:

- Seeding inaccessible and/or steep slopes
- Seeding stock piles
- Seeding flat slopes

Planning Considerations Hydro applications such as hydroseeding and bonded fiber matrices (BFM) are an economical means of applying and securing seed. Its greatest applications are on steep slopes with limited access or on flat terrain where there will be very limited sheet flows.

Hydraulic mulch applications do not provide protection on slopes generally greater than 4:1 or 5:1. Additional measures may be necessary to manage stormwater run-on and provide additional erosion control. Hydro applications should not be applied to channels and ditches.

BFM differs from general hydroseeding in that a BFM is applied at a higher rate of product (3,500-4,000 lbs/ac) and can be used on steep slopes up to 2:1. The BFM is applied uniformly over a prepared and planted seed bed so that there are no areas where the soil surface is visible. Proper coverage provides soil stabilization and protection of the seed bed for approximately one growing season.

Design Criteria

The following recommendations relating to design may enhance the use of, or avoid problems with the practice:

- Hydraulic applications have limited application on non-cohesive soils
- Ensure material is applied at the correct rate with the appropriate seed ratio, if applicable.

Construction Specifications

Apply hydromulch/BFM within 24 hours of seed application. Do not apply any type of hydraulic seeding or mulching during high wind conditions or very dry conditions.

Prohibit foot, equipment and vehicle traffic across the area after application.

Hydraulic equipment and adequate water supply are necessary.

Apply the hydroseed/hydromulch/BFM uniformly leaving no visible soil. To aid in visually verifying the correct application, a dye is typically added to the mixture. To ensure the proper application rate, mark off a section on the ground, such as a 1,000 ft^2 area, and calibrate the sprayer to apply the correct seeding rate for 1,000 ft^2.

Maintenance and Inspection Points

Inspect slopes for rill formation. If necessary, make repairs, reseed and reapply hydraulic material.

If rilling occurs this means that slopes are too steep for hydro application. Repair the surface reseed and cover with a straw mulch to prevent erosion. Mulch should be tacked or crimped depending on the soil type.

References

TDOT Construction Manual

North Carolina Erosion and Sediment Control Planning and Design Manual

STABILIZATION PRACTICES

7.13 SOIL BINDERS

SOIL BINDERS AND TACKIFIERS

Definition

Soil binders are a large family of products that include polyacrylamides, vegetable based products and other chemical based products that are employed as a primary short-term surface protection material.

Purpose

To reduce soil surface erosion due to wind and/or water forces.

Conditions Where Practice Applies

Soil binders are typically applied to disturbed areas requiring short term temporary protection. Because soil binders can often be incorporated into the work, they are a good alternative to mulches in areas where grading activities will soon resume. Soil binders are also suitable for use on stockpiles.

Planning Considerations

Soil binders are materials that are typically used alone to provide surface protection for exposed soils. In most cases, they are not used in conjunction with seeding although they can be. In general, soil binding materials do not provide the microclimatic modification that is provided by mulches or blankets. They work by binding the upper layer of soil together, forming a crust on the surface so that soil particles resist being suspended in surface flows. Although they form a surface crust, most of the materials do not seal the surface to the point where infiltration is prevented, so they do not prevent the establishment of vegetation.

Polyacrylamides have been used successfully to help bind cohesive soils and to reduce the suspension of fine clay particles. It is critical when using polymer based materials to use the type specified and to check carefully to be sure it is properly applied. Some polyacrylamides can be highly toxic to aquatic life if released into a water body but these are not labeled for use as soil binding materials used in erosion control.

General Considerations

- Regional soil types will dictate appropriate soil binders to be used.
- A soil binder must be environmentally benign (non-toxic to plant and animal life), easy to apply, easy to maintain, economical, and should not stain paved or painted surfaces. Soil binders should not pollute stormwater.

- Some soil binders may not be compatible with existing vegetation.
- Performance of soil binders depends on temperature, humidity, and traffic across treated areas.
- Avoid over spray onto roads, sidewalks, drainage channels, existing vegetation, etc.

Selecting a Soil Binder

Properties of common soil binders used for erosion control are provided in Table 7.13-1. Use this table to select an appropriate soil binder. Factors to consider when selecting a soil binder include the following:

- Suitability to situation – Consider where the soil binder will be applied, if it needs a high resistance to leaching or abrasion, and whether it needs to be compatible with any existing vegetation. Determine the length of time soil stabilization will be needed, and if the soil binder will be placed in an area where it will degrade rapidly. In general, slope steepness is not a discriminating factor for the listed soil binders.
- Soil types and surface materials – Fines and moisture content are key properties of surface materials. Consider a soil binder's ability to penetrate, likelihood of leaching, and ability to form a surface crust on the surface materials.
- Frequency of application – The frequency of application can be affected by subgrade conditions, surface type, climate, and maintenance schedule. Frequent applications could lead to high costs. Application frequency may be minimized if the soil binder has good penetration, low evaporation, and good longevity. Consider also that frequent application will require frequent equipment clean up.

Plant-Material Based (Short Lived) Binders

Guar: Guar is a non-toxic, biodegradable, natural galactomannan based hydrocolloid treated with dispersant agents for easy field mixing. It should be mixed with water at the rate of 11 to 15 lb per 1,000 gallons. Recommended minimum application rates are as follows:

Application Rates for Guar Soil Stabilizer

Slope (H:V):	Flat	4:1	3:1	2:1	1:1
lb/ac:	40	45	50	60	70

Psyllium: Psyllium is composed of the finely ground muciloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil. It dries to form a firm but rewettable membrane that binds soil particles together but permits germination and growth of seed. Psyllium requires 12 to 18 hours drying time. Application rates should be from 80 to 200 lb/acre, with enough water in solution to allow for a uniform slurry flow.

Starch: Starch is non-ionic, cold water soluble (pre-gelatinized) granular cornstarch. The material is mixed with water and applied at the rate of 150 lb/acre. Approximate drying time is 9 to 12 hours.

Plant-Material Based (Long Lived) Binders

Pitch and Rosin Emulsion: Generally, a non-ionic pitch and rosin emulsion has a minimum solids content of 48%. The rosin should be a minimum of 26% of the total solids content. The soil stabilizer should be non-corrosive, water dilutable emulsion that upon application cures to a water insoluble binding and cementing agent. For soil erosion control applications, the emulsion is diluted and should be applied as follows:

- For clayey soil: 5 parts water to 1 part emulsion
- For sandy soil: 10 parts water to 1 part emulsion

Application can be by water truck or hydraulic seeder with the emulsion and product mixture applied at the rate specified by the manufacturer.

Polymeric Emulsion Blend Binders

Acrylic Copolymers and Polymers: Polymeric soil stabilizers should consist of a liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55% solids. The polymeric compound should be handled and mixed in a manner that will not cause foaming or should contain an anti-foaming agent. The polymeric emulsion should not exceed its shelf life or expiration date; manufacturers should provide the expiration date. Polymeric soil stabilizer should be readily miscible in water, non-injurious to seed or animal life, non-flammable, should provide surface soil stabilization for various soil types without totally inhibiting water infiltration, and should not re-emulsify when cured. The applied compound should air cure within a maximum of 36 to 48 hours. Liquid copolymer should be diluted at a rate of 10 parts water to 1 part polymer and the mixture applied to soil at a rate of 1,175 gallons/acre or according to manufacturer specifications.

Liquid Polymers of Methacrylates and Acrylates: This material consists of a tackifier/sealer that is a liquid polymer of methacrylates and acrylates. It is an aqueous 100% acrylic emulsion blend of 40% solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants or silicates. For soil stabilization applications, it is diluted with water in accordance with manufacturer's recommendations, and applied with a hydraulic seeder at the rate of 20 gallons/acre. Drying time is 12 to 18 hours after application.

Copolymers of Sodium Acrylates and Acrylamides: These materials are non-toxic, dry powders that are copolymers of sodium acrylate and acrylamide. They are mixed with water and applied to the soil surface for erosion control at rates that are determined by slope gradient:

Slope Gradient (H:V)	lb/acre
Flat to 5:1	3.0 – 5.0
5:1 to 3:1	5.0 – 10.0
2:2 to 1:1	10. – 20.0

Table 7.13-1 Properties of Soil Binders for Erosion Control
(Source: Ca BMP Manual)

Evaluation Criteria	Binder Type			
	Plant Material Based (Short Lived)	Plant Material Based (Long Lived)	Polymer Emulsion Blends	Cemetitious-Based Binders
Relative Cost	Low	Low	Low	Low
Resistance to Leaching	High	High	Low to Moderate	Moderate
Resistance to Abrasion	Moderate	Low	Moderate to High	Moderate to High
Longevity	Short to Medium	Medium	Medium to Long	Medium
Minimum Curing Time before Rain	9 to 18 hrs	19 to 24 hrs	0 to 24 hrs	4 to 8 hrs
Compatibility with Existing vegetation	Good	Poor	Poor	Poor
Mode of Degradation	Biodegradable	Biodegradable	Photodegradable/ Chemically Degradable	Photodegradable/ Chemically Degradable
Labor Intensive	No	No	No	No
Specialized Application Equipment	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher
Liquid/Powder	Powder	Liquid	Liquid/Powder	Powder
Surface Crusting	Yes, but dissolves on rewetting	Yes	Yes, but dissolves on rewetting	Yes
Clean Up	Water	Water	Water	Water
Erosion Control Application Rate	Varies	Varies	Varies	4,000 to 12,000 lbs/ac

Design Criteria

The following recommendations relating to design may enhance the use of, or avoid problems with the practice:

- Use 25 foot setbacks when applying soil binders near natural water bodies.
- Vegetable based materials have up to 6 month longevity; some polyacrylamides have as much as 12 month longevity.
- Consider that performance of binders decreases over time and exposure to ultraviolet light.
- The effectiveness of the practice decreases in concentrated flow paths.
- Excessive application can lower the infiltration rate or suspend solids in water, rather than promote settling.

Construction Specifications

Applying Soil Binders

After selecting an appropriate soil binder, the untreated soil surface must be prepared before applying the soil binder. The untreated soil surface must contain sufficient moisture to assist the agent in achieving uniform distribution. In general, the following steps should be followed:

- Follow manufacturer's written recommendations for application rates, pre-wetting of application area, and cleaning of equipment after use.
- Prior to application, roughen embankment and fill areas.
- Consider the drying time for the selected soil binder and apply with sufficient time before anticipated rainfall. Soil binders should not be applied during or immediately before rainfall.
- Avoid over spray onto roads, sidewalks, drainage channels, sound walls, existing vegetation, etc.
- Soil binders should not be applied to frozen soil, areas with standing water, under freezing or rainy conditions, or when the temperature is below 40°F during the curing period.
- More than one treatment is often necessary, although the second treatment may be diluted or have a lower application rate.
- Generally, soil binders require a minimum curing time of 24 hours before they are fully effective. Refer to manufacturer's instructions for specific cure time.
- For liquid agents:
  - Crown or slope ground to avoid ponding.
  - Uniformly pre-wet ground at 0.03 to 0.3 gal/yd^2 or according to manufacturer's recommendations.
  - Apply solution under pressure. Overlap solution 6 to 12 in.
  - Allow treated area to cure for the time recommended by the manufacturer; typically at least 24 hours.
  - Apply second treatment before first treatment becomes ineffective, using 50% application rate.
  - In low humidities, reactivate chemicals by re-wetting with water at 0.1 to 0.2 gal/yd^2.

The effectiveness of these products depends on rate, slope, and weather. Most will be effective until vegetation is established.

- Application rates should conform to manufacturer's guidelines for application.
- Application of binders and tackifiers should be heaviest at the edges, crests of ridges, and banks to resist wind. Binders should be applied uniformly to the remaining area.
- Use a color dye to achieve more uniform coverage.

Maintenance and Inspection Points

Reapply soil binders to disturbed areas including high use traffic areas that interfere in the performance of this practice. If the application rate is too light reapply over the entire site. If seed application is too light or not uniform as evidenced by spotty germination, reseed the exposed areas.

References

TDOT Construction Manual

North Carolina Erosion and Sediment Control Planning and Design Manual

California Stormwater BMP Handbook

STABILIZATION PRACTICES

7.14 EMERGENCY STABILIZATION WITH PLASTIC

PLAS EMERGENCY STABILIZATION WITH PLASTIC

Definition A plastic cover or sheeting used to protect stockpiles or slopes for short periods of time for immediate protection.

Purpose To prevent erosion on slopes for short periods of time.

Conditions Where Practice Applies This practice is suitable in sheet flow applications. Specific examples include:

- On stockpiles or slopes where vegetation cannot be achieved due to soils, slopes, or seasonal limitations.
- In flood situations to prevent steep hillsides, in particular in mountainous areas, from becoming further saturated which may lead to slope failure.

Planning Considerations Plastic sheeting is easily vandalized, easily torn, photodegradable, and must be disposed of at a landfill. While plastic sheeting can protect a slope against erosion, it results in 100% runoff, which may cause serious erosion problems in the areas receiving the increased flow.

The use of plastic should be limited to covering stockpiles or very small graded areas for short periods of time (such as through one imminent storm event) until alternative measures, such as seeding and mulching, may be installed.

Design Criteria Plastic sheeting shall be polyethylene and have a minimum thickness of 6 mils.

Construction Specifications

- Firmly secure the plastic at the top of the slope with sandbags or other weights placed no more than 10 feet apart.
- Overlap and tape or weigh down seams down their entire length. The overlap should be seams at least 12 inches to 24 inches.
- Embed edges in a minimum of 6 inches in soil.

Maintenance and Inspection Points

All sheeting must be inspected after installation and after significant rainstorms to check for erosion, undermining, and anchorage failure. Any failures must be repaired immediately. If washout or breakages occur, the material should be re-installed after repairing the damage to the slope. Watch for erosion at the end of the plastic.

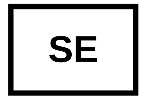
References

TDOT Design Division Drainage Manual

California Stormwater BMP Handbook

STABILIZATION PRACTICES

7.15 SOIL ENHANCEMENT



SOIL ENHANCEMENT

Definition Soil enhancement consists of incorporating compost within the root zone to improve soil quality, plant viability and soil hydraulic conductivity.

Purpose Naturally occurring (undisturbed) soil and vegetation provide important stormwater functions including:

- water infiltration;
- nutrient, sediment, and pollutant adsorption;
- sediment and pollutant biofiltration;
- water interflow storage and transmission; and
- pollutant decomposition.

The primary soil impact from construction is compaction. Compaction impacts relate to a change in soil porosity. Bulk density is an indicator of soil compaction. As bulk densityh increases, soil porosity decreases as does a soil's capacity for water infiltration and storage, and plant root penetration and growth. The result of compaction is poor vegetative vigor. Generally this occurs as bulk densities reach 99 lbs./ft^3 (1.58g/cm^3).

Soil functions are largely lost when development strips away native soil and vegetation and replaces it with minimal topsoil and seed or sod. Not only are these important stormwater functions lost, but the landscapes themselves become pollution-generating pervious surfaces due to increased use of pesticides, fertilizers and other landscaping and household/industrial chemicals, the concentration of pet wastes, and pollutants that accompany roadside litter.

Establishing soil quality and depth regains greater stormwater functions in the post development landscape. This provides increased treatment of pollutants and sediments that result from development and habitation, and minimizes the need for some landscaping chemicals, thus reducing pollution through prevention.

Establishing a minimum soil quality and depth is not the same as preservation of naturally occurring soil and vegetation. However, establishing a minimum soil quality and depth will provide improved onsite management of stormwater flow and water quality.

Soil organic matter can be attained through numerous materials such as compost, composted woody material, biosolids, and forest product residuals. It is important that the materials used to meet the soil quality and depth be appropriate and beneficial to the plant cover to be established. Likewise, it is important that imported topsoils improve soil conditions and do not have an excessive percent of clay fines.

Conditions Where Practice Applies

At any construction site using vegetation as a component of the overall stabilization plan.

Planning Considerations

Prior to beginning work on the construction site, identify sources of soil enhancement materials, such as compost.

Design Criteria

Soil retention. The native topsoil should be retained onsite (see Section 7.3 Topsoiling) to the maximum extent practicable. In any areas requiring grading, remove and stockpile topsoil on site in a designated, controlled area, not adjacent to water resources and critical areas, to be reapplied to other portions of the site where feasible.

Soil quality. All areas subject to clearing and grading that have not been covered by impervious surface, incorporated into a drainage facility or engineered as structural fill or slope shall, at project completion, demonstrate the following:

1. A topsoil layer with a minimum organic matter content of 10% dry weight in planting beds, and 5% organic matter content in turf areas, and a pH from 6.0 to 8.0 or matching the pH of the original undisturbed soil. The topsoil layer shall have a minimum depth of eight inches except where tree roots limit the depth of incorporation of amendments needed to meet the criteria. Subsoils below the topsoil layer should be scarified at least 4 inches with some incorporation of the upper material to avoid stratified layers, where feasible.

2. Planting beds must be mulched with 2 inches of organic material.

3. Quality of compost and other materials used to meet the organic content requirements:
    a) The compost must have an organic matter content of 35% to 65%, and a carbon to nitrogen ratio below 25:1.
    b) Calculated amendment rates may be met through use of composted materials as defined above.
    c) The resulting soil should be conducive to the type of vegetation to be established.

Construction Specifications

The soil quality design guidelines listed above can be met by using one of the methods listed below:

1) Leave undisturbed native vegetation and soil, and protect from compaction during construction.

2) Amend existing site topsoil or subsoil either at default "pre-approved" rates, or at custom calculated rates based on specifiers tests of the soil and amendment.

3) Stockpile existing topsoil during grading, and replace it prior to planting. Stockpiled topsoil must also be amended if needed to meet the organic matter or depth requirements, either at a default "pre-approved" rate or at a custom calculated rate.

4) Import topsoil mix of sufficient organic content and depth to meet the requirements. More than one method may be used on different portions of the same site. Soil that already meets the depth and organic matter quality standards, and is not compacted, does not need to be amended.

Maintenance and Inspection Points

Soil quality and depth should be established toward the end of construction and once established, should be protected from compaction, such as from large machinery use, and from erosion.

Soil should be planted and mulched after installation.

Plant debris or its equivalent should be left on the soil surface to replenish organic matter.

It should be possible to reduce use of irrigation, fertilizers, herbicides and pesticides. These activities should be adjusted where possible, rather than continuing to implement formerly established practices.

References

TDOT Design Division Drainage Manual

Stormwater Management Manual for Western Washington

POLLUTION PREVENTION

7.16 CONCRETE WASHOUT

CONCRETE WASHOUT

Definition

A designated area where concrete wash can harden, can be broken up, and can then be placed in the dumpster or backfilled.

Purpose

To prevent or reduce the discharge of pollutants to stormwater from concrete waste by conducting washout offsite or performing onsite washout in a designated area.

Conditions Where Practice Applies

Concrete washout areas are applicable where:

- Concrete trucks and other concrete-coated equipment are washed onsite.
- Slurries containing portland cement concrete or asphalt concrete are generated, such as from saw cutting, coring, grinding, grooving, and hydro-concrete demolition.
- Washing of exposed aggregate concrete.
- Building or house construction mortar mixer waste

Planning Considerations

There are two main types of concrete washouts to be considered, prefabricated washout containers and site-built washouts.

PREFABRICATED WASHOUT CONTAINERS

Many private companies offer heavy-duty, prefabricated concrete washout containers that are delivered to the site. Some services provide only the containers while others also provide the maintenance and disposal of the materials. Utilizing full-service concrete washout companies removes much of the burden from the jobsite superintendent and tends to result in a more maintained washout facility. When selecting a company to handle concrete waste, ensure that they are properly disposing of all materials. If the project utilizes a concrete pump truck, the prefabricated container should have an adequate ramp to accommodate the concrete pump truck.

SITE-BUILT WASHOUTS

There are many design options for the site-built washout, but preference should be given to those built below-grade to prevent breaches and reduce the likelihood of runoff. Above-grade structure can also be used if they are sized properly to avoid spillage, constructed properly to prevent leaks, and diligently maintained.

An important factor that dictates the success of concrete washout facilities is whether or not concrete truck drivers and subcontractors are educated on the use of the washout facilities. The site superintendent should educate all appropriate parties on proper use of concrete washout facilities. Signs should be posted indicating the location and designated use of the facilities.

Design Criteria

When using prefabricated washout containers, ensure containers can withstand heavy impacts and are watertight.

Site-built washouts should be constructed by providing a temporary pit or bermed area sized large enough to handle solids, wash slurry, and rainfall to prevent overflow and include a minimum of 4” freeboard. Above-grade washouts should allow adequate at least 4” of freeboard for structural stability of berms or containment walls. The temporary pit containing dry waste concrete may be incorporated into fill areas as needed. The waste concrete may be broken into smaller pieces to allow proper soil compaction. The storage area should be lined with geotextile fabric to allow water to infiltrate, further aiding the dewatering and drying process.

Consideration should be given to locating washout facilities. The designer should included suggested concrete washout areas on all applicable SWPPPs. Each facility should be located conveniently for concrete trucks, preferably near the area where concrete is being poured, and away from heavy volume construction traffic or access areas to prevent disturbance or tracking. Facilities should also be located a minimum of 50 feet away from storm drains, open ditches, and waterbodies. Appropriate gravel or rock should cover paths to concrete washout facilities if the facilities are located in undeveloped areas.

On large sites with extensive concrete work, concrete washouts should be located in multiple areas for ease of use.

Construction Specifications

- The storage pit area should be lined with a permeable geotextile fabric.
- Do not allow runoff from the storage area. Construct a temporary pit or bermed area large enough to contain anticipated slurry amount, solid waste, and direct rainwater.
- Wash out wastes into the temporary pit where the concrete can set, be broken up, and then disposed properly.
- Avoid creating runoff by draining water to a bermed or level area when washing concrete to remove fine particles and expose the aggregate.

Maintenance and Inspection Points

Ensure contractors avoid mixing excess amounts of fresh concrete and perform washout of concrete trucks offsite or in designated areas only. Do not allow concrete trucks to wash into storm drains, open ditches, streets, or streams. Do not allow excess concrete to be dumped onsite, except in designated areas. Do not wash sweepings from exposed aggregate concrete into the street or storm drains.

Temporary concrete washout facilities should be maintained to provide adequate holding capacity with a minimum freeboard of 4 inches for above grade facilities and 12 inches for below grade facilities. Inspect plastic linings and sidewalls of site-built washouts to ensure they have not been damaged during construction activities. Inspect all surfaces of prefabricated washouts to ensure the container is not leaking.

Washout facilities must be cleaned, or new facilities must be constructed and ready for use once the washout is 75% full.

Inspectors should note whether washout facilities are being used and maintained regularly. If inspector finds that concrete trucks are being washed out in locations other than designated washout areas, the inspector should notify the site superintendent immediately and the site superintendent should correct the issue.

References

California Stormwater BMP Handbook

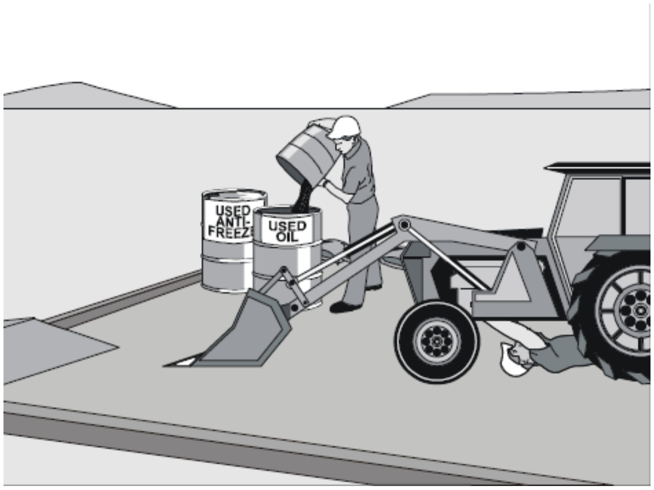
City of Knoxville Best Management Practices Manual

Hamilton County, TN BMP Manual

EPA National Pollutant Discharge Elimination System Concrete Washout

POLLUTION PREVENTION

7.17 VEHICLE MAINTENANCE



VEHICLE MAINTENANCE

Definition Procedures and practices to reduce the discharge of pollutants to storm drain systems, or to watercourses as a result of vehicle and equipment maintenance.

Purpose To prevent or reduce the contamination of stormwater resulting from vehicle and equipment maintenance.

Conditions Where Practice Applies These procedures are suitable on all construction projects where heavy equipment and vehicles are maintained onsite.

Planning Considerations Outdoor vehicle or equipment maintenance is a potentially significant source of stormwater pollution. Activities that can contaminate stormwater include engine repair and service, changing or replacement of fluids, equipment fueling, and outdoor equipment storage and parking (engine fluid leaks).

Onsite vehicle and equipment maintenance should only be used where it is impractical to send vehicles and equipment offsite for maintenance and repair.

Design Criteria There is no formal design for this measure. However, the following requirements may affect your site design and SWPPP:

Locate maintenance areas where they are protected from stormwater run-on and runoff and at least 50 feet from downstream drainage facilities and watercourses. Dedicated maintenance areas should be covered and paved wherever practical. Washing and maintenance areas should be properly contained, and liquids should be treated before discharging. Utilizing a municipal sanitary sewer system may be practical, but proper coordination and permitting should be obtained before doing so.

Develop a spill prevention and cleanup plan and provide to maintenance personnel. The site superintendent should educate workers on the spill prevention and cleanup procedures.

Construction Specifications

Inspect construction equipment for leaks daily, and repair immediately. Soil staining under or near equipment could be evidence of equipment leaks. Recycle or properly dispose of used oils, antifreeze, solvents, and automotive-related chemicals. Maintain drip pans, absorbent materials and covered trash receptacles in maintenance areas to dispose of spills and leakage. Place a stockpile of spill cleanup materials where it will be readily accessible.

Use vacuums or blowers instead of water to remove dry material from equipment and vehicles whenever possible. Utilize high-pressure water alone for washing instead of detergents whenever possible.

Use offsite repair shops as much as possible. These businesses are better equipped to handle vehicle fluids and spills properly. Performing this work offsite can also be economical by eliminating the need for a separate maintenance area.

If maintenance must occur onsite, use designated areas located away from drainage courses and stream buffer zones.

Drip pans or absorbent pads should be used during vehicle and equipment maintenance work that involves fluids. All fueling trucks and fueling areas are required to have spill kits and/or use other spill protection devices. Use adsorbent materials on small spills. Remove the absorbent materials after using and dispose of properly.

Segregate and recycle wastes, such as greases, used oil or oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic and transmission fluids. Provide secondary containment and covers for these materials if stored onsite.

Do not place used oil in a dumpster or pour on ground or into a storm drain or watercourse.

Properly dispose of or recycle used batteries.

Maintenance and Inspection Points

Vehicles and equipment should be inspected on each day of use. Leaks should be repaired immediately or the problem vehicle(s) or equipment should be removed from the project site.

Keep ample supplies of spill cleanup materials onsite.

References

Hamilton County BMP Manual

7.18 CHEMICAL STORAGE

CHEMICAL STORAGE CHEMICAL STORAGE

Definition A designated storage area equipped to minimize the risk stormwater pollution of storing chemicals on a construction site.

Purpose To prevent, reduce, or eliminate the discharge of pollutants from material storage to the stormwater system or watercourses by minimizing the storage of materials onsite, storing materials kept on site in a designated area, installing secondary containment, conducting regular inspections, and training employees and subcontractors.

Conditions Where Practice Applies This practice is applicable for storage of the following materials:

- Soil stabilizers and binders
- Pesticides and herbicides
- Fertilizers
- Detergents
- Plaster
- Petroleum products such as fuel, oil, and grease
- Asphalt and concrete components
- Hazardous chemicals such as acids, lime, glues, adhesives, paints, solvents, and curing compounds
- Concrete compounds
- Other materials that may be detrimental if released to the environment.

Planning Considerations Space limitation may preclude indoor storage.

Storage sheds often must meet building and fire code requirements.

Storage areas should not be located near wetlands, streams and other sensitive features.

Design Criteria

There is no formal design for this measure. However, the following requirements may affect your site design and SWPPP:

All chemicals must be stored in covered areas or with containment systems constructed in or around the storage areas. These areas should also be designed for easy access for materials delivery and storage. Show storage areas on the SWPPP and site development plans. Locate temporary storage areas away from high volume vehicular traffic and waterways. Ensure that the site has an accessible 55-gal drum (or similar) container to receive and contain small spill amounts and resulting cleanup materials.

Storage of reactive, ignitable, or flammable liquids must comply with the fire codes of your area.

Construction Specifications

Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and in secondary containment. Whenever possible, store materials in a covered area and within secondary containment such as an earthen dike or prefabricated storage unit. If drums must be kept uncovered, store them at a slight angle to reduce ponding of rainwater on the lids to reduce corrosion. Domed plastic covers are inexpensive and snap to the top of drums, preventing water from collecting.

Chemicals should be kept in their original labeled containers.

If significant residual materials remain on the ground after construction is complete, properly remove materials and any contaminated soil. If the area is to be paved, pave as soon as materials are removed to stabilize the soil.

Maintenance and Inspection Points

Keep an up-to-date inventory of materials stored onsite.

Contain and clean up any spill immediately. Dispose of chemicals and materials used for cleaning up after use. Include emergency contact information for spills, such as the local emergency management agency contact information. This spill response information should be prominently displayed. Contact TDEC Water Pollution Control's EFO in the event that a chemical spill reaches a stream or wetland or exceeds 50 gallons.

Keep storage areas clean, well organized, and equipped with ample cleanup supplies as appropriate for the materials being stored.

Repair or replace perimeter controls, containment structures, covers, and liners as needed to maintain proper function.

References

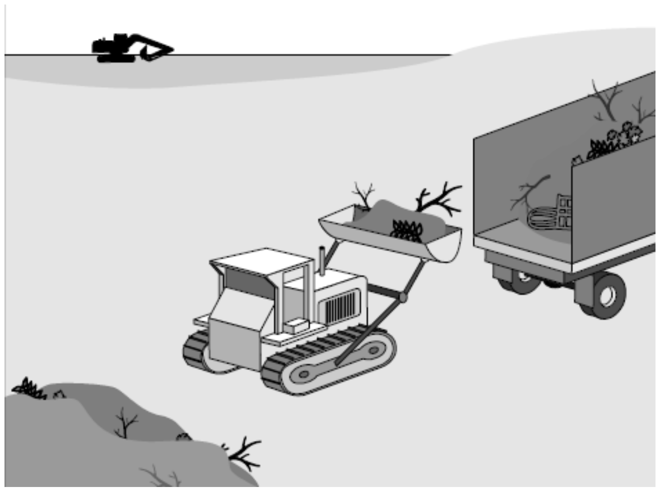
California Stormwater BMP Handbook

Hamilton County BMP Manual

Knox County BMP Manual

POLLUTION PREVENTION

7.19 TRASH AND DEBRIS MANAGEMENT



TRASH AND DEBRIS MANAGEMENT

Definition The management of waste materials and debris on the construction site.

Purpose To prevent or reduce the discharge of pollutants to stormwater from solid or construction waste by providing designated waste collection areas and containers, and arranging for regular disposal.

Conditions Where Practice Applies This practice is applicable when the following items may be found on the construction site:

- Waste generated from trees and shrubs removed during land clearing, demolition of existing structures (rubble), and building construction.
- Packaging materials including wood, paper, and plastic.
- Scrap or surplus building materials including scrap metals, rubber, plastic, glass pieces and masonry products.
- Domestic wastes including food containers such as beverage cans, coffee cups, paper bags, plastic wrappers, and cigarettes.
- Construction wastes including brick, mortar, timber, steel and metal scraps, pipe and electrical cuttings, non-hazardous equipment parts, Styrofoam and other materials used to transport and package construction materials.
- Construction crew sanitary waste management facilities.

Planning Considerations All construction trash and debris must be properly collected and managed for proper offsite disposal. A debris storage area should be included on the SWPPP when the materials noted above will be encountered on the project.

Consider using onsite ground trees and brush as mulch. Identify other recyclable materials, and keep them sorted for easy removal.

Design Criteria

Select designated waste collection areas onsite. These areas should be located well away from sensitive site features such as streams, wetlands, and sinkholes.

Locate containers in an easily accessible area and post signage designating waste disposal areas if needed. Provide enclosed containers or locate containers in covered areas to prevent direct rainwater contact or loss of waste due to wind. If using large containers, ensure they have lids to prevent rain from mixing with the debris and trash.

Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris. Post signage and provide worker education related to items that should not be disposed of in municipal waste and construction debris containers.

Construction Specifications

Do not hose out dumpsters on the construction site. Dumpster cleaning should be taken care of by the solid waste management company providing the containers. Do not allow solid waste management workers to clean their containers on the construction site.

Arrange for regular waste collection before containers overflow.

Stormwater runoff should be prevented from contacting stored waste through the use of berms, dikes, or other temporary diversion structures or through the use of measures to elevate waste from site surfaces.

Waste storage areas should be located at least 50 feet from drainage facilities and watercourses and should not be located in areas prone to flooding or ponding or in the stream buffer zone.

Clean up immediately if a container does spill.

Ensure that construction debris and trash are not being used as fill onsite unless approved by the local municipality and TDEC.

Maintenance and Inspection Points

Inspect the site for evidence of trash and construction debris being placed outside of the designated trash and debris collection area. Make sure that construction waste is collected, removed, and disposed of only at authorized disposal areas. Contractors should ensure all waste and debris is removed from construction site after construction is completed before leaving.

To prevent clogging of the storm drainage system, litter and debris removal from drainage grates, trash racks, and ditch lines should be a priority.

Litter from work areas within the construction limits of the project site should be collected and placed in watertight dumpsters before a rain event, regardless of whether the litter was generated by the contractor, the public, or others. Collected litter and debris should not be placed in or next to drain inlets, stormwater drainage systems, or watercourses.

Inspect trash and debris collection areas after wind and/or rain events to ensure that they are keeping the trash and debris contained.

References

California Stormwater BMP Handbook

RUNOFF CONTROL AND MANAGEMENT

This section contains measures that are permanent or temporary. They are designed to convey storm water runoff non-erosively. Rip rap is a material incorporated into many of the management practices. The following rip rap classes and stone sizes apply to measures throughout this manual:

Table 7.20-1 TDOT Rip Rap Classification and Sizes

TDOT Classification	D_{50} Stone Size (inches)	Overall Stone Sizes (inches)	Placement Depth
Class A-1	9	2 – 15	18 inches
Class A-3	4	2 – 6	As noted on plans
Class B	15	3 – 27	2.5 feet
Class C	20	5 – 36	3.5 feet

7.20 CHECK DAM

CHECK DAM

Definition

A small temporary barrier, grade control structure or dam constructed across a swale, drainage ditch, or area of concentrated flow.

Purpose

To minimize the erosion rate by reducing the velocity of stormwater in areas of concentrated flow. While check dams are primarily erosion control devices, they provide limited sediment control by slowing velocities and ponding runoff. Note that wattles and tubes installed as check dams are addressed in Section 7.25.

Conditions Where Practice Applies

This practice is applicable for use in ditches and small open channels and **is not to be used in a stream**. Specific applications include:

- Temporary or permanent swales or ditches in need of protection during establishment of grass linings.
- Temporary or permanent swales or ditches that, due to their short length of service or for other reasons, cannot receive a permanent non-erodible lining for an extended period of time.
- Other locations where small localized erosion and sedimentation problems exist in areas of concentrated flow.

Planning Considerations

Check dams are an expedient way to reduce gullying in the bottom of channels that will be filled or stabilized at a later date. The dams should only be used while permanent stabilization measures are being put into place.

Check dams installed in grass-lined channels may kill the vegetative lining if submergence after it rains is too long and/or silting is excessive. All stone and riprap must be removed if mowing is planned as part of vegetative maintenance.

The main function of a check dam is to decrease velocity, not to collect sediment, although sediment capture is an added benefit.

Design Criteria

The channel and check dam must be designed to adequately convey the design storm for the associated drainage area.

Spacing: Maximum spacing between dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam. Two or more check dams in series should be used when the drainage area exceeds the limitation for one dam.

Height: The height of the check dam from the bottom of the channel to the bottom of the weir should be a minimum of 1 foot above the ditch bottom.

Weir: The depth of flow on the center of the structure (weir) shall be computed for the peak flow rate generated by the 2-year, 24-hour storm in order to ensure that the top of the structure will not be overtopped. For sites draining to high quality streams or streams listed as impaired by sediment, the depth must be determined for the 5-year, 24-hour peak flow rate. The weir must be at least 9 inches deep.

Side Slopes: The side slopes should be 2:1 or flatter.

Materials: A geotextile should be used as a separator between the graded stone and the soil base and abutments. The geotextile will prevent the migration of soil particles from the subgrade into the graded stone. Geotextiles should be "set" into the subgrade soils. The geotextile should be placed immediately adjacent to the subgrade without any voids and extend three feet beyond the downstream toe of the dam to prevent scour.

Construction Specifications

- Rock check dams should be constructed out of machined riprap, Class A-1 (see Table 7.20-1 for stone size and d_{50}).
- Place stone to the lines and dimensions shown in the plan on a filter fabric foundation.
- Keep the center stone section at least 9 inches below natural ground level where the dam abuts the channel banks.
- Set spacing between dams to assure that the elevation at the top of weir section of the lower dam is the same as the toe elevation of the upper dam.
- Extend geotextile fabric 3 feet down gradient from the toe of the check dam to prevent scour at the toe.
- Protect the channel after the lowest check dam from heavy flow that could cause erosion.
- Ensure that the channel reach above the most upstream dam is stable.
- Ensure that other areas of the channel, such as culvert entrances below the check dams, are not subject to damage or blockage from displaced stones.

Maintenance and Inspection Points

Sediment should be removed before it reaches a depth of one-half the original dam height.

Add rock as needed to maintain design height and cross section.

If the area is to be mowed, check dams must be removed once final stabilization has occurred. After removal, the disturbed area should be seeded and mulched immediately.

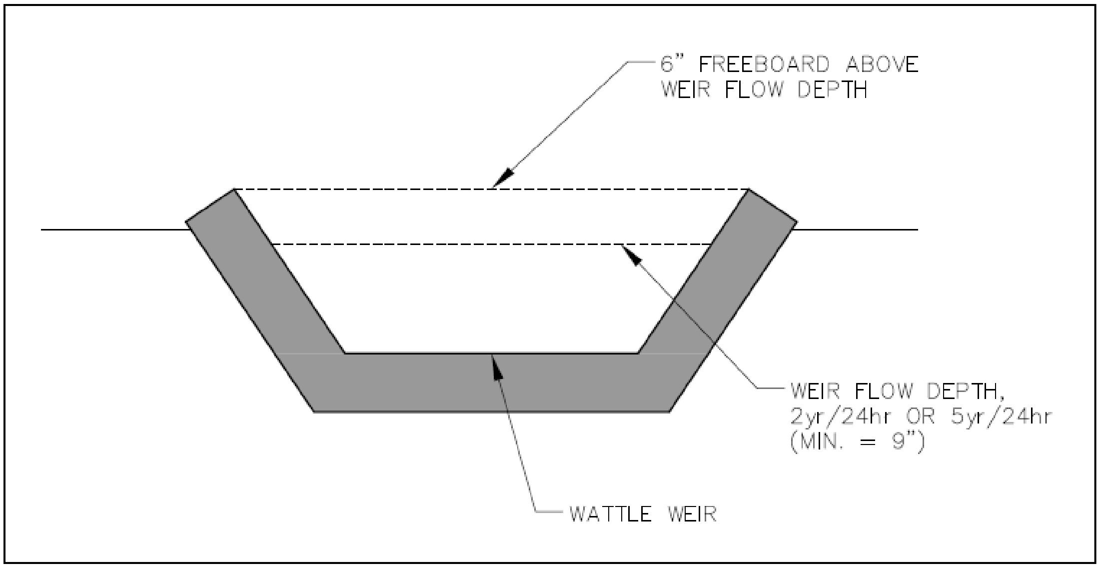


Figure 7.20-1. Wattle Check Dam

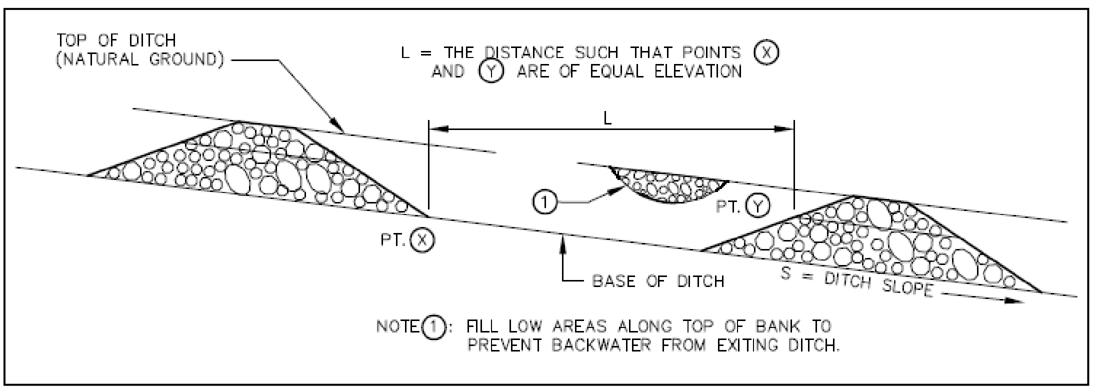


Figure 7.20-2 Spacing between check dams (Source: TDOT)

References

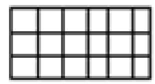
TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-6

North Carolina Erosion and Sediment Control Planning and Design Manual

RUNOFF CONTROL AND MANAGEMENT

7.21 DEWATERING TREATMENT PRACTICES



DEWATERING STRUCTURE

Definition A temporary sediment control structure that combines riprap and geotextile fabric to settle and/or filter sediment laden water which has been pumped from an excavated work area.

Purpose To settle and 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 activity by means of pumping.

Planning Considerations Water that is pumped from a construction site usually contains a large amount of sediment. A dewatering structure is typically needed to remove the sediment before water is released off-site. One of several types of dewatering structures may be constructed depending upon site conditions and type of operation. A well stabilized, onsite, vegetated area may serve as a dewatering device if the area is stabilized so that it can filter sediment and at the same time withstand the velocity of the discharged water without eroding. The discharge of sediment-laden water onto a vegetated area should not pose a threat to the survival of the existing vegetative stand through smothering by sedimentation. Where a grass filter strip alone is to be used to filter pumped water, a minimum filtering length of **75 feet** must be available in order for such a method to be feasible. Regardless, the runoff must not cause a water quality violation where it enters a stream or wetland.

Dewatering structures should not be placed within a jurisdictional wetland, stream buffer or within 20 feet of a stabilized outlet, stream, or other natural water resource.

Design Criteria

A dewatering structure must be sized (and operated) to allow pumped water to flow through the filtering device without overtopping the structure. An excavated basin may be lined with geotextile to help reduce scour and to prevent the inclusion of soil from within the structure.

The minimum required volume of storage in cubic feet for a dewatering structure is obtained by multiplying the pumping rate (in gallons per minute) by 16. The recommended volume is based on 2 hours of pumping at the full rate shown on the drawing. In situations where it is likely that a pump will be operated for longer periods of time, the volume of the structure should be appropriately increased. Where the structure is to be placed in a sloping area, the available storage capacity will be reduced. It may be necessary to increase the size of the structure to compensate for this.

Construction Specifications

Portable Sediment Tank:

Materials: The sediment tank may be constructed with steel drums, sturdy wood or other material suitable for handling the pressure exerted by the volume of water. The structure should have a minimum depth of two feet.

Location: The location for the sediment tank should be chosen for easy clean-out and disposal of the trapped sediment, and to minimize the interference with construction activities.

Storage Volume: The following formula should be used to determine the storage volume of the sediment tank:

Pump discharge (gpm) x 16 = cubic feet of storage required

Operation: 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. The tank should be designed to allow for emergency flow over the top of the tank. Clean-out of the tank is required once one-third of the original capacity is depleted due to sediment accumulation. The tank should be clearly marked showing the clean-out point.

Straw Bale/Silt Fence Pit:

Materials: The straw bale/silt fence pit should consist of straw bales, silt fence, washed stone (TDOT size 57) and an optional excavated wet storage pit.

Storage Volume: The following formula should be used to determine the storage volume of the straw bale/silt fence pit:

Pump discharge (gpm) x 16 = cubic feet of storage required

In calculating the capacity, include the volume available from the floor of the excavation to the top of the structure. Excavation may not be necessary to obtain the necessary storage volume.

Operation: Once the water level nears the top of the straw bales, **the pump must be shut off** while the structure drains down to at least half of the storage volume. Overtopping the dewatering structure is not allowed. If turbidity is not adequately addressed through the silt fence material, straw bales and washed stone, additional treatment must be considered. When the excavated area becomes filled to one-half of the excavated depth, accumulated sediment should be removed and properly disposed of.

Sediment Filter Bag:

Materials: The filter bag should be constructed of non-woven geotextile material that will provide adequate filtering ability to capture the larger soil particles from the pumped water. The bag should be constructed so that there is an inlet neck that may be clamped around the dewatering pump discharge hose so that all of the pumped water passes through the bag.

Location: A temporary sediment filter bag may be used whenever sediment laden water is removed from an area by means of pumping and where there is insufficient room to use a temporary dewatering structure. A temporary sediment filter bag should not be placed within a jurisdictional wetland, a stream buffer, or within 20 feet of a stabilized outlet, stream or ditch line. A filled sediment bag can weigh as much as 7 tons. The designer should ensure that there will be adequate access for the equipment necessary for the disposal of the bag.

Design: A temporary sediment filter bag should be placed on a level pad a minimum of 6 inches thick composed of mineral aggregate (size 57). This pad should be constructed on an area with sufficient slope to allow water entering the pad to drain away from the project work area. However, it is necessary for the pad to be level in order to prevent the bag from rolling along the slope as water is pumped into the structure. The upper surface of the pad, including the slopes, should be lined with geotextile fabric. In addition, it should be separated from the existing ground by a layer of polyethylene sheeting. Off-site stormwater runoff should be diverted around the temporary dewatering filter bag location. The capacity of the sediment filter bag should be adequate to handle the dewatering pump discharge and should be based upon the manufacturer’s recommendation on pump sizing. Failure to correlate the pump capacity and the bag capacity can result in failure of the bag. The filter bag must be equipped with a sleeve to receive the pump hose. Slitting the bag to make the hose connection is not acceptable.

Storage Volume: The capacity of the sediment filter bag should be adequate to handle the dewatering pump discharge, and should be based on the bag manufacturer’s recommendation and expected sediment volume.

Operation: Pumping into the bag can only occur when being supervised. Unsupervised pumping is not allowed. Discharge from the filter bag cannot cause an objectionable color contrast with the receiving stream. Additional treatment may be necessary if an objectionable color contrast is observed

Disposal: In determining the location for a proposed sediment filter bag, the designer should allow sufficient room and a clear path to allow access for the equipment needed for bag removal. When the filter bag has accumulated a 6inch depth of sediment, it should be removed and replaced with a new filter bag.

Maintenance and Inspection Points

The filtering devices must be inspected frequently and repaired or replaced once the sediment build-up prevents the structure from functioning as designed. 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 the SWPPP.

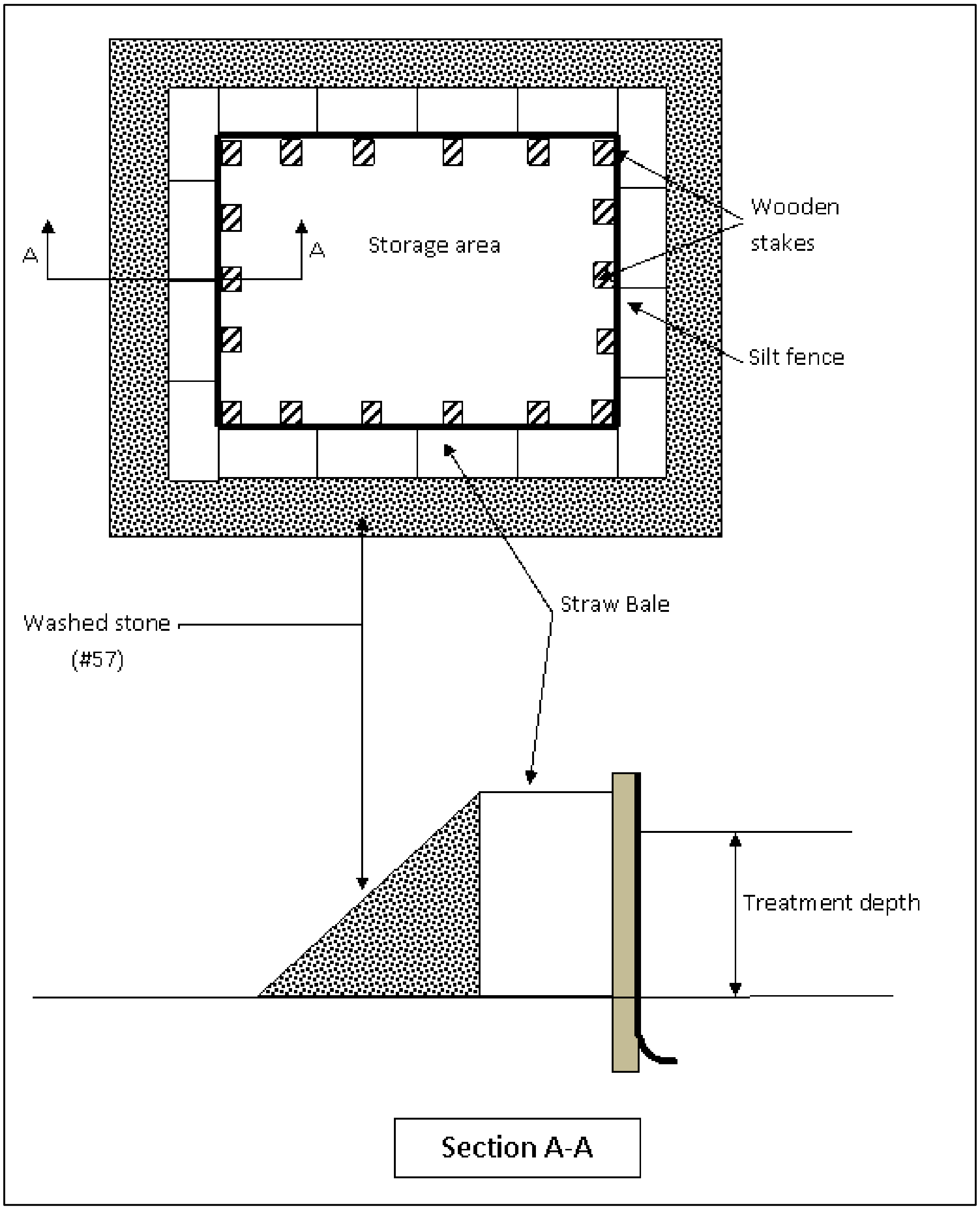


Figure 7.21-1 Silt fence and straw bale dewatering pit

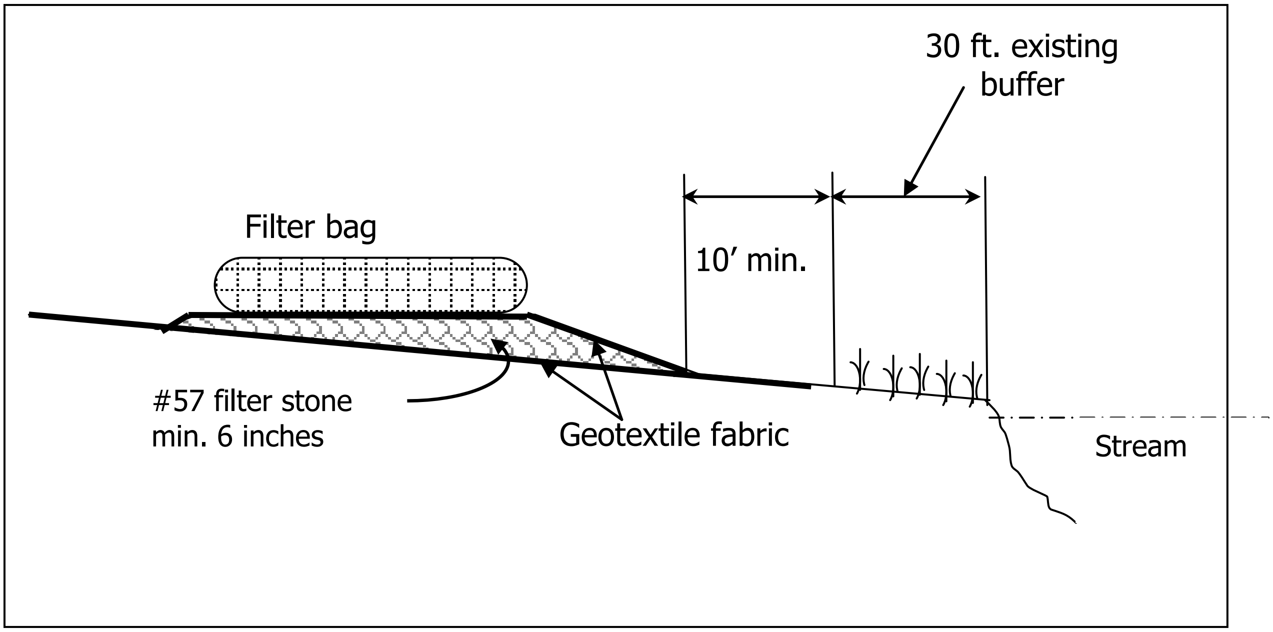


Figure 7.21-2 Sediment filter bag

References *TDOT Design Division Drainage Manual*

TDOT Erosion Control Standard Drawing EC-STR-1

North Carolina Erosion and Sediment Control Planning and Design Manual

RUNOFF CONTROL AND MANAGEMENT

7.22 DIVERSION

DIVERSION

Definition

A temporary ridge or excavated channel or combination ridge and channel constructed across sloping land on a predetermined grade.

Purpose

To reduce the erosion of steep, or otherwise, highly erodible areas by reducing slope lengths, intercepting storm runoff and diverting it to a stable outlet at a non-erosive velocity, or to convey storm water through a construction site. Stream diversions are covered in Section 7.43.

Conditions Where Practice Applies

This practice applies to construction areas where runoff can be diverted and disposed of properly to control erosion, sedimentation, or flood damage. Specific locations and conditions include:

- Where the slope length needs to be reduced to minimize erosion.
- Where runoff from upslope areas is, or has the potential for, damaging property, flooding or preventing the establishment of vegetation on lower areas.
- When clean stormwater is coming onto the site and needs to be conveyed across or around the disturbed area to prevent contamination.
- Where excess runoff needs to be diverted to stabilized outlets.
- Where sediment laden water needs to be directed to sediment traps.
- At or near the perimeter of construction areas to prevent sediment from leaving the site.

Planning Considerations

It is important that diversions are properly designed, constructed and maintained since they concentrate water flow and increase erosion potential. Particular care must be taken in planning diversion grades. Too much slope can result in erosive velocity in the diversion channel or at the outlet. A change of slope from steeper grade to flatter may cause deposition to occur. The deposition reduces carrying capacity, and may cause overtopping and failure. Frequent inspection and timely maintenance are essential to the proper functioning of diversions.

Sufficient area must be available to construct and properly maintain diversions. It is usually less costly to excavate a channel and form a ridge or dike on the downhill side with the spoil than to build diversions by other methods. Where space is limited, it may be necessary to build the ridge by hauling in diking material, or using a silt fence to divert the flow. Use gravel to form the diversion dike when vehicles must cross frequently.

Plan temporary diversions to function 1 year or more, or they may be constructed anew at the end of each day's grading operation to protect new fill. Diversions that are to serve longer than 30 working days should be seeded and mulched as soon as they are constructed to preserve dike height and reduce maintenance.

A channel lining should be used to prevent erosion. Channels using rock linings should be undercut to account for the rock thickness to preserve the required flow depth.

Temporary diversions may serve as in-place sediment traps if over-excavated 1 to 2 feet and placed on a nearly flat grade. The dike serves to divert water as the stage increases. A combination of silt fence and channel diversion – where fill from the channel is used to stabilize the fence – can trap sediment and divert runoff simultaneously.

Wherever feasible, build and stabilize diversions and outlets before initiating other land-disturbing activities.

Design Criteria

Drainage Area: 5 acres or less.

Ridge Design: The ridge should be compacted and designed to have stable side slopes, which should not be steeper than 2:1. When maintenance by machine mowing is planned, side slopes should be no steeper than 3:1. The ridge should be a minimum width of 4 feet at the design water elevation after settlement. Its design should allow for ten percent settlement.

Channel Design: Land slope must be taken into consideration when choosing channel dimensions. On the steeper slopes, narrow and deep channels may be required. On the more gentle slopes, broad, shallow channels usually are applicable. The wide, shallow section will be easier to maintain. Since sediment deposition is often a problem in diversions, the designed flow velocity should be kept as high as the channel lining will permit. Unless the purpose of the diversion is to convey clean water around the disturbed area, a diversion should lead to a sediment trapping device. For more detailed information on channel design, see Section 7.27, Stable Channel Design.

Location: Diversion location should be determined by considering outlet conditions, topography, land use, soil type, length of slope, seep planes (when seepage is a problem), and the development layout. Diversions should be tailored to fit the conditions for particular location and soil type(s).

Outlet: Each diversion must have an adequate outlet. The outlet may be a constructed or natural waterway, a stabilized vegetated area or another energy dissipation device.

In all cases, the outlet must discharge in such a manner as to not cause erosion or sedimentation problems. Protected outlets should be constructed and stabilized prior to construction of the diversion.

Grade: Either a uniform or a gradually increasing grade is preferred. Sudden decreases in grade accumulate sediment and should be expected to cause overtopping. A large increase in grade may erode the diversion.

Stabilization: Channels should be stabilized in accordance with sound engineering practice to provide adequate stability for expected water velocities. See Section 7.27 for more detailed information on channel linings.

WATERBAR DIVERSIONS FOR ROADS

A detailed design is not required for this type of diversion. Diversions installed to divert water off a road or right-of-way should consist of a series of compacted ridges of soil running diagonally across the road at a 30º angle. Ridges are constructed by excavating a channel up-slope, and using the excavated material for the compacted ridge.

The compacted ridge height should be 8-12” above the original road surface; the channel depth should be 8-12” below the original road surface. Channel bottoms and ridge tops should be smooth enough to be crossed by vehicular traffic. The maximum spacing between diversions is shown in Table 7.22-1. Waterbars should discharge to a stabilized conveyance that carries the storm water to an approved outlet or treatment structure.

Construction Specifications

- All trees, brush, stumps, obstructions, and other objectionable material should be removed and disposed of so as not to interfere with the proper functioning of the diversion.
- The diversion should be excavated or shaped to line, grade, and cross section as designed to meet the criteria specified herein and be free of irregularities that will impede normal flow.
- All fills should be machine compacted as needed to prevent unequal settlement that would cause damage in the completed diversion.
- All earth removed and not needed in construction should be spread or disposed of so that it will not interfere with the functioning of the diversion.
- Provide sufficient room around the diversion to permit machine regarding and cleanout.
- Diversion channels should be stabilized in accordance with designed plans and specifications.

Maintenance and Inspection Points

Remove sediment from the flow area and repair the diversion ridge if necessary. Carefully check outlets and make timely repairs as needed. When the area protected is permanently stabilized, remove the ridge and the channel to blend with the natural ground level and appropriately stabilize it.

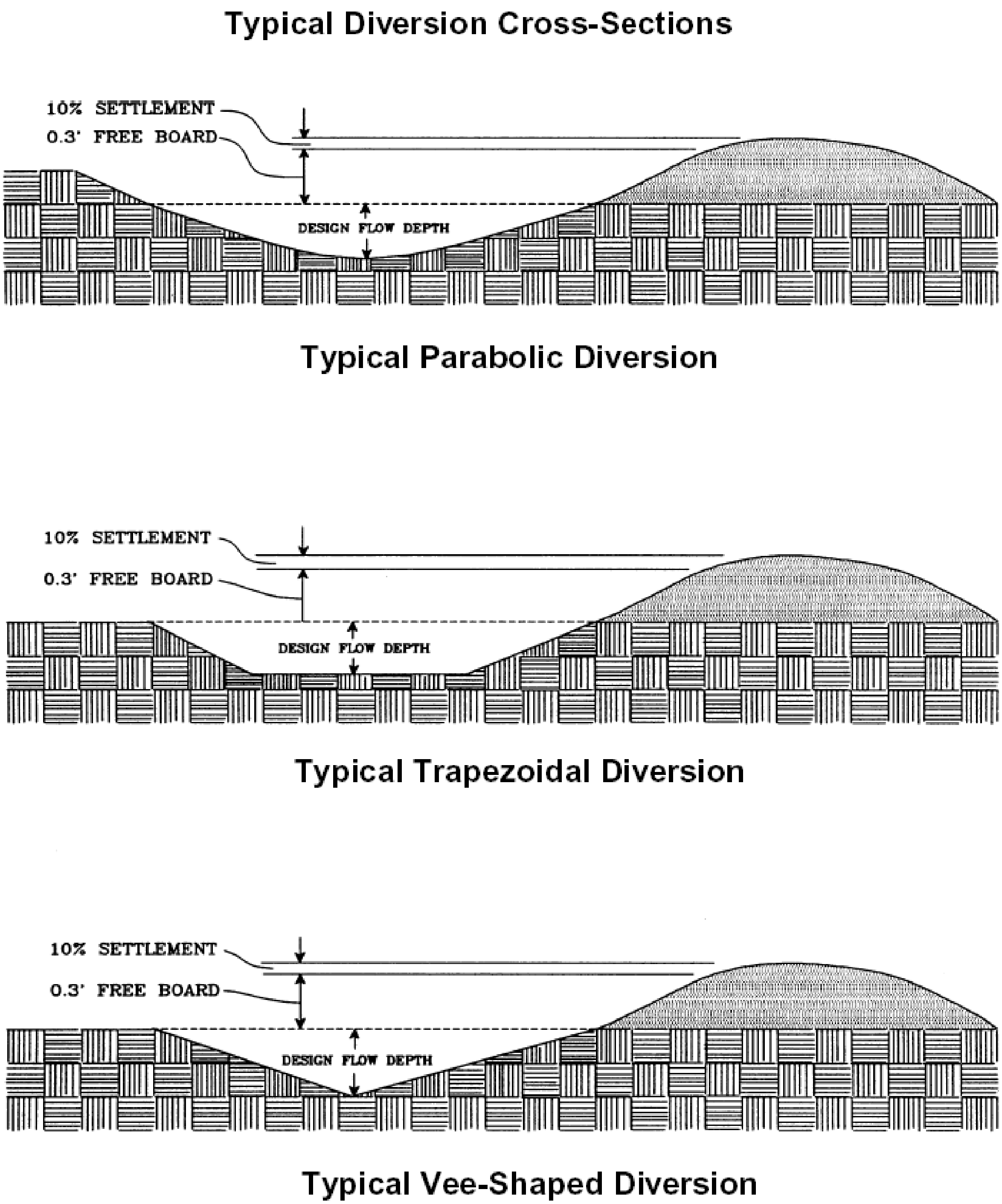


Figure 7.22-1 Typical diversion cross sections (Source: VA DSWC)

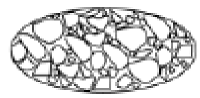
Road Grade (Percent)	Distance Between Diversions (Feet)
1	400
2	250
5	125
10	80
15	60
20	50

Table 7.22-1 Maximum spacing between waterbar diversions (Source: GA SWCC)

References *North Carolina Erosion and Sediment Control Planning and Design Manual*

RUNOFF CONTROL AND MANAGEMENT

7.23 OUTLET PROTECTION



Definition A structure designed to control erosion at the outlet of a channel or conduit.

Purpose To prevent outlet scouring, reduce water velocity, and dissipate the energy from the flow leaving a pipe to prevent erosion in the downstream channel.

Conditions Where Practice Applies This practice applies where the discharge velocity of a pipe, box culvert, diversion, open channel, or other water conveyance structure exceeds the permissible velocity of the receiving water channel or disposal area. Specific applications include:

- Storm drain outlets
- Road culvert outlets
- Paved channel outlets
- Slope drain outlets
- Sediment basin outlets

Planning Considerations The outlets of channels, conduits, and other structures are points of high erosion potential because they frequently carry flow at velocities that exceed the allowable limit for the area downstream. To prevent scour and undermining, an outlet stabilization structure is needed to absorb the impact of the flow and reduce the velocity to non-erosive levels. A riprap-lined apron is the most commonly used practice for this purpose because of its relatively low cost and ease of installation. The riprap apron should be extended downstream until stable conditions are reached even though this may exceed the length calculated for design velocity control. Riprap stilling basins or plunge pools reduce flow velocity rapidly. They should be considered in lieu of aprons where pipe outlets are cantilevered or where high flows would require an excessive apron length. Consider other energy dissipaters such as concrete impact basins or paved outlet structures where conditions warrant.

The installation of a culvert in a stream is subject to the conditions of a U.S. Army Corps of Engineers 404 permit and Tennessee ARAP conditions. These permit conditions may not allow the use of a riprap apron, and may require that the bottom of the culvert be buried below the natural stream bed elevation. A pre-formed scour pool or plunge pool should be considered in these situations.

Design Criteria

Capacity: The structure should be designed to handle the peak storm flow (Q) in cubic feet per second (cfs) from the 25-year, 24-hour frequency storm, or the design discharge of the water conveyance structure, whichever is greater.

Velocity: Compute velocity using Manning's equation with an appropriate *n* value for the selected outlet protection material.

Tailwater Depth: The design depth of the tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine the tailwater depth. If the tailwater depth is less than half the diameter of the pipe, it should be classified as a low tailwater condition. If the tailwater depth is greater than half the pipe diameter, then it should be classified as a high tailwater condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a low tailwater condition.

Apron Length (L_A): The apron length should be determined according to tailwater conditions described in Table 7.23-1.

Apron Width (W_A): See Figure 7.23-1. If the pipe discharges directly into a well-defined channel, the apron should extend across the channel bottom and up the channel banks to an elevation 1 foot above the high 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 should be determined as follows:

- The upstream end of the apron, adjacent to the pipe, should have a width three times the diameter of the outlet pipe
- For a low tailwater condition, the downstream end of the apron should have a width equal to the pipe diameter plus the length of the apron.
- For a high tailwater condition, the downstream end should have a width equal to the pipe diameter plus 0.4 times the length of the apron.

Grade: The apron should be constructed on zero grade. The invert elevation of the downstream end of the apron should be equal to the elevation of the invert of the receiving channel. There should be no turbulence at the end of aprons.

Side Slope: If the pipe discharges into a well defined channel, the side slopes of the channel should not be steeper than 2:1.

Alignment: The apron should be straight throughout its entire length, but if a curve is necessary to align the apron with the receiving stream, locate the curve in the upstream section of the riprap.

Materials: The apron may be lined with riprap, grouted riprap, or concrete. The median sized stone for riprap (d_{50}) should be determined according to tailwater conditions described in Table 7.23-1. Maximum stone size is equal to 1.5 times the d_{50} value. The gradation, quality, and placement of riprap should conform to riprap specifications.

Thickness: Make the minimum thickness of riprap 1.5 times the maximum stone diameter.

Stone Quality: Select stone for riprap from field stone or quarry stone. The stone should be hard, angular, and highly weather resistant. The specific gravity for the individual stones should be at least 2.5.

Separators: A separator must be provided between the riprap and natural ground. Suitable filters are flexible and consist of a well-graded gravel or sand-gravel layer or a synthetic filter fabric manufactured for this express purpose. The design of a gravel filter blanket is based on the ratio of particle size in the overlying filter material to that of the base material in accordance with the criteria below. The designed gravel filter blanket may consist of several layers of increasingly large particles from sand to erosion control stone.

A gravel filter blanket should have the following relationship for a stable design:

$$\frac{d_{15}\text{ filter}}{d_{85}\text{ base}} \leq 5$$

$$5 \leq \frac{d_{15}\text{ filter}}{d_{15}\text{ base}} \leq 40$$

$$\frac{d_{50}\text{ filter}}{d_{50}\text{ base}} \leq 40$$

In these relationships, filter refers to the overlying material, and base refers to the underlying material. These relationships must hold between the filter material and the base material (soil foundation), and between the riprap and the filter. More than one layer of filter material may be needed. Each layer of filter material should be at least 6 inches thick.

A synthetic filter fabric may be used with or in place of gravel filters. The following particle size relationships should exist:

- Filter fabric covering a base with granular particles containing 50% or less (by weight) of fine particles (less than U.S. Standard Sieve no. 200 [0.074mm]):
  a. $\frac{d_{85}\text{ base (mm)}}{\text{EOS* filter fabric (mm)}} > 1$
  b. total open area of filter should not exceed 36%.

- Filter fabric covering other soils:
  a. EOS is no larger than U.S. Standard Sieve no. 70 (0.21mm),
  b. total open area of filter should not exceed 10%.

**EOS - Equivalent opening size compared to a U.S. standard sieve size.*

No filter fabric should have less than 4% open area, or an EOS less than U.S. Standard Sieve No. 100 (0.15mm). The permeability of the fabric must be greater than that of the soil. The fabric may be made of woven or nonwoven monofilament yarns, and should meet the following minimum requirements:

- thickness 20 - 60 mils,
- grab strength 90 - 120 lb, and
- conform to ASTM D-1682 or ASTM D-177.

Filter blankets should always be provided where seepage is significant, or where flow velocity and duration of flow or turbulence may cause the underlying soil particles to move through the riprap.

Energy Dissipators and Stilling Basins: Structural controls, generally made from precast concrete or from pour-in-place concrete, should be used whenever concrete aprons are installed. The design of the energy dissipaters and stilling basins shown in Figure 7.23-2 are discussed in the Federal Highways Administration (FHWA) publication HEC-14, Hydraulic Design of Energy Dissipaters for Culverts and Channels.

Stilling basins are used to convert flows from supercritical to subcritical flow rates by allowing a hydraulic jump to occur. The stilling basin allows a controlled hydraulic jump to occur within the structure over a wide range of flow conditions and depths. A professional engineer must design energy dissipaters and stilling basins using hydraulic computations. A primary concern for both energy dissipaters and stilling basins is whether sediment and trash can accumulate. TDOT standard drawings include a riprap basin energy dissipater, based upon procedures in HEC-14. The United States Bureau of Reclamation (USBR) also has developed many designs of such structures.

Construction Specifications

- Ensure that the subgrade for the geotextile and riprap follows the required lines and grades shown in the plan. Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on undisturbed soil may also be filled by increasing the riprap thickness.
- Install a geotextile liner to prevent soil movement through the openings in the riprap
- The geotextile must meet design requirements and be properly protected from punching or tearing during installation. Repair any damage by removing the riprap and placing another piece of geotextile over the damaged area. All connecting joints should overlap a minimum of 1 foot. If the damage is extensive replace the entire geotextile liner.
- Riprap may be placed by equipment, but take care to avoid damaging the geotextile.
- The minimum thickness of the riprap should be 1.5 times the maximum stone diameter, but not less than 6 inches.
- The outlet structure must conform to the specified grading limits shown on the plans.

- Construct the apron on zero grade with no turbulence at the end. Make the top of the riprap at the downstream end level with the receiving area or slightly below it.
- Ensure that the apron is properly aligned with the receiving stream and, preferably, straight throughout its length.
- Immediately after construction, stabilize all disturbed areas with vegetation.
- Select stone for riprap from fieldstone or quarry stone. The stone should be hard, angular, and highly weather-resistant. The specific gravity of the individual stones should be at least 2.5.

Maintenance and Inspection Points

Inspect riprap outlet structures after heavy rains to see if any erosion around or below the riprap has taken place, if the stones have been dislodged, or if the separator has been damaged. Immediately make all needed repairs to prevent further damage.

References

TDOT Design Division Drainage Manual

TDOT Standard Drawing EC-STR-21

North Carolina Erosion and Sediment Control Planning and Design Manual

Federal Highways Administration, HEC-14

Riprap Aprons for Low Tailwater (downstream flow depth < 0.5 x pipe diameter)															
Culvert Diameter	Lowest value			Intermediate values to interpolate from									Highest value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12"	4	7	2.5	6	10	3.5	9	131	6	12	16	7	14	17	8.5
15"	6.5	8	3	10	12	5	15	16	7	20	18	10	25	20	12
18"	10	9	3.5	15	14	5.5	20	17	7	30	22	11	40	25	14
21"	15	11	4	25	18	7	35	22	10	45	26	13	60	29	18
24"	21	13	5	35	20	8.5	50	26	12	65	30	16	80	33	19
27"	27	14	5.5	50	24	9.5	70	29	14	90	34	18	110	37	22
30"	36	16	6	60	25	9.5	90	33	15.5	120	38	20	140	41	24
36"	56	20	7	100	32	13	140	40	18	180	45	23	220	50	28
42"	82	22	8.5	120	32	12	160	39	17	200	45	20	260	52	26
48"	120	26	10	170	37	14	220	46	19	270	54	23	320	64	37

Riprap Aprons for High Tailwater (downstream flow depth > 0.5 x pipe diameter)															
Culvert Diameter	Lowest value			Intermediate values to interpolate from									Highest value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12"	4	8	2	6	18	2.5	9	28	4.5	12	36	7	14	40	8
15"	7	8	2	10	20	2.5	15	34	5	20	42	7.5	25	50	10
18"	10	8	2	15	22	3	20	34	5	30	50	9	40	60	11
21"	15	8	2	25	32	4.5	35	48	7	45	58	11	60	72	14
24"	20	8	2	35	36	5	50	55	8.5	65	68	12	80	80	15
27"	27	10	2	50	41	6	70	58	10	90	70	14	110	82	17
30"	36	11	2	60	42	6	90	64	11	120	80	15	140	90	18
36"	56	13	2.5	100	60	7	140	85	13	180	104	18	220	120	23
42"	82	15	2.5	120	50	6	160	75	10	200	96	14	260	120	19
48"	120	20	2.5	170	58	7	220	85	12	270	105	16	320	120	20

Table 7.23-1 Riprap outlet protection design parameters for low tailwater and high tailwater conditions (Source: Knoxville Engineering Department)

Note that the above table is intended to select two parameters for the design of riprap outlet protection, based upon outlet velocities that correspond with circular culverts flowing full. Flow values less than the lowest value for the culvert size usually indicate a full-flow velocity less than 5 feet per second, for which riprap is usually not necessary. Flow values more than the highest value for the culvert size usually indicates that a concrete stilling basin or energy dissipater structure is necessary.

Adjust values upward if the circular culvert is not flowing full based upon outlet conditions. For noncircular pipes, convert into an equivalent cross-sectional area of circular culvert to continue design.

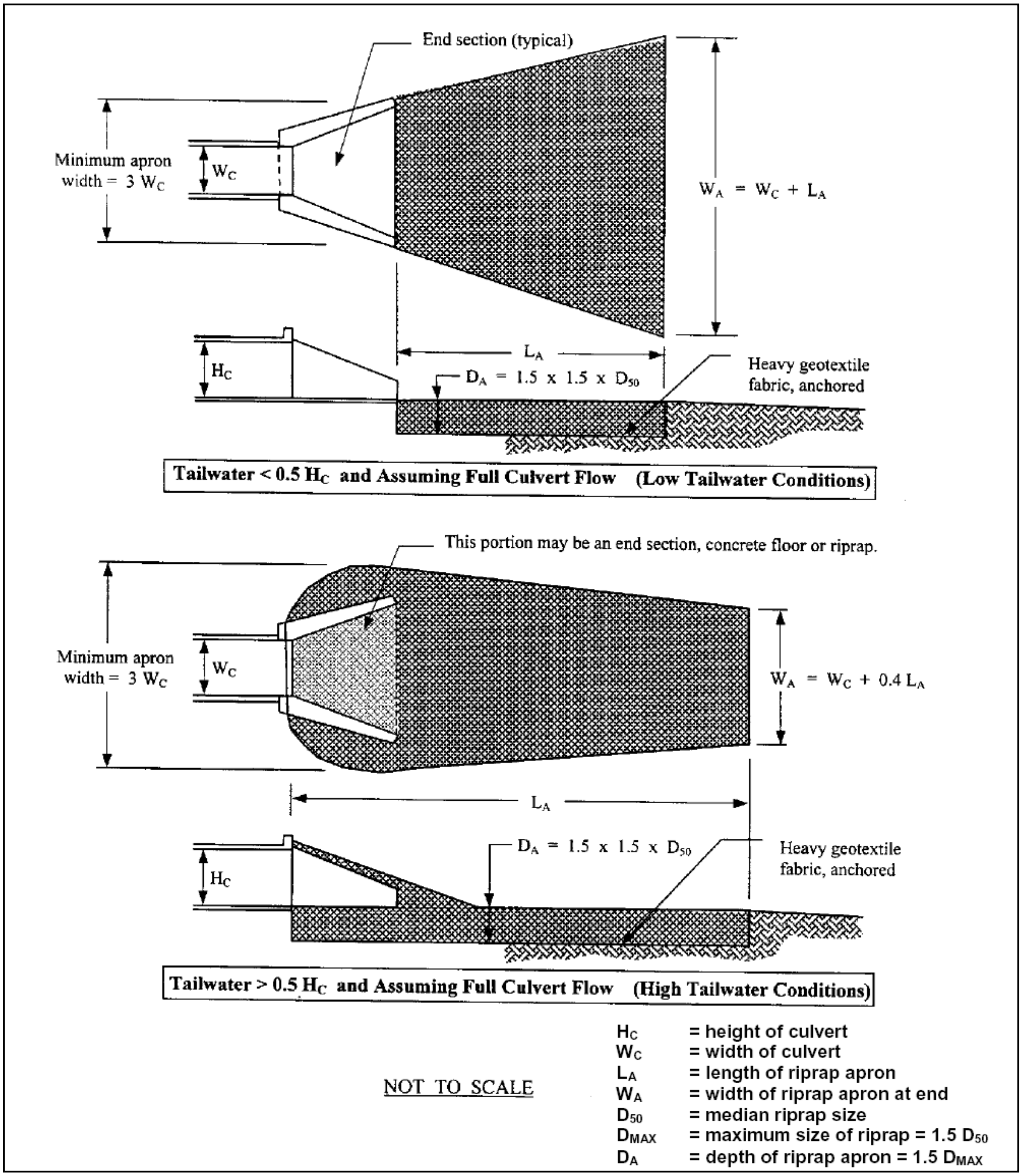


Figure 7.23-1 Riprap outlet protection dimensions
(Knoxville Engineering Department)

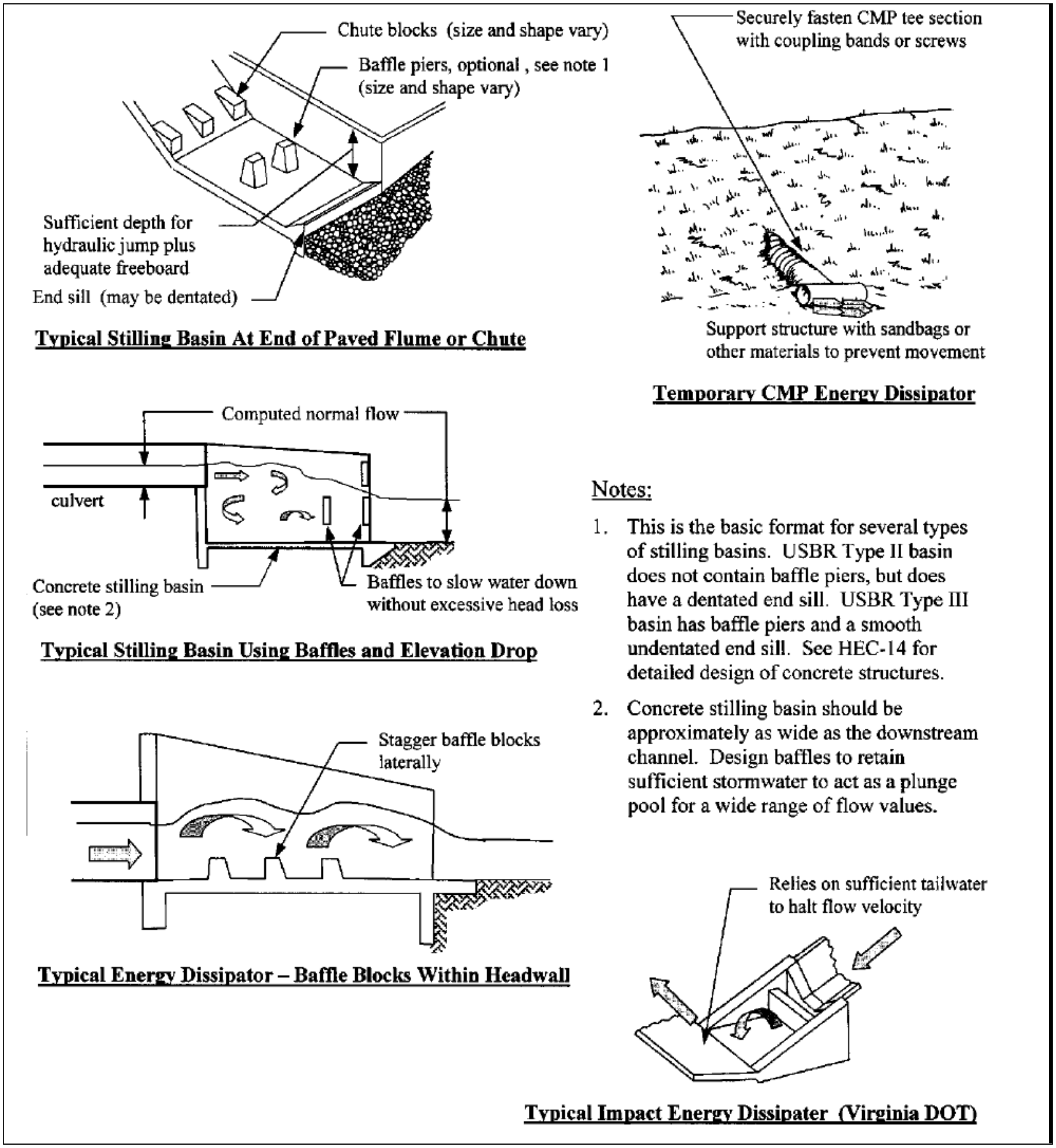
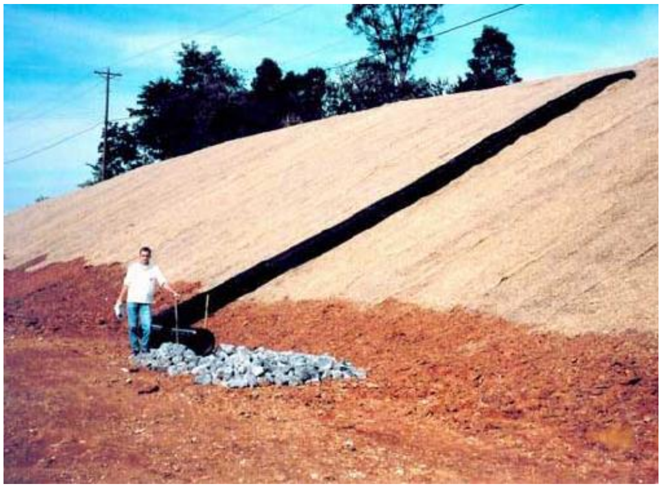
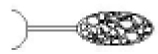


Figure 7.23-2 Stilling basins and other energy dissipaters (Source: Knoxville Engineering Department)

RUNOFF CONTROL AND MANAGEMENT

7.24 SLOPE DRAIN





SLOPE DRAIN

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

Purpose To convey storm water runoff down the face of a cut or fill slope without causing erosion on or below the slope.

Conditions Where Practice Applies Temporary slope drains are used where sheet or concentrated storm water flow could cause erosion as it moves down the face of a slope. These structures are removed once the permanent storm water disposal system is installed.

Planning Considerations There is often a significant lag between the time a cut or fill slope is graded and the time it is permanently stabilized. During this period, the slope is vulnerable to erosion, and temporary slope drains together with temporary diversions can provide valuable protection.

It is very important that these temporary structures be sized, installed, and maintained properly because their failure will usually result in severe erosion of the slope. The entrance section to the drain should be well entrenched and stable so that surface water can enter freely. The drain should extend down slope beyond the toe of the slope to a stable area or appropriately stabilized outlet.

Other points of concern are failure from overtopping from inadequate pipe inlet capacity and lack of maintenance of diversion channel capacity and ridge height.

Design Criteria

Placement: The temporary slope drain should be located on undisturbed soil or well compacted fill.

Diameter: The diameter of the temporary slope drain should provide sufficient capacity to convey the maximum runoff expected during the life of the drain. Refer to the table below for selecting the pipe diameter of a slope drain.

Maximum Drainage Area per Pipe (acres)	Pipe Diameter (inches)
0.50	12
0.75	15
1.00	18
>1.00*	as designed

*Inlet design becomes more complex beyond this size.

Table 7.24-1 Slope drain sizing
(Source: North Carolina Erosion and Sediment Control Planning and Design Manual)

Slope Drain Inlet and Outlet: See

Figure 7.24-1 for typical slope drain details. Diversion structures are used to direct runoff to the slope drain's "Tee" or "Ell" inlet at the top of the slope. Use an earthen diversion with a dike ridge to direct surface runoff into the temporary slope drain. Make the height of the ridge over the drain conduit a minimum of 1.5 feet and at least 6 inches higher than the adjoining ridge on either side. The lowest point of the diversion ridge should be a minimum of 1 foot above the top of the drain so that design flow can freely enter the pipe.

The entrance section should slope toward the entrance to the slope drain at a minimum of 1/2–inch per foot. Make all fittings watertight. A standard T-section fitting may also be used at the inlet. **Thoroughly compact selected soil around the inlet section to prevent the pipe from being washed out by seepage or piping.** A stone filter ring or other inlet protection may be placed at the inlet for added sediment filtering capacity. These sediment-filtering devices should be removed if flooding or bank over wash occurs.

Rock riprap should be placed at the outlet for energy dissipation. A Tee outlet, flared end section, or other suitable device may be used in conjunction with the riprap for additional protection.

Pipe Material: Construct the slope drain from heavy-duty, flexible materials such as nonperforated, corrugated plastic pipe or specially designed flexible tubing. Install reinforced, hold-down grommets or stakes to anchor the pipe at intervals not to exceed 10 ft with the outlet end securely fastened in place. The pipe must extend beyond the toe of the slope.

Construction Specifications

A common failure of slope drains is caused by water saturating the soil at the inlet section and seeping along the pipe. This creates voids and piping to occur, causing washouts. Proper back filling around and under the pipe with stable soil material, and hand compacting in 6-inch lifts to achieve firm contact between the pipe and the soil at all points, will eliminate this type of failure.

- Stabilize the slope with seed and mulch or matting.
- Place slope drains on the stabilized sloped.
- The entrance section should slope toward the inlet to the slope drain at a minimum of 1/2–inch per foot.
- Hand compact the soil under and around the inlet and exit sections in lifts not to exceed 6 inches.
- Ensure that the fill used to anchor the slope drain inlet at the top of the slope has minimum dimensions of 1.5 ft. depth, 2 ft. top width, and 3:1 side slopes.
- Ensure that all slope drain connections are watertight. Poor connections of sections of pipe can cause pipe failure and erosion on the slope.
- Ensure that all fill material is well compacted. Securely fasten the exposed section of the drain with grommets or stakes at all joints and spaced not to exceed 10 feet apart.
- Place the drain slightly diagonally across the slope, extending the drain beyond the toe of the slope. The outlet end should be directed toward the downstream direction. Protect the outlet area from erosion by installing rip rap outlet protection.
- If the drain is conveying sediment-laden runoff, direct all flows into a sediment trap or sediment basin.
- Make the settled, compacted diversion no less than one foot above the top of the pipe at every point.
- Immediately stabilize all disturbed areas following construction.

Maintenance and Inspection Points

Inspect the slope drain and supporting diversion after rainfall, and promptly make necessary repairs. When the protected area has been permanently stabilized and the permanent storm water disposal system is fully functional, temporary measures may be removed, materials disposed of properly, and all disturbed areas stabilized appropriately.

References

TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-27

North Carolina Erosion and Sediment Control Planning and Design Manual

Georgia Soil and Water Conservation Commission

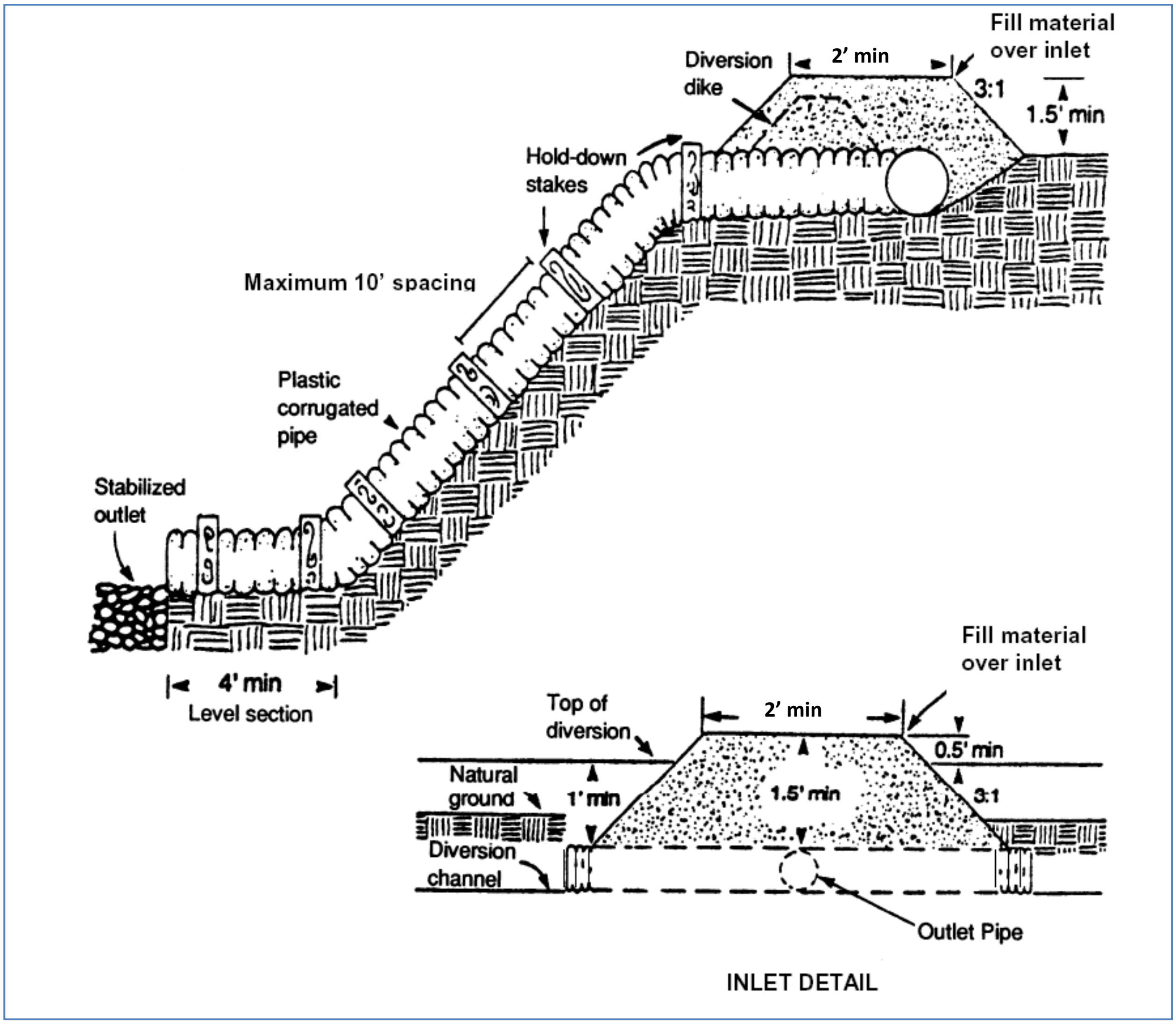
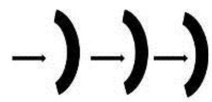


Figure 7.24-1 Slope drain pipe and inlet detail
(Source: GA SWCC)

RUNOFF CONTROL AND MANAGEMENT

7.25 TUBES AND WATTLES



Definition A small temporary barrier, grade control structure or dam constructed across a swale, drainage ditch, or area of concentrated flow.

Purpose To minimize the erosion rate by reducing the velocity of storm water in areas of concentrated flow, and to capture larger soil particles.

Conditions Where Practice Applies This practice is applicable in a ditch to help reduce the effects of soil erosion and aid in sediment retention. Sediment tubes and wattles should not be used in streams.

Planning Considerations The stability of tubes and wattles is very dependent upon proper staking. Thus, they may not be utilized on pavement, rocky soil or at any location where the stakes cannot be driven to the required depth.

Design Criteria The maximum drainage area to any given tube or wattle should be no more than 5 acres. When applied in a ditch, the same design requirements as rock check dams apply. The depth of flow on the center of the wattle or tube (weir) shall be computed for the peak flow rate generated by the 2-year, 24-hour storm in order to ensure that the top of the structure and ditch will not be overtopped. For sites draining to high quality streams or streams listed as impaired by sediment, the depth must be determined for the 5-year, 24-hour peak flow rate. The weir section must be at least 9 inches deep. See Table 7.25-1 for the minimum spacing for ditch applications.

Joints within a ditch section should be avoided. However, where joints are necessary, a second row of tubes or wattles is required with the joints staggered by a distance equal to half of the individual segment length.

Tube/wattle netting should be a knitted material with 1/8 to 3/8 inch openings and made of photodegradable (polypropylene, HDPE) or biodegradable (cotton, jute, coir) material. The minimum diameter for any tube or wattle applied in a ditch should be 12 inches. This will ensure that the tube will function effectively as a velocity control device.

Slope (%)	Maximum Tube/ Wattle Spacing (ft.)
< 2	125
2	100
3	75
4	50
5	40
6	30
> 6	25

Table 7.25-1 Maximum Spacing for Wattles/Tubes in Ditch Application *(Source: TDOT)*

Construction Specifications

Proper site preparation is essential to ensure tubes and wattles are in complete contact with the underlying soil surface. Remove all rocks, clods, vegetation or other obstructions so installed tubes and wattles have direct contact with the underlying soil surface.

Install tubes and wattles by laying them flat on the ground. Install stakes at spacings per the manufacturer's recommendation. Stakes should be installed on the downstream side of the wattles/tubes.

Install tubes so no gaps exist between the soil and the bottom of the tube.

Keep tubes in place until the contributing drainage area has been stabilized.

The ends of the wattle or tube must extend up the ditch side slopes at least 6" vertical above the weir flow depth (see Figure 7.25-1 below).

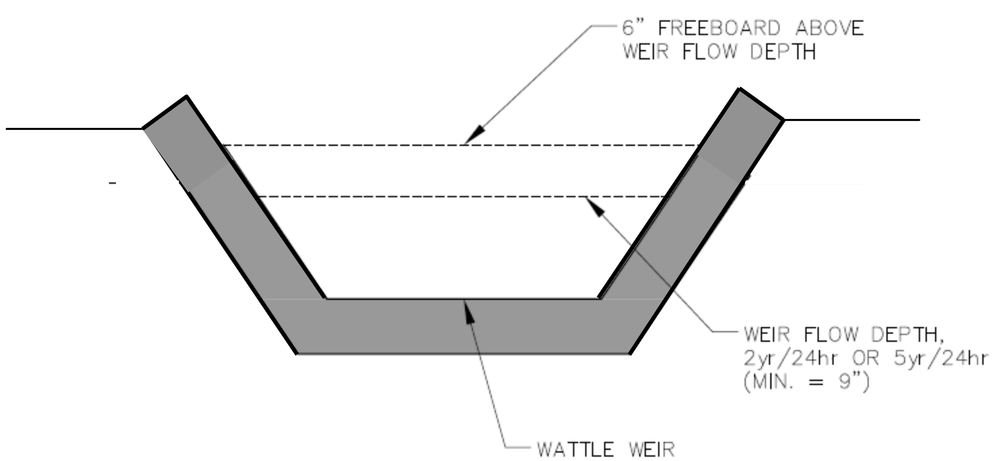


Figure 7.25-1 Cross sectional view of wattle installed in ditch

Maintenance and Inspection Points

- Inspect wattles and tubes after installation for gaps under the tubes and for gaps between the joints of adjacent ends of tubes. Ensure stakes are on the downstream side.
- Repair all rills, gullies, and undercutting near tubes.
- Remove all sediment deposits when the sediment reaches 1/3 the height of the exposed tube.
- Remove and/or replace installed sediment tubes as required to adapt to changing construction site conditions.
- Most tubes and wattles are filled with biodegradable materials. When the fill materials degrade and settle, the wattle should be replaced.
- At the end of the project, biodegradable wattles and tubes can be split open, the netting material and stakes removed, and the biodegradable material left in place to aid stabilization.

References

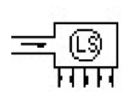
TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-31

South Carolina Department of Health & Environmental Control Stormwater Management BMP Handbook

RUNOFF CONTROL AND MANAGEMENT

7.26 LEVEL SPREADER



Definition

A level spreader is a flow control measure that receives concentrated, potentially erosive inflows and converts them to a sheet flow condition by means of a horizontal weir and channel.

Purpose

To convert concentrated flow to sheet flow and release it uniformly over a stabilized area.

Conditions Where Practice Applies

Where sediment-free storm runoff can be released in sheet flow down a stabilized slope without causing erosion.

Where a level lip can be constructed without filling.

Where the area below the spreader lip is uniform with the slope of 10% or less and is stable for anticipated flow conditions, preferably well-vegetated.

Where the runoff water will not re-concentrate after release.

Where there will be no traffic over the spreader.

Planning Considerations

The level spreader is a relatively low-cost structure to release small volumes of concentrated flow where site conditions are suitable. The outlet area must be uniform and well-vegetated with slopes of 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. Evaluate the outlet system to be sure that flow does not concentrate below the outlet. The level spreader is most often used as an outlet for temporary or permanent diversions and diversion dikes. Runoff water containing high sediment loads must be treated in a sediment trapping device before release in a level spreader.

Design Criteria

Level spreaders contain 3 components:

1. **Forebay**: The forebay is used for the preliminary treatment of stormwater. It is an excavated, bowl-shaped feature that slows the influent stormwater and allows heavy sediment and debris to settle. The forebay may be lined with riprap to reduce erosion within the excavated area. The uneven riprap surfaces function as small sediment traps. Forebays dissipate energy and reduce the sediment that accumulates behind the level spreader lip.
2. **Channel**: After the stormwater passes though the forebay, it enters a concrete, rock, or grassed channel – the main body of the level spreader. This is a dead-end channel because it does not directly connect the watershed to the stream. Instead, the channel is a long, shallow impoundment that fills to the level of its lower side. The lower side (the *downslope side*) of the channel is constructed so that it is level along its full length. This lower side, or **level spreader lip**, is often constructed of concrete or rock so that it resists erosion. As stormwater enters the channel, it rises until it fills the channel and exits evenly over the lip. The downslope side of the system functions as a long, broad-crested weir.
3. **Vegetated buffer**. After the runoff passes over the level spreader lip, it enters the vegetated buffer. As runoff passes through the buffer vegetation, some of the water infiltrates. Ideally, the buffer will remove sediment and nutrients from runoff before it reaches the stream.

Design parameters:

Capacity – Determine the capacity of the spreader by estimating peak flow from the 10-year storm. Restrict the drainage area so that maximum flows into the spreader will not exceed 30 cfs.

Channel dimensions – When water enters the spreader from one end, as from a diversion, select the appropriate length, width, and depth of the spreader from Table 7.26-1.

Construct a 20-foot transition section in the diversion channel so the width of the channel will smoothly meet the width of the spreader to ensure uniform outflow.

Design Flow cfs	Entrance Width ft	Depth ft	End Width ft	Length ft
0-10	10	0.5	3	10
10-20	16	0.6	3	20
20-30	24	0.7	3	30

Table 7.26-1 Spreader Dimensions

The grade of the last 20 feet of the diversion channel should provide a smooth transition from the diversion channel to the level spreader. The grade of the spreader should be 0%.

Spreader lip – A level spreader system must have a stable lip that cannot be eroded. Concrete level spreaders can be built with minimal slope along the length of the channel's downslope side. Concrete level spreaders resist erosion better than level spreaders made of earth, gravel, or both (see Figure 7.26-1). If a flow greater than the design flow is routed over a level spreader made of concrete, the level spreader lip will not be damaged. Level spreaders made of earth, gravel, or both should not be used in any urban applications because they routinely fail. Another stable material is a metal gutter. Like concrete level spreaders, pre-fabricated metal level spreaders can be expected to remain level with minimal maintenance.

The lip of the concrete level spreader must be higher than the existing ground by 3 to 6 inches. This allows water to pass over the lip without interference from buffer vegetation. To limit any erosion that could occur as water falls from the top of the level spreader to the existing soil, extend a layer of filter fabric a distance of 3 feet from the level spreader lip towards the riparian vegetation. Stone, such as No. 57 stone, should be placed on top of the filter fabric (3 to 4 inches deep) to reduce erosion just downslope of the level spreader (Figure 7.26-1). A 3-foot wide strip of erosion control matting can be used in place of the filter fabric and No. 57 stone combination. However, such an area must be stable and have adequate vegetation before receiving stormwater.

Construct the level lip on undisturbed soil to uniform height and zero grade over the length of the spreader. Protect it with an erosion-resistant material, such as fiberglass matting, to prevent erosion and allow vegetation to become established. Other materials can be considered for the construction of a level lip, such as concrete, pressure treated wood and other rigid materials. Regardless of the materials used, the lip of the spreader must be level.

Outlet area – The outlet disposal area must be generally smooth and well-vegetated with a maximum slope of 10%.

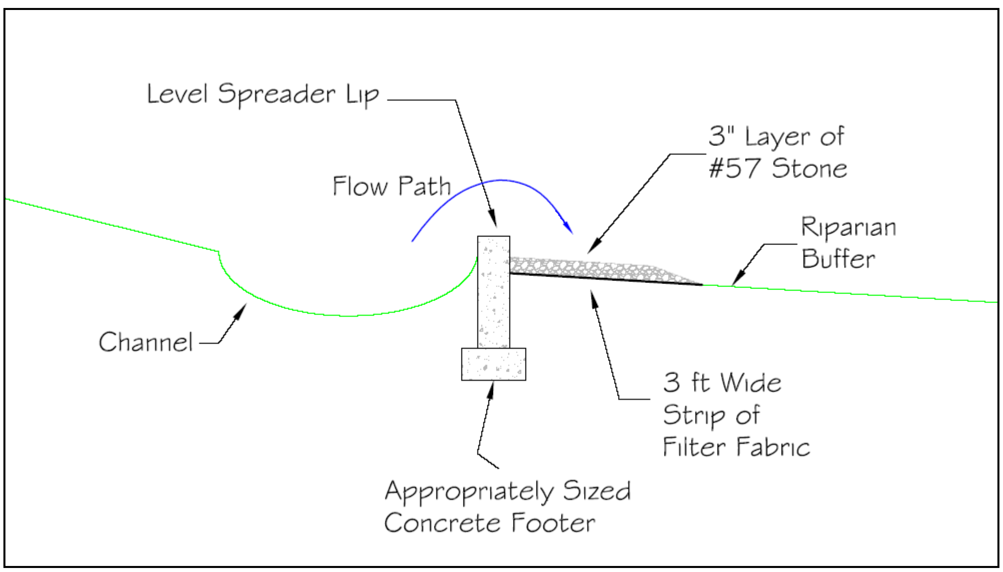


Figure 7.26-1 Cross Section of Concrete Level Spreader
(Source: NCSU Cooperative Extension Service)

Construction Specifications

- Construct the level spreader on undisturbed soil (not on fill).
- Ensure that the spreader lip is level for uniform spreading of runoff.
- Construct a 20-foot transition section from the diversion channel to blend smoothly to the width and depth of the spreader.
- Disperse runoff from the spreader across a properly stabilized slope not to exceed 10%. Make sure the slope is sufficiently smooth to keep flow from concentrating.
- Immediately after its construction, appropriately seed and mulch the entire disturbed area of the spreader.

Maintenance and Inspection Points

Immediately remove any sediment which has collected in the level spreader channel or in the forebay.

References

TDOT Design Division Drainage Manual

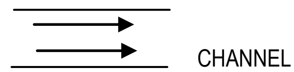
TDOT Erosion Control Standard Drawing EC-STR-61

North Carolina Erosion and Sediment Control Planning and Design Manual

North Carolina State University Cooperative Extension Service.

RUNOFF CONTROL AND MANAGEMENT

7.27 CHANNELS (STABLE CHANNEL DESIGN)



Definition A runoff conveyance measure constructed to the design cross section and grade, and stabilized with erosion-resistant linings such as vegetation, riprap, paving, or other structural material. For the purposes of this section, channels do not include streams.

Purpose To convey and dispose of concentrated surface runoff without damage from erosion, deposition, or flooding.

Conditions Where Practice Applies This practice applies to construction sites that contain concentrated runoff in a ditch or open channel. Typical locations of channels or ditches include roadside ditches, channels at property boundaries, channels created by diversion structures, or channels designed as part of a site's permanent storm water conveyance system.

Planning Considerations **Location.** Generally, channels should be located to conform with and use the natural drainage system. Channels may also be needed along development boundaries, roadways, and rear lot lines. Avoid channels crossing watershed boundaries or ridges. Plan the course of the channel to avoid sharp changes in direction or grade. Site development should conform to natural features of the land and use natural drainageways rather than drastically reshape the land surface. Major reconfiguration of the drainage system often entails increased maintenance and risk of failure.

Stabilized channels must be isolated from sedimentation from disturbed areas.

Stable grass-lined channels resemble natural drainage systems and, therefore, are usually preferred if design shear stress is below 2 lb/ft^2 and velocities below 5 ft/sec.

Construct and stabilize channels early in the construction schedule before grading and paving increase the rate of runoff. Where grass-lined channels are designed, geotextile fabrics or straw and netting provide stability until the vegetation is fully established. These protective liners must be used whenever design velocities exceed 2 ft/sec for bare soil conditions. It may also be necessary to divert water from the channel until vegetation is established, or to line the channel with sod.

Sediment traps may be needed at channel inlets and outlets.

V-shaped channels generally apply where the quantity of water is small, such as in short reaches along roadsides. The V-shaped cross section is least desirable because it is difficult to stabilize the bottom where velocities may be high.

Parabolic channels are often used where larger flows are expected and space is available. The swale-like shape is pleasing and may best fit site conditions.

Trapezoidal channels are used where runoff volumes are large and slope is low.

Subsurface drainage, or riprap channel bottoms, may be necessary on sites that are subject to prolonged wet conditions due to long duration flows or high water tables.

Construction drawings should include specifications to provide sufficient channel undercutting to allow for thickness of some linings such as rock to preserve the required flow depth.

Outlets. Channel outlets must be stable. Where channel improvement ends, the exit velocity for the design flow must be nonerosive for the existing receiving system conditions. Stability conditions beyond the property boundary should always be considered.

Where velocities exceed 2 ft/sec, more durable channel liners are required. Liners for channels may be classified as either flexible or rigid. The primary difference between rigid and flexible channel linings from an erosion control standpoint is the lining's response to changing channel shape. Flexible linings are able to conform to changes in the channel shape while rigid linings will not. Flexible linings can accommodate some change in channel shape while maintaining their overall integrity. Rigid linings tend to fail if a portion of the lining is damaged by undermining or slumping. Thus, where flexible linings are capable of withstanding the design shear stress, they are preferred over rigid linings. Flexible linings usually will consist of sod or seeded grasses, erosion control blankets or turf reinforcement mats, machined rock (riprap), cobbles, or wire-enclosed rock (such as gabions or mattresses).

Rigid linings may consist of either cast-in-place concrete, grouted riprap, or stone masonry. As a general rule, the use of rigid linings should be avoided unless they are intended to be permanent. Channel design in this manual only addresses flexible channel linings.

Design Criteria

Design of channels should be consistent with the U.S. Department of Transportation – Federal Highway Administration: Hydraulic Engineering Circular Number 15 (HEC15). This design method is based on the concept of maximum permissible tractive force, or shear stress. The method has two parts, computation of the flow conditions for a given design discharge and determination of the degree of erosion protection required. The flow conditions are a function of the channel geometry, design discharge, channel roughness, channel alignment and channel slope. The erosion protection required can be determined by computing the shear stress on the channel lining (and underlying soil, if applicable) at the design discharge and comparing that stress to the permissible value for the type of lining/soil that makes up the channel boundary.

For simplification, the following channel design conditions are addressed in this manual:

- Straight channels
- Channel bends
- Flexible linings
- Uniform flow

<u>General design guidance:</u>

- Avoid supercritical flow or include a drop structure and hard armoring in the design. Where design indicates supercritical flow, consider changing the channel geometry.
- Design must consider the construction phase and permanent stormwater management conveyance (after construction is complete) phase. Factors used in the design should reflect these conditions.
- Where slopes over 10% and/or supercritical flow cannot be avoided, use FHWA's HEC 15 for a more detailed design using hard armoring and/or grade control structures.
- On steep slopes, shorten the effective slope length by installing drop structures or "turn outs" that discharge runoff non-erosively over stable slopes.
- At a minimum, the freeboard should be sufficient to prevent waves or fluctuations in water surface from washing over the sides. In a permanent roadway channel, about 0.5 ft of freeboard should be adequate, and for transitional channels, zero freeboard may be acceptable. Steep gradient channels should have a freeboard height equal to the flow depth. This allows for large variations to occur in flow depth for steep channels caused by waves, splashing and surging. Lining materials should extend to the freeboard elevation.
- Check overall channel width for fitting within available alignment space, easement or right-of-way.

The following graphic depicts the decision flow chart for design of flexible channel linings.

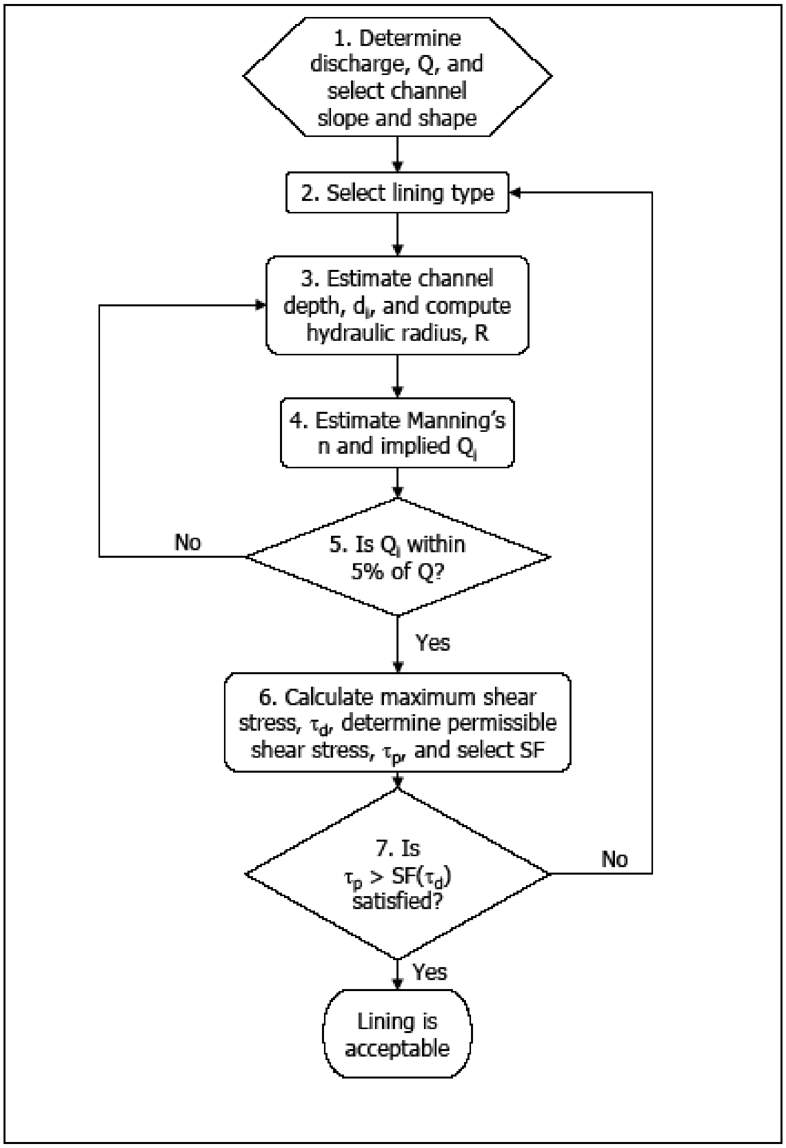
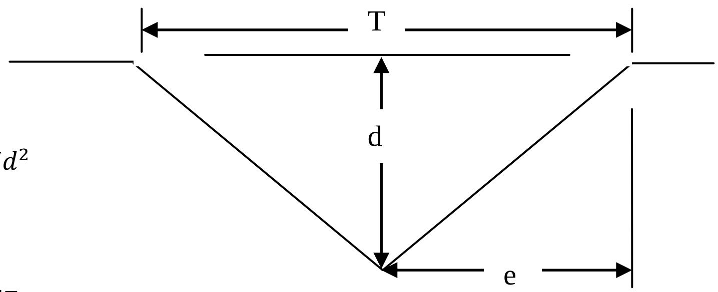


Figure 7.27-1 Decision Flow Chart for Design of Flexible Channel Linings (Source: FHWA HEC 15)

Flexible channel liner design (mulch and grass, ECBs TRMs)
FHWA HEC-15 Method:

Step 1. Determine discharge, Q, and determine channel slope and shape. Channel geometry determines cross sectional area and hydraulic radius (see Equation 7.27-1). Hydraulic radius and cross sectional area equations for triangular or "vee" ditches, parabolic ditches and trapezoidal ditches is provided in Figure 7.27-2.

TRIANGULAR



Area $A = Zd^2$

Side Slopes $Z = \frac{e}{d}$

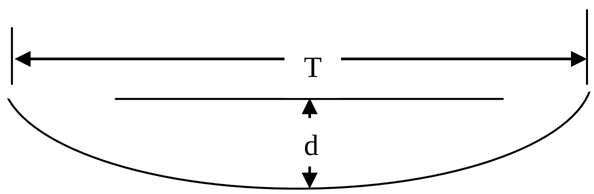
Top Width T = 2dZ

Hydraulic Radius

$$R = \frac{Zd}{2\sqrt{Z^2 + 1}}$$

PARABOLIC

Area $A = \frac{2}{3}Td$

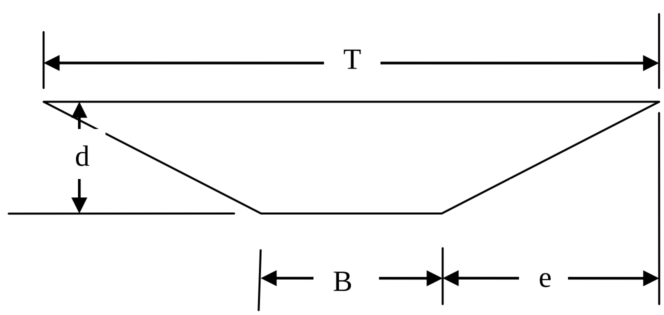


Hydraulic Radius

$$R = \frac{T^2 d}{1.5T^2 + 4d^2}$$

TRAPEZOIDAL

Area $A = Bd + Zd^2$



$Z = \frac{e}{d}$

$T = B + 2dZ$

Hydraulic Radius

$$R = \frac{Bd + Zd^2}{B + 2d\sqrt{Z^2 + 1}}$$

Figure 7.27-2 Channel Geometry, Cross-sectional Area and Hydrologic Radius

For determining flow, use Manning's equation:

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

Equation 7.27-1

Where
Q = design discharge, ft^3/sec
n = Manning's roughness coefficient, dimensionless
A = cross sectional area, ft^3
R = hydraulic radius, ft
S_f = friction gradient, which for uniform flow conditions equals the channel bed gradient, so, ft/ft

Step 2. Select a trial lining type. Initially, the designer must determine if a long term lining is needed and whether or not a temporary or transitional lining is required. To determine if a temporary lining is required, the initial trial lining type should be bare soil. For example, it may be determined that the bare soil is insufficient for a long-term solution, but vegetation is a good solution. For the transitional period between construction and vegetative establishment, analysis of the bare soil will determine if a temporary lining is required. A trial lining allows an initial Manning's n to be estimated.

Step 3. Estimate the depth of flow, d_i in the channel and compute the hydraulic radius, R. The estimated depth may be based on physical limits of the channel, but this first estimate is essentially a guess. Iterations on steps 3 through 5 may be required.

Step 4. Estimate Manning's n and the discharge implied by the estimated n and flow depth values. See Tables 7.27-1 and 7.27-2 depending on lining type of interest for Manning's n values. Calculate the discharge, Qi.

Note that Table 7.27-1 summarizes linings for which the n value is dependent on flow depth as well as the specific properties of the material. Values for rolled erosion control products (RECPs) are presented to give a rough estimate of roughness for the three different classes of products. Although there is a wide range of RECPs available, jute net, curled wood mat, and synthetic mat are examples of open-weave textiles, erosion control blankets, and turf reinforcement mats, respectively. Manufacturers of RECPs can provide more specific roughness coefficients as well.

Table 7.27-2 presents typical values for the stone linings: riprap, cobbles, and gravels. These are highly depth-dependent for roadside channel applications. More in-depth lining-specific information should be considered.

Table 7.27-1 Typical Roughness Coefficients for Selected Linings

		Manning's n		
Lining Category[1]	**Lining Type**	**Maximum**	**Typical**	**Minimum**
Rigid	Concrete	0.015	0.013	0.011
	Grouted Riprap	0.040	0.030	0.028
	Stone Masonry	0.042	0.032	0.030
	Soil Cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare Soil	0.025	0.020	0.016
	Rock Cut (smooth, uniform)	0.045	0.035	0.025
RECP	Open-weave textile	0.028	0.025	0.022
	Erosion control blankets	0.045	0.035	0.028
	Turf reinforcement mat	0.036	0.030	0.024

[1]Minimum value accounts for grain roughness. Typical and maximum values incorporate varying degrees of form roughness.

Table 7.27-2 Typical Roughness Coefficients for Riprap, Cobble, and Gravel Linings

		Manning's n for Selected Flow Depths[1]		
Lining Category	**Lining Type**	**0.5 ft**	**1.6 ft**	**3.3 ft**
Gravel Mulch	D_{50} = 1 in.	0.040	0.033	0.031
	D_{50} = 2 in.	0.056	0.042	0.038
Cobbles	D_{50} = 0.33 ft	- [2]	0.055	0.047
Rock Riprap	D_{50} = 0.5 ft	- [2]	0.069	0.056
	D_{50} = 0.33 ft	- [2]	- [2]	0.080

[1]Manning's n estimated assuming a trapezoidal channel with 1:3 side slopes and 2 ft bottom width.
[2]Shallow relative depth (average depth to D_{50} ratio less than 1.5) and is slope-dependent.

Step 5. Compare Q_i with Q. If Q_i is within 5 percent of the design Q then proceed on to Step 6. If not, return to Step 3 and select a new estimated flow depth, d_{i+1}. This can be estimated from the following equation

$$d_{i+1} = d_i \left(\frac{Q}{Q_i}\right)^{0.4}$$

Step 6. Calculate the shear stress at maximum depth, τ_d, determine the permissible shear stress, τ_p, and select an appropriate safety factor. Permissible shear stress for different linings is provided in Tables 7.27-3 through 7.27-8.

The maximum channel shear stress is taken as:

$$\tau_d = \gamma d S_o$$

where,

τ_d = shear stress in channel at maximum depth, lb/ft^2

d = maximum depth of flow in the channel for the design discharge, ft

S_o = channel bed slope, ft/ft

Table 7.27-3 Typical Permissible Shear Stresses for Bare Soil and Stone Linings

		Permissible Shear Stress τ_p
Lining Category	Lining Type	lb/ft^2
Bare Soil Cohesive (PI=10)[1]	Clayey sands	0.037-0.095
	Inorganic silts	0.027-0.11
	Silty sands	0.024-0.072
Bare Soil Cohesive[1] (PI≥20)	Clayey sands	0.094
	Inorganic silts	0.083
	Silty sands	0.072
	Inorganic clays	0.14
Bare Soil Non-cohesive (PI<10)	Finer than coarse sand D_{75}<0.05 in	0.02
	Fine gravel D_{75}=0.3 in	0.12
	Gravel D_{75}=0.6 in	0.024
Gravel Mulch	Coarse gravel D_{50}=1 in	0.4
	Very coarse gravel D_{50}=2 in	0.8
Rock Riprap	D_{50}=0.5 ft	2*
	D_{50}≥1.0 ft	4*

[1]Assuming a soil void ratio of 0.5

* Assumes $D_{50} = \tau_p/4$

Table 7.27-4 Ultra Short Term Channel Liner Shear Stress

Typical 3-month functional longevity			
Type	Product Description	Material Composition	Max. Shear Stress τ_p
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	0.25 lbs/ft^2
1.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	0.5 lbs/ft^2
1.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5 lbs/ft^2
1.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	1.75 lbs/ft^2

Table 7.27-5 Short Term Channel Liner Shear Stress

Typical 12-month functional longevity			
Type	Product Description	Material Composition	Max. Shear Stress τ_p
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	0.25 lbs/ft^2
2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	0.5 lbs/ft^2
2.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5 lbs/ft^2
2.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	1.75 lbs/ft^2

Table 7.27-6 Extended-Term Channel Liner Shear Stress

EXTENDED-TERM - Typical 24-month functional longevity			
Type	Product Description	Material Composition	Max. Shear Stress τ_p
3.A	Mulch Control Nets	A slow degrading synthetic mesh or woven natural fiber netting.	0.25 lbs/ft^2
3.B	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	2.00 lbs/ft^2

Table 7.27-7 Long-Term Channel Liner Shear Stress

LONG-TERM - Typical 36 month functional longevity			
Type	Product Description	Material Composition	Max. Shear Stress τ_p
4	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	2.25 lbs/ft^2

Table 7.27-8 Permanent Turf Reinforcement Channel Lining Shear Stress

<table>
<tr><th colspan="4">PERMANENT Turf Reinforcement Mat - U.V. stability of 80%</th></tr>
<tr><th>Type</th><th>Product Description</th><th>Material Composition</th><th>Max. Shear Stress τ_p</th></tr>
<tr><td>5.A</td><td>Turf Reinforcement Mat</td><td rowspan="3">Turf Reinforcement Mat (TRM) – A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.</td><td>6.0 lbs/ft^2</td></tr>
<tr><td>5.B</td><td>Turf Reinforcement Mat</td><td>8.0 lbs/ft^2</td></tr>
<tr><td>5.C</td><td>Turf Reinforcement Mat</td><td>10.0 lbs/ft^2</td></tr>
</table>

Step 7. Compare the permissible shear stress to the calculated shear stress from step 6. If $\tau_p \geq \tau_d$, then the channel lining is adequate. If the permissible shear stress is inadequate, then return to Step 2 and select an alternative lining type with greater permissible shear stress. As an alternative, a different channel shape may be selected that results in a lower depth of flow.

Channel Bend Analysis

Flow around a bend creates secondary currents, which impose higher shear stresses on the channel sides and bottom compared to a straight reach (Nouh and Townsend, 1979) as shown in Figure 7.27.3. At the beginning of the bend, the maximum shear stress is near the inside and moves toward the outside as the flow leaves the bend. The increased shear stress caused by a bend persists downstream of the bend.

The following procedure should be used to select an adequate lining for a channel in a bend section. It assumes that the channel has already been designed for the straight sections. First, the required lining and the length of the channel that must be reinforced is determined. After the channel lining has been checked for stability, the capacity of the bend section is analyzed.

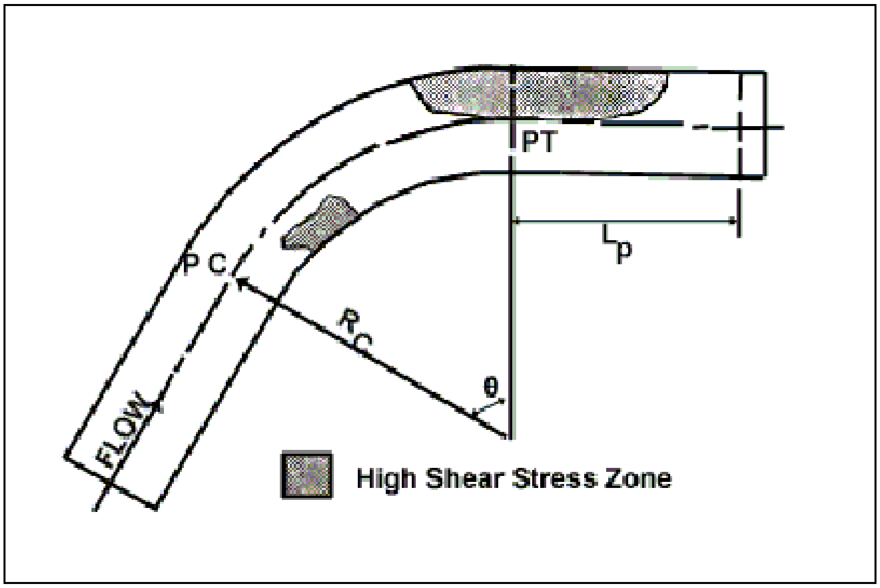


Figure 7.27-3 Shear Stress Distribution in a Channel Bend
(Nouh and Townsend, 1979)

Step 1. Determine the value of the ratio $\frac{R_c}{B}$, where R_c is the radius of curvature, and B is the channel width.

Step 2. Calculate K_b as follows:

Where $Rc/T \leq 2$ — $K_b = 2.00$

Where $2 < Rc/T < 10$ — $K_b = 2.38 - 0.206\left(\frac{R_c}{T}\right) + 0.0073\left(\frac{R_c}{T}\right)^2$

Where $10 \leq Rc/T$ — $K_b = 1.05$

Step 3. Calculate the shear stress in the channel bend using the following equation.

$$\boldsymbol{\tau_b = K_b\, \tau_d}$$

where,
τ_d = maximum shear stress in the straight section of the channel

If τ_b is greater than the permissible shear stress for the selected channel lining, then a different lining is required for the channel bend. Select a new lining (and corresponding Manning's coefficient), and repeat the previous procedures to demonstrate stability.

Step 4. Calculate the required length of lining. The channel lining in the bend section should be installed from the beginning of the bend, all the way through the bend, and downstream a distance L_p determined in the following equation:

$$L_p = 0.604 \left(\frac{R^{1/6}}{n_b}\right) R$$

where,
R = hydraulic radius, ft
n_b = Manning's roughness coefficient in the bend

Step 5. Check the capacity in the bend. First, calculate the velocity in the bend using Manning's Equation (Equation 7.27-1). This should be done using the roughness coefficient for the final condition of the channel (i.e. fully vegetated, instead of just a temporary blanket). Then calculate the super elevation in the bend with the following equation:

$$\Delta h = \frac{V^2\, T}{g\, R_c}$$

where,
V = velocity, ft/s
T = top width of the channel, ft
g = acceleration due to gravity, 32.2 ft/s^2
R_c = radius of curvature of the bend, ft
Δh is the difference between the inside and outside depths at the superelevation in the bend.

The design depth of the channel in the bend section must be capable of conveying an extra height $\Delta h/z$ in addition to the flow depth calculated for the straight section. If the depth is insufficient, the channel geometry must be modified and the calculations performed again.

Rip rap channel lining design

The design process for riprap-lined ditches is iterative, as flow depth, roughness, and shear stress are interdependent. It is assumed that the designer begins this procedure with the channel shape, slope, and design flow rate. From there, a preliminary D_{50} is determined for the rip rap, and the design depth and Manning's 'n' are calculated.

Step 1 Determine discharge, Q, and determine channel slope and shape. Channel geometry determines cross sectional area and hydraulic radius (see Equation 7.27-1). The side slopes of a riprap-lined channel should not be steeper than 3H:1V (Z should be ≥3).

Step 2 Select a trial D_{50} based on previous experience and available stone sizes for the project. Refer to Table 7.20-1 TDOT Rip Rap Classification and Sizes for standard riprap classes in Tennessee.

Step 3 Assume an initial trial depth. For the first iteration, select a channel depth, d_i. For subsequent iterations, a new depth can be estimated from the following equation:

$$d_{i+1} = d_i \left(\frac{Q}{Q_i}\right)^{0.4}$$

Equation 7.27-2

Determine Area (A), Hydraulic Radius (R), and Top Width (T) using the equations shown in Figure 7.27-2.

Determine the average flow depth, d_a, in the channel using the following relationship: $d_a = A/T$

After calculating d_a, recalculate A, R, and T at this depth to get your Average Area (Aa), Average Hydraulic Radius (Ra), and Average Top Width (Ta).

Step 4 Calculate Manning's roughness coefficient, 'n'. First, calculate the relative depth ratio, d_a/D_{50}. If d_a/D_{50} is greater than or equal to 1.5, use Equation 7.27-3 to calculate Manning's 'n'. If d_a/D_{50} is less than 1.5, use Equation 7.27-4.

$$n = \frac{\alpha {d_a}^{1/6}}{2.25 + 5.23\ log\left(\frac{d_a}{D_{50}}\right)}$$

Equation 7.27-3

where,

n = Manning's roughness coefficient, dimensionless
d_a = average flow depth in the channel, ft
D_{50} = median riprap size, ft
α = unit conversion constant, 0.262 (CU)

$$n = \frac{\alpha {d_a}^{1/6}}{\sqrt{g}\, f(Fr) f(REG) f(CG)}$$

Equation 7.27-4

where,

α = unit conversion constant, 1.49 (CU) and 1.0 (SI)
n = Manning's roughness coefficient, dimensionless
d_a = average flow depth in the channel, ft
g = acceleration due to gravity, 32.2 ft/s^2
f(Fr) = Froude number (see Equation 7.27-5 below)
f(REG) = roughness element geometry (see Equation 7.27-6)
f(CG) = channel geometry (see Equation 7.27-7)

$$f(Fr) = \left(\frac{0.28Fr}{b}\right)^{\log(0.755/b)}$$

Equation 7.27-5

$$f(REG) = 13.434\left(\frac{T}{D_{50}}\right)^{0.492} b^{1.025(T/D_{50})^{0.118}}$$

Equation 7.27-6

$$f(CG) = \left(\frac{T}{d_a}\right)^{-b}$$

Equation 7.27-7

The following variables are necessary for the above equations:

T = channel top width, ft (see Figure 7.27-2)
b = parameter describing the effective roughness coefficient (see Equation 7.27-9)
v = Q/A_a , ft/s
A_a = Area at d_a (see Step 3)

$$Fr = \frac{v}{\sqrt{g\, d_a}}$$

Equation 7.27-8

$$b = 1.14\left(\frac{D_{50}}{T}\right)^{0.453}\left(\frac{d_a}{D_{50}}\right)^{0.814}$$

Equation 7.27-9

Step 5 Calculate the discharge for this iteration using Manning's equation with the d_a from Step 3. If the calculated discharge is within 5% of the design discharge, continue to Step 6. Otherwise, return to Step 3 and select a new flow depth.

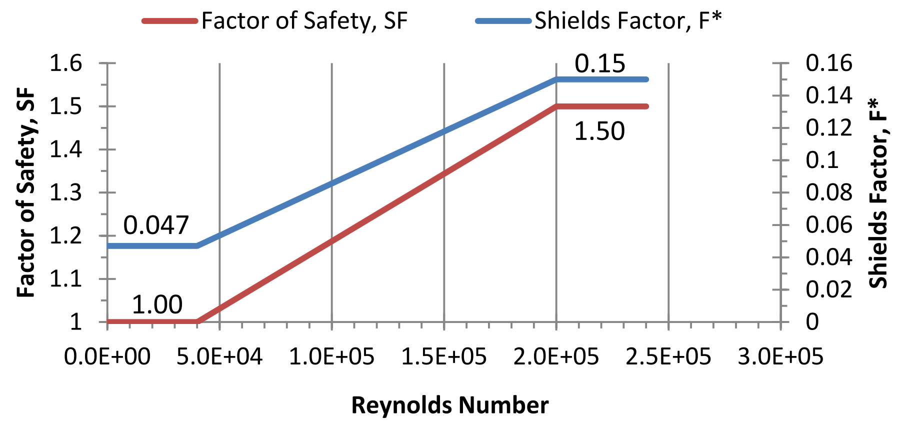
Step 6 Calculate the particle Reynolds number, R_e, using Equation 7.27-10, then determine the appropriate Shield's parameter, F*, and safety factor, SF, values from Figure 7.27-4.

$$R_e = \frac{\sqrt{gdS}\, D_{50}}{\nu}$$

Equation 7.27-10

Where,

g = acceleration due to gravity, 32.2 ft/s^2
d = maximum channel depth, ft (d_a + minimum freeboard of 0.5')
S = channel slope, ft/ft
ν = kinematic viscosity, 1.217x10^{-5} ft^2/s at 60°F



Reynolds Number, R_e	Shield's Parameter, F*	Factor of Safety, SF
$\leq 4x10^4$	0.047	1
$4x10^4 < R_e < 2x10^5$	Linear Interpolation	Linear Interpolation
$\geq 2x10^5$	0.15	1.5

Figure 7.27-4 Reynolds Number, Shield's Parameter and Factor of Safety Values

Step 7 Calculate the required D_{50}. For channel slopes less than 5%, use Equation 7.27-11. For channel slopes greater than 10%, use Equation 7.27-12. For channel slopes between 5 and 10%, use both equations and choose the larger outcome.

$$\boldsymbol{D_{50}} \geq \frac{\boldsymbol{SF\ d\ S}}{\boldsymbol{F^*}\left(\frac{\gamma_s}{\gamma}-\boldsymbol{1}\right)}$$

Equation 7.27-11

$$\boldsymbol{D_{50}} \geq \frac{\boldsymbol{SF\ d\ S\ \Delta}}{\boldsymbol{F^*}\left(\frac{\gamma_s}{\gamma}-\boldsymbol{1}\right)}$$

Equation 7.27-12

where,
SF = Safety factor (from Figure 7.27-4)
d = maximum channel depth, ft (d_a + minimum freeboard of 0.5')
S = channel slope, ft/ft
F* = Shield's parameter (from Figure 7.27-4)
γ_s = specific weight of rock, lb/ft^3
γ = specific weight of water, 62.4 lb/ ft^3
Δ = function of channel geometry and riprap size (see Equation 7.27-13)

If the specific weight, γ, of the available stone is known, it should be used. Otherwise, a typical value of 165 lb/ft^3 may be selected.

$$\Delta = \frac{K_1(1+\sin(\alpha+\beta))\tan\phi}{2\,(\cos\theta\tan\phi - SF\ \sin\theta\cos\beta)}$$

where,

α = angle of the channel bottom slope

β = angle between the weight vector and the weight/drag resultant vector in the plane of the side slope (see Equation 7.27-14)

ϕ = angle of repose for the riprap

θ = angle of the channel side slope

K_1 = .77 ($Z \leq 1.5$)

= 0.066Z + 0.67 ($1.5 < Z < 5$)

= 1.0 ($Z \geq 5$)

Equation 7.27-13

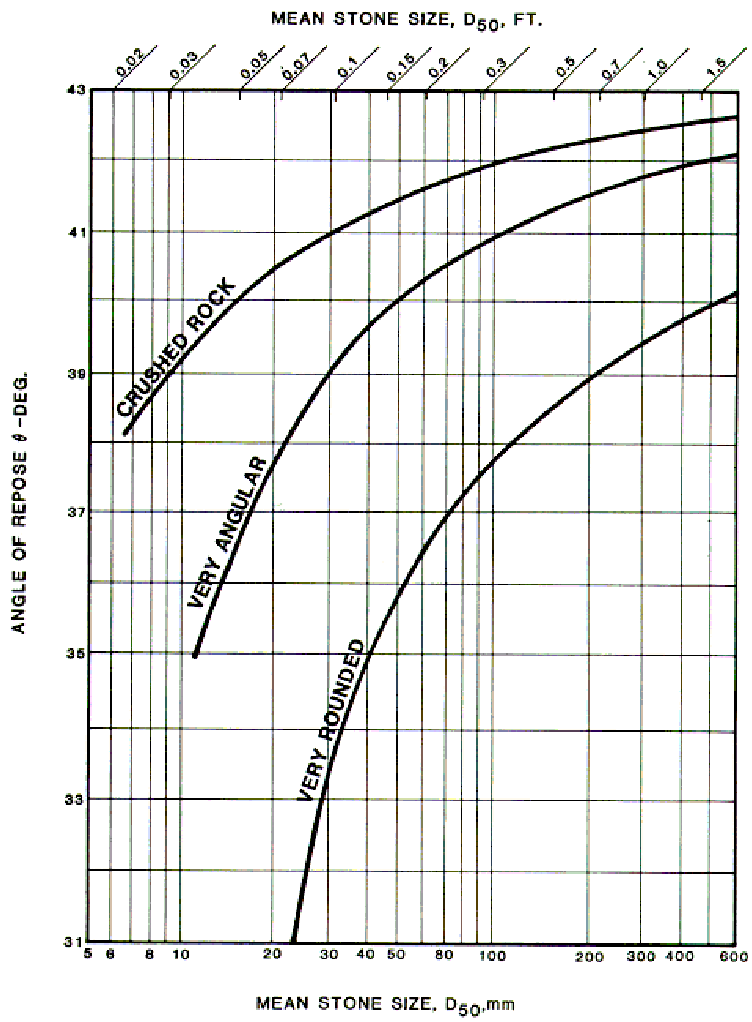


Figure 7.27-5 Angle of Repose of Riprap in Terms of Mean Size and Shape of Stone

$$\beta = \tan^{-1}\left(\frac{\cos\alpha}{\frac{2\sin\theta}{\eta\tan\phi}+\sin\alpha}\right)$$

Equation 7.27-14

where,

η = stability number:

$$\eta = \frac{\tau_s}{F^*(\gamma_s-\gamma)D_{50}}$$

Equation 7.27-15

where,

τ_s = shear stress for d_a

$$\tau_s = \gamma d_a S_o$$

Equation 7.27-16

Step 8 Compare the required D_{50} to the trial size selected in Step 2. If the trial size is smaller than the required size, it is unacceptable for the design. Repeat the procedure from Step 2, selecting a larger trial size. If the trial size is larger than the required D_{50}, then the design is acceptable. However, if the required D_{50} is sufficiently smaller than the trial size, the procedure may be repeated from Step 2 with a smaller, more cost-effective stone size.

Construction Specifications

For grass lined channels, with RECPs or TRMs:
RECPs and TRMs should be selected and designed according to manufacturer's specifications and allowable shear stresses and velocities to withstand actual design flow shear stresses and velocities.

Prepare a stable and firm soil surface free of rocks and other obstructions. Apply soil amendments as necessary to prepare seedbed. Place fertilizer, water, and seed in accordance with manufacturer, local/state regulations, or engineer/specifiers requirements. Typically, RECPs are unrolled parallel to the primary direction of flow. Ensure the product maintains intimate contact with the soil surface over the entirety of the installation. Do not stretch or allow material to bridge over surface inconsistencies. Staple/stake RECPs to soil such that each staple/stake is flush with underlying soil. Install anchor trenches, seams and terminal ends as specified.

Install RECPs after application of seed, fertilizer, mulches (if necessary) and other necessary soil amendments, unless soil in-filling of the TRM is required. For TRMs if soil in-filling, install TRM, apply seed, and other soil amendments lightly brush or rake 0.3 to 0.7 inches of topsoil into TRM matrix to fill the product thickness. If in-filling with a hydraulically-applied matrix or medium is required; install

TRM, then install hydraulically-applied matrix or medium at the manufacturer's suggested application rate.

Construct an anchor trench at the beginning of the channel across its entire width. Excavate a 6 in. by 6 in. anchor trench. Extend the upslope terminal end of the RECPs 3 ft. past the anchor trench. Use stakes or staples to fasten the product into the bottom of the anchor trench on 1 ft. centers. Backfill the trench and compact the soil into the anchor trench. Apply seed and any necessary soil amendments to the compacted soil and cover with remaining 1 ft. terminal end of the RECPs. Fold product over compacted soil in anchor trench to overlap downslope material. Secure terminal end of RECPs with a single row of stakes or staples on 1 ft. centers.

Follow the manufacturer's installation guidelines in constructing additional anchor trenches or stake/staple check slots at intervals along the channel reach and at the terminal end of the channel. Unroll RECPs down the center of the channel in the primary water flow direction. Securely fasten all RECPs to the soil by installing stakes/staples at a minimum rate of 1.7/yd^2. Significantly higher anchor rates and longer stakes/staples may be necessary in sandy, loose, or wet soils and in severe applications.

Seams. For adjacent and consecutive rolls of RECPs, utilize one of the methods detailed below for seaming of RECPs:

1. **Adjacent seams.** Overlap edges of adjacent RECPs by 2 to 4 inches or by abutting products as defined by manufacturer. Use a sufficient number of stakes or staples to prevent seam or abutted rolls from separating.
2. **Consecutive rolls.** Shingle and overlap consecutive rolls 2 to 6 inches in the direction of flow. Secure staples through seam at 1 ft. intervals.
3. **Check seam.** Construct a stake/staple check seam along the top edge of RECPs for slope application and at specified intervals in a channel by installing two staggered rows of stakes/staples 4 inches apart on 4 inch centers.
4. **Slope interruption check slot.** Excavate a trench measuring 6 in. wide by 6 in. deep. Secure product to the bottom of the trench. Fold product over upslope material and fill and compact the trench on the downslope side of check slot and seed fill. Continue rolling material downslope over trench.

Terminal ends. All terminal ends of the RECPs must be anchored using one of the methods below:

1. **Staples**. Install the RECPs 3 ft. beyond the end of the channel and secure end with a single row of stakes/staples on 1 ft. centers. Stakes/staples for securing RECPS to the soil are typically 6 in. long.
2. **Anchor trench**. Excavate a 6 in. by 6 in. anchor trench. Extend the terminal end of the RECPs 3 ft. past the anchor trench. Use stakes or staples to fasten the product into the bottom of the anchor trench on 1 ft. centers. Backfill the trench and compact the soil into the anchor trench. Apply seed and any necessary soil amendments to the compacted soil and cover with remaining 1 ft. terminal end of the RECPs. Secure terminal end of RECPs with a single row of stakes or staples on 1 ft. centers.

3. **Check slot**. Construct a stake/staple check slot along the terminal end of the RECPs by installing two rows of staggered stakes/staples 4 in. apart on 4 in. centers.

With any RECP installation, ensure sufficient staples to resist uplift from hydraulics, wind, mowers, and foot traffic. For the most effective installation of RECPs, the ECTC recommends using stake/staple patterns and densities as recommended by the manufacturer.

For riprap lined channels:

Subgrade preparation – Prepare the subgrade for riprap and filter to the required lines and grades shown on the plans. Remove brush, trees, stumps, and other objectionable material. Cut the subgrade sufficiently deep that the finished grade of the riprap will be at the elevation of the surrounding area. Channels should be excavated sufficiently to allow placement of the riprap in a manner such that the finished inside dimensions and grade of the riprap meet design specifications.
Place filters and beddings to line and grade in the manner specified.

Synthetic filter fabric – Used to separate rock from underlying soil bed. Place the cloth filter directly on the prepared foundation. Overlap the edges by at least 12 inches, and space anchor pins every 3 ft along the overlap. Bury the upstream end of the cloth a minimum of 12 inches below ground and where necessary, bury the lower end of the cloth or overlap with the next section as required. Take care not to damage the cloth when placing riprap. If damage occurs remove the riprap, and repair the sheet by adding another layer of filter material with a minimum overlap of 12 inches around the damaged area. If extensive damage is suspected, remove and replace the entire sheet.

Riprap placement – Riprap should be placed so it is flush with the surrounding ground, to the depth specified in the design plans. See Figure 7.27-6 for the correct installation of riprap lining in channels.

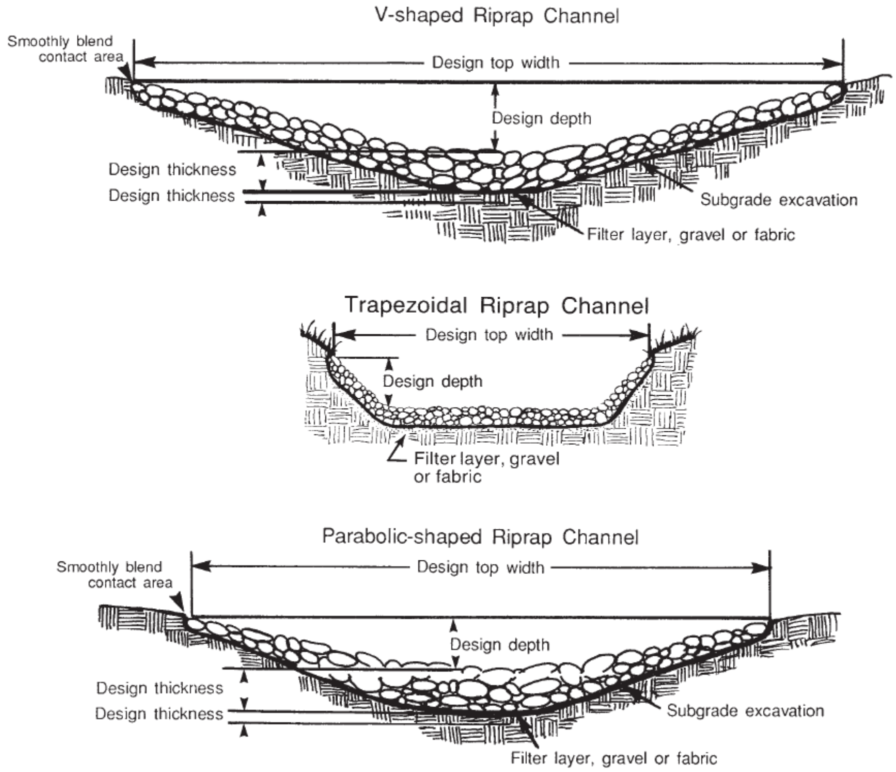


Figure 7.27-6 Construction details for riprap lined channels

Maintenance and Inspection Points

For channels lined with RECPs, repair any damaged areas immediately by restoring soil to finished grade, re-applying soil amendments and seed, and replacing the RECPs.

For riprap lining, repair any areas of erosion or displacement of rock.

Protect stabilized channels from areas of active construction.

Check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes. Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel. If continuous destabilization or erosion occurs, an alternative channel lining may be needed.

References

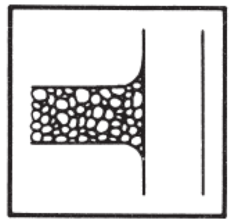
North Carolina Erosion and Sediment Control Planning and Design Manual

Erosion Control Technology Council RECP Specifications

Federal Highways Administration HEC 15, Design of Roadside Channels with Flexible Linings

SEDIMENT CONTROL PRACTICES

7.28 CONSTRUCTION EXIT



GRAVEL CONSTRUCTION EXIT

Definition

A stone pad on geotextile fabric or a rumble strip located at any point where traffic will be moving from a construction site onto a public roadway or other paved area.

Purpose

To reduce or eliminate the transport of material from the construction area onto a public roadway by providing an area where mud and soil can be removed from the tires of construction vehicles.

Conditions Where Practice Applies

This practice is applicable wherever construction traffic leaves a construction site and enters a public right of way.

Planning Considerations

Construction exits should be planned and installed at any point that construction traffic exits the project. These stone pads should not be placed in areas with hydric or saturated soils.

Stormwater management must be considered around the construction exit as well.

Avoid steep grades and exits in or near curves in public roads.

Design Criteria

Calculations are not required; however, a typical construction exit should conform to the specifications listed below.

- A layer of geotextile fabric is required to stabilize and support the aggregate. The geotextile fabric should extend the full length and width of the construction exit. The fabric should meet the requirements of the standard specifications for geotextiles, AASHTO designated M-288, erosion control.
- The stone pad should be constructed from clean, washed stone with a 2 inch to 4 inch gradation at a minimum thickness of 8 inches. At a minimum, the stone pad should be 50 feet long and 20 feet wide. In addition a turning radius of 20 feet should be provided on each side of the pad where it intersects with the public roadway. See Figures 7.28-1 and -2.
- The area where the pad is to be installed must be undercut at least 3 inches, and then the geotextile fabric should be installed before placing the stone.

- Stormwater management around the construction exit must be taken into consideration. If stormwater runoff flows across the stone pad and onto the public right of way, mud on the pad can be washed into the ROW as well. Diversions or waterbars should be installed at the upgradient end of the pad, directing runoff into sediment traps for treatment prior to discharging runoff into the ROW.

Construction Specifications

- Excavate areas where construction exits are to be constructed to a depth of at least 3 inches and clear the area of all vegetation, roots, and other objectionable material.
- Construction exit areas should be at minimum 50 feet in length by 20 feet in width.
- Install a geotextile underliner across the full width and depth of the construction exit to separate the rock from underlying soil.
- Provide clean, washed stone to a depth of 8 inches. Stone should vary in size from 2 to 4 inches. Rock must be clean rock with no fines. Crusher run and road base are not acceptable materials for a construction exit, as the fines can be tracked out onto the road.

Waterbar Diversion:
On sites where the grade toward the public roadway is greater than 2%, a waterbar diversion 6 to 8 inches in depth with 3:1 side slopes should be constructed at the upper end of the construction exit to prevent stormwater from washing sediment off the construction exit and into the public roadway or storm drain system. See Figure 7.28-1. Other devices, such as berms also may be used to divert stormwater from flowing down the construction exit and onto the pubic ROW.

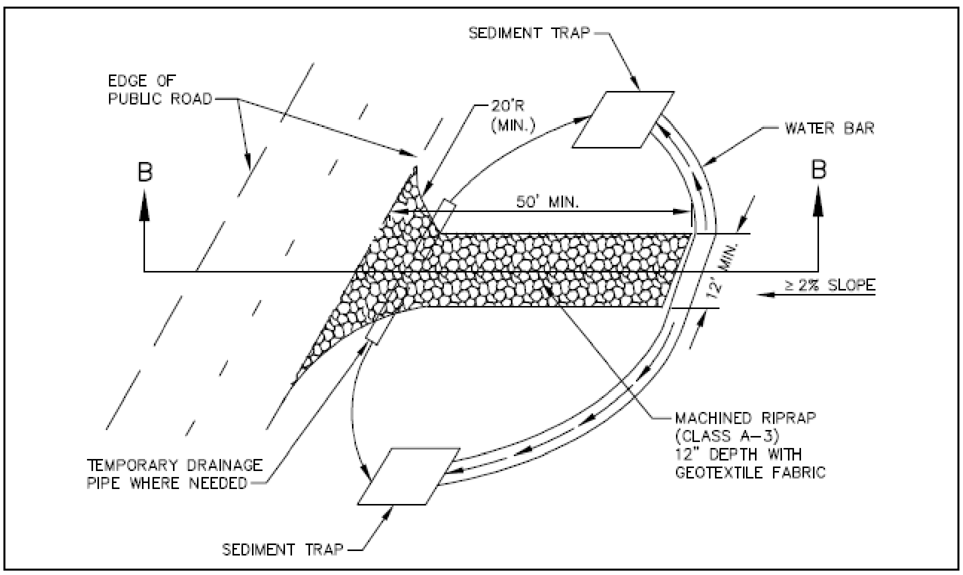


Figure 7.28-1 Construction Exit with Water Bars

Maintenance and Inspection Points

The exit must be maintained in a condition that will prevent tracking or flow of material onto public rights-of-way or into the storm drain system. This may require periodic top dressing with fresh stone or full replacement of stone as conditions demand, and repair and/or cleanout of any related diversions and sediment traps. All materials spilled, dropped, washed, or tracked from vehicles or site onto roadways or into storm drains must be removed by the end of the day.

References

TDOT Design Division Drainage Manual

North Carolina Erosion and Sediment Control Planning and Design Manual

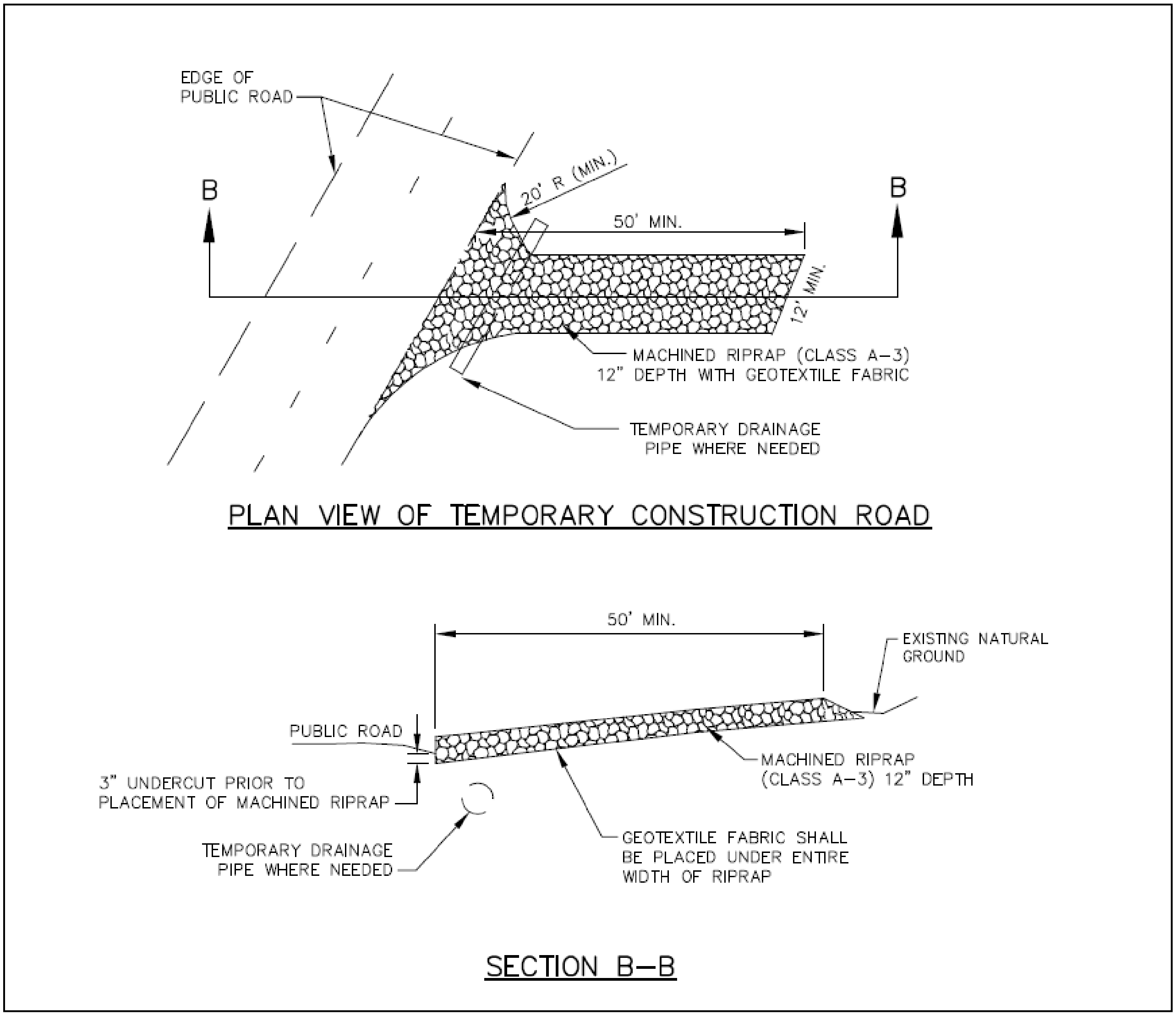
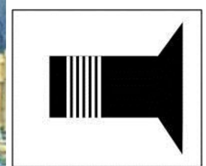


Figure 7.28-2 Construction Exit Detail

SEDIMENT CONTROL PRACTICES

7.29 TIRE WASHING FACILITY



TIRE WASHING FACILITY

Definition A station for washing tires prior to construction traffic exiting the construction site. Used in conjunction with a gravel construction exit to remove sediment from tires and undercarriages.

Purpose To prevent or reduce the discharge of pollutants as a result of vehicular egress from the construction site by providing facilities that remove mud and dirt from vehicle tires and undercarriages with sprayed water prior to entering public roads.

Conditions Where Practice Applies Tire washing facilities are used in addition to gravel construction exits where typical gravel construction exits do not provide sufficient dirt and mud removal from construction equipment. Tire washes are not necessary in all cases but should be considered for sites located in sensitive areas or where track out cannot be controlled with typical gravel construction exits.

Planning Considerations Tire washing requires a supply of water either by overhead tank, pressurized tank or by water pipeline. All wash water should drain into a sediment-trapping device such as a sediment basin or sediment trap before discharging off the construction project.

If chlorinated water (such as ordinary tap water or hydrant water) is used, allow the water to sit for 24 hours, to allow chlorine to dissipate into the air, prior to discharging effluent to a stream. Effluent may be checked by a standard pool test kit to verify that it is chlorine-free.

A turnout or an extra-wide exit may be necessary to avoid entering vehicles from driving through the tire wash rack area (which is only intended for exiting vehicles).

Design Criteria

- Wash racks should be designed and constructed/manufactured for anticipated traffic loads.
- Provide a drainage ditch that will convey the runoff from the wash area to a sediment trapping device. The drainage ditch should be of sufficient grade, width, and depth to carry the wash runoff. Refer to sediment trap and channel design sheets, 7.32 Sediment Traps and 7.27 Channels.

Construction Specifications

- Incorporate with a stabilized construction entrance/exit.
- Construct on level ground when possible, on a pad of coarse aggregate greater than 3 in. but smaller than 6 in. A geotextile fabric should be placed below the aggregate.
- Use hoses with automatic shutoff nozzles to prevent hoses from being left on.
- Require that all employees, subcontractors, and others that leave the site with mud caked tires and undercarriages to use the wash facility.
- Post signage at tire washing facilities or designate personnel to oversee traffic exiting the construction site at tire washing facility locations.

Maintenance and Inspection Points

Remove accumulated sediment in tire wash rack and sediment traps as necessary to maintain system performance. Inspect routinely for damage and repair as needed.

References

California Stormwater Best Management Practices Handbook

City of Knoxville Best Management Practices Manual

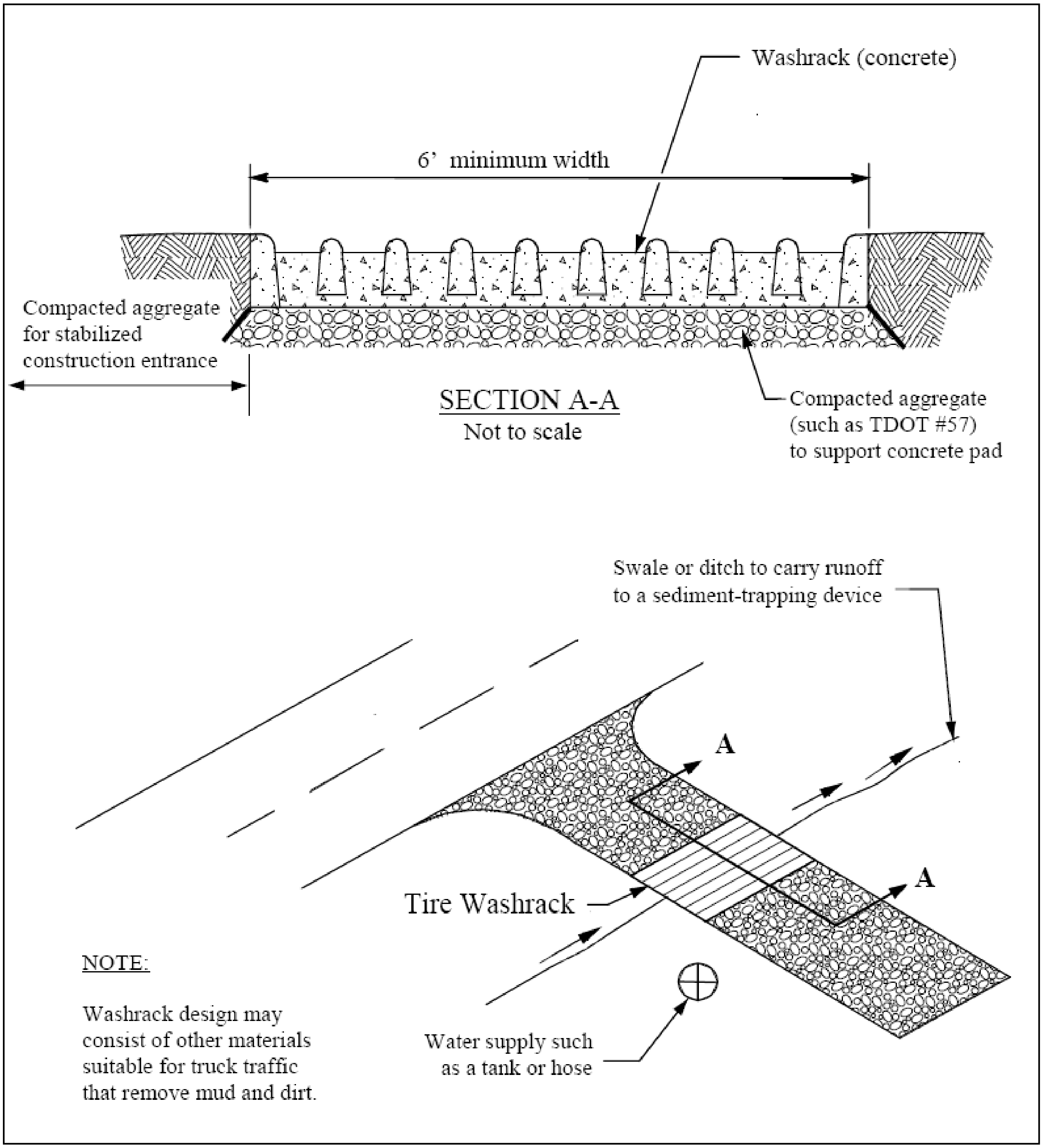


Figure 7.29-1 Tire Wash Rack (Source: City of Knoxville)

SEDIMENT CONTROL PRACTICES

7.30 FILTER RING

Definition A temporary sediment control constructed of riprap and installed at storm drain and culvert inlets.

Purpose To reduce flow velocities and prevent the failure of other sediment control devices. It also prevents sediment from entering, accumulating in, and being transferred by a culvert or storm drainage system prior to stabilization of the disturbed area. This practice allows early use of the storm drainage system.

Conditions Where Practice Applies This practice should be used in combination with other sediment control measures. They can be installed at or around devices such as storm drain inlets or slope drain inlets.

Planning Considerations When construction on a project reaches a stage where culverts and other storm drainage structures are installed and many areas are brought to the desired grade, there is a need to protect the points where runoff can leave the site through culverts or storm drains. Similar to drop and curb inlets, culverts receiving runoff from disturbed areas can convey large amounts of sediment to lakes or streams. Even if the pipe discharges into a sediment trap or basin, the pipe or pipe system itself may clog with sediment. Although filter rings may slow runoff entering into a storm drain inlet or culvert, they should not divert water away from the storm drain.

Design Criteria

Location:

The filter ring should surround all sides of the structure receiving runoff from disturbed areas. See Figure 7.30-1 for a typical filter ring. It should be placed a minimum of 4 feet from the structure. The ring should be constructed so that it does not cause flooding or damage to adjacent areas.

Stone Size:

When utilized at inlets/outlets with diameters less than 12 inches, the filter ring should be constructed of small riprap such as TDOT Class A-3 (clean from fines) with stone sizes from 2 to 6 inches.

When utilized at inlets with diameters greater than 12 inches, the filter ring should be constructed of a small riprap such as TDOT Class A-1 (clean from fines) with stone sizes from 2 to 15 inches.

For added sediment filtering capabilities, the upstream side of the riprap can be faced with smaller coarse aggregate, such as TDOT #57 (clean of fines) with a minimum stone size of ¾ inch.

Geotextiles:

A geotextile should be used as a separator between the graded stone and soil base and abutments. The geotextile will prevent the migration of soil particles from the subgrade into the graded stone. Geotextiles should be set into the subgrade soils. The geotextile should be placed immediately adjacent to the subgrade without any voids and extend to beneath the inlet to prevent scour within the filter ring.

Height:

The filter ring should be constructed at a height of two feet with slopes no steeper than 2:1.

Construction Specifications

- Clear the area of all debris that might hinder excavation and disposal of soil.
- Install the Class A riprap in a semi-circle or ring around the inlet or outlet. The stone should be built up higher on each end where it ties into the embankment. The minimum crest width of the riprap should be 1.5 feet, with a minimum bottom width of 11 feet. The minimum height should be 2 feet.
- A 1 foot thick layer of No. 57 stone should be placed on the outside slope of the riprap.
- The sediment storage area should be excavated around the outside of the filter ring 12 inches below natural grade.
- When the contributing drainage area is stabilized, fill the depression and establish final grade elevations, compact the area properly, and stabilize with groundcover.

Maintenance and Inspection Points

The filter ring must be kept clear of trash and debris. Sediment should be removed when the level reaches one half the height of the filter ring. These structures are temporary and should be removed when the land disturbing project has been stabilized.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

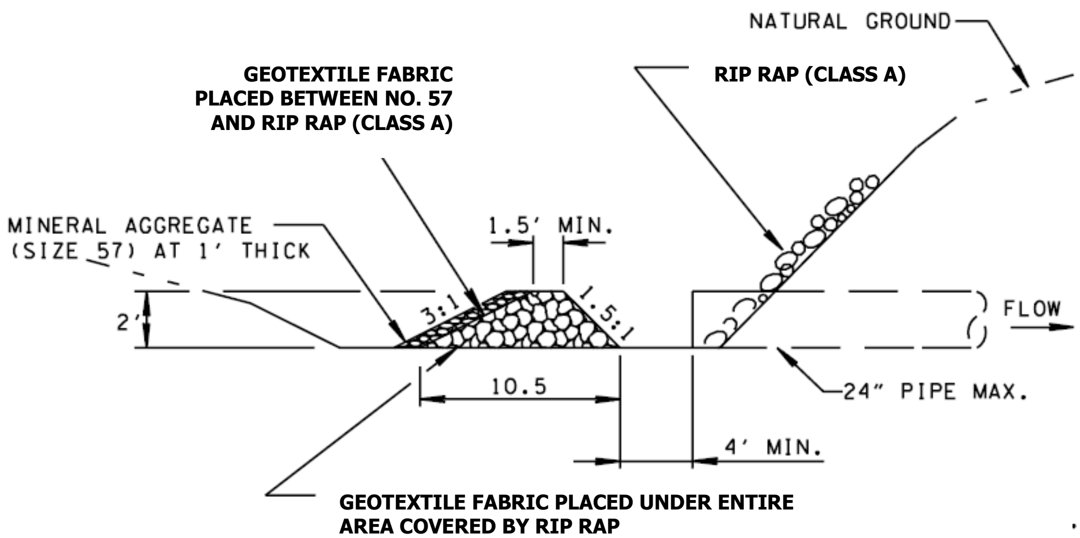


Figure 7.30-1 Filter Ring Detail (Source: TDOT Standard Drawing)

SEDIMENT CONTROL PRACTICES

7.31 SEDIMENT BASIN

Definition A temporary basin created by an embankment constructed across a drainage way, or by an excavation that creates a basin, or by a combination of both, suitably located to capture sediment. A sediment basin consists of an embankment (dam), a sediment storage area, a sediment forebay, a dewatering mechanism, a principal (or primary) spillway and emergency spillway system, a permanent pool, and scour protection at the outlet of the principal spillway pipe.

Purpose To capture and retain sediment on the construction site, and to prevent sedimentation in off-site streams, lakes, and drainageways. Given the likelihood that the storm water peak flow from the active construction site will exceed the pre-construction peak flow, a sediment basin can also function as a peak flow attenuation measure during construction to protect the downstream channel from damage due to erosion and sedimentation. Temporary sediment basins may be used to limit post-construction discharges to pre-construction conditions for one or more storm frequency events, as required by local regulations.

Conditions Where Practice Applies Sediment basins, or equivalent measures, are required where:

- The total drainage area at an outfall from a construction site is ten (10) acres or greater for sites draining into unimpaired streams and waters
- The total drainage area at an outfall from a construction site that discharges into Impaired or Exceptional TN Waters, as defined by TDEC, where the total drainage area is five (5) acres or more.
- Sediment basins should also be installed at outfall points that do not meet the criteria above, but where treatment of sediment-laden runoff is necessary.

Sediment basins are **not** to be located in streams.

Planning Considerations

Sediment basins should be carefully located to capture sediment from all areas not treated adequately by other sediment controls. Basins are one part of an overall sediment control treatment train. The choice of construction materials for the sediment basin shall be based upon the basin's design life, which is typically 18 to 30 months.

Access for cleanout and disposal must be considered when choosing the location of a basin. Locations where a small pond can be formed by construction of a low dam across a natural swale are generally preferred to areas that require excavation.

Sediment basins may be located in areas where permanent detention or retention ponds are located; however they must be properly cleaned before converting the basin into a permanent pond. If a sediment basin is located in the same location as a permanent detention pond, then the permanent outlet structure should not be installed until all sediment is cleaned from the sediment basin, the proper grades are established in the detention area, and the basin is fully stabilized.

The size and performance of any sediment basin depends on several factors: (1) shape of the basin, (2) soil properties, (3) runoff volume and peak flow, (4) water chemistry, (5) permanent vs. dry basin design, (6) dewatering the "dry" or temporary storage following a storm, (7) effective erosion prevention practices, (8) effective inspection and maintenance, including pond cleaning, (9) quality of construction practices, and (10) whether the basin side slopes are stabilized. Basins should not be regarded as a single solution to erosion prevention and sediment control on a construction site. Instead, basins should always be used in conjunction with primary controls and stabilizing practices (as found throughout this manual) such as temporary vegetation, mulching, diversion dikes, etc. designed to prevent or reduce the possibility of soil from being eroded in the first place.

Sediment basins should be installed before any land-disturbance takes place within the drainage area. Where practical, sediment-free runoff should be diverted away from the basin.

Sediment basins must be designed by either a professional engineer or a landscape architect, trained in the design of impoundment structures, and in accordance with good engineering practices. Sediment basins must be designed and constructed in accordance with all applicable state and local laws, ordinances, permit requirements, rules, and regulations. Tennessee dam safety regulations apply if the dam height and/or pond volume meet or exceed specified limits provided below.

Embankments must comply with the Tennessee Safe Dams Act of 1973, as amended, if **either** of the following two conditions exist:

a. the embankment is twenty feet or more in height, or
b. the impoundment will have a capacity, at maximum water storage elevation, of thirty (30) acre-feet (48,400 CY) or more.

Any such dam which is equal to or less than six feet in height, regardless of storage capacity, or which has a maximum storage capacity not in excess of fifteen (15) acre-feet (24,200 cy/yds), regardless of height, would not be regulated under the Safe Dams Act. If basins and dams meet or exceed the criteria mentioned above, permit certificates of construction and operation are required by the Tennessee Dam Safety Office in the Division of Water Supply of the Tennessee Department of Environment and Conservation. Further information on safe dam design standards, regulations, and permit applications are available at the website:

http://www.state.tn.us/environment/permits/safedam.htm.

Three sediment basin modifications can be included in the sediment basin design to increase the settling efficiency for basins:

Surface skimmers. Surface skimmers should be utilized as the dewatering device whenever practical. A skimmer dewaters from the water surface rather than from below the surface.

Baffles. Both porous and non-porous baffles are often used to prevent decrease turbulent flow in a basin settling zone such as the forebay, thereby increasing the settling rate for sediment.

Chemical flocculents. Flocculents such as polyacrylamides (PAM) can be used to enhance the settling efficiency of fine particles such as colloidal clays. This type of treatment should be introduced as part of the sediment treatment train, *upstream* from sediment basins, if conventional settling basin treatment is not, or is unlikely not, effective. In any case, contingency plans for using flocculents, such as PAM, should be built into SWPPPs in case conventional treatment fails and TDEC deems its use necessary.

Design Criteria

Note that the following design procedure is founded on the premise that the engineer or landscape architect has a fundamental understanding of hydrology and hydraulics, as well as an understanding of the necessity of all standard components of the sediment basin. Therefore, all sediment basins shall have a permanent pool. The purpose of having a permanent pool of water is to allow sediment particles to settle out and remain in the pond while skimming off or dewatering the upper layer of relatively clear water near the pond surface. Under no circumstances should an opening be placed at the bottom of a sediment pond. A bottom opening in a principal spillway riser pipe would eliminate a permanent pool by forcing the pond to empty after each storm, along with most of the fine sediment particles concentrated near the bottom of the pond. A riser with a bottom opening, surrounded by porous rock, silt fence fabric, or straw bales, is not effective practice for removing fine sediment particles.

STEP 1: DETERMINE THE BEST LOCATION

Runoff from off-site undisturbed areas should be diverted away from or around the disturbed areas and the basin. To improve the effectiveness of the basin, it should be located so as to intercept the largest possible amount of runoff from the disturbed area, while undisturbed areas are routed around the treatment area. The best locations are generally low areas and natural swales or drainageways below disturbed areas. It is recommended that the basin be located at least 50 feet outside the designated floodway or 60 feet from the top of bank of small streams, or as otherwise required by local ordinance, whichever is greater. Basin efficiency can be improved by the use of baffles and by introducing chemical flocculants.

The basin should not be located where its failure would result in the loss of life or interruption of the use or service to public utilities or roads.

Maximum Drainage Area: The maximum allowable total drainage area (disturbed and undisturbed) feeding into a temporary sediment basin is 50 acres. The 50 acre maximum drainage area limitation is derived from the CGP; additional engineering controls and/or treatment may be necessary for management of stormwater runoff originating from drainage areas exceeding 50 acres, covered under individual NPDES permit(s). However, basins cannot be installed in streams. It is recommended that when the drainage area to any one temporary basin exceeds 25 acres, an alternative design procedure that more accurately defines the specific hydrology, sediment loading, hydraulics of the site, and the control measures in use be utilized to perform design calculations. The design criteria in this manual do not generate hydrographs, estimate sediment erosion and delivery rates, provide hydraulic routing, or predict sediment capture efficiency. More rigorous and accurate design considerations, which are more site-specific than those in this manual, are acceptable and encouraged with any size basin.

Access to maintain the basin must be provided during basin construction and operation. Maintenance access road(s) shall be provided to the sediment basin facility for inspection and for access by maintenance and emergency vehicles. An access road around the basin is recommended for convenient removal of sediment from the basin or basin cells with appropriate equipment. An access ramp into the basin itself is discouraged because of the potential for creating equipment-generated rutting and stabilization problems.

STEP 2. SET THE BASIN GEOMETRY

Basin Shape: It is important that the designer of a sediment basin incorporate features to maximize detention time within the basin in order to improve its trapping efficiency. The primary means for accomplishing this will be specifying a length to width ratio of at least 4L: 1W. Other suggested methods of accomplishing this objective are:

- A wedge shape with the inlet located at the narrow end - ideally, the shape would be symmetrical about the pond's central axis formed by the inlet – riser – center of the dam.
- Installation of baffles or diversions in situations where a 4L: 1W ratio is otherwise not practical (See Figure 7.31-1 for more information).

4L:1W Ratio

The purpose of having a length to width ratio of at least 4L:1W is to minimize the "short-circuiting" effect of the sediment-laden inflow to the riser and increasing the flow length through the treatment zone. Having a symmetrical basin about the central axis from the inlet to the riser tends to reduce dead or ineffective space.

The length of the flow path (L) is the distance from the point of inflow to the riser outflow point. The point of inflow is the point that the stormwater runoff enters the active (sometimes called "normal") pool, created by the elevation of the riser crest. The pool area (A) is the area of the active pool. The effective width (We) is equal to the area (A) divided by the length (L). The length to width ratio (L:W) is determined from the equation:

$$L:W = L/W_e = L/(A/L) = L^2/A$$

The designer is encouraged to locate all inflows at or near the point of the wedge. However, where there is more than one inflow point and where circumstances preclude this ideal arrangement, any inflow point which conveys more than 30 percent of the total peak inflow rate shall meet the above length-width ratio criteria. If the 4:1 ratio pond cannot be attained on the site, an equivalent 4:1 flow path must be provided through the use of non-porous baffles. Specifications for the stabilization of the basin side slopes and possibly reinforcement through the use of erosion control matting must be included in the design. Otherwise, the inflow point could potentially become the point of greatest concentrated erosion within the basin’s watershed.

Non-porous Baffles

The required basin shape should be obtained by proper site selection and by excavation to reduce dead storage and to maximize sediment removal efficiency. Where less than ideal conditions exist, a non-porous baffle may be constructed in the basin. The purpose of the non-porous baffle is to increase the effective flow length from the inflow point(s) to the riser. Non-porous baffles shall be placed mid-way between the inflow point and the riser. The non-porous baffle length shall be as required to achieve the minimum 4L:1W length-width ratio at less than ideal site conditions. The effective length (L_e) shall be the shortest distance the water must flow from the inflow point around the end of the non-porous baffle to the outflow point.

Then:

$$L:W = L_e/W_e = L_e^2/A$$

Three baffle situations where non-porous baffles should be used are shown in Figure 7.31-1. Note that for cases A and B:

$$L_e = L_1 + L_2$$

Where L_1 and L_2 are the shortest travel path segments around the non-porous baffles. For case C, $L_e = 2(L_1 + L_2)$

Non-porous baffle material shall be outdoor grade and weather resistant. Non-porous baffles should be placed in such a manner as to minimize interference with basin cleaning. Construction should be modular for easy maintenance and convenient replacement in the event of damage from cleaning or from deterioration. Non-porous baffles should be inspected frequently for tears or breaks from weathering, high flows, and from cleaning damage. Damaged materials shall be replaced or repaired immediately.

The dimensions necessary to obtain the required basin volume and surface area shall be clearly shown on the plans to facilitate plan review and inspection.

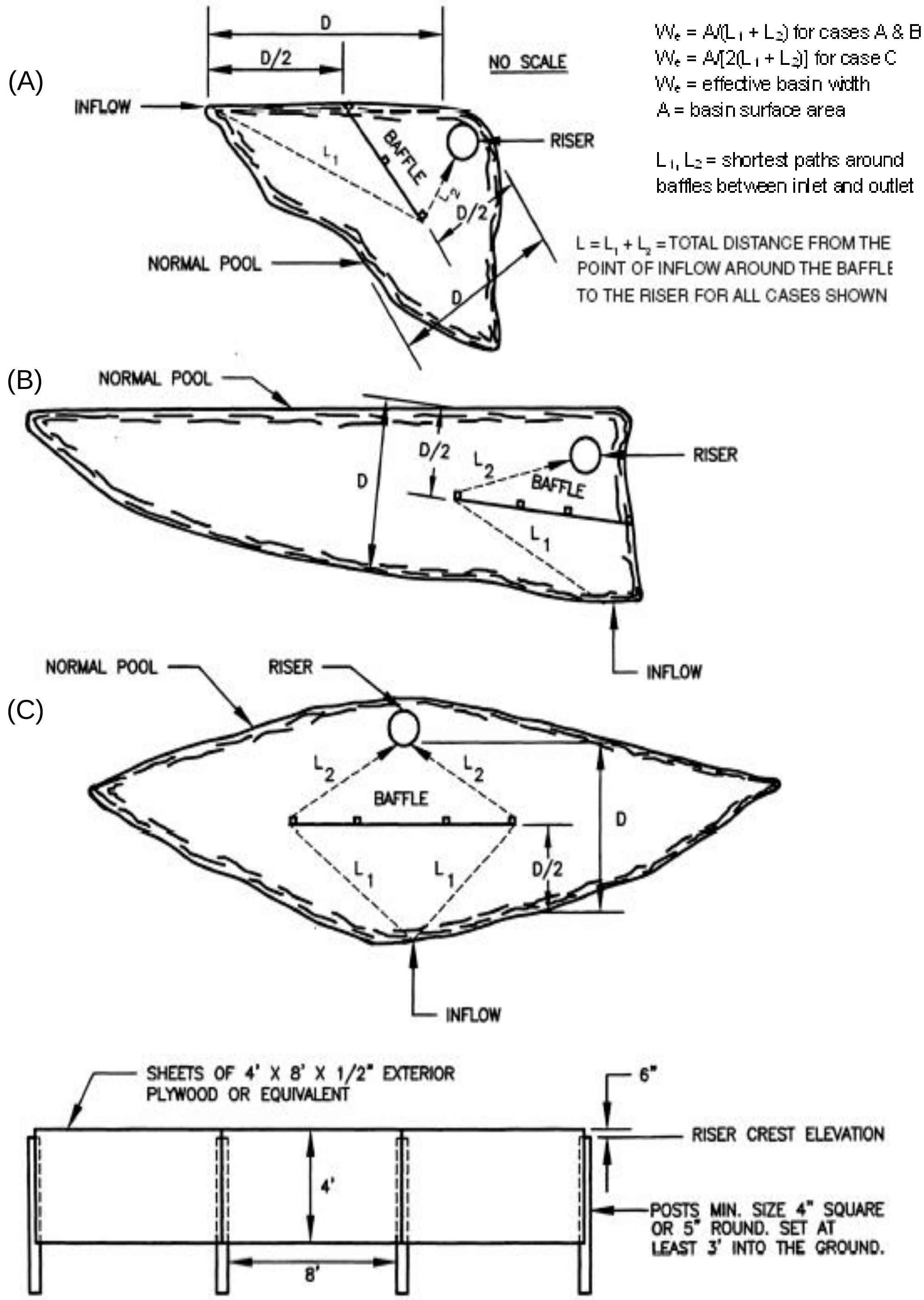


Figure 7.31-1 Non-porous Baffle Locations in Sediment Basins – To Increase Flow Length (*Source: NRCS*)

Volume: The sediment basin treatment area is designed based upon two major components, wet and dry storage:

> Total volume = 134 yd^3/acre (3618 ft^3/acre) of drainage. This total volume is allocated into two major storage components. Half of this volume (67 yd^3/acre or 1809 ft^3/acre) must be provided as *wet* storage, which establishes the permanent pool and the sediment capture zone. The volume below permanent pool shall be measured from the lowest point of the basin up to the bottom elevation of the dewatering device. The other half, or *dry* storage, also should have a minimum volume of 67 yd^3/acre (1809 ft^3/acre), including both the sediment removal zone and the forebay volume (described below). The top of the dry storage defines the principal spillway riser crest and establishes a minimum volume for treatment in the sediment basin. The dry storage volume is to be dewatered down to the permanent pool in 72 hours.

The above total volume requirements, representing one inch of erosion and sediment yield over one acre, are regarded as **minimum** criteria. Where construction sites have steep slopes and/or soils capable of producing greater sediment yields, design professionals should consider using an alternative physically-based approach, such as RUSLE , to size the total storage volume and to protect critical aquatic resources and safety/health of the public. It is noted that disturbed and unprotected areas can contribute large amounts of runoff containing a significant amount of fine-grained sediment particles that are difficult to remove and can reduce the overall performance of a sediment basin. The following conditions and circumstances need to be considered in determining whether or not the basin volume would need to be increased:

- Highly erodible soils
- Steep upslope topography
- Space-limiting basin geometry (depth and/or shape)
- Degree to which off- and/or on-site runoff is diverted from contributing undisturbed areas
- Sediment cleanout schedule
- Degree to which chemical flocculent agents are added to inflowing runoff
- Extent to which other erosion and sediment control practices are used
- Critical downstream conditions

Surface area: Pond surface area is very important to overall sediment basin efficiency. Research shows that sediment trapping efficiency depends primarily on the sediment particle size and the ratio of basin surface area to inflow rate. Basins with a large surface area to volume ratio are most effective in trapping sediment. Generally, the smaller the sediment particle size, the slower the settling velocity, and the larger the required basin surface area. Additionally, the larger the storm water flow into the basin, the larger the required basin surface area. The minimum required surface area, measured at the top of the dry storage pool zone, establishes the crest of the principal spillway, and is calculated by the following empirical formula (Barfield and Clar, 1986):

$$A_s = 0.01Q_p$$

Where

A_s = Surface area (acres)

Q_p = Peak inflow (cfs) for the design storm (2- or 5-year, 24-hour as appropriate)

The method above provides about 75% trapping efficiency for silt loams and higher efficiencies for coarser particles. Additional treatment may be necessary to trap small silt and clay particles.

The permanent pool protects against re-suspension of sediment, promotes better settling conditions between runoff events, and provides a zone for sediment storage. Therefore an opening at the bottom of the riser is not acceptable because it allows the pond to completely drain between storms and prevents the establishment of a permanent pool and sediment capture zone. A minimum depth of 3 feet shall be designed for the permanent pool.

The dry storage is to be dewatered over a period of 72 hours as discussed in the section on Dewatering. The forebay compartment of the dry storage area must have at least 2 porous baffles to promote more effective settling (see Section 7.33 Baffles).

Elevations: The lower elevation limit of the dewatering device should be installed to dewater the dry storage in 72 hours. The volume of the active or drawdown zone shall be measured from the crest elevation of the principal (service) spillway riser pipe down to the permanent pool level.

Forebay: A forebay is required at the primary inlet of the sediment basin to intercept the initial flow and provide an opportunity for larger sand and silt particles to settle out before entering the primary basin. The forebay volume shall be at least 25% of the dry sediment storage volume; this 25% forebay volume can be credited toward the primary basin's required dry storage volume. The bottom elevation of the forebay should equal the top of the permanent pool elevation of the primary basin, and the forebay should be separated from the primary basin with a porous barrier such as a rock berm to promote larger particle settling and spread the incoming flow out to help prevent short-circuiting of the primary basin. The berm overflow crest shall be set no higher than the top of the principal spillway riser crest. To minimize resuspension of trapped sediment and scour in the forebay during high flows, the energy of the influent flow must be controlled as it enters and flows through the forebay. This can be in the form of a plunge pool, rip-rap, or other energy-dissipating control measures. The rock berm shall be designed to pass the 2 or 5-year, 24-hour storm peak flow, as appropriate, without eroding the berm abutments.

The forebay must be readily accessible for maintenance as it will fill up with sediment more quickly than the primary basin. Porous baffles are recommended within the forebay as well to enhance the sediment capture efficiency. Refer to Figures 7.31-2A, -2B and 7.31-3 below for more information. More details can be found in the standard drawing.

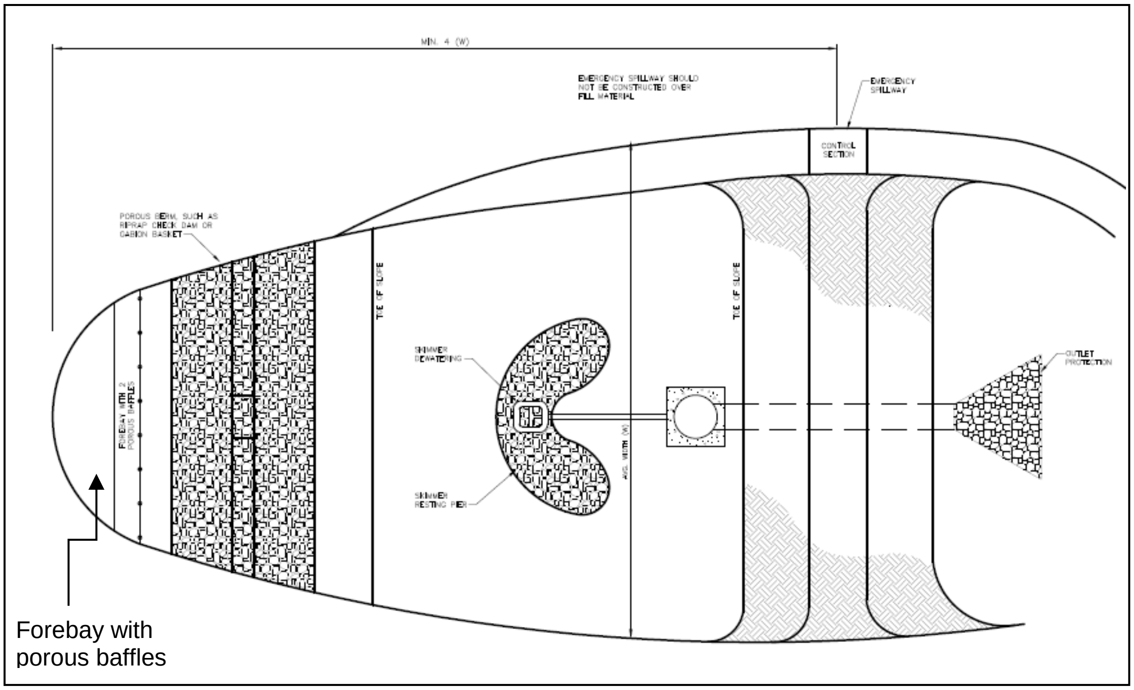
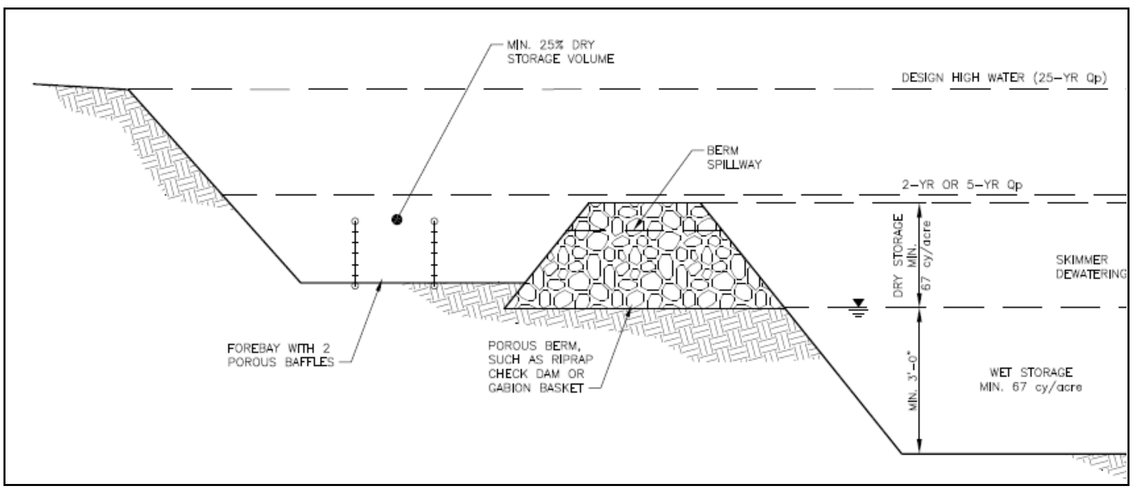


Figure 7.31-2A Sediment Basin with Forebay, Plan View



re 7.31-2B Cross Sectional View of Forebay, Showing Elevations

Figure 7.31-2C Forebay with Porous Berm (Gabion Rock)

STEP 3: DESIGN THE PRINCIPAL SPILLWAY AND DEWATERING DEVICE.

Design the principal spillway for the 2-yr, 24-hr (or 5-yr, 24hr) storm. Incoming flow and storage calculations must begin at the elevation of the permanent pool. Flow through the dewatering device cannot be credited when calculating the 25yr. 24 hr storm outflow from the basin.

The outlets for the basin should consist of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 25-year, 24- hour storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 25-year 24-hour storm. However, an attempt to provide a separate emergency spillway should always be made (refer to "Emergency Spillway" later on in this section) because the principal spillway riser is vulnerable to clogging by debris during high runoff events. Runoff computations shall be based upon the soil cover conditions that are expected to prevail during the life of the basin. In determining total outflow capacity, the flow through the dewatering device cannot be credited when calculating the 25- year 24-hour storm elevation because of its potential to become clogged. However, the capacity of the principal spillway (i.e. the flow expected through the top of the riser) can be credited to the emergency spillway when determining the peak flow and maximum pond elevation resulting from the 25-year, 24-hour storm. In other words, routing calculations can assume both the principal spillway and emergency spillway are actively flowing for determining the maximum depth of the 25-year, 24-hour storm. Incoming flood flow and storage calculations must begin at the elevation of the permanent pool.

Note that temporary sediment basin storage and outflow controls are not normally designed to reduce incoming peak flows. Consequently, the spillways designed by the procedures contained in the standard and specification will not necessarily result in any major reduction in the peak rate of runoff. If a reduction in peak runoff is desired or required by local regulations during the construction period, the appropriate hydrographs/storm routings should be generated to adjust the basin and outlet sizes.

Principal Spillway: The principal spillway typically consists of a vertical riser pipe or box of corrugated metal or reinforced concrete. The riser should have a minimum diameter of 18 inches, and be joined by a watertight connection to a horizontal drain pipe (barrel) extending through the embankment and discharging beyond the downstream toe of the fill. The riser and all pipe connections shall be mechanically sound and completely water tight except for the inlet opening at the top or dewatering openings, and shall not have any other holes, leaks, rips, or perforations. If the principal spillway is used in conjunction with a separate emergency spillway, the principal spillway must be designed to pass at least the peak flow expected from of 2-year (5-year), 24-hour storm. If no emergency spillway is used, a combined principal/emergency spillway must be designed to pass the entire peak flow expected from a 25-year 24-hour storm. See Figure 7.31-3 for details.

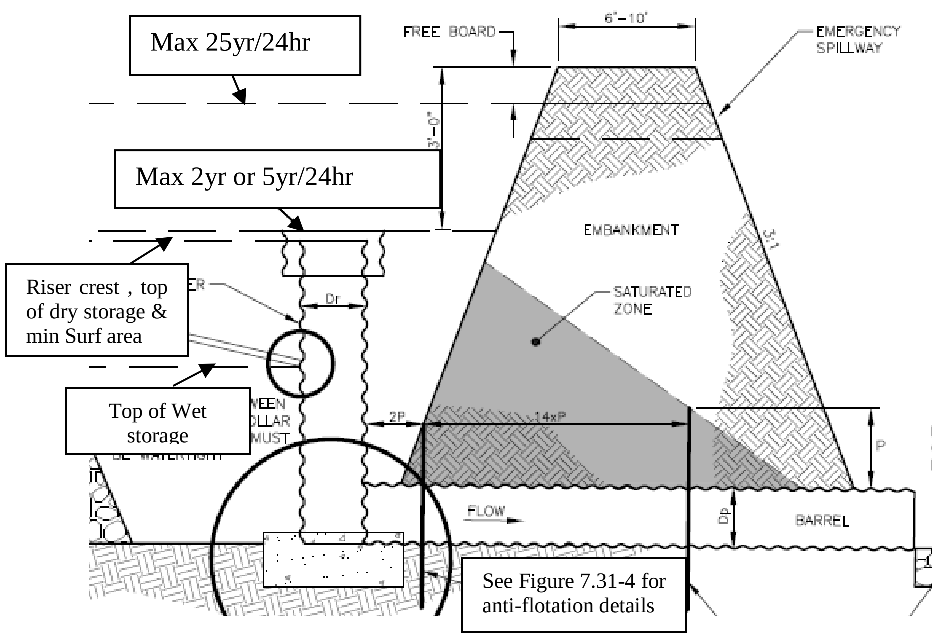


Figure 7.31-3 Elevations within the Basin

Spillway Foundation:
The foundation base of the principal spillway must be firmly anchored to prevent floating due to buoyancy. Computations must be made to determine the anchoring requirements to prevent flotation. A minimum factor of safety of 1.25 shall be used (downward forces = 1.25 x upward forces). For risers 10 feet or less in height, the anchoring may be done in one of the two following ways:

1. A concrete base 18 inches thick and twice the width of riser diameter shall be used and the riser embedded at least 6 inches into the concrete.

See Figure 7.31-4 for details.

2. A square steel plate, a minimum of 1/4-inch thick and having a width equal to twice the diameter of the riser shall be welded to the riser pipe. It shall be covered with 2.5 feet of stone, gravel, or compacted soil to prevent flotation. See Figure 7.31-4 for details. If compacted soil is selected, compaction of 95% of maximum proctor density is required over the plate. Also, added precautions should be taken to ensure that material over the plate is not removed accidentally during removal of sediment from basin. One method would be to use simple marker posts at the four corners.

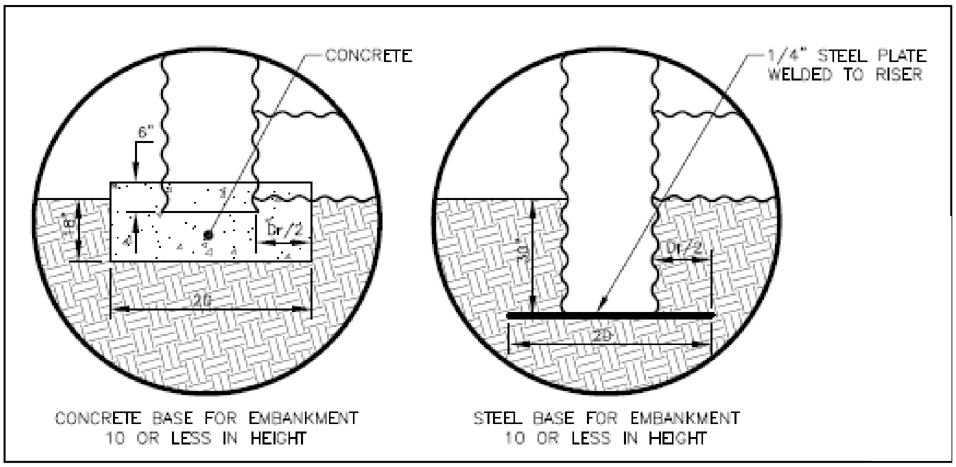


Figure 7.31-4 Anti-Flotation Device

Design Elevations:

The crest of the principal spillway riser shall be set either at the required surface area elevation or at the elevation corresponding to the total wet and dry storage volume required, whichever is greater (See the Basin Geometry for details).

If the principal spillway is used in conjunction with an emergency spillway, the riser elevation shall be a minimum of 1.0 foot below the crest of the emergency spillway. In addition, a minimum freeboard of 1.0 foot shall be provided between the maximum 25-year pool level and the top of the embankment. If no separate emergency spillway is used, the crest of the combined principal/emergency spillway shall be a minimum of 3 feet below the top of the embankment with a minimum freeboard of 2.0 feet between the 25-year pool level and the top of the embankment. Refer to Figures 7.31-3 and 7.31-12 for freeboard details.

Anti-Vortex Device and Trash Rack:

An anti-vortex device and trash rack shall be attached to the top of the principal spillway to improve the flow characteristics of water into the spillway and to reduce the possibility of floating debris from blocking the principal spillway. The anti-vortex device shall be of the concentric type similar to that shown in Figure 7.31-5 and 7.31-6, and designed using the information provided in Table 7.31-1.

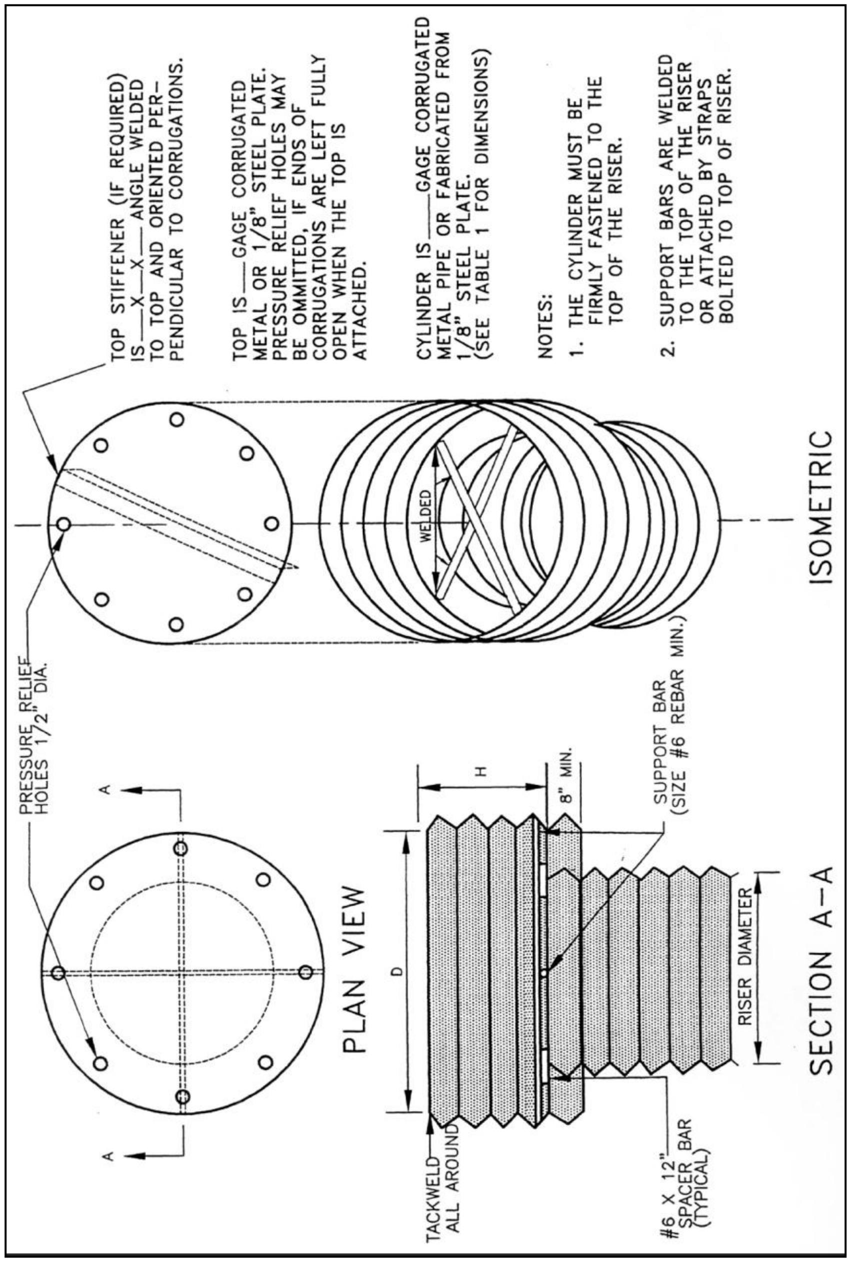


Figure 7.31-5 Anti-Vortex Device Design (*Source: US-NRCS*)

Riser Diam., inches	Cylinder			Minimum Size Support Bar	Minimum Top	
	Diameter, inches	Thickness, gage	Height, inches		Thickness	Stiffener
12	18	16	6	#6 Rebar or 1 1/2" x 1 1/2" x 3/16" angle	16 ga. (F&C)	-
15	21	16	7	" "	" "	-
18	27	16	8	" "	" "	-
21	30	16	11	" "	16 ga.(C), 14 ga.(F)	-
24	36	16	13	" "	" "	-
27	42	16	15	" "	" "	-
36	54	14	17	#8 Rebar	14 ga.(C), 12 ga.(F)	-
42	60	14	19	" "	" "	-
48	72	14	21	1 1/4" pipe or 1 1/4" x 1 1/4" x 1/4" angle	14 ga.(C), 10 ga.(F)	-
54	78	14	25	" "	" "	-
60	90	14	29	1 1/2" pipe or 1 1/2" x 1 1/2" x 1/4" angle	12 ga.(C), 8 ga.(F)	-
66	96	14	33	2" pipe or 2" x 2" x 3/16" angle	12 ga.(C), 8 ga.(F) w/stiffener	2" x 2 1/4" angle
72	102	14	36	" "	" "	2 1/2" x 2 1/2" x 1/4" angle
78	114	14	39	2 1/2" pipe or 2" x 2" x 1/4" angle	" "	" "
84	120	12	42	2 1/2" pipe or 2 1/2" x 2 1/2" x 1/4" angle	" "	2 1/2" x 2 1/2" x 5/16" angle

Note: The table above is useful only for corrugated metal pipe. Concrete trash rack and anti-vortex devices are also available. Manufacturer's recommendations should be followed for concrete applications.

Note: Corrugation for 12"-36" pipe measures 2 2/3" x ½"; for 42"-84" the corrugation measures 5" x 1" or 8" x 1".

Note: C = corrugated; F = flat.

Figure 7.31-6 Dewatering device on Riser with Trash Rack

Outlet Barrel: The drainpipe barrel of the principal spillway, which extends through the embankment, shall be designed to carry the flow provided by the riser of the principal spillway with the water level at the crest of the emergency spillway. The minimum size of the pipe shall be 12 inches in diameter to minimize clogging. The riser and all pipe connections shall be mechanically sound and completely watertight and not have any other holes, leaks, gashes, or perforations other than designed openings. Do not use dimple (mechanical) connectors for CM pipe under any circumstances. The connection between the riser and the barrel must be watertight to prevent local scouring. The use of plastic pipe through the dam should be done with caution because of potential deflection, creep and separation from surrounding embankment soil. The outlet of the barrel must be protected to prevent erosion or scour of downstream areas. Measures may include excavated plunge pools, riprap, impact basins, revetments, or other effective methods. Refer to Section 7.23 Outlet Protection. Where discharge occurs at or near the property line, drainage easements should be obtained in accordance with local ordinances. Caution should be given in directing all outlet water from the impoundment to a receiving watercourse so that natural flow paths are preserved above off-site property owners.

Anti-Seep Collars: Anti-seep collars are used to reduce uncontrolled seepage and prevent internal erosion or "piping" inside the dam along the drainpipe barrel. Anti-seep collars shall be used on the drainpipe barrel of the principal spillway within the normal saturation zone of the embankment to increase the seepage length by at least 10%, if either of the following two conditions is met:

1. The settled height of the embankment exceeds 10 feet.

2. The embankment has a low silt-clay content (Unified Soil Classes SM or GM) and the barrel is greater than 10 inches in diameter.

The anti-seep collars shall be installed within the saturated zone. The assumed normal saturation zone shall be determined by projecting a line at a slope of 4 horizontal: 1 vertical from the point where the normal water elevation (can be assumed to be the top of the principal spillway) meets the upstream slope to a point where this line intersects the invert of the barrel pipe or bottom of the cradle, whichever is lower. The collars shall extend a minimum of 2 feet around the barrel. The maximum spacing between collars shall be 14 times the projection of the collars above the barrel. Collars shall not be closer than 2 feet to a pipe joint. Collars should be placed sufficiently far apart to allow space for hauling and compacting equipment. Precautions should be taken to ensure that 95% compaction is achieved around the collars. Connections between the collars and the barrel shall be watertight. Plans should specify method of compaction around the pipe barrel to ensure adequacy and to prevent damage to the antiseep collars and joints. See Construction Details (Principal Spillway) and refer to Figure 7.31-7 for details. Drainage filter diaphragms may be substituted for anti-seep collars, per NRCS (2003) design practice guidelines.

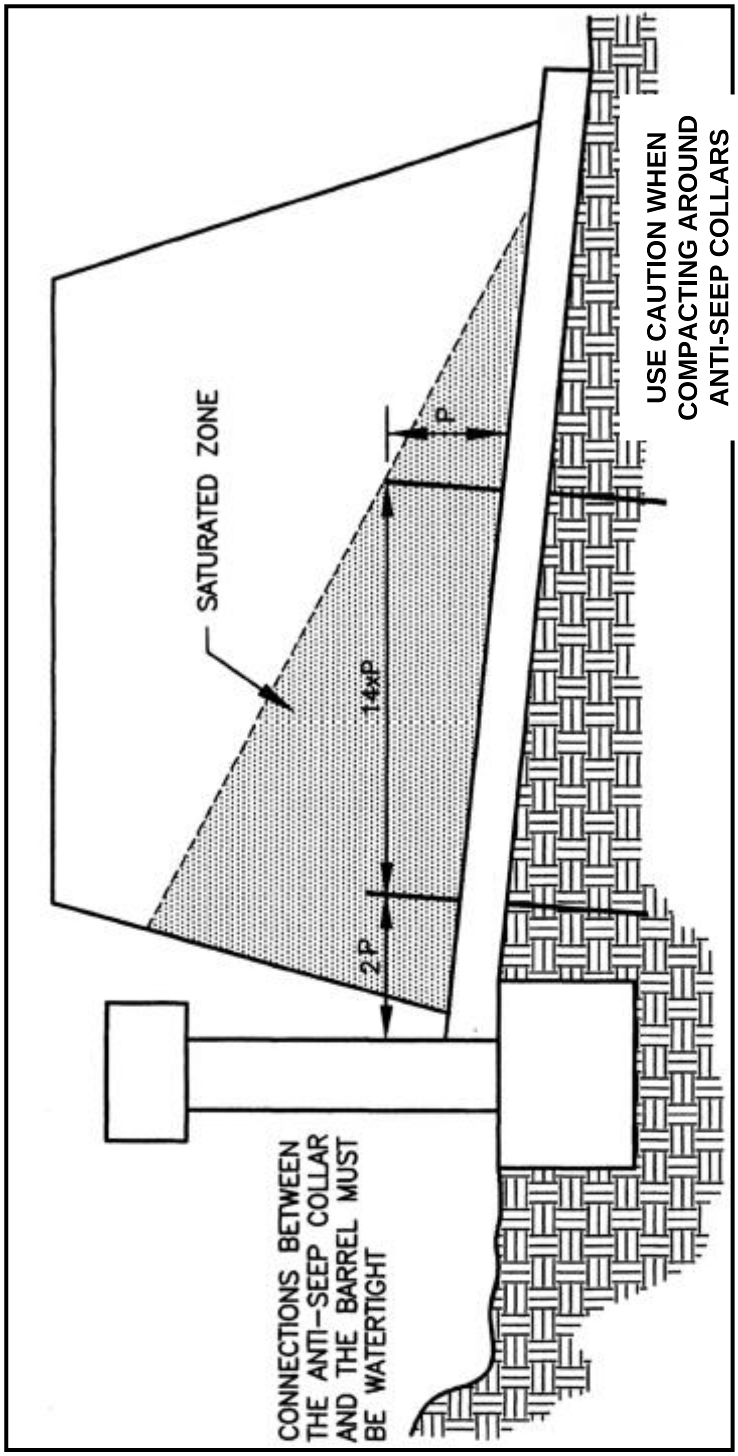


Figure 7.31-7 Anti-Seep Collar *(Source: VA DSWC)*

Dewatering: Provisions shall be made to dewater the basin down to the permanent (wet) pool elevation. Particle characteristics, flow-through velocity, surface loading rate, turbulence levels, sediment concentration and other lesser factors can have a significant effect on the sediment trapping efficiency in a basin. The dry storage zone above the permanent pool should draw down in 72 hours to promote settling. Drawdown or dewatering must occur from the ponded water surface. Two types of devices are acceptable for dewatering the dry storage zone of a sediment basin. The floating surface skimmer is the preferred dewatering method, as it dewaters from the top of the water column.

1. *Perforated vertical pipe or tubing*

An economical and efficient device for performing the drawdown is a section of perforated vertical pipe or tubing, which is connected to and braced to the principal spillway at two locations. The perforations in the pipe allow the upper 2 to 3 foot zone of pond water containing the lowest sediment concentration to be drawn off. The number, diameter and location of drawdown holes should be designed, specified and constructed to drain the dry storage volume in the 72-hour period. A slide gate type of valve is required at the bottom of this tubing for achieving the desired drawdown time and seasonal control. Figure 7.31-8 provides a schematic orientation of such a device. A dewatering operation procedure might be to keep the slide gate valve closed during dry periods, or close it before anticipated precipitation events. Then, during and after the precipitation event, the slide gate valve is manually adjusted to allow the draw down to begin. The amount of adjustment should be determined so that the draw down to the wet pool elevation occurs over a period of 72 hours, as stated above.

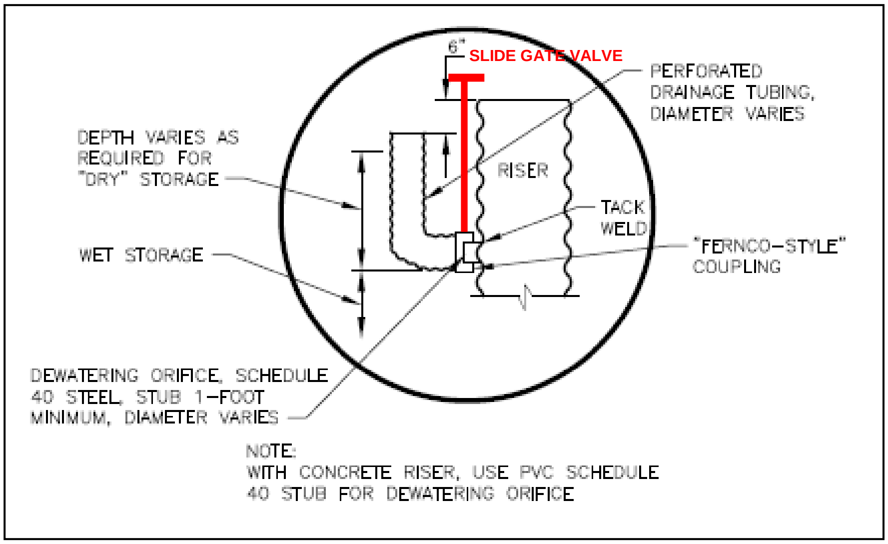


Figure 7.31-8 Slotted Drain Pipe Dewatering Device

2. *Floating surface skimmer*

Selection of floating skimmer and orifice sizes should be based on the volume of “dry” water storage to be drained over the dewatering time of 72 hours and designed according to skimmer manufacturer design specifications, charts and tables, calculators and procedures. The surface skimmer design and selection involves two steps:

1. Selecting appropriate overall skimmer size having a capacity for dewatering a specified volume (V) of “dry” storage water over a time period (t) of 72 hours (3 days).

2. Determining the skimmer’s inlet orifice diameter sized for a flow based on Q = V/t and using either the manufacturer’s orifice sizing tables or the

orifice equation with the recommended head (H) and coefficient (C) for a particular skimmer: $Q = CA_o \sqrt{2gH}$

Unlike stationary perforated pipe dewatering devices where the flow rate decreases as the dry pool zone dewaters, the flow rate will be constant for a surface skimmer since the head over the floating skimmer inlet orifice remains constant over the dewatering period.

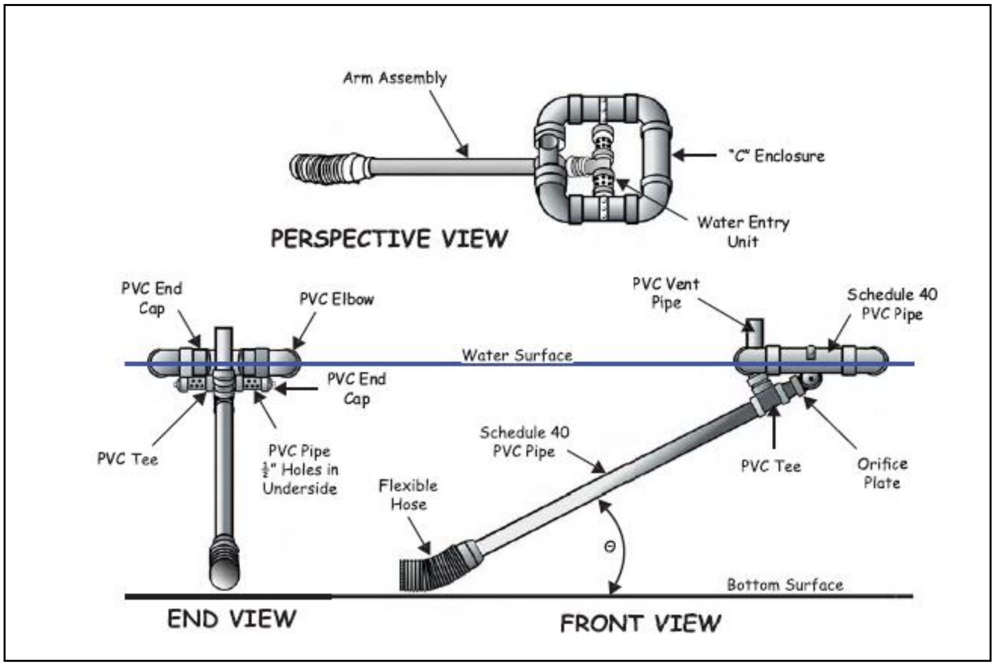


Figure 7.31-9 Schematic of a floating skimmer dewatering device

Include a pier constructed of concrete block or stone for the skimmer to rest upon to limit the dewatering depth and to prevent the skimmer from getting stuck in the muddy bottom. The top of the pier should be set at the elevation of the permanent wet pool. Figure 7.31-9 and Figures 7.31A and 7.31-10B below illustrate the construction and installation of a skimmer dewatering device and resting pier.

Because of the low flow capacity of the dewatering device or orifice and its potential for becoming clogged, no credit should be given for drawdown by the device in the calculation of the principal or emergency spillway locations.

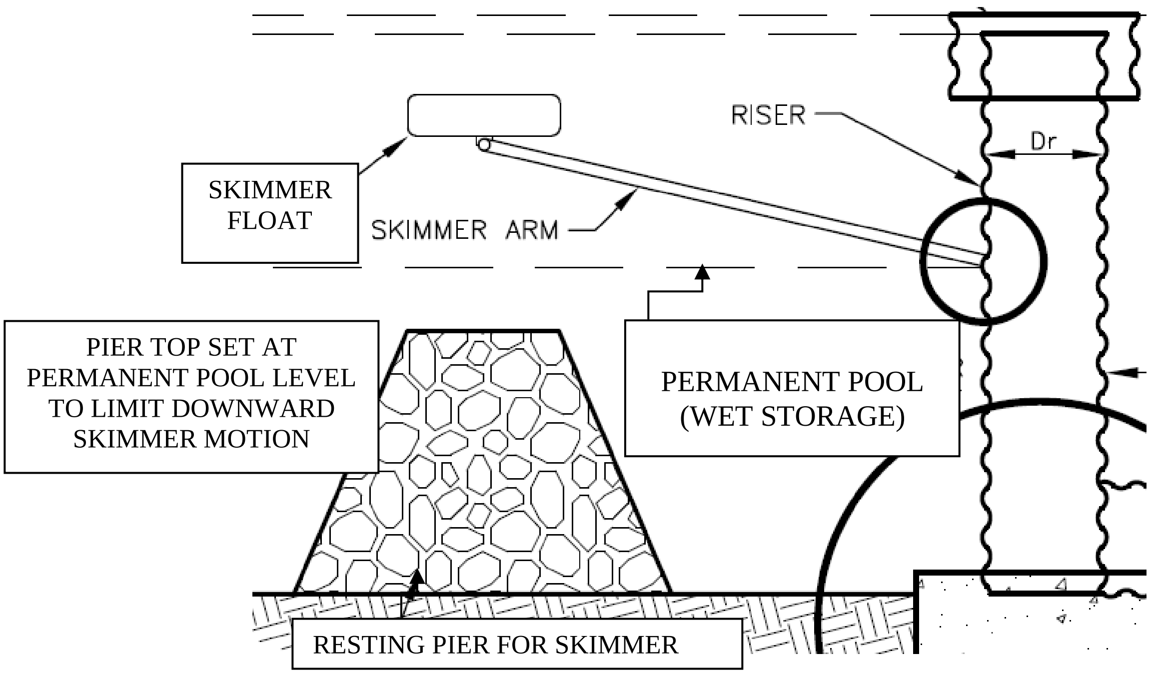


Figure 7.31-10A Skimmer Pier and Permanent Pool

Figure 7.31-10B Floating Skimmer Installation

STEP 4: SET THE EMERGENCY SPILLWAY AND TOP OF EMBANKMENT ELEVATIONS.

Emergency Spillway: The emergency spillway acts as a safety release for a sediment basin, or any impoundment structure, by conveying the larger, less frequent storms (minimum 25-year, 24-hour storm) through the basin without overtopping or damaging the embankment. The emergency spillway also acts as its name implies - an emergency outlet - in case emergency circumstances arise from excessive sedimentation or damage to the riser, which prevents flow through the principal spillway. The emergency spillway shall consist of an open channel constructed adjacent to the embankment. The emergency spillway should be installed over undisturbed ground or consolidated soil, rather than over an unconsolidated embankment fill of the dam, whenever possible, to prevent damage to the dam. An emergency spillway constructed over a section of the embankment fill is susceptible to settlement, reduced freeboard, and dangerous scouring during the spillway design storm. The emergency spillway shall be lined with a non-erodible material based upon the designed shear stress in the channel (see Channel Design Section 7.27). Design of an emergency spillway requires the special expertise of a qualified, engineering design professional. The control section is a level portion of the spillway channel at the highest elevation in the channel. See Figure 7.31-9 for location of emergency spillway and Figure 7.31-11 for an example of an excavated earthen spillway.

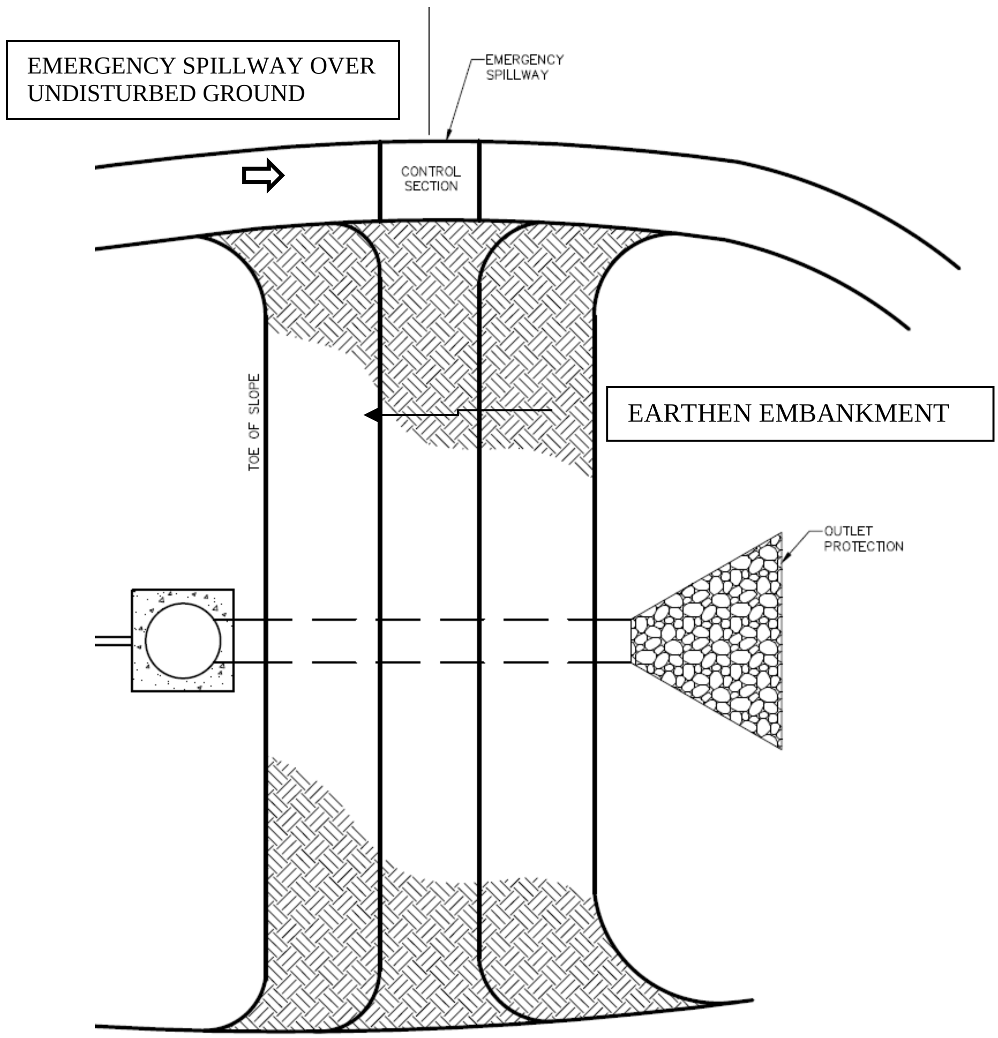


Figure 7.31-11 Earthen Embankment

An evaluation of site and downstream conditions must be made to determine the feasibility and justification for the incorporation of an emergency spillway. In some cases, the site topography does not allow a spillway to be constructed in undisturbed material, and the temporary nature of the facility may not warrant the cost of disturbing more acreage to construct and armor a spillway. The principal spillway must then be sized as a combined spillway to convey all the design storms, through the 25-year storm at a minimum.

The outlet channel to which the emergency spillway discharges where the flow transitions from the spillway to a channel must be designed to prevent erosion based upon shear stress.

Capacity: The emergency spillway shall be designed such that the 25-year 24-hour storm event is routed through the pond and discharge channel and allows for a minimum freeboard of 1.0 foot above the 25-year, 24-hour peak flow depth.

Design Elevations: The maximum 25-year storm pool elevation shall have a freeboard of at least 1.0 foot below the top of the embankment as shown in Figure 7.31-12.

Embankment Elevation: The height of the embankment dam is measured from its crest down to the lowest point of natural grade (at the downstream toe of the embankment). Embankment geometries are provided in the table below.

Table 7.31-2 Embankment geometries

Embankment Height, ft.	**Top width**	**Upstream Side Slopes**	**Downstream Side slopes**
<10	6 ft min.	2:1 or flatter	3:1 or flatter
10-14	8 ft. min.	2.5:1 or flatter	3:1 or flatter
15-19 ft	10 ft. min.	2.5:1 or flatter	3:1 or flatter

The site foundation for the embankment should be prepared by removing all vegetation, debris, topsoil, and large rocks down to competent material. Embankments should be keyed into the foundation soil. The embankment height should include a 10 percent settlement allowance across the longitudinal axis of the dam to ensure required freeboard. The minimum 1-foot freeboard required between the maximum 25-year design flow level and top of the dam is shown in Figure 7.31-12.

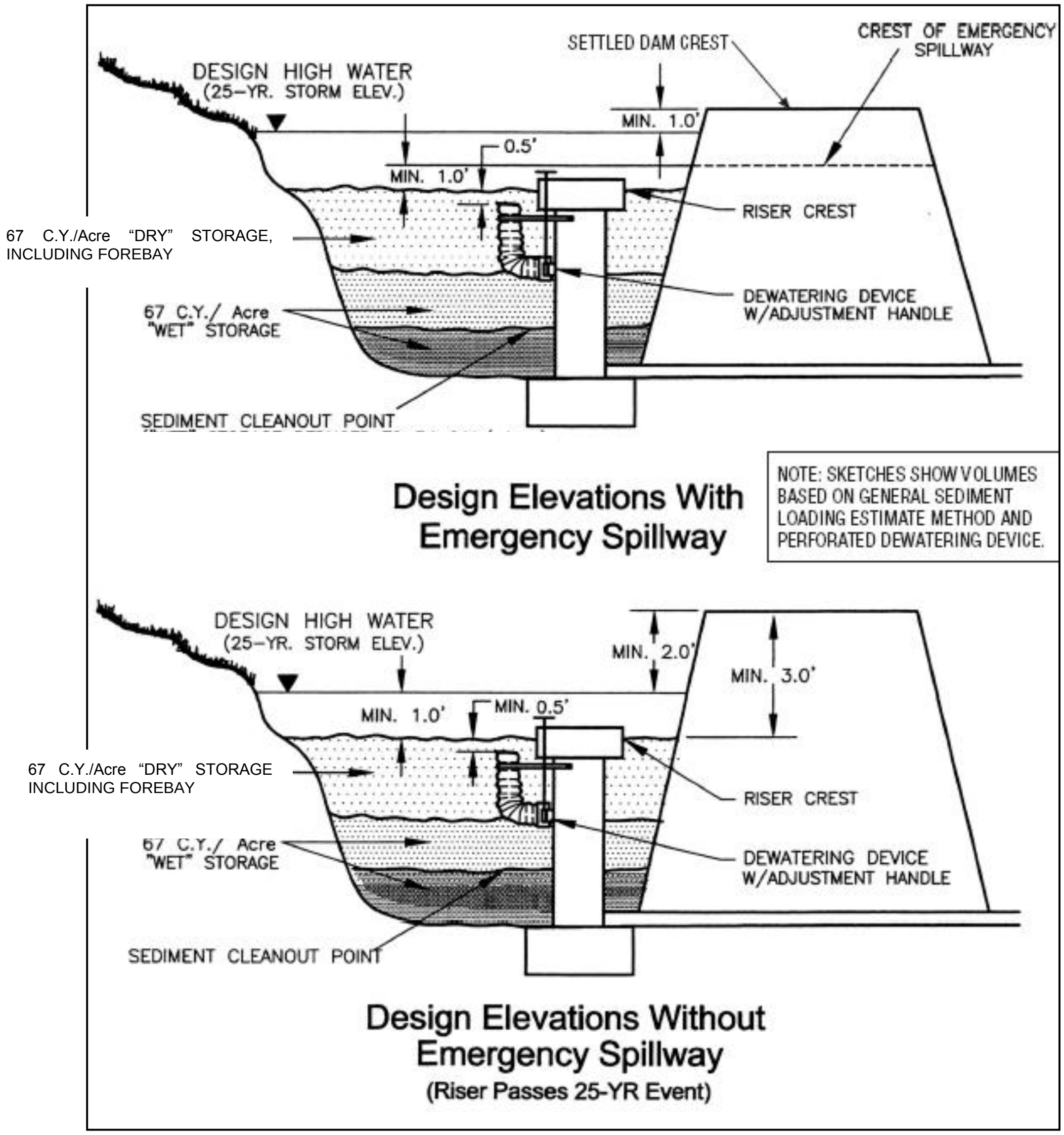


Figure 7.31-12 Schematic Drawing of Typical Sediment Basin (*Source: VA DSWC*)

Multiple Uses:
Sediment basins may remain in place after final site stabilization is completed to serve as permanent stormwater management structures. They also may be used *during* construction for stormwater management. Because the most practical location for a sediment basin is often the most practical location for a stormwater management basin, it is often desirable to utilize these structures for permanent stormwater management purposes. It should be noted, however, that in most cases, a typical structure's outlet control system would vary from construction to post construction periods. Care must be taken to avoid constructing an outlet control system, which will achieve the desired permanent stormwater management treatment but will not provide the necessary facility for the containment and settling of sediment-laden construction runoff. For example, a permanent stormwater detention structure may have a bottom control orifice in the riser, while a temporary sediment pond does not. Notably, the design for such

permanent flow control ponds is beyond the scope of these standards and specifications.

Equivalent Measures: For locations which serve 10 or more acres of disturbed and undisturbed drainage area (5 or more acres discharging into impaired or high quality waters), but where temporary sediment basins are not practical or feasible because of topographical or other physical constraints, equivalent control measures must be used until final stabilization of the site. Examples of equivalent control measures include combinations of multiple, smaller sediment ponds and sediment traps or other proven treatment processes. Where equivalent control measures are substituted for a sediment basin, the basis of and equivalency for trapping sediment using other BMPs must be justified in the SWPPP calculations and narrative to TDEC in terms of equivalent volume, surface area, and hydraulic capacity. The total trapping capacity of these must have an equivalent storage of 3,618 cubic feet (134 cubic yards) of runoff per acre. The total surface area must meet the minimum surface area requirement of 0.01 x Qp. The measure must be able to convey the design storm (2- or 5-year, 24-hour storm, as required).

Construction Specifications

Construction of the sediment basin shall be in accordance with the SWPPP, engineering drawings and specifications. Accurate implementation of specified design elevations, grades, dimensions and sizes, volumes, channel slopes, and erosion control materials are critical to successful and safe operation of the sediment basin. Elevations and dimensions should be constructed within ± 0.1 feet tolerance.. After construction the design engineer or landscape architect shall inspect the sediment basin, according to Site Assessment requirements, to confirm that the plans have been accurately implemented.

Plans and Specifications: The construction plans shall contain sufficient detail in the form of layout, typical details, elevations, dimensions, placement, and specification notes so that the designer’s intent can be understood and be properly constructed.

Site Preparation: Areas under the proposed embankment (or any structural works related to the sediment basin) shall first be cleared, grubbed, and stripped of topsoil. All trees, vegetation, roots, and/or other objectionable or inappropriate materials should be removed and disposed of by appropriate methods. In order to facilitate clean out and restoration, the pool area should be cleared of all brush and trees.

Cut-Off Trench: For earth-fill embankments, a cutoff trench shall be excavated along the centerline of the earth fill embankment (dam) to prevent excessive seepage and possible internal erosion. The trench must extend at least 1 foot into a stable, impervious layer of soil and have a minimum depth of 2 feet. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum width shall be 4 feet, but also must be wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for the embankment. The trench shall be drained during the backfilling/compacting operations.

Embankment: The fill material shall be taken from approved borrow areas (shown on the plans). It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, oversized stones, rocks, or other perishable or objectionable material. The fill material selected must have enough strength for the dam to remain stable and be tight enough, when properly compacted, to prevent excessive percolation of water through the dam. Fill containing particles ranging from small gravel or coarse sand to fine sand and clay in desired proportion is appropriate. Any embankment material should contain approximately 20% clay particles by weight. Using the Unified Soil Classification System, SC (Clayey sand), GC (clayey gravel) and CL ("low liquid limit" clay) are among the preferred types of embankment soils. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material should contain the proper amount of moisture to ensure that at least 95% compaction will be achieved. **Fill material will be placed in 6-inch continuous layers over the entire length of the fill.** Loosely placed embankment soil is subject to excessive settlement, severe erosion and slope failure. Compaction shall be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is traversed by at least one wheel or tread track of the equipment, or by using a compactor. Note that the spillway barrel must be installed in the embankment as it is being constructed in lifts and proper compaction is occurring around the barrel, especially under the haunches. Special care shall be taken in compacting around the anti-seep collars (compact by hand, if necessary) to avoid damage and achieve desired compaction. The embankment shall be constructed to an elevation 10% higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compaction equipment is used, the overbuild may be reduced to not less than 5%. All components of the embankment must be stabilized with vegetation after construction is complete.

Principal Spillway: The riser of a metal pipe principal spillway shall be securely attached to the barrel pipe by welding the full circumference, making a watertight connection. The barrel and riser shall be placed on a firmly compacted soil foundation. The base of the riser shall be firmly anchored according to design criteria to prevent it from floating. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the barrel or anti-seep collars. Fill material shall be placed around the pipe in 4- inch layers and compacted until 95% compaction is achieved (compact by hand, if necessary). A minimum of two feet of fill shall be hand-compacted around and over the barrel before crossing it with construction equipment. An antiflotation device shall be constructed to prevent movement of the barrel and riser. A trash rack shall be properly fitted and attached to the principal spillway inlet. Soil should be hand-tamped around the pipe barrel, especially below the haunches, to achieve good compaction around the pipe and to prevent damage to the joints and antiseep collars.

Dewatering device: If a skimmer dewatering device is installed, attach a rope or other mechanism to the skimmer arm to retrieve it from the pond for cleaning. Install a rock or concrete pier for the skimmer to rest on. The pier should be at the elevation of the wet storage pool.

Emergency Spillway: The emergency spillway shall be installed in undisturbed ground. The implementation of planned elevations, grades, design width, entrance and exit channel slopes are critical to the successful operation of the emergency spillway and must be constructed within a tolerance of +/-0.1 feet. The emergency spillway should be protected against scouring and erosive shear stress. The spillway should be over-excavated to compensate for the thickness of linings such as rock rip rap in order to preserve its intended design flow capacity.

Inlets: Discharge water into the basin in a manner to prevent erosion and turbulence. Use diversions with outlet protection to divert sediment-laden water to the upper end of the pool area to prevent pond shortcutting and to improve basin trapping efficiency.

Baffles: At least two baffles shall be installed in the forebay. These should be installed as shown in Figures 7-31-2A and -2B and per Section 7.33.

Vegetative Stabilization: The embankment and emergency spillway of the sediment basin shall be stabilized immediately after construction of the basin. Trees and/or shrubs should not be allowed to grow upon the embankment due to the ability for the roots of such vegetation to destabilize the embankment and/or encourage piping.

Erosion prevention and sediment control: The construction of the sediment basin shall be carried out in a manner such that it does not result in sediment problems downstream.

Health and Safety: All state and local requirements shall be met concerning fencing and signs warning the public of the hazards of soft, saturated sediment and flood water. Avoid steep side slopes, and fence - mark basins with warning signs, especially in urban areas where trespassing is likely. The designer and developer should be aware of the potential hazards that a temporary wet pond represents to the health and safety of a neighborhood. Sediment basins can be attractive to children and can be dangerous to those who may accidentally slip into the water and soft mud or who may become entrapped at flowing inlets. Incidents have been reported involving children drowning at construction site sediment ponds. The basin area should, therefore, be fenced or otherwise made inaccessible to persons or animals, unless this is deemed unnecessary due to the remoteness of the site or other circumstances. Strategically placed signs around the impoundment reading "DANGER KEEP OUT" or "DANGER-QUICKSAND" should also be installed. In addition to signs and fences, consideration should be given to frequent inspection, regular maintenance and provision for security at such facilities. Special consideration may need to be given in pond design, operation and maintenance in areas of the state where health hazards stemming from mosquito breeding and West Nile Virus have occurred. In any case, local ordinances and regulations regarding health and safety must be adhered to.

Final Disposal: When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, and unless the sediment pond is scheduled for conversion into a permanent stormwater detention facility, the embankment and resulting sediment deposits are to be leveled or otherwise disposed of in accordance with the SWPPP. The proposed use of a sediment basin site will often dictate final disposition of the basin and any sediment contained therein. If the site is scheduled for future construction, then the embankment and trapped sediment must be removed, safely disposed of, and backfilled with a structural fill. When the basin area is to remain open space, the pond may be pumped dry, graded and backfilled.

Maintenance and Inspection Points

Sediment shall be removed from the forebay (and upstream energy dissipation structure, if provided) when 50% of the storage has been filled with sediment. Removing sediment from the dry forebay is much easier than removing sediment from the wet portion of the sediment basin. Also, sediment should be removed from the wet portion of the basin before the sediment level reaches higher than 1 foot below the bottom of the dewatering orifice, or before one-half of the permanent pool volume has been filled in, whichever occurs first. Plans for the sediment basin should indicate the methods for properly disposing of sediment removed from the basin. Possible alternatives are to use the material in fill areas on-site or removal to an approved off-site location.

Accumulated sediment shall be removed from the basin as specified in the SWPPP and/or plan sheets. Sediment shall not enter adjacent streams or drainage ways during sediment removal or disposal. The sediment shall not be deposited downstream from the embankment, adjacent to a stream or floodplain.

Other inspection check points include:

- Inspect storage areas for stabilization of accumulated sediments.
- Check for erosion at the entrances into the basin. These areas should be stabilized to reduce basin maintenance needs.
- Check for blocked spillway systems, including dewatering devices. Remove debris from the basin that may get lodged in the spillways.
- Clean dewatering device(s)
- Check for evidence of piping and internal erosion along the principal spillway barrel by inspecting for embankment crest cracks and subsidence over the barrel and for lost embankment soil appearing at the outlet from along the outside surface of the discharge pipe. Most embankment failures occur at this point.
- If possible, look up the inside of the outlet pipe with a flashlight to check for joint failures
- Inspect the entire embankment for
    - Evidence of erosion or significant settling
    - Downstream slope bulges
    - Structural instability (initial formation of slides)
    - Longitudinal and lateral cracking
- Inspect downstream from the outlet structures for evidence of erosion.
- Inspect the baffles to ensure they are properly anchored and haven't deteriorated.

References

Barfield, B. J. and M.L. Clar, Erosion and Sediment Control Practices, Report to the Sediment and Stormwater Division, Maryland Water Resources Administration, 1986.

TDOT Design Division Drainage Manual

North Carolina Erosion and Sediment Control Planning and Design Manual

SEDIMENT CONTROL PRACTICES

7.32 SEDIMENT TRAP

SEDIMENT TRAP

Definition

A temporary sediment storage area with a permanent pool, formed by an embankment or excavation, or combination.

Purpose

To detain sediment-laden runoff from small, disturbed areas, allowing larger sediment particles to settle out of runoff.

Conditions Where Practice Applies

Sediment traps, along with other controls intended to retain sediment, should be constructed as a first step in any land disturbing activity and should be made functional before upslope land disturbance takes place. The sediment trap may be constructed either independently or in conjunction with a diversion. Sediment should be periodically removed from the trap to maintain the required volume. The SWPPP 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.

This practice is applicable for use in applications such as:

- At the outlets of diversions, channels, slope drains, or other runoff conveyances that discharge sediment-laden runoff.
- Below areas that are draining < 5 acres.
- Where access can be maintained for sediment removal and proper disposal.
- In the approach to a stormwater inlet location below a disturbed area as part of an inlet protection system.

Sediment traps are **not** to be located in a stream.

Planning Considerations

Select locations for sediment traps during site evaluation. Note natural drainage divides and select trap sites so that runoff from potential sediment producing areas can easily be diverted into traps. Diversion berms and ditches should be installed to direct runoff into traps as needed. Ensure the drainage areas for each trap does not exceed 5 acres.

Sediment traps must be readily accessible for periodic sediment removal and other necessary maintenance. Locations should be planned for sediment disposal as part of trap site selection; disposal areas should be clearly designated in the SWPPP and on construction plans.

The maximum usable life of a sediment trap should be no longer than 2 years. Traps should be installed in the first stages of project development before any land disturbance activity upslope takes place.

Design Criteria

Storage Capacity:
The trap shall have an initial storage volume of 3618 cubic feet (134 cubic yards) per acre of **drainage** area. The required storage volume may also be determined by modeling soil loss using RUSLE or other approved methods. Half of the storage volume must be in the form of a permanent pool or wet storage to provide better settling efficiency. To provide the wet storage area, the sediment storage zone will have to be over excavated below the surrounding ground elevation. The other half of the sediment storage is in the form of a draw down or dry storage that provides extended settling time during storm events. The volume of the wet storage area is measured from the low point of the excavated area to the base of the outlet structure. The volume for dry storage is measured from the base of the outlet to the crest of the outlet overflow. See Figures 7.32-1 for notation.

For a sediment trap, the wet storage volume may be approximated by average end method as follows:

$$V_1 = \left[\frac{(A_0 + A_1)}{2}\right] x\ D_1$$

where,

V_1 = the wet storage volume in cubic feet
A_0 = the surface area of the bottom of the trap in square feet
A_1 = the surface area of the flooded area at the base of the outlet in square feet
D_1 = the maximum depth in feet, measured from the low point in the trap to the base of the outlet

The dry storage volume may be approximated by the average end method as follows:

$$V_2 = \left[\frac{(A_1 + A_2)}{2}\right] x\ D_2$$

where,

V_2 = the dry storage volume in cubic feet.
A_1 = the surface area of the flooded area at the base of the outlet in square feet
A_2 = the surface area of the flooded area at the crest of the outlet (overflow mechanism) in square feet
D_2 = the depth in feet, measured from the base of the outlet to the crest of the outlet

Trap efficiency:
The following design elements must be provided for adequate trapping efficiency:

- Provide a surface area of 0.01 acres (435 square feet) per cfs based on the 2-year or 5-year storm
- Convey runoff into the trap through stable diversions or temporary slope drains
- Locate sediment inflow to the trap away from the outlet to prevent short circuiting from the inlet to the outlet
- Provide at least 2 porous baffles (see Section 7.33)
- Excavate the wet storage volume, V_1, below grade.

The sediment storage area should have a length to width ratio of 3:1, measured from the point of maximum runoff introduction to outlet. Settling efficiency is improved with longer flow paths and residence time in the sediment storage zone.

Spillway:
The spillway is constructed of rip rap and smaller graded, clean stone such as TDOT #57 stone. Geotextile fabric must be placed between the rip rap and soil to prevent piping and erosion of the spillway. A four (4) foot minimum weir width must be provided (See Figure 7.32-1). The weir section of the spillway must be designed to pass the 2-year or the 5-year storm event, based upon the total drainage area.

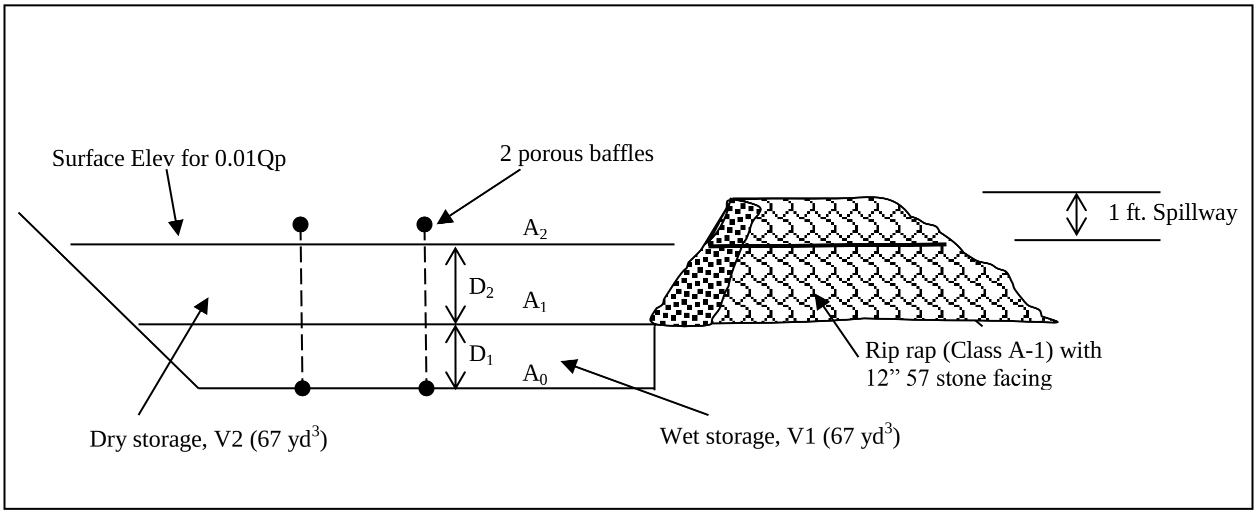


Figure 7.32-1 Sediment trap

Embankment:
The embankment should be no taller than five (5) feet. Side slopes must be 2:1 or flatter and stabilized as soon as construction on the trap has been completed. Keep the crest of the spillway outlet 1.5 feet below the settled top of the embankment. Embankments must have a minimum top width of 5 feet. Machine compact embankments.

Construction Specifications

1. Clear, grub, and strip the area under the embankment of all vegetation and root mat. Remove all surface soil containing high amounts of organic matter, and stockpile it or dispose of it properly. Haul all objectionable material to the designated disposal area.

2. Ensure that fill material for the embankment is free of roots, woody vegetation, organic matter, and other objectionable material. Place the fill in lifts not to exceed 9 inches, and machine compact it. Overfill the embankment 6 inches to allow for settlement.

3. Construct the outlet section in the embankment. Protect the connection between the riprap and the soil from piping by using geotextile fabric between the rip rap and soil. Place the filter fabric between the soil and rip rap. Extend the fabric across the spillway foundation and sides to the top of the dam.

4. Clear the sediment trap storage zone area below the elevation of the crest of the spillway to facilitate cleanout.

5. All cut and fill slopes must be 2:1 or flatter.

6. Ensure that the stone section of the embankment has a minimum bottom width of 3 feet and maximum side slopes of 1:1 that extend to the bottom of the spillway section.

7. Construct the minimum finished stone spillway bottom width, as shown on the plans, with 2:1 side slopes extending to the top of the over filled embankment. The weir must be level and constructed to the width noted on the plans.

8. Material used in the stone section should be a well graded mixture of stone with a d_{50} size of 9 inches (Class A-1). The stone can be machine placed and the smaller stones worked into the voids of the larger stones.

9. Runoff should be discharged into the trap in a manner to prevent erosion. Use temporary slope drains or diversions with outlet protection to divert runoff to the upper end of the storage area to improve trap efficiency. Avoid discharging runoff over unprotected steep side slopes.

10. Ensure that the stone spillway outlet section extends downstream past the toe of the embankment until stable conditions are reached and outlet velocity is acceptable for the receiving system. Keep the edges of the stone section flush with the surrounding ground.

11. Stabilize the embankment and all disturbed areas above the sediment pool and downstream from the trap immediately after construction.

12. Install at least two porous baffles as specified in Section 7.33.

Maintenance and Inspection Points

Sediment traps must be maintained and function as designed until all areas draining to the trap have been stabilized.

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.

Any rip rap displaced from the spillway must be replaced immediately.

Filter stone should be checked to ensure that filtration performance is maintained. Replace stone caked with sediment.

Sediment shall be removed when it has accumulated to one half the design volume of the wet storage. Sediment removed from the trap should be deposited in an area up gradient from the sediment trap and other measures and stabilized or removed from the site. Do not place removed sediment below sediment controls.

Once the areas draining to the sediment trap have been stabilized, remove the stone and rip rap spillway and backfill the sediment storage area. Stabilize the area.

References

TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-7

North Carolina Erosion and Sediment Control Planning and Design Manual

SEDIMENT CONTROL PRACTICES

7.33 POROUS BAFFLES

Baffles

Definition Porous baffles are made of highly porous materials such as coir or jute netting. Porous baffles installed inside temporary sediment traps and sediment basins reduce the velocity and turbulence of the water flowing through the measure, distribute the flow, and facilitate the settling of sediment from the water before discharge.

Purpose Improve the rate of sediment settling by distributing the flow and reducing turbulence. Sediment traps and basins are designed to temporarily pool runoff water to allow sediment to settle before the water is discharged. Unfortunately, these measures are not typically very efficient due to high turbulence and short circuiting flows which take runoff quickly to the outlet with little residence time for settling to occur.

Conditions Where Practice Applies Baffles can be installed in any temporary sediment trap or sediment basin. A secondary benefit of installing porous baffles in sediment traps and basins is that the majority of the sediment load tends to settle on the upstream side of the first porous baffle, making maintenance and cleanout of the sediment storage area much easier.

Planning Considerations Porous baffles effectively spread the flow across the entire width of a sediment basin or trap. Water flows through the baffle material but is slowed sufficiently to back up the flow, causing it to spread across the entire width of the baffle. Spreading the flow in this manner utilizes the full cross section of the sediment storage area, which in turn reduces the flow rates. In addition, turbulent flow is reduced. This combination increases sediment deposition and retention and also decreases the particle size of sediment settling in the storage area.

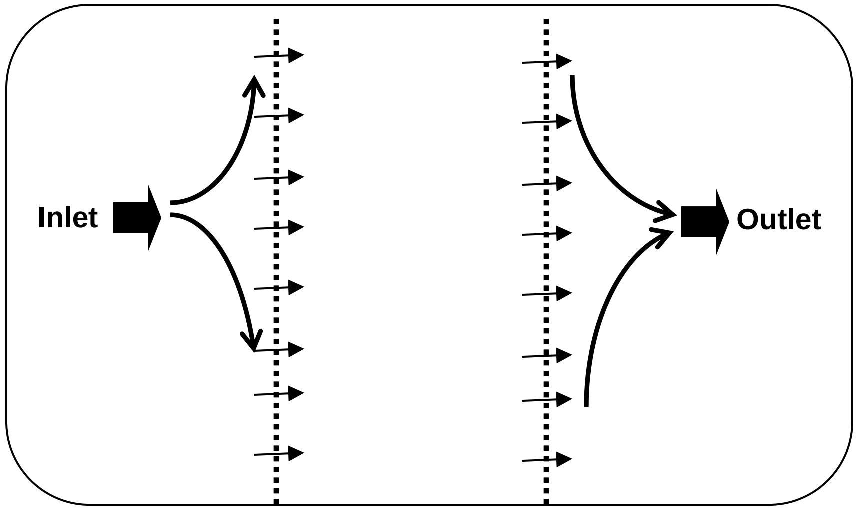


Figure 7.33-1 Porous baffle spreading flow in a sediment trap

Installation of porous baffles is similar to silt fence. The baffles must be installed perpendicular to flow in the sediment storage area. At least two baffles must be installed to be most effective.

Design Criteria

Refer to the design for sediment basins and sediment traps (Section 7.31-7.32).

The porous baffles should be shown on the design plans (and installed in the field) to divide the basin into three sections.

Materials such as 0.14 lb/ft^2 (20 oz/yd^2) coir erosion blanket, coir mesh, or jute fabric can be used to construct the baffle. See Table 7.33-1 for material specifications for coir baffles. Silt fence material is not porous enough to allow enough flow through the material fast enough and can therefore have flow over the material and cause turbulent flow on the downstream side, so it is not recommended. Wire backing can be installed to provide structural support for the baffles between posts. A support wire or rope across the top will help prevent excessive sagging if the material is attached to it with strong zip ties or similar fastenings. These structures work well and can be prefabricated off site and quickly installed.

Table 7.33-1 Coir Baffle Material Specifications (*Source: NCDOT)*

100% coconut fiber (coir) twine woven into high strength matrix	
Thickness	0.30 in. minimum
Tensile strength	1248 x 626 lb/ft minimum
Elongation	34% x 38% maximum
Flexibility (mg-cm)	65030 x 29590
Flow velocity	Observed 11 ft/sec
Weight	20 oz/yd^2
Size	6.6 x 164 ft (120 yd^2)
Open area	50%

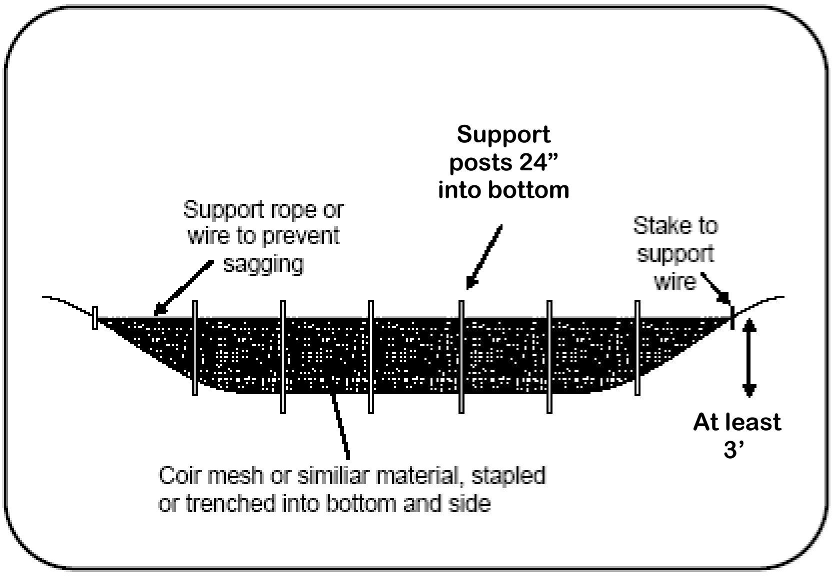


Figure 7.33-2 Cross section of a porous baffle in a sediment trap (*Source: NCDENR)*

Note that in Figure 7.33-2 there is no weir in the baffles because water flows through the porous baffle, not over it.

Construction Specifications

Staples

- Provide staples made of 0.125 in. diameter new steel wire formed into a *u* shape not less than 12" in length with a throat of 1" in width.

Posts

- Steel posts shall be T-type at least 5 ft. in length, approximately 1 3/8" wide measured parallel to the fence, and have a minimum weight of 1.25 lb/ft of length. The post shall be equipped with an anchor plate having a minimum area of 14.0 square inches, and shall be of the self-fastener angle steel type to have a means of retaining wire and coir fiber mat in the desired position without displacement.

Wire

- Provide 9-gauge high tension wire strand of variable lengths.

Construction

Place the coir fiber baffles immediately upon excavation of basins or traps. Install baffles as required in Sections 7.31 Sediment basins and 7.32 Sediment traps. Steel posts shall be placed at a depth of 2 ft. below the bottom of the basin, with a maximum spacing of 4 ft. The top height of the coir fiber baffles shall not be below the elevation of the emergency spillway base of dams and basins. Attach a 9-gauge high-tension wire strand to the steel posts at a height of 3 ft. with plastic ties or wire fasteners. To anchor the coir fiber mat, install a steel post into the side of the basin at a variable depth at a height of 3 ft. from the bottom of the basin. Secure anchor post to the upright steel post in basin with wire fasteners.

The porous baffle material shall be draped over the wire strand to a minimum of 3 ft. of material on each side of the strand. Secure the baffle material to the wire strand with plastic ties or wire fasteners. Place staples across the matting at ends and junctions approximately 1 ft. apart at the bottom and side slopes of the basin or trap. Overlap matting at least 6" where 2 or more widths of matting are installed side by side.

Maintenance and Inspection Points

- Inspect the sediment deposition cells created by the baffles. Heavier sediments will accumulate in the upper most cell.
- Clean sediment from the cells when half of the storage capacity depth has been filled.
- Ensure that baffle material stays securely installed along the sediment trap sides and in the bottom. Material should stay taunt across the trap.
- Watch for scour along the sides of the baffle.
- Replace baffle material if torn or if evidence of deterioration is noted.

References

North Carolina State University Cooperative Extension, Soil Facts

North Carolina Department of Environment and Natural Resources, Erosion and Sediment Control Planning and Design Manual

North Carolina Department of Transportation, Roadside Environmental Details

SEDIMENT CONTROL PRACTICES

7.34 SILT FENCE

SILT FENCE

Definition A temporary sediment control measure, composed of woven geotextile fabric supported by steel or wood posts, used to intercept sediment transported from areas where runoff occurs as sheet flow.

Purpose To prevent sediment carried by sheet flow from leaving the site and entering natural drainage ways or storm drainage systems by slowing storm water runoff, causing ponding and the deposition of sediment at the structure. Silt fence does not filter sediment.

Conditions Where Practice Applies Silt fence may be used in a variety of locations including:

- at the toe of, or on, an exposed slope
- around the perimeter of an exposed construction site
- along the banks of ditches or swales
- around the perimeter of a soil stockpile
- around buffer areas

Silt fence shall not be installed across streams, ditches, waterways, or other concentrated flow areas.

Planning Considerations Silt fence is a system to retain sediment on the construction site. The fence retains sediment primarily by retarding flow and promoting deposition. In operation, the geotextile silt fence material ponds runoff behind it, as the flow rate through the geotextile is often much lower than the flow rate of the runoff coming to the silt fence. Ponding behind the silt fence is necessary to encourage sediment settling. The designer should anticipate ponding and provide sufficient storage areas and overflow outlets to prevent flows from overtopping the fence. Since silt fence is not designed to withstand high water levels, locate them so that only shallow pools can form. Tie the ends of silt fence into higher ground to prevent flow around the end of the fence before the pool reaches design level. Silt fence should be curled uphill on each end of the fence in a “J” pattern to prevent end flow and scour. Provide stabilized outlets to protect the fence system and release storm flows that exceed the design storm.

Deposition occurs as the storage pool forms behind the fence. The designer can direct flows to specified deposition areas through appropriate positioning of the fence or by providing an excavated area behind the fence. Plan deposition areas at accessible points to promote routine cleanout and maintenance.

Silt fence serves no function along ridges or near drainage divides where there is little movement of water. Confining or diverting runoff unnecessarily with a sediment fence may create erosion and sedimentation problems that would not otherwise occur.

Anchoring of silt fence is critical. The toe of the fabric must be anchored in a trench backfilled with compacted earth. Mechanical compaction must be provided in order for the fence to effectively pond runoff.

Design Criteria

Silt fence should be installed along the contour, never up or down a slope. This is essential to ensure that the fence will not accidentally concentrate stormwater flows, thus creating worse erosion problems.

Silt fence can be installed without backing or with wire backing.

- The maximum drainage area for a continuous fence without backing shall be 1/4 acre per 100 linear feet of fence length, up to a maximum area of 2 acres. The maximum slope length behind the fence on the upslope side should be 110 feet (as measured along the ground surface).
- The maximum drainage area for a continuous silt fence with backing shall be 1 acre per 150 linear feet of fence length. The slope length above the silt fence with backing should be no more than 300 feet.

Silt fence should be installed so as to be as close as possible to the ground contour. The bottom of the fence at the ground line should be on a 0% grade, plus or minus 0.5%.

When used at the bottom of a slope, silt fence should be installed 5 feet to 7 feet away from the toe to allow extra space for the ponding of water and collection of sediments.

The expected life span of the silt fence is 6 to 12 months. Therefore, projects of long duration may require a complete replacement of the silt fence. The quantity for silt fence to be in place for a long period of time should be based on the assumption that the material will be replaced every 9 months, on the average.

Table 7.34-1 contains the fabric specifications for silt fence with and without backing. For silt fence without backing, posts shall be hardwood posts that are 2.25” (nominal) x 2.25” (nominal) x 58”. T-type steel posts also may be used. Silt fence with backing shall be installed on a minimum of 1.25 lb/ft steel posts with 14 gauge wire backing that has a maximum mesh size of 6 inches. Ensure that steel posts have projections for fastening the fabric.

Table 7.34-1 Silt Fence Fabric Specifications

	Test Material	Without backing	With backing
Geotextile fabric type		Woven slit film	Woven monofilament
Apparent opening size	ASTM D4751	#30 to #70 standard sieve	#70 to #100 standard sieve
Water flux	ASTM D4491	≥ 4 gpm/ft^2	≥ 18 gpm/ft^2
Tensile strength	ASTM D4632	≥ 120 lb. (warp direction) 100 lb. (fill direction)	≥ 310 lb. (warp direction) 200 lb. (fill direction)
UV Stability (after 500 hrs)	ASTM D4355	≥ 70%	≥ 90%
Elongation	ASTM D4632	≤ 20% max.	---
Burst strength	ASTM D3786	≥ 250 PSI	≥ 400 psi
Puncture strength	ASTM D4833	≥ 60 lb.	≥ 105 lb.
Trapezoidal tear	ASTM D4533	≥ 50 lb (warp direction) 40 lb (fill direction)	≥ 100 lb (warp direction) 60 lb (fill direction)

Construction Specifications

- Ensure that the height of the sediment fence does not exceed 24 inches above the ground surface. Ponding water depth should not exceed 1.5 feet. (Higher fences may impound volumes of water sufficient to cause failure of the structure.)
- Construct the filter fabric from a continuous roll cut to the length of the barrier to avoid joints. When joints are necessary, securely fasten the filter cloth only at a support post with 4 feet minimum overlap to the next post or roll the fabric together and fasten to one post to create a stronger joint. Where joints are necessary, plan the roll layout so as not to have joints at low points.
- Do not attach filter fabric to trees.
- When silt fence is installed adjacent to streams, wetlands and other natural resources, silt fence with backing should be used.
- Install posts no more than 6 feet apart.
- Install posts 2 feet deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.
- Securely attach the silt fence fabric to the posts on the **upstream** side of the posts. For steel posts, attach fabric to the posts using wire or plastic zip ties with a minimum 50 pound tensile strength, at least 5 to a post. Three ties should be installed in the upper 8 inches for top strength. Ties should be installed on the diagonal, as opposed to on the horizontal, to grab more strands. For hardwood posts, attach fabric with 17 gauge wire staples (3/4" wide x 1/2" long), at least 5 to a post. 3 staples should be installed in the upper 8 inches for top strength.
- Install J-hooks for confining the water behind the fence and maximizing the trapping efficiency. See Figure 7.34-1 below.

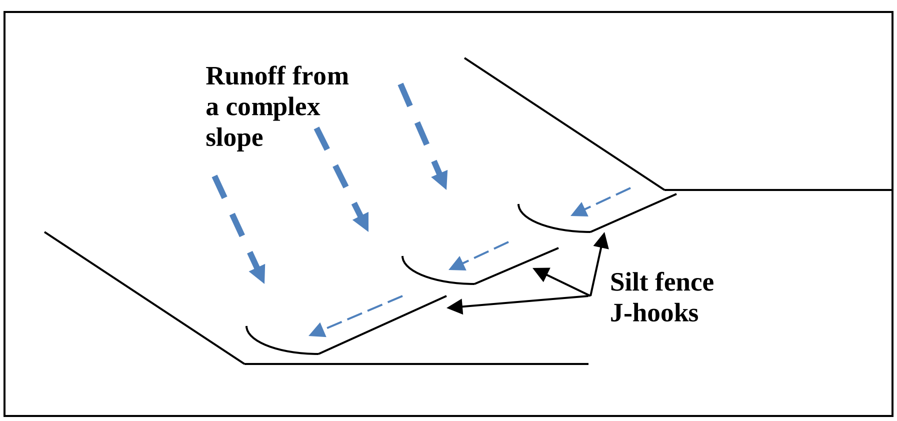


Figure 7.34-1 J-Hook Installation Example

Traditional silt fence trenching method for installation:

- Excavate a trench approximately 4 inches wide and 6 inches deep along the proposed line of posts and upslope from the barrier
- Place 10 inches of the fabric along the bottom and side of the trench. Backfill the trench with soil placed over the filter fabric and compact. Thorough compaction of the backfill is critical to silt fence performance. Poor compaction can cause failure of the silt fence along the toe.
- The base of both end posts should be at least one foot higher than the middle of the fence. Check with a level as necessary.

Slicing method for installation:

- A slicing machine can be used to install silt fence. This method of installation provides excellent compaction and joint integrity along the toe.
- Posts should be set a maximum of 6 feet apart.
- The geotextile fabric should be inserted in a slit in the soil 8-12 inches deep. The slit should be created such that a horizontal chisel point, at the base of a soil-slicing blade, slightly disrupts the soil upward as the blade slices through the soil. This upward disruption minimizes horizontal compaction and creates an optimal soil condition for mechanical compaction against the geotextile. The geotextile should be mechanically inserted directly behind the soil-slicing blade in a simultaneous operation, achieving consistent placement and depth. No turning over (plowing) of soil is allowed for the slicing method.

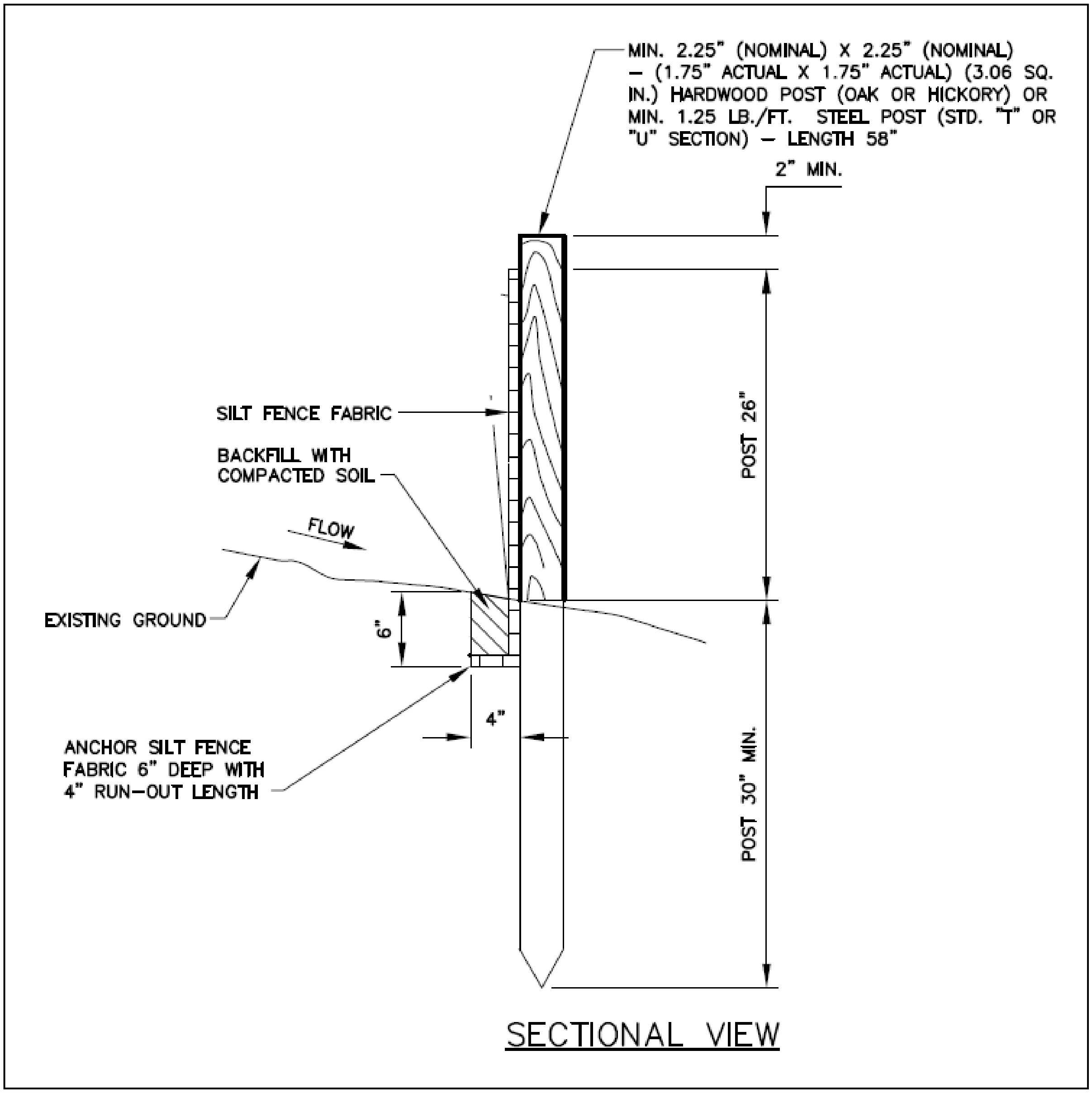


Figure 7.34-2 Silt fence details

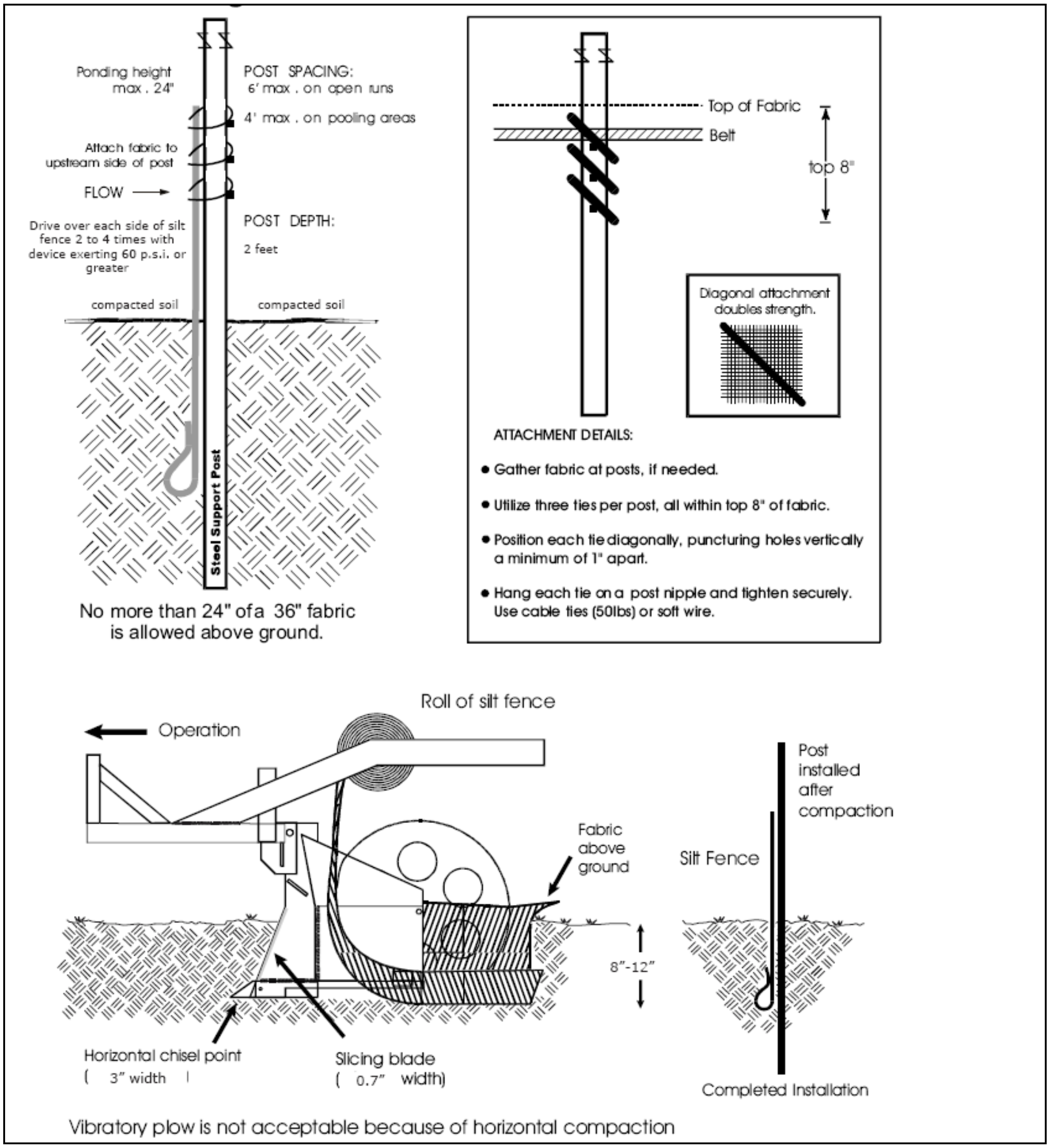


Figure 7.34-3 Silt Fence Slicer Installation Details (*Adapted from Silt Fence That Works)*

Maintenance and Inspection Points

Remove sediment once it has accumulated to ½ the original height of the barrier.

Replace filter fabric whenever it is worn or has deteriorated to such an extent so that the effectiveness of the fabric is reduced.

All sediment accumulated at the fence should be removed and properly disposed of before the fence is removed.

Repair sagging silt fence to prevent failure or overtopping.

Monitor the toe for evidence of piping or erosion along the toe. Install J-hooks wherever runoff flows along the toe of the fencing to prevent undermining.

Silt fence should remain in place until disturbed areas have been permanently stabilized.

References

TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-3B

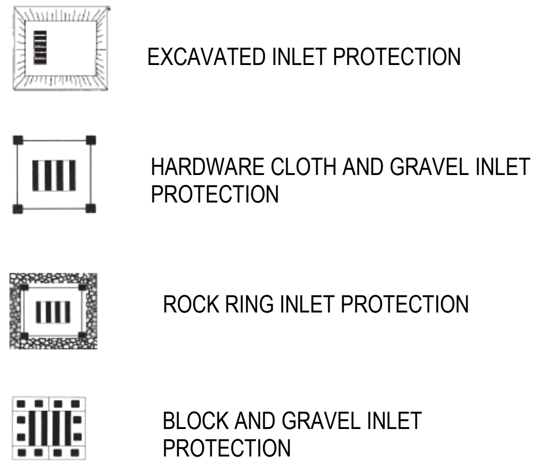
North Carolina Erosion and Sediment Control Planning and Design Manual

Devon Distributing Corporation. http://www.tommy-sfm.com/index.html

Metropolitan Council (Minnesota) Minnesota Urban Small Sites BMP Manual

SEDIMENT CONTROL PRACTICES

7.35 INLET PROTECTION



Definition A temporary protective device formed around a storm drain drop inlet to trap sediment.

Purpose To prevent sediment from entering the storm drainage system, prior to temporary or permanent stabilization of the disturbed area.

Conditions Where Practice Applies Many different types of inlet protection devices are available. The types highlighted in this section are non-manufactured. Manufactured inlet protection devices are allowable alternatives, provided the following:

- At least 3600 ft^3/acre of drainage is available to store sediment.
- No more than 1 acre of drainage to each measure - 0.5 acre drainage area per each measure is preferable.
- An overflow is provided to safely pass storm events larger than the 5-yr storm.

Non-manufactured inlet protection devices:

Excavated Drop Inlet Protection is applicable where relatively heavy flows are expected and overflow capability is needed.

Hardware Cloth and Gravel Inlet Protection is applicable where the flow is light to moderate. This method is effective where the inlet is expected to drain shallow sheet flow. The immediate land area around the inlet should be relatively flat (less than 1 percent) and located so that accumulated sediment can be easily removed.

Block and Gravel Inlet Protection is applicable to both drop inlets and curb inlets where heavy flows are expected, and an overflow capacity is necessary to prevent excessive ponding around the structure. Shallow temporary flooding after rainfall however, should be expected.

Sod Drop Inlet Protection is applicable where the drainage area of the drop inlet has been permanently seeded and mulched, and the immediate surrounding area is to remain in dense vegetation. This practice is well suited for lawns adjacent to large buildings.

Rock Ring Inlet Protection is applicable at drop inlets with large drainage areas or at drop inlets that receive high velocity water flows, possibly from many directions.

Rock Pipe Inlet Protection is applicable at pipes with a maximum diameter of 36 inches. This inlet protection may be used to supplement additional sediment traps or basins at the pipe outlet, or used in combination with an excavated sediment storage area to serve as a temporary sediment trap.

Silt fence inlet protection is not allowed, as the failure rate for this type of inlet protection is very high.

Planning Considerations

Inlet protection should be installed at or around all storm drain drop inlets that receive runoff from disturbed areas. Inlet protection should not be used in streams or other natural water resources. It should also not be placed in ditches, swales or other depressions with a depth greater than 1 foot. Due to the high maintenance requirements, inlet protection should be considered secondary sediment controls and not primary sediment controls. These measures should be used in conjunction with other erosion prevention and sediment control measures to be effective. Exercise installation caution so that stormwater runoff cannot back up out adjacent traffic lanes.

Design Criteria

Excavated Drop Inlet Protection (Figure 7.35-1):

- Limit the drainage area to 1 acre. Keep the minimum depth at 1 foot and the maximum depth of 2 feet as measured from the crest of the inlet structure.
- Maintain side slopes around the excavation no steeper than 2:1
- Keep the minimum volume of excavated area around the drop inlet at approximately 3600 ft^3/acre of drainage.
- Shape the sediment storage area to fit site conditions, with the longest dimension oriented toward the longest inflow area to provide maximum trap efficiency.
- Install provisions for draining the temporary pool to improve trapping efficiency for small storms and to avoid problems from standing water after heavy rains.

Hardware Cloth and Gravel Inlet Protection (Figure 7.35-2):

- Ensure that drainage area does not exceed 1 acre per inlet.
- Secure the wire mesh hardware cloth barriers using steel T posts. The posts need to be 1.25 lb/linear ft steel with a minimum length of 5 feet. Make sure the posts have projections to facilitate fastening the hardware cloth. Securely drive each stake into the ground to a minimum depth of 2 feet. The maximum spacing for the posts is 4 feet.
- The wire mesh should be at least a 19-gauge hardware cloth with a ¼ inch mesh opening. The total height should be a minimum of 2 feet. Providing a

flap of hardware cloth on the ground projecting away from the inlet can aid in removal of the stone at the project's completion. Place #57 washed stone to a height of 16 inches on the upstream face of the cloth with an outside slope of 2:1.

- The top elevation of the structure must be at least 12 inches lower than the ground elevation downslope from the inlet. It is important that all storm flows pass over the structure into the storm drain and not bypass the structure. Temporary dikes below the structure may be necessary to prevent bypass flow.

Block and Gravel Inlet Protection (Figure 7.35-3):

- Keep the drainage area no greater than 1 acre unless site conditions allow for frequent removal and adequate disposal of accumulated sediment.
- Keep the height of the barrier at least 12 inches and no greater than 24 inches. Do not use mortar. Limit the height to prevent excess ponding and bypass flow.
- Recess the first course of blocks at least 2 inches below the crest opening of the storm drain for lateral support. Support subsequent courses laterally if needed by placing a 2 x 4-inch wood stud through the block openings that are perpendicular to the block course needing support. Lay some blocks on their side in the bottom row for dewatering the pool.
- Place gravel just below the top of the blocks on slopes of 2:1 or flatter. Place hardware cloth or comparable wire mesh with 1/2-inch openings over all block openings to hold gravel in place.

Sod Drop Inlet Protection (Figure 7.35-4):

- Keep velocity of design flow over the sod area at all points less than 5 ft/sec.
- Place sod to form a turf mat completely covering the soil surface for a minimum distance of 4 feet from each side of the drop inlet where runoff will enter.
- Maintain the slope of the sodded area no greater than 4:1.
- Keep the drainage area no greater than 2 acres; maintain this area undisturbed or stabilize it.

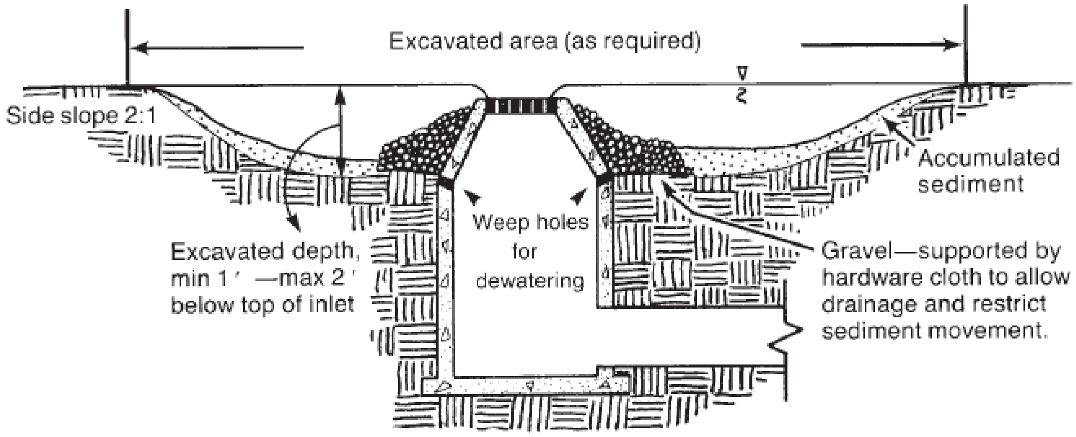
Rock Ring Inlet Protection:

- Place measure at least 30 feet away from vehicular traffic. This inlet protection can be modified to protect one side of the inlet if only one side receives flow.
- Stone – A minimum 1-foot wide level area set 4 inches below the drop inlet crest will add protection against the entrance of material. Structural stone should be Class A-1 riprap with 2:1 side slope, and a minimum crest width of 18 inches. The height of the stone should be from 2 to 3.5 feet. The outside face of the riprap should be covered in a 12-inch thick layer of #5 or #57 washed stone. Wire mesh with 2-inch openings may be placed over the drain grating but must be inspected frequently to avoid blockage by trash.

- The top elevation of the stone structure must be at least 12 inches lower than the ground elevation downslope from the inlet. It is important that all stormwater flow over the structure into the storm drain, and not past the structure. Temporary diking below the structure may be necessary to prevent bypass flow. Material may be excavated from inside the sediment pool for this purpose.

Rock Pipe Inlet Protection (Figure 7.35-5):

- When used in combination with an excavated sediment storage area to serve as a temporary sediment trap, the design criteria for temporary sediment traps must be satisfied. The maximum drainage area should be 5 acres, and 3600 cubic feet of sediment storage per acre of drainage area should be provided.
- The minimum stone height should be 2 feet, with side slopes no steeper than 2:1. The stone “horseshoe” around the pipe inlet should be constructed of Class A-1 or Class B riprap, with a minimum crest width of 3 feet. The outside face of the riprap should be coved with a 12-inch thick layer of #57 washed stone.
- In preparing plans for rock pipe inlet protection, it is important to protect the embankment over the pipe from overtopping. The top of the stone should be a minimum of 1 foot below the top of the fill over the pipe. The stone should tie into the fill on both sides of the pipe. The inside toe of the stone should be no closer than 2 feet from the culvert opening to allow passage of high flows.
- The sediment storage area should be excavated upstream of the rock pipe inlet protection, with a minimum depth of 18 inches below grade.



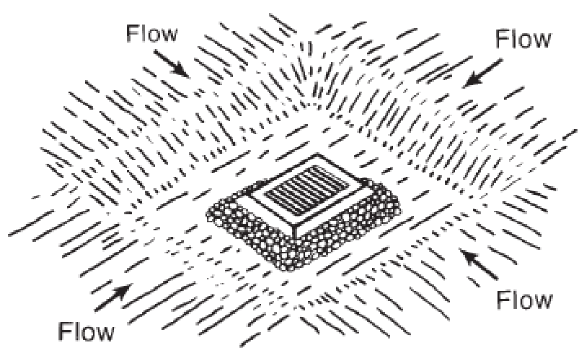


Figure 7.35-1 Excavated Inlet Protection (*Source: NCDENR)*

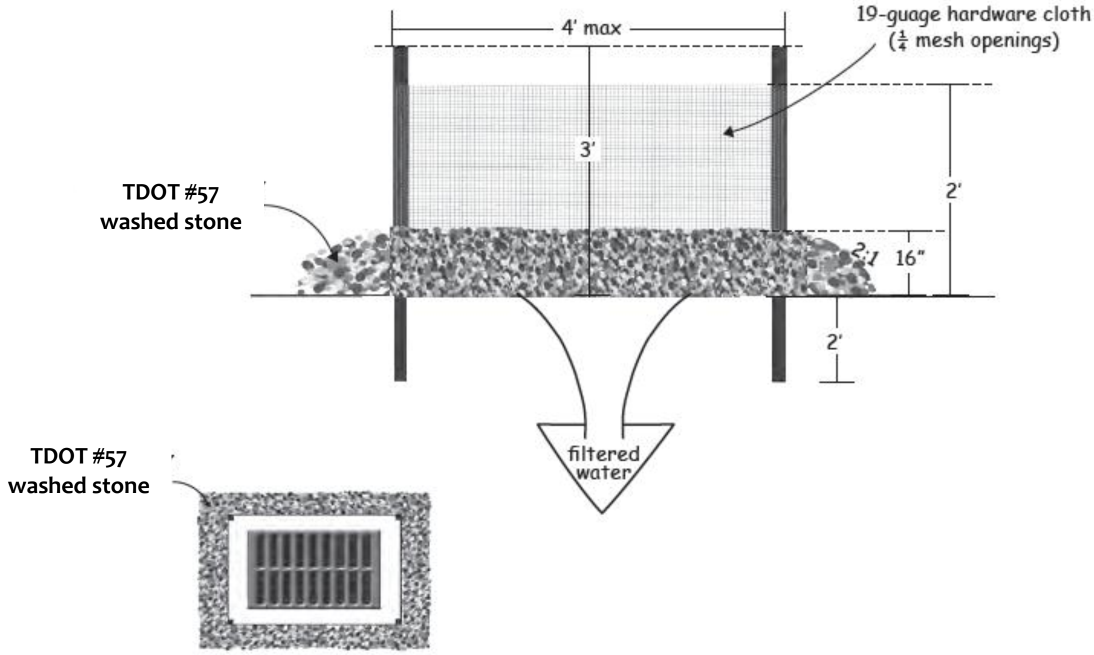


Figure 7.35-2 Hardware Cloth and Gravel Inlet Protection (*Source: NCDENR)*

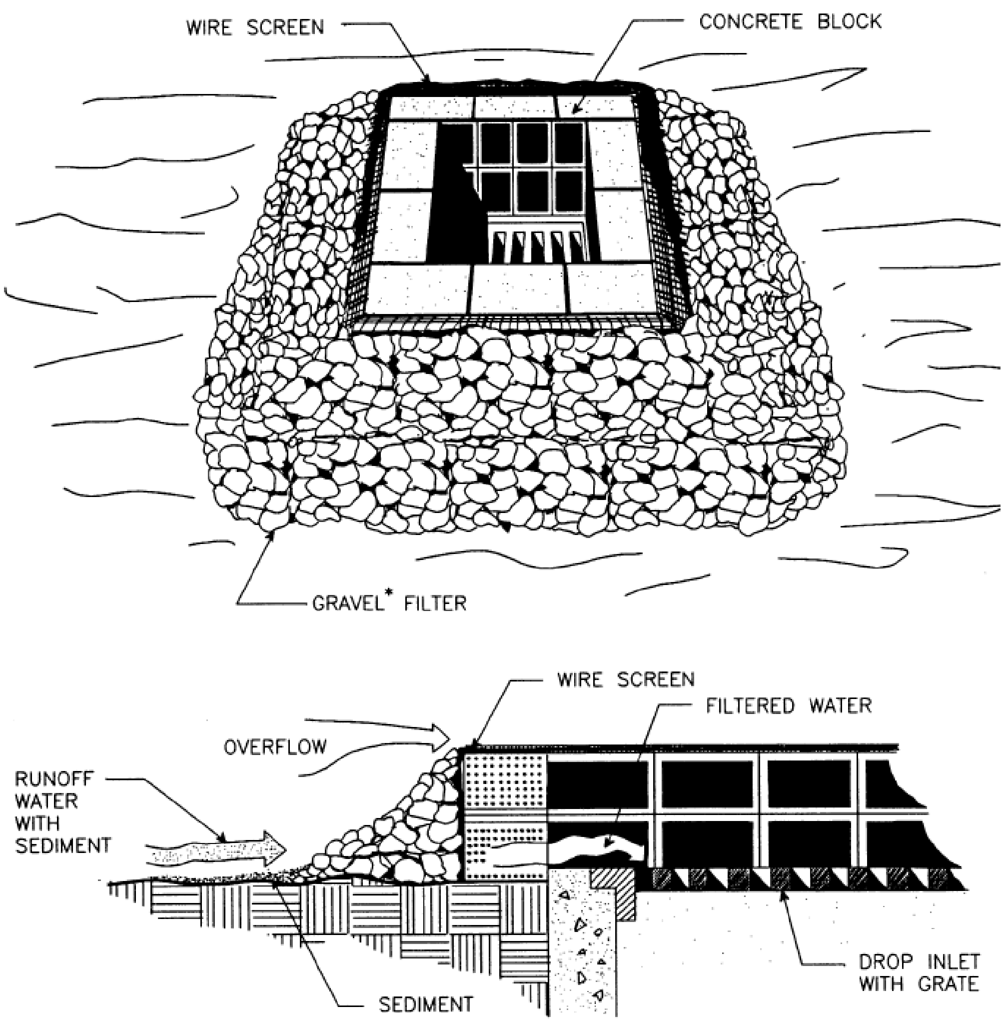


Figure 7.35-3 Block and Gravel Inlet Protection (*Source: VA DSWC)*

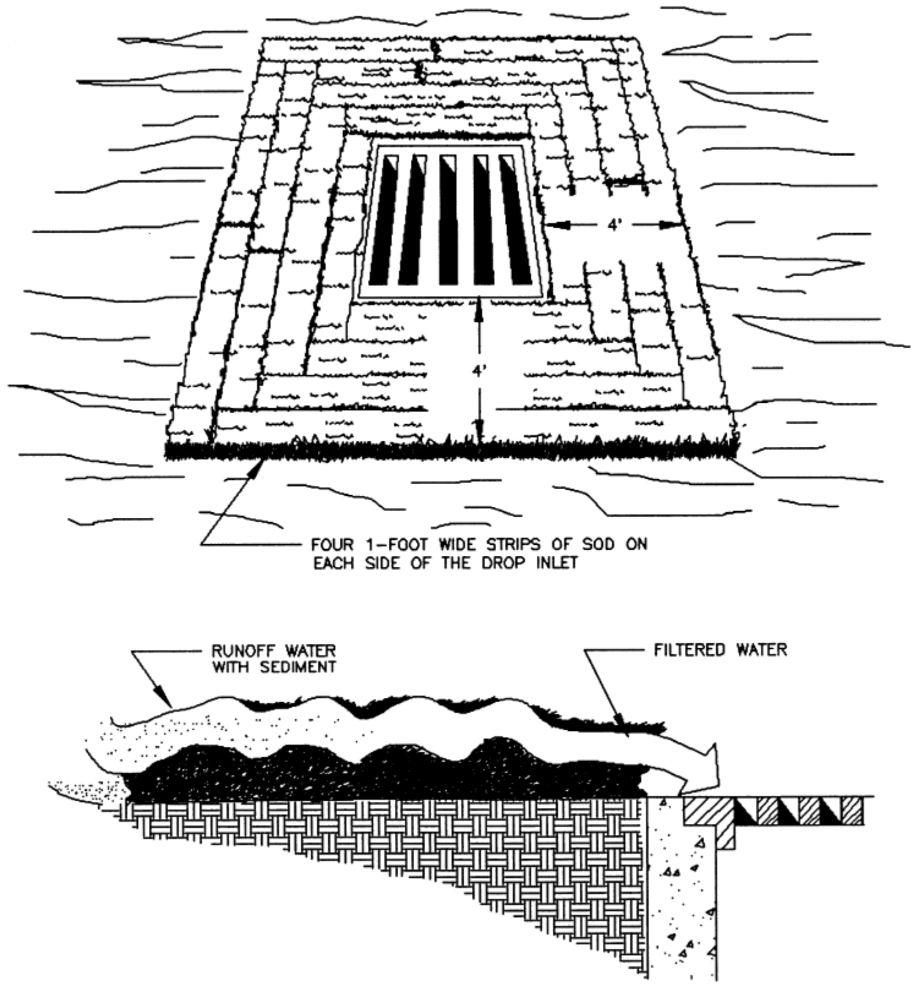


Figure 7.35-4 Sod Inlet Protection Device

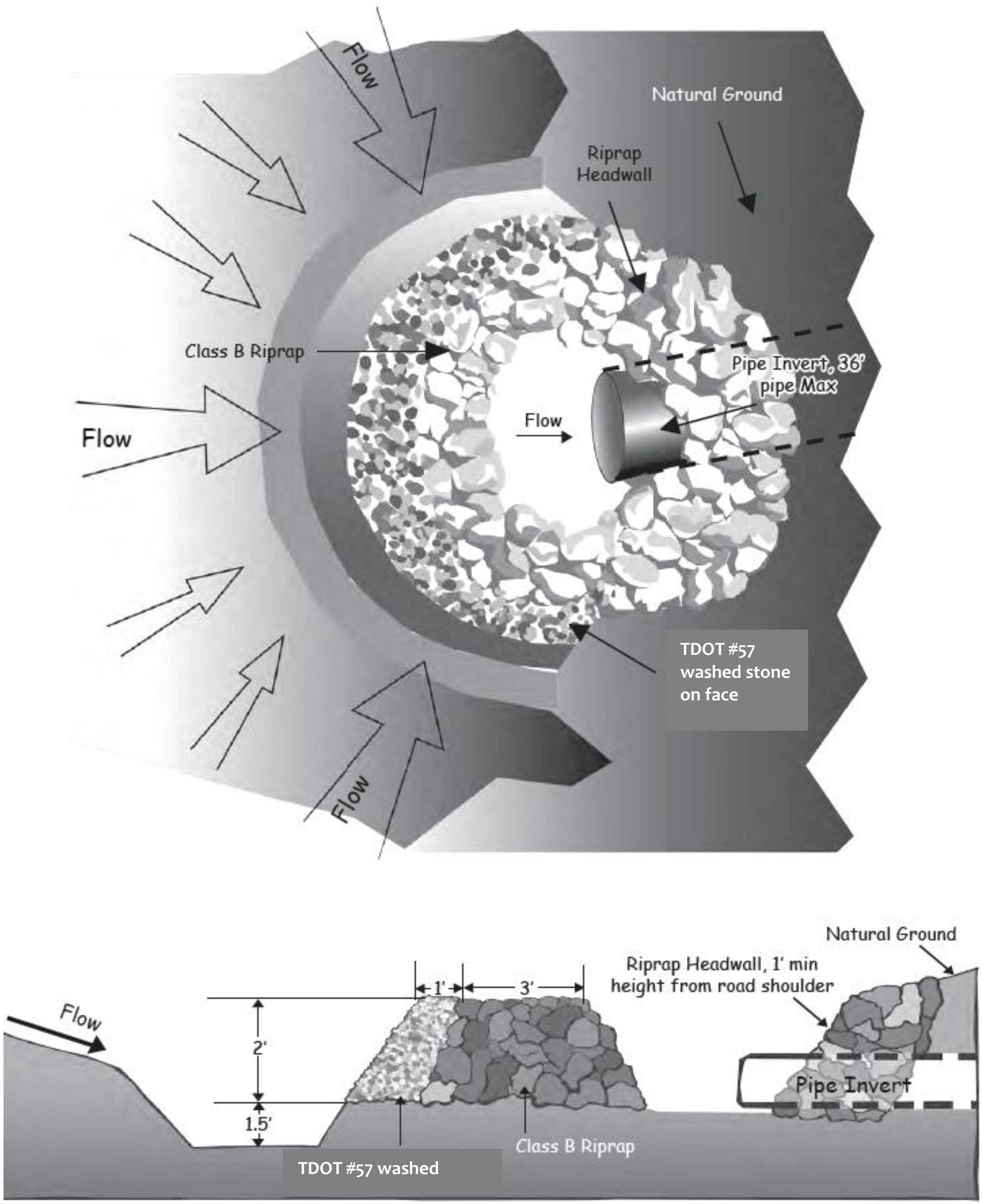


Figure 7.35-5 Rock Pipe Inlet Protection (*Source: NCDENR)*

Construction Specifications

Excavated Drop Inlet Protection:

- Clear the area of all debris that might hinder excavation and disposal of spoil.
- Grade the approach to the inlet uniformly.
- Protect weep holes by gravel.
- When the contributing drainage area has been permanently stabilized, seal weep holes, fill the basin with stable soil to final grading elevations, compact it properly, and stabilize.

Hardware Cloth and Gravel Inlet Protection:

- Uniformly grade a shallow depression approaching the inlet.
- Drive 5-foot steel posts 2 feet into the ground surrounding the inlet. Space posts evenly around the perimeter of the inlet, a maximum of 4 feet apart.
- Surround the posts with wire mesh hardware cloth. Secure the wire mesh to the steel posts at the top, middle, and bottom. Placing a 2-foot flap of the wire mesh under the gravel for anchoring is recommended.
- Place clean gravel (#57 stone) on a 2:1 slope with a height of 16 inches around the wire, and smooth to an even grade.
- Once the contributing drainage area has been stabilized, remove accumulated sediment, and establish final grading elevations.
- Compact the area properly and stabilize it with groundcover.

Block and Gravel Drop Inlet Protection:

- Lay one block on each side of the structure on its side in the bottom row to allow pool drainage. The foundation should be excavated at least 2 inches below the crest of the storm drain. Place the bottom row of blocks against the edge of the storm drain for lateral support and to avoid washouts when overflow occurs. If needed, give lateral support to subsequent rows by placing 2 x 4 wood studs through block openings.
- Carefully fit hardware cloth or comparable wire mesh with ½-inch openings over all block openings to hold gravel in place.
- Use clean gravel, ½- to ¾-inch in diameter, placed 2 inches below the top of the block on a 2:1 slope or flatter and smooth it to an even grade. #57 washed stone is recommended.
- If only stone and gravel are used, keep the slope toward the inlet no steeper than 3:1. Leave a minimum 1-foot wide level stone area between the structure and around the inlet to prevent gravel from entering inlet. On the slope toward the inlet, use stone 3 inches in diameter or larger. On the slope away from the inlet use ½ to ¾-inch gravel (#57 washed stone) at a minimum thickness of 1 foot.

Sod Drop Inlet Protection:

- Bring the area to be sodded to final grade elevation with top soil. Add fertilizer and lime, if necessary.
- Lay all sod strips perpendicular to the direction of flows.
- Keep the width of the sod at least 4 feet in the direction of flows.
- Stagger sod strips so that adjacent strip ends are not aligned.

Rock Doughnut Inlet Protection:

- Clear the area of all debris that might hinder excavation and disposal of spoil.
- Grade shallow depression uniformly towards the inlet with side slopes no greater than 2:1. Grade a 1 foot wide level area set 4 inches below the area adjacent to the inlet.
- Install the Class A-1 or Class B riprap in a circle around the inlet. The minimum crest width of the riprap should be 18 inches, with a minimum bottom width of 7.5 feet. The minimum height of the stone is 2 feet.
- The outside face of the riprap is then lined with 12 inches of #57 washed stone.

Rock Pipe Inlet Protection:

- Clear the area of all debris that might hinder excavation and disposal of spoil.
- Install the Class A-1 or Class B riprap in a semi-circle around the pipe inlet. The stone should be built up higher on each end where it ties into the embankment. The minimum crest width of the riprap should be 3 feet, with a minimum bottom width of 11 feet. The minimum height should be 2 feet, but also 1 foot lower than the shoulder of the embankment or diversions.
- A 1 foot thick layer of #5 or #57 stone should be placed on the outside slope of the riprap.
- The sediment storage area should be excavated around the outside of the stone horseshoe 18 inches below natural grade.
- When the contributing drainage area has been stabilized, fill depression and establish final grading elevations, compact area properly, and stabilize with ground cover.

Maintenance and Inspection Points

Sediment should not be allowed to wash into the inlet. It should be removed from the inlet protection and disposed of and stabilized so that it will not enter the inlet again. Remove sediment from the deposition areas when half the height of the storage area has been filled.

Check measure for damage or evidence of erosion and bypassing around the inlet protection. If inlets are in series, runoff that bypasses an upgradient inlet can overwhelm a downgradient inlet protection device. Sand bags, diversions, or other methods should be used to direct runoff into storm drain inlets.

When the contributing drainage area has been permanently stabilized, all materials and any sediment should be removed, and either salvaged or disposed of properly. The disturbed area should be brought to proper grade, then smoothed and compacted. Appropriately stabilize all disturbed areas around the inlet.

References

TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-11

North Carolina Erosion and Sediment Control Planning and Design Manual

SEDIMENT CONTROL PRACTICES

7.36 CONSTRUCTION ROAD STABILIZATION

CRS

CONSTRUCTION ROAD STABILIZATION

Definition The stabilization of temporary construction access routes, on-site vehicle transportation routes, and construction parking areas.

Purpose To provide a stabilized surface for construction traffic, and to reduce erosion and subsequent re-grading of permanent roadbeds between the time of initial grading and final stabilization.

Conditions Where Practice Applies This practice is applicable where travel ways are needed in a planned land use area or wherever stone-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

Planning Considerations Improperly planned and maintained construction roads can become a continual erosion problem. Excess runoff from roads causes erosion in adjacent areas and an unstabilized road may become a dust problem. Construction vehicle routes are especially susceptible to erosion because they become compacted, and collect and convey runoff water along their surfaces. Rills, gullies, and troublesome muddy areas form unless the road is stabilized.

During wet weather unstabilized dirt roads may become so muddy they are virtually unusable, generating sediment and causing work interruption. Proper grading and stabilization of construction routes often saves money for the contractor by improving the overall efficiency of the construction operation while reducing the erosion problem.

Situate construction roads to reduce erosion potential, following the natural contour of slopes, wet or rocky areas, and highly erosive soils.

Controlling surface runoff from the road surface and adjoining areas is a key erosion control consideration. Generally locate construction roads in areas where seasonally high water tables are deeper than 18 inches. Otherwise, subsurface drainage may be necessary.

When practical, install permanent paved roads and parking areas and use them for construction traffic early during the construction operation to minimize site disruption.

Design Criteria

Location: Temporary roads should be located to serve the purpose intended; facilitate the control and disposal of water; control or reduce erosion; and make the best use of topographic features. Temporary parking areas should be located on naturally flat areas to minimize grading.

Temporary roads should follow the contour of the natural terrain to minimize disturbance of drainage patterns. If a temporary road must cross a stream, the crossing must be designed, installed, and maintained according to specification. **All stream crossings require authorization from the Tennessee Division of Water Pollution Control and United States Army Corps of Engineers prior to construction. For more information, see Appendix C of CGB and:**

http://www.state.tn.us/environment/permits/arap.htm

Grade and Alignment: The gradient and vertical and horizontal alignment should be adapted to the intensity of use, mode of travel, and level of development. Grades for temporary roads should not exceed ten percent except for very short lengths (200 feet or less), but maximum grades of 20 percent or more may be used if necessary for special uses. Frequent grade changes generally cause fewer erosion problems than long continuous gradients. Grades for temporary parking areas should be sufficient to provide drainage but should not exceed four percent.

Curves and switchbacks must be of sufficient radius for trucks and other large vehicles to negotiate easily. On temporary roads, the radius should be no less than 35 feet for standard vehicles and 50 feet for tractor trailers.

Width: Temporary roadbeds should be at least 14 feet wide for one-way traffic and 20 feet wide for two-way traffic. The width for two-way traffic should be increased approximately four feet for trailer traffic. A minimum shoulder width should be two feet on each side. Where turnouts are used, road width should be increased to a minimum of 20 feet for a distance of 30 feet.

Side Slopes: All cuts and/or fills should have side slopes designed to be stable for the particular site conditions and soil materials involved. All cuts and/or fills should be 2:1 or less, to the extent possible. When maintenance by machine mowing is planned, side slopes should be no steeper than 3:1.

Drainage: The type of drainage structure used will depend on the type of activity and runoff conditions. The capacity and design should be consistent with sound engineering principles and should be adequate for the class of vehicle, type of road, development, or use. Structures should be designed to withstand flows from a 25-year, 24-hour frequency storm. Ditches should be designed to be on stable grades and/or protected with structures or linings for stability.

Stabilization: A 6-inch layer of coarse aggregate, such as TDOT #57, should be applied immediately after grading or the completion of utility installation within the right-of-way. In areas experiencing heavy traffic, stone should be placed at an 8 to 10 inch depth to avoid excessive dissipation or maintenance needs.

Geotextile: Geotextile should be applied beneath the stone for additional stability.

All roadside ditches, cuts, fills, and disturbed areas adjacent to parking areas and roads should be stabilized with appropriate temporary or permanent seeding or with rock armoring.

Permanent Roads and Parking Areas
Permanent roads and parking areas should be designed and constructed according to criteria established by the local authority and TDOT. Permanent roads and parking areas should be stabilized in accordance with this specification, applying an initial base course of gravel immediately following grading.

Construction Specifications

- Trees, stumps, brush, roots, weeds, and other objectionable material should be removed from the work area.
- Unsuitable material should be removed from the roadbed and parking areas.
- Ensure that road construction follows the natural contours of the terrain if possible.
- Locate parking areas on naturally flat areas, if they are available. Keep grades sufficient for drainage, but generally not more than 2 to 3 percent.
- Grading, subgrade preparation, and compaction should be done as needed. Fill material should be deposited in layers not to exceed 9 inches and compacted with the controlled movement of compacting and earth moving equipment.
- Provide surface drainage, and divert excess runoff to stable areas by using water bars or turnouts.
- Keep cuts and fills at 2:1 or flatter for safety and stability and to facilitate the establishment of vegetation and maintenance.
- Spread, at minimum, a 6 inch course of TDOT #57 stone evenly over the full width of the road and smooth to avoid depressions.
- Where seepage areas or seasonally wet areas must be crossed, install subsurface drains or geotextiles fabric cloth before placing the crushed stone.
- Vegetate all roadside ditches, cuts, and fills, and other disturbed areas or otherwise appropriate stabilization as soon as grading in complete.
- Structures such as culverts, pipe drops, or bridges should be installed to the lines and grades shown on the plans or as staked in the field. Culverts should be placed on a firm foundation. Selected backfill material should be placed around the culvert in layers not to exceed 6 inches. Each layer should be properly compacted.

Maintenance and Inspection Points

Add top dressing of stone to roads and parking areas to maintain a gravel depth of 6 inches.

Remove any silt or other debris causing clogging of roadside ditches or other drainage structures.

Treat sediment-producing areas immediately.

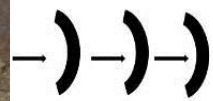
References

TN Department of Transportation

North Carolina Erosion and Sediment Control Planning and Design Manual

SEDIMENT CONTROL PRACTICES

7.37 TUBES AND WATTLES



TUBES, WATTLES, SOCKS

Definition A small temporary sediment barrier constructed to intercept sheet flow. In this application, wattles and tubes are primarily sediment control measures. Section 7.25 discusses wattles as erosion control measures used in concentrated flow applications.

Purpose To interrupt flow, decrease velocities, pond water and allow runoff-produced sediment to settle out behind barrier.

Conditions Where Practice Applies This practice is applicable along or on the ground contour or at the toe of slopes and aids in sediment retention. While they are generally used at regular intervals on a slope, they may also be placed at the top or toe of the slope, or at breaks in grade. In addition, they may be placed on or around the perimeter of soil stockpiles or around catch basin inlets.

Planning Considerations The stability of tubes, wattles, and socks are very dependent upon proper staking. Thus, they may not be utilized on pavement, rocky soil or at any location where the stakes cannot be driven to the required depth.

Design Criteria When applied on slopes, temporary sediment tubes should be placed along the contour, and the ends of the tubes should be turned upslope in order to prevent erosion which could occur as flow bypasses around the ends of the row. This will force the discharge to overtop the row away from the end points. The spacing between rows of tubes should be based on Table 7.37-1. The maximum drainage area to a wattle is ¼ acre per 100 linear feet of wattle.

Table 7.37-1 Wattle and Tube Spacing Table for Slope Application

Slope	Wattle and Tube Diameter				
	8”	12”	18”	20”	24”
2%	70’	100’	N/A	N/A	N/A
5%	30’	60’	100’	100’	100’
10%	20’	30’	70’	85’	100’
6:1	N/A	20’	40’	50’	55’
4:1	N/A	20’	30’	30’	30’
3:1	N/A	N/A	20’	20’	25’
2:1	N/A	N/A	20’	20’	20’

The size of a sediment tube for a slope application should be selected based on the gradient and length of the slope. In general, larger tube diameters should be selected for steeper or longer slopes.

Where long rows are required on a slope, the ends of the individual tube segments should be overlapped as shown on the standard drawing. This will ensure that gaps will not occur between individual tube segments, allowing sediment-laden water to escape the measure. Tube/wattle netting should be a knitted material with 1/8 to 3/8 inch openings and made of photodegradable (polypropylene, HDPE) or biodegradable (cotton, jute, coir) material.

Construction Specifications

Proper site preparation is essential to ensure sediment wattles and tubes are in complete contact with the underlying soil or underlying surface. Remove all rocks, clods, vegetation or other obstructions so installed sediment tubes have direct contact with the underlying soil or surface.

Install tubes by laying them flat on the ground. Excavate a small trench 2-3 inches in depth on the contour and perpendicular to water flow. Soil from the excavation should be stored close by for use after the wattle has been installed.

Install tubes so no gaps exist between the soil and the bottom of the sediment tube. Lap the ends of adjacent sediment tubes a minimum of 6-inches to prevent flow and sediment from passing through the field joint.

Wooden stakes should be used to fasten the wattles to the soil. When conditions warrant, a straight metal bar can be used to drive a "pilot hole” through the wattle and into the soil.

Drive wooden stakes through the wattle and angled slightly against the direction of flow (see figure 7.37-1). Install wooden stakes at 4 feet intervals, unless the wattle manufacturer specifies otherwise, leaving less than 1-2 inches of stake exposed above the wattle. Alternately, stakes may be placed on each side of the wattle tying across with a natural fiber twine or staking in a crossing manner ensuring direct soil contact at all times.

Terminal ends of wattles may be dog legged up slope to ensure containment and prevent channeling of sedimentation.

Backfill the upslope length of the wattle with the excavated soil and compact.

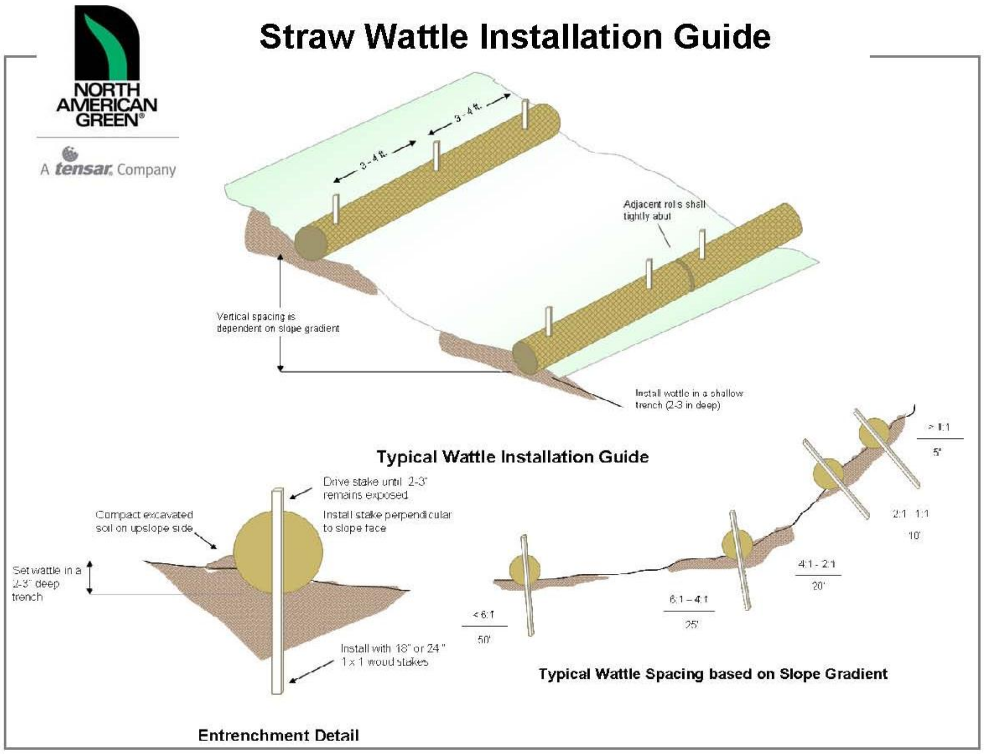


Figure 7.37-1 Wattle Stake Installation

Care shall be taken during installation so as to avoid damage occurring to the wattle as a result of the installation process. Should the wattle be damaged during installation, a wooden stake shall be placed either side of the damaged area terminating the log segment.

Maintenance and Inspection Points

Inspect wattles and tubes after installation for gaps under and between the joints of adjacent ends of wattles and tubes.

Repair all rills, gullies, and undercutting near wattles and tubes.

Remove all sediment deposits that impair the filtration capability of the tubes when the sediment reaches 1/3 the height of the exposed tube.

Remove and/or replace installed sediment tubes as required to adapt to changing construction site conditions.

Prior to final stabilization, backfill all trenches, depressions and other ground disturbances caused by the removal of the devices.

References

TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-31

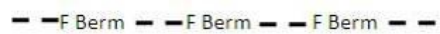
South Carolina DHEC Stormwater Management BMP Handbook

US Department of Transportation Federal Highway Administration, Western Federal Lands Highway Division, Sediment Wattle Detail WM157-20

Earth Savers, http://www.earth-savers.com/

SEDIMENT CONTROL PRACTICES

7.38 FILTER BERM



FILTER BERM

Definition Filter berms are a linear sediment trapping measure composed either of wood chips (mulch) or a 50/50 combination of wood chips and compost material.

Purpose To reduce runoff flow velocities so that eroded sediments can be settled upstream of the filter, and to act as a filter as runoff passes through the materials in the berm.

Conditions Where Practice Applies Filter berms may be applied on any slope along the contour where runoff can be expected to be in the form of sheet flow. Usually, this will be on slopes less than 300 feet in length or at the toe of a given slope. Filter berms may also be used where silt fence would not be feasible due to exposed rock or other conditions which would prevent the fence from being trenched in.

However, care should be taken in locating filter berms, as mulch material is easily floated away in runoff. Mulch berms are most appropriate treating very small drainage areas.

Planning Considerations This measure consists of un-compacted buoyant materials and tends to be moved by concentrated flows. Thus, filter berms should be used only where sheet flow conditions are expected. They cannot treat flows in gullies, ditches, or channels. Mulch berms may require the addition of structural components, such as silt fence or wattles, to prevent movement of mulch.

Design Criteria Detailed design of this measure is not required; however, when filter berms are specified, the following standards should be used.

- Compost is a manufactured product which should be acquired from an approved supplier. Thus, the cost of bringing this material to the job site may be a factor at some locations. Wood chips, on the other hand, can be produced on-site as a byproduct of site clearing activities. The choice of measure (mulch berm, compost berm, etc.) to be applied at a given site should be based on the availability and relative costs of the required materials.

- The filter berm shall be at least 1.5’ in height and 3’ wide at the base.

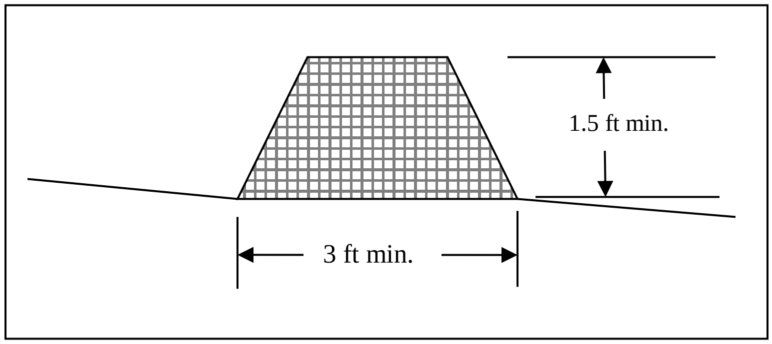


Figure 7.38-1 Filter Berm Dimensions

- The drainage area upstream of a filter berm should be less than ¼ acre per 100 linear feet of berm. On long slopes where this limit would be exceeded, structural components, such as silt fence and wattles, should be installed on the upgradient side of the filter berm. The fence or wattle will prevent excessive hydraulic forces from displacing the material in the berm, while the filter berm provides increased filtration of runoff passing through the fence.

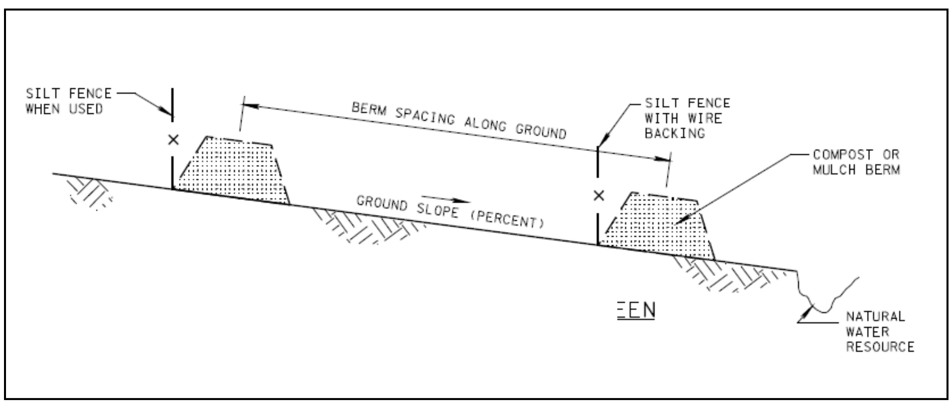


Figure 7.38-2 Mulch Berm with Silt Fence with Backing

- Both ends of a run of filter berm should be turned up-slope to a point where the base of the berm at the terminus points will be higher than the top of the berm anywhere along the contour.

- The material used to construct a filter berm should be well-graded. Usually, the particles in a berm will range in size from ¼ inch to 6 inches in length. The smaller particles serve to increase the effectiveness of the measure as a filter while the larger particles help to increase its stability under the pressure exerted by the runoff.

Construction Specifications

- Filter berms should be trapezoidal in shape and installed along the contour by means of pneumatic blowers or by other suitable equipment. It is important that a berm be placed along the ground contour as they will be sensitive to failure due to concentration of flows. Runoff must be intercepted on the contour to insure that sheet flow is not converted into concentrated flow. When placed at the base of a slope, the berm should be located at least 10 feet away from the toe in order to provide an area for the storage of sediments. As a general rule, steeper slopes would require a larger berm size. In addition, the bottom width of a berm should be about twice its height.
- The material in a mulch filter berm usually will not support vegetation; therefore, these berms should not be seeded with either temporary or permanent seed. A compost filter berm will support vegetation if the material is properly graded and the portion of compost is 65% or less. Compost materials with greater percentages of organic matter usually contain more nutrients than required by the seeded grasses.
- A compost filter berm which has been seeded can be left in place as a permanent feature as long as the structure is stable against erosion and movement from water.

Maintenance and Inspection Points

Routinely inspect filter berms and maintain to a functional condition throughout construction. Install additional filter material if necessary. Upon project completion, disperse or remove the berm.

Remove sediment from behind the filter berm when it has accumulated to ½ the original height of the structure.

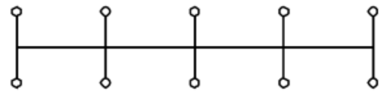
References

TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-35

SEDIMENT CONTROL DEVICES

7.39 TURBIDITY CURTAIN



Definition An in-stream sediment control measure designed to trap or filter sediment without halting the movement of the water itself. This device consists of a filter fabric curtain suspended from floats and held vertically in the water by means of a bottom ballast chain.

Purpose To provide an isolated work zone where sediments generated by the project can settle. In this way, it prevents the migration of these sediments into the larger remaining water body.

Conditions Where Practice Applies Floating turbidity curtains may be applied adjacent to the shoreline of a river or lake to contain sediments which may be carried into the water by construction site runoff. They should be considered only where adequate or conventional on-shore sediment control measures are not feasible or possible. They may also be used to surround a work site within the channel of a river (i.e. bridge pier construction, dredging or filling) or within a larger water body in order to prevent worksite sediments from being dispersed.

Planning Considerations Any work in a stream, river or lake requires approval by TDEC and the Corps of Engineers. To minimize the impact to the resource, the in-stream construction period should be minimized and should be conducted during periods of low flow.

- Turbidity curtains should not be applied where the anticipated flow velocities will exceed 5 ft/sec. In addition, turbidity curtains are not designed as prefabricated dams; and therefore, should not be used across flowing streams.
- In ponds and lakes, large changes in stage can cause the curtain to become submerged or to be damaged. This measure is best applied in situations or during periods of time when anticipated changes in the water surface elevation will be minimal. Also, wave action from boats or wind can significantly reduce the effectiveness of a floating turbidity curtain.

Design Criteria

A floating turbidity curtain consists of a geotextile filter cloth with sufficient permeability to allow flow to pass through while retaining sediments. The cloth is suspended from floats which are anchored into place to maintain the shape and location of the barrier. A ballast chain is included in a pocket at the bottom of the curtain to help hold the cloth in a vertical position and to provide tensile strength when the material is stressed.

The curtain is formed by joining segments of geotextile fabric which are 50 to 100 feet long, and an anchor (consisting of two weights, cables and floats) should be placed at each joint in the fabric. Additional anchors may be utilized, depending upon the anticipated flow velocities or wave action, based on manufacturer recommendations. At a minimum, each end of the curtain should be provided with an on-shore anchor and two anchors would be required in the water.

The designer should consider the morphology of the river in evaluating the anticipated flow velocities at a proposed turbidity curtain site. Where a river runs a straight course, flow velocities adjacent to shore are usually much lower than the velocities in the center of the channel. On the other hand, flow velocities can be very high on the outside of a bend in the river. The measure should not be applied where the anticipated flow velocities will exceed 5 ft/sec.

Proper consideration should be given to safety measures at locations where boat traffic may be present. Usually, this is addressed by providing floats with a bright yellow or orange color and by providing lighted marker buoys for night time use. The Corps of Engineers, TVA, or other regulating agency may require the use of lighted buoys on navigable waterways.

Construction Specifications

The floating turbidity curtain **must not** be installed perpendicular across the main flow of a significant body of moving water.

When applied in a river, a floating turbidity curtain should be installed parallel to the shore such that it would not intercept the main force of the current.

The turbidity curtain must be anchored to prevent drift shoreward or downstream. Anchorage should be installed on both shore and stream side. The curtain should be located as close as possible to the project, while allowing sufficient room for any equipment which must work in or near the water.

The bottom of the curtain should be approximately 12 inches above the bottom of the lake or river to prevent the bottom of the curtain from being buried by retained sediments, and in turn, reduce the quantity of sediment released into the water when the curtain is removed.

In situations where significant wave action is anticipated, either as the result of wind or boat traffic, the depth of the curtain should be no greater than 12 feet. This will prevent stresses in the fabric from becoming excessive as it billows with the force of the waves.

In shallow water (2 feet in depth of less) a turbidity curtain may be installed on stakes driven into the bed of the water body.

When installed in a navigable waterway, buoys should be lit according to regulatory agency standards.

Maintenance and Inspection Points

Maintain a 12 inch minimum gap between the skirt bottom and channel bottom to prevent accumulated sediment from pulling the top of the curtain below the water surface.

The turbidity curtain and adjacent work areas should not be disturbed 12 hours prior to removal of the curtain from the water body. Maintenance should be performed as needed. The curtain should be removed upon completion of the work in a manner that will prevent siltation of the waterway. During removal extreme care should be taken to not disturb any sediment deposits.

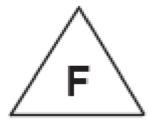
References

TDOT Design Division Drainage Manual

TDOT Erosion Control Standard Drawing EC-STR-38

SEDIMENT CONTROL PRACTICES

7.40 FLOCCULANTS



FLOCCULANT

Definition Flocculation is the chemical process of causing small, suspended soil particles to stick to each other to form “flocs”. These flocs more readily settle out compared to the individual particles.

Purpose To promote the formation of flocculants in an effort to treat storm water so that suspended clays and fine silts will settle out of the water quickly before leaving the construction site. To reduce the time required to settle out smaller soil particle sizes.

Conditions Where Practice Applies This temporary application is not intended for application to surface waters of the state. It is intended for application on construction sites where construction stormwater feeds into pre-constructed sediment ponds, basins or other settling areas.

Water discharged from sediment control measures can have high concentrations of suspended clays and fine silts that are very difficult to settle out. There are three ways to reduce suspended sediment: (1) store the runoff long enough for the materials to settle, (2) store and filter runoff, or (3) treat water with chemical flocculants. Filtering water can be high maintenance and expensive. The most practical and least expensive option for most situations is flocculation. Flocculants should be used to prevent damage to water resources. However, sediment at each site has to be evaluated individually for responsiveness to flocculants, as flocculant use is very soil-type dependent and requires a screening process to determine the best chemical for each specific location.

Planning Considerations

PAM is a term describing a wide variety of chemicals based on the acrylamide unit. When linked in long chains, a portion of the acrylamide units can be modified to result in a net positive, neutral, or negative charge on the PAM molecule. The positively charged (cationic) PAMs are not widely used because they can be toxic to fish and other aquatic organisms if they enter water bodies in sufficient concentrations. **Cationic PAMs are not allowed in TN.**

The negatively charged (anionic) PAMs are much less toxic to aquatic organisms and are widely used in furrow irrigation agriculture. This is the type of PAM which is commonly allowed for use in stormwater treatment. Anionic PAM is available in emulsions, powders, gel bars and logs. Other management practices must be used in combination with anionic PAM.

When including PAM as a treatment option on a project, the following items must be addressed:

- All PAM applications require prior review by TDEC.
- Areas where PAM has been applied must drain to a sediment basin or trap for final settling and polishing prior to discharging from the site.
- Adequate mixing is necessary for PAM to be fully effective. Passive treatment using the turbulent flow of water in a channel or at the outlet of a pipe as the mixing method is encouraged.
- PAM effectiveness decreases with exposure rain events. Reapplication is likely necessary after 2 storm events.
- PAM is water soluble, but it dissolves slowly and requires considerable agitation and time to dissolve.
- Soil tests are required to ensure that the PAM is matched with the soil.
- Follow the manufacturer's application or dosage rates and application instructions for site sediment conditions.

Design Criteria

PAMs mixed with water having high suspended solid loads can greatly reduce turbidity and suspended solid concentrations. It may be used in a dewatering operation discharge from borrow pits or construction excavations, from discharged settling ponds, or from stormwater from land disturbance. It is critical that an application system be in place that minimizes the chances of malfunctions that could result in over-application of PAMs and subsequent adverse effects to aquatic life. It is especially important to be cautious near sensitive streams, such as those classified as exceptional or outstanding national resource waters.

In using any form of PAM, several basic guidelines shall be followed:

1. Only use PAM after all appropriate physical BMP's have been implemented at a particular site.
2. PAMs shall not be applied directly to streams, wetlands and other waters of the state.
3. A sediment basin or similar structure between the application point of PAMs and surface waters is required. PAM cannot be applied downgradient from the sediment basin or sediment trap.

4. Choose the appropriate PAM for the soil type.
5. Ensure PAM emulsions and powders are of the **anionic type only** and meet the following requirements:
    a. Meets the EPA and FDA acrylamide monomer limits of equal to or greater than 0.05% acrylamide monomer.
    b. Has a density of 10% to 55% by weight and a molecular weight of 16 to 24 Mg/mole.
    c. Mixture is non-combustible.
    d. Contains only manufacturer-recommended additives.
6. PAM shall be mixed and/or applied in accordance with all Occupational Safety and Health Administration (OSHA) Material Safety Data Sheet (MSDS) requirements and the manufacturer's recommendations for the specified use conforming to all federal, state and local laws, rules and regulations.
7. All vendors and suppliers of PAM, PAM mix or blends shall present or supply a written toxicity report which verifies that the PAM, PAM mix or blend exhibits acceptable toxicity parameters which meet or exceed the EPA requirements for the state and federal water quality standards. Whole effluent testing does not meet this requirement as primary reactions have occurred and toxic potentials have been reduced. This document shall be a component of the field SWPPP.
8. Cationic forms of PAM are not allowed for use due to their high levels of toxicity to aquatic organisms. Emulsions shall never be applied directly to streams or wetlands due to surfactant toxicity.
9. Emulsion batches shall be mixed following recommendations of a testing laboratory that determines the proper product and rate to meet site requirements. Application method shall insure uniform coverage to the target area**.**
10. Dry form (powder) may be applied by hand spreader or a mechanical spreader. Mixing with dry silica sand will aid in spreading. Pre-mixing of dry form PAM into fertilizer, seed or other soil amendments is allowable. Application method shall ensure uniform coverage to the target area.
11. Block or log forms shall be applied following site testing results to ensure proper placement and performance and shall meet or exceed state and federal water quality requirements. Place anionic gel logs upstream from the inlet to ponds and traps on-site, or other locations where flow and mixing are optimal. Logs or blocks must be installed upgradient from the sediment basin or trap.
12. PAM application must occur upstream such that at least 60 seconds of mixing time occurs <u>prior</u> to discharging to a sediment basin or trap.

Construction Specifications

One of the key factors in making a flocculant work is to ensure that it is dissolved and thoroughly mixed with the runoff water, which can be accomplished in several ways. Introducing the PAM to the runoff at a point of high velocity will help to provide the turbulence and mixing needed to maximize the suspended sediment exposure to the large PAM molecules. Examples include a storm drain junction box where a pipe is dropping water, inside a slope drain, or other areas of falling or fast moving water upslope from a sediment trap or basin.

Another option for introducing PAM into runoff involves running the water over a solid form of PAM. Powders can be sprinkled on various materials, such as jute, coir, or other geotextiles. When wet, PAM granules become very sticky, and bind to the geotextile fabric. The product binds to the material, and resists removal by flowing water rendering it ineffective for turbidity control. PAM' may also be purchased as solid blocks or logs. The logs are designed to be placed in flowing water to dissolve the PAM from the log somewhat proportionately to flow. While using these solid forms of PAM does not have the same challenges as liquid forms, they do have drawbacks. The amount of PAM released is not adjustable and is generally unknown, so the user has to adjust the system by moving or adding logs to get the desired effect. Because the PAM is sticky when wet, it can accumulate materials from the runoff and become coated, releasing little PAM. The solid forms also tend to harden when allowed to dry. This causes less PAM to be released initially during the next storm until the log becomes moist again.

To avoid these problems, the user must do two things to ensure PAM releases from the solid form:

- Reduce sediment load in the runoff upstream of the PAM location. This avoids burying the PAM under accumulated sediment.
- Create constant flow across or onto the solid PAM. The flow will help dissolve and mix the PAM as well as prevent suspended solids from sticking to the PAM product.

Once the PAM is introduced into the runoff and thoroughly mixed, the runoff needs to be captured in a sediment trap or basin in order for the flocs to settle out. It is important that the inlet of this structure be stabilized with geotextile or stone to prevent gully erosion at the upper end of the basin. Such erosion can contribute significantly to the turbidity in the basin and overwhelm the treatments. Other modifications may also be useful such as installing baffles across the basin or dewatering from the surface using a skimmer or similar device.

Maintenance and Inspection Points

Dosing systems using pumps should be checked daily.

Floc logs should be checked at least once a week or after a rainfall event of ½" or greater to ensure the logs remain in place, are moist, and are not covered with sediment.

References

North Carolina Erosion and Sediment Control Planning and Design Manual

STREAM PROTECTION PRACTICES

7.41 STREAM BUFFERS

STREAM BUFFER
DO NOT DISTURB

Definition A stream buffer is a non-structural low impact development control in areas along a stream or wetland where disturbance is restricted or prohibited.

Purpose A stream buffer's primary function is to physically protect and separate a stream or wetland from future disturbance or encroachment. It is **not** a sediment control.

Conditions Where Practice Applies All construction sites containing and/or adjacent to receiving streams or waters are required to have stream buffers between the top of the stream bank and the disturbance.

Planning Considerations Effective stream buffers consist of undisturbed natural vegetation, including maintaining the original tree line along the stream or channel banks. Promptly stabilize disturbed buffers with a dense cover of strong rooted grasses, native plants and native trees.

Construction related materials and equipment must be stored outside the buffer area.

Other municipalities and counties may have more restrictive requirements for the width or maintenance of a stream buffer. The more restrictive stream buffer requirements shall apply.

Design Criteria For sites that contain and/or are adjacent to a receiving stream designated as impaired or Exceptional Tennessee waters a 60-foot natural riparian buffer zone adjacent to the receiving stream shall be preserved, to the maximum extent practicable, during construction activities at the site. The natural buffer zone should be established between the top of stream bank and the disturbed construction area. The 60-feet criterion for the width of the buffer zone can be established on an average width basis at a project, as long as the minimum width of the buffer zone is more than 30 feet at any measured location.

A 30-foot natural riparian buffer zone adjacent to all streams at the construction site shall be preserved, to the maximum extent practicable, during construction activities at the site. The riparian buffer zone should be preserved between the top of stream bank and the disturbed construction area. The 30-feet criterion for the width of the buffer zone can be established on an average width basis at a project, as long as the minimum width of the buffer zone is more than 15 feet at any measured location.

For optimal stormwater treatment, it is recommended that concentrated flow be converted into sheet flow through the use of a level spreader prior to discharging into the buffer. Concentrated flow can cause erosion in the buffer.

Construction Specifications

Install controls along the outer upstream edge of the stream buffer to prevent inadvertent disturbance to the buffer. Consider high visibility controls, such as fencing.

Where a stream crossing is necessary, comply with the conditions of the Aquatic Resource Alteration Permit for the amount of stream buffer that can be disturbed.

Ensure that sediment controls are installed upgradient from the buffer to protect it from sediment-laden runoff.

Install level spreaders to convert concentrated flow into sheet flow prior to discharging across the buffer.

If a buffer is disturbed, the buffer should be restored as follows:

1. All areas of the buffer being restored must be planted with native or natural vegetation that is appropriate to achieve a stable stream protection corridor, including tree canopy.
2. All areas of the buffer being restored must be stabilized against erosion.
3. During restoration activities, erosion prevention and sediment control measures must be installed to protect the stream. These measures can include turf reinforcement mats, erosion control blankets, wattles, etc., to stabilize the area in the short- and long-term.
4. To increase the chances for the success and health of the buffer, the plant species, density, placement, and diversity in the buffer restoration plan must be appropriate for stream buffers. Proposed planting and long-term maintenance practices must also be appropriate and properly performed.
5. Vegetation mortality must be included in the planting densities in buffer restoration plans.

More detailed information on streambank and buffer restoration techniques, planting guidelines and native plant species can be found from the following sources:

- Tennessee Valley Authority's Riparian Restoration webpage, located at www.tva.com/river/landandshore/stabilization/index.htm

- Tennessee Valley Authority's Native Plant Finder webpage, located at www.tva.com/river/landandshore/stabilization/plantsearch.htm;
- Banks and Buffers: A guide to selecting native plants for streambanks and shorelines. Contact information to obtain this publication is provided at www.tva.com/river/landandshore/stabilization/websites.htm;
- The Tennessee Native Plant Society at www.tnps.org
- The Tennessee Exotic Plant Pest Council website, located at www.tneppc.org; and
- The Natural Resource Conservation Service (NRCS).

Maintenance and Inspection Points

Inspections must focus on stability of the buffer. No disturbance of the buffer is allowed unless accounted for in the overall plan and a minimum average buffer width is provided, as noted above.

During inspections, ensure that buffer boundaries are well defined and clearly marked.

Where erosion in the buffer is identified, measures shall be taken to halt the erosion and repair the buffer.

Where the buffer is disturbed, a buffer restoration plan shall be developed and included in the SWPPP.

References

South Carolina DHEC Storm Water Management BMP Handbook

North Carolina Sediment and Erosion Control Planning and Design Manual

Knox County Stormwater Manual

STREAM PROTECTION PRACTICES

7.42 STREAM DIVERSION

Definition

A stream diversion is a temporary diversion constructed to convey stream flow around in-stream construction.

Purpose

Stream diversion channels are required by Aquatic Resource Alteration Permits in order to perform in-stream work separate from flowing water.

Conditions Where Practice Applies

Construction often includes stream crossings thus creating a potential for excessive sediment loss into the stream, by both the disturbance and approach areas, and by work within the streambed and banks.

Stream diversions separate the flowing stream from the active construction area, reducing the potential for impacts from the instream construction activity.

Planning Considerations

Disturbance within the confines of stream banks are required to be conducted “in the dry” or separate from flowing water. No excavation equipment should ever be operated in flowing waters.

In cases where in-stream work is unavoidable, a stream diversion should be considered to prevent excessive damage from sedimentation. To limit land-disturbance, overland pumping of the stream should be considered in low-flow conditions whenever possible.

Temporary pipes can also convey smaller stream flows.

Some streams are too large to construct a diversion channel of pipe. In those cases, consider the use of alternative structures, such as cofferdams and geotextile tubes, in order for work to be conducted in dry conditions.

There may be certain times of the year, especially in the summer, when rip rap or fabric-lined diversion channels may cause thermal pollution.

The duration of the instream work should be minimized to the shortest period possible. Clearing of the streambed and banks should be kept to a minimum.

Work that requires a stream diversion channel requires authorization from the Tennessee Division of Water Pollution Control and United States Army Corps of Engineers. All conditions of the ARAP and COE permit must be followed.

Design Criteria

Professionals familiar with the design of water conveyance systems should prepare construction plans and drawings for this technique. Several methods of diverting a stream are detailed below. There may be certain seasonal components to consider when attempting flow diversion of a stream, such as spawning times of individual fish species. Several other methods can be used to temporarily divert stream flows around an active work area. Regardless of the type of stream diversion chosen, the capacity of the diversion shall be designed to be equivalent to the bankfull capacity of the existing channel.

Bypass Pumping

A bypass pump and an impervious dike divert the flow of the watercourse from the inlet of the pipe to the outlet of the pipe (Figure 7.42-1). This is a water-to-water operation and care should be taken that the discharge is at a low flow rate to minimize turbidity and/or potential erosion of the stream channel at the outlet of the bypass pipe or hose. Use this practice when another type of diversion is not physically possible or practical or when the construction activities will not require pumping for an extended period. Do not use this practice when the discharge location cannot be adequately stabilized; when ponding of the stream to adequately submerge the pump suction line is not allowed or not practical; or when the normal flow of the stream cannot be handled by the typical bypass pump.

Suspended Bypass Pipe

The suspended bypass pipe is used where an existing pipe or culvert is extended. This bypass pipe is constructed inside the existing pipe or culvert to divert the watercourse through the work area while allowing the work area to remain dry (Figure 7.42-2). Use this practice when a pipe or culvert is being extended and is large enough to accommodate the bypass pipe or when space limitations do not allow for a fabric lined diversion channel (for example, widening grade and drain projects). Do not use this practice when the upstream ponding required to enter the suspended pipe inlet is unacceptable.

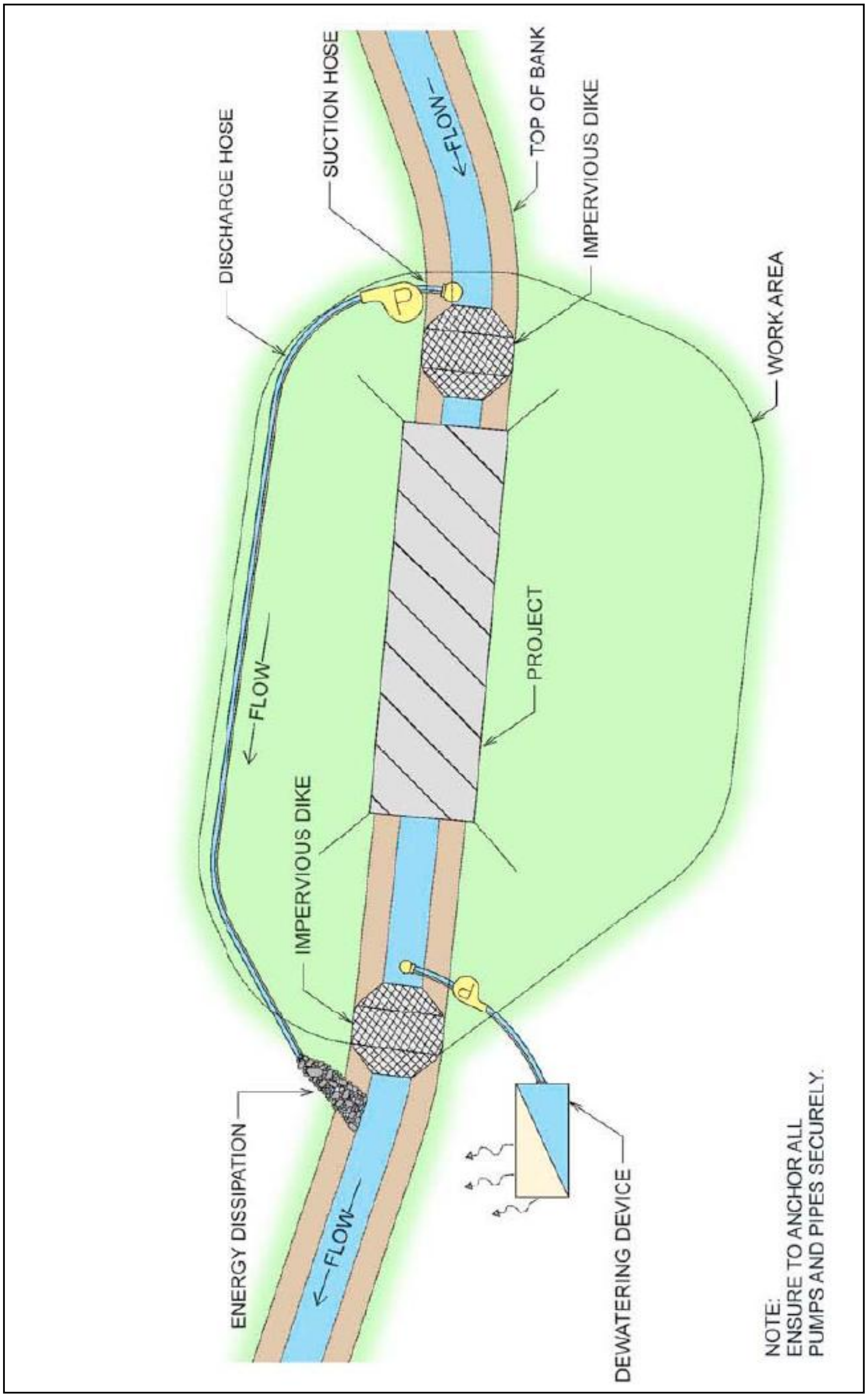


Figure 7.42-1 Stream Diversion Using Bypass Pumping (*Source: NCDOT)*

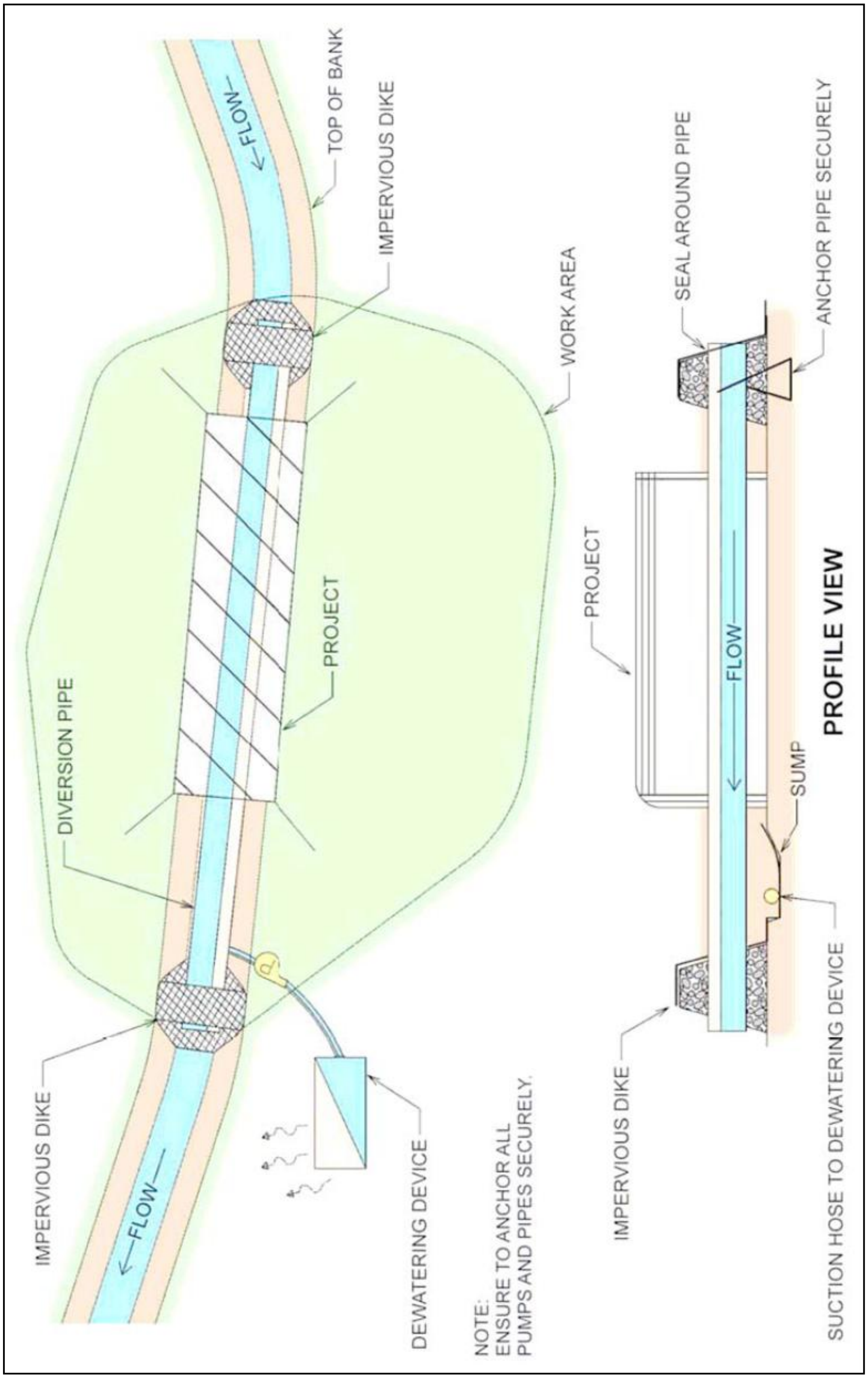


Figure 7.42-2 Stream Diversion Using Suspended Bypass Pipe (*Source: NCDOT)*

Piped Diversion

Install a temporary pipe to divert the flow of the watercourse around the work area without the use of pumping operations (Figure 7.42-3). While the cost is higher for this operation than an open plastic lined channel, the probability of offsite sediment loss is much lower than with an open diversion channel. Use this practice where adequate slope and space exist between the upstream and downstream ends of the diversion. Do not use this practice where adequate space in unavailable, such as at pipe extensions, headwall installations and some pipe/culvert replacements.

Fabric Lined Diversion Channel

A fabric lined temporary diversion channel is used to divert normal stream flow and small storm events around the work area without the use of pumping operations (Figure 7.42-4). The temporary diversion channel is typically constructed adjacent to the work area and is lined with a poly-fabric to minimize the potential for erosion within the temporary diversion channel. Use this practice where adequate space and slopes exist adjacent to the work area. Do not use this practice where adequate space is unavailable such as at pipe extensions, headwall installations and some pipe/culvert replacements.

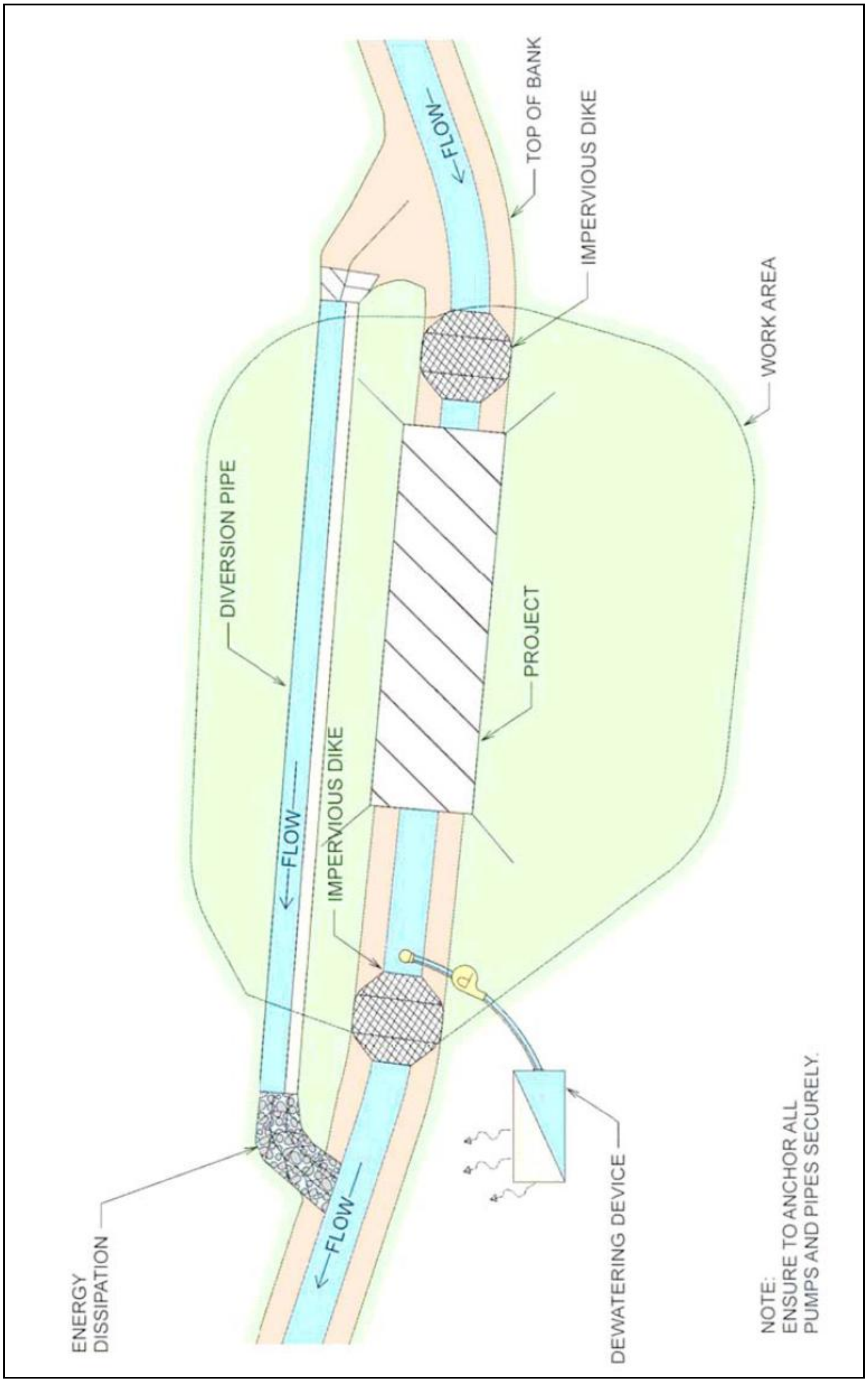


Figure 7.42-3 Stream Diversion Using Piped Diversion (*Source: NCDOT*)

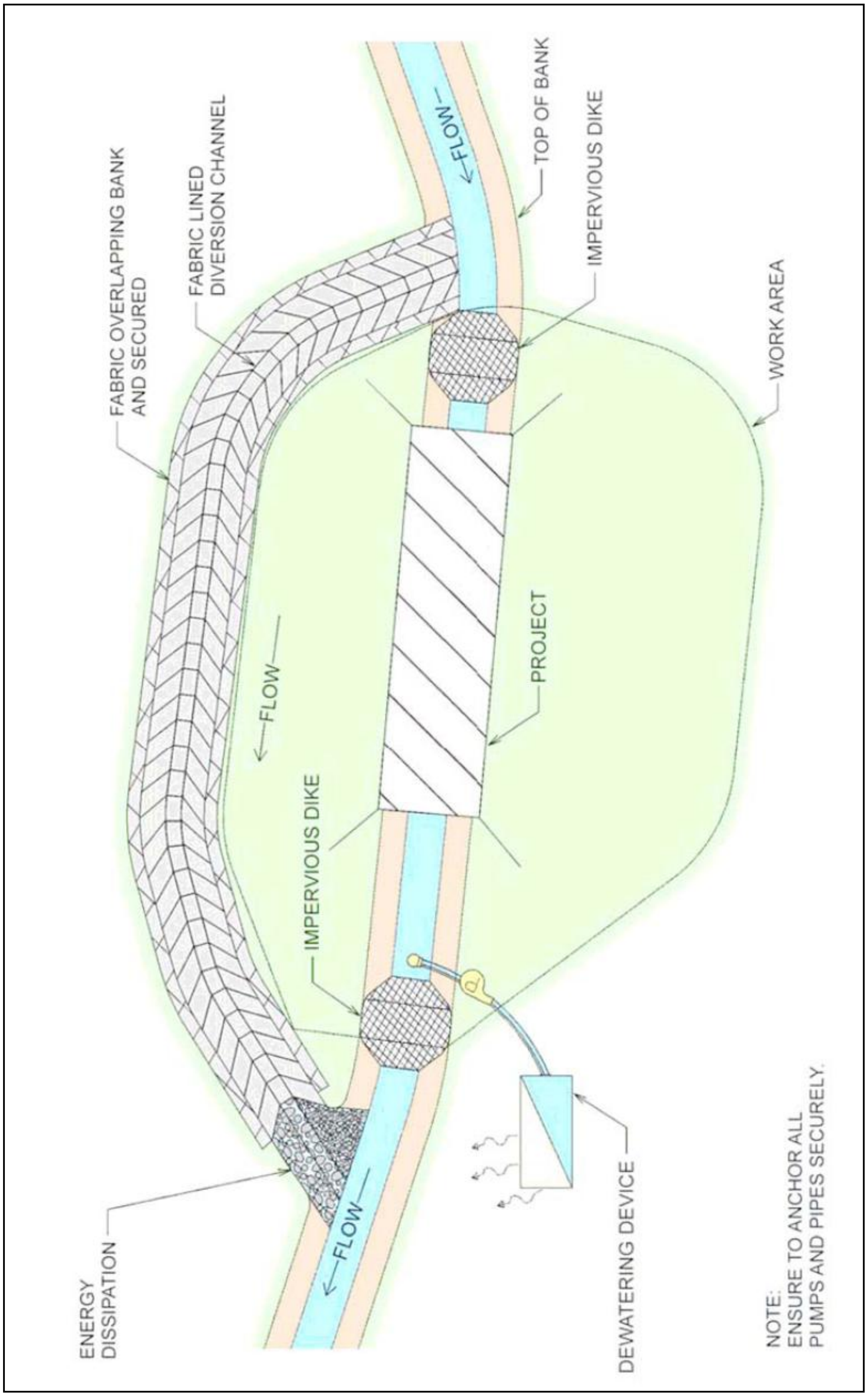


Figure 7.42-4 Stream Diversion Using Fabric Lined Channel (*Source: NCDOT)*

Construction Specifications

General

The impervious dikes used to divert normal stream flow or expected flow path around a construction site must be constructed of non-erodible material. Acceptable materials for impervious dikes include, but are not limited to, sheet piles, sandbags, and/or the placement of an acceptable size stone lined with polypropylene, or other impervious fabric. Prefabricated dams are also an option. Earthen material should not be used to construct an impervious dike when it is in direct contact with the stream. Dewatering devices include stilling basins and sediment filter bags.

Bypass Pumping

- Set up bypass pump and temporary piping. Place outlet of temporary pipe to minimize erosion at discharge site or provide temporary energy dissipation measures. Firmly anchor pump and piping.
- Construct outlet protection if needed.
- Construct impervious dike upstream of work area to impound water for bypass pump intake. Use a floating intake for pumps where possible.
- Construct an impervious dike downstream, if necessary, to isolate work area.
- Check operation of pump and piping system.
- Upon completion of construction, remove impervious dike, bypass pump, and temporary pipe and stabilize disturbed area.

Suspended Bypass Pipe

- Install sediment controls.
- Install temporary pipe through the existing pipe or culvert to be extended. Place outlet of temporary pipe to minimize erosion at discharge site or provide temporary energy dissipation measures.
- Construct an impervious dike upstream of the work area to divert flow through the temporary pipe. Anchor and seal temporary pipe securely at inlet.
- Construct an impervious dike at the downstream side of the bypass pipe to isolate work area.
- Upon completion of the culvert or pipe extension, remove the impervious dike and temporary pipe and stabilize disturbed area.

Piped Diversion

- Install sediment controls.
- Install temporary pipe adjacent to work area. Excavation may be required to provide a positive drainage slope from the upstream to downstream side.
- Connect the downstream temporary pipe into the downstream existing channel. Place outlet of pipe to minimize erosion at the discharge site or provide temporary energy dissipation measures.
- Connect the upstream temporary pipe into the upstream existing channel.
- Construct an impervious dike at the upstream side of the existing channel to divert the existing channel into the temporary pipe.
- Construct an impervious dike at the downstream side of the bypass pipe to isolate work area.

- Upon completion of construction, remove the impervious dike and temporary pipe and stabilize the disturbed area**.**

Fabric Lined Diversion Channel

- Install sediment controls.
- Excavate the diversion channel without disturbing the existing channel.
- Place poly-fabric liner in diversion channel with a minimum of 4 feet of material overlapping the channel banks. Secure the overlapped material using at least 1 foot of fill material.
- Connect the downstream diversion channel into the downstream existing channel and secure the poly-fabric liner at the connection.
- Connect the upstream diversion channel into the upstream existing channel and secure the poly fabric liner at the connection.
- Construct an impervious dike in the existing channel at the upstream side to divert the flow into the diversion channel.
- Construct an impervious dike in the existing channel at the downstream side to isolate the work area.
- Upon completion of the culvert construction, remove the impervious dikes and divert the channel back into the culvert.
- Remove the poly-fabric liner and fill in the diversion channel.
- Establish vegetation on fill section and all other bare areas.

Maintenance and Inspection Points

Bypass Pump

- Inspect bypass pump and temporary piping daily to ensure proper operation.
- Inspect impervious dike for leaks and repair any damage.
- Inspect discharge point for potential erosion.
- Ensure flow is adequately diverted through pipe

Suspended Bypass Pipe

- Inspect the inlet regularly and impervious dike for damage and/or leakage and to ensure flow is adequately diverted through pipe.
- Remove sediment and trash that accumulate behind the dike and at the inlet on a regular basis.
- Inspect the outlet regularly for potential erosion and to ensure flow is adequately diverted through the system.
- Ensure that the inlet is properly anchored and sealed.

Piped Diversion

- Inspect diversion berm and piping for damage.
- Remove accumulated sediment and debris from berm and inlet.
- Inspect outlet for potential erosion.

- Inspect for diverted flow that bypasses the temporary pipe and causes erosion as surface flow.

Fabric Lined Diversion Channel

- Check the poly-fabric liner for stability during normal flow.
- Check the liner for stability after each rainfall event.
- Do not allow earthen material to contact the water body.

The stream diversion channel should be inspected at the end of each day to make sure that the stream flow control measures and construction material are positioned securely. This will ensure that the work area stays dry and that no construction materials float downstream. Inspect impounded work area to ensure water is not contaminated with construction materials or chemicals and that dewatering/treatment is adequate. All repairs should be made immediately.

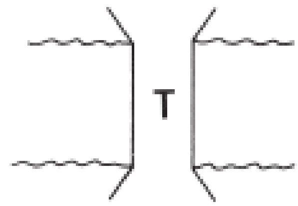
References

NCDOT Inspector Training

TDOT Environmental Division Mitigation Practices, Statewide Stormwater Management Plan

STREAM PROTECTION PRACTICES

7.43 TEMPORARY STREAM CROSSING



Definition A temporary stream crossing is a temporary structure installed across a flowing stream or watercourse for use by construction equipment.

Purpose This standard provides a means for construction vehicles to cross streams or watercourses without moving sediment into the stream, damaging the streambed or channel, or causing flooding.

Conditions Where Practice Applies Temporary stream crossings should be installed anywhere construction traffic cannot be routed around the stream but where the crossing will later be removed.

Planning Considerations All work in a stream must have prior approval from TDEC through the Aquatic Resource Alteration Permit (ARAP) process and all conditions of the ARAP must be followed. For more information, see:

http://www.state.tn.us/environment/permits/arap.shtml.

Structures may include bridges, round pipes, or pipe arches. Temporary stream crossings should be in place for less than one year and should not be accessible to the public.

Design Criteria Professional familiar with the hydraulic calculations necessary to accomplish the work should design stream crossing construction plans and drawings using sound engineering practices.

Size: The structure may be sized large enough to convey the bankfull flow of the stream, typically flows produced by a 2-year, 24-hour frequency storm, with normal high water protection since the flood plain will become effective at the bankfull elevation. However, if the crossing is designed as a low-water crossing, provision must be made for additional overflow protection of the structure, to prevent washout during high flow events.

Location: The temporary stream crossing should be perpendicular to the stream. Where approach conditions dictate, the crossing may vary up to 15° from the perpendicular.

Overflow Protection: Structures should be protected from washout during periods of peak discharges by diverting high flows around or over the structures. Methods to be considered for washout protection may include elevation of bridges above adjacent flood plain lands, crowning of fills over pipes or by the use of diversions, dikes or island type structures. Frequency and intended use, stream channel conditions, overflow areas, potential flood damage, and surface runoff control should be considered when selecting the type of temporary stream crossing to be used.

Temporary Bridge Crossing: A temporary access bridge causes the least erosion of the stream channel crossing when the bridge is installed and removed. It also provides the least obstruction to flow and fish migration. If the bridge is properly designed and appropriate materials are used, a temporary access bridge typically is long lasting and requires little maintenance. It may also be salvaged at project's end and used again in the future. However, a temporary bridge crossing is generally the most expensive crossing to design and construct. It also creates the greatest safety hazard if not adequately designed, installed and maintained.

Temporary Culvert Crossing: A temporary access culvert is the most common stream crossing. It can control erosion effectively, but can cause erosion when it is installed and removed. A temporary culvert can be easily constructed and enables heavy equipment loads to be used. However, culverts create the greatest obstruction to flood flows and are subject to blockage and washout.

The crossing may be designed based on the stream flows resulting from a 2-year 24-hour frequency storm, in which case, Class A or B riprap may be used for normal erosion protection of the aggregate fill, and the roadbed would be at the elevation of the top of the banks. For temporary crossings of streams with large watersheds, the crossing may also be designed based on the low-flow channel conditions as a low water crossing. The culvert size would be adequate to convey base flows, but high water events would overtop the structure and make the crossing temporarily unusable. Additional erosion protection of the fill would be necessary for this design, in the form of Class C or larger riprap to prevent the washout of the culverts.

Construction Specifications

All Crossings

- In-stream work should be performed in dry conditions. Utilize a stream diversion or cofferdams to provide dry conditions for conducting the work. Refer to specification **7.42 Stream Diversion Channel.** Clearing of the streambed and banks should be kept to a minimum.
- All surface water from the construction site should be diverted onto undisturbed areas adjoining the stream. Unstable stream banks should be lined with riprap or otherwise be appropriately stabilized.

- The crossing alignment shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary up to 15° from a line drawn perpendicular to the centerline of the stream at the intended crossing location.
- The centerline of both roadway approaches should 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.
- A water diverting structure such as a waterbar diversion should 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 distance is measured from the top of the waterway bank. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.
- The crossing structure should be removed as soon as it is no longer necessary for access. During structure removal, utilize a stream diversion channel or cofferdams to provide dry conditions for conducting the work.
- Upon removal of the crossing structure, the stream shall immediately be restored to its original cross-section and properly stabilized.

Temporary Bridge Crossing

The temporary bridge should be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.

- Abutments should be placed parallel to the stream and on stable banks.
- Bridges should be constructed to span the entire channel. If the channel width exceeds eight feet (as measured from the tops of the banks), a temporary footing, pier, or bridge support may be constructed within the waterway.
- Decking materials should be of sufficient strength to support the anticipated load. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.
- Bridges should be securely anchored at only one end using steel cable or chain. This will prevent channel obstruction in the event that floodwaters float the bridge. Large trees, large boulders or driven steel anchors can serve as anchors.

Temporary Culvert Crossing

- All culverts must be strong enough to support their cross-sectioned area under maximum expected loads.
- The invert elevation of the culvert should be installed on the natural streambed grade at both ends.
- A geotextile should be placed on the streambed and stream banks prior to the placement of the pipe culvert(s) and aggregate. The geotextile will prevent the migration of soil particles from the subgrade into the graded

stone. The geotextile should 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. Refer to specification **Geotextile.**

- The culverts should extend a minimum of one foot beyond the upstream and downstream toe of the aggregate placed around the culvert.
- The culvert(s) should be covered with small riprap, such as TDOT Class A-1. The depth of riprap above the top of the culvert should be one-half the diameter of the culvert or 18”, whichever is greater.
- Multiple culverts should be separated by one-half the diameter of the culvert or 12” whichever distance is greater. A final layer of coarse aggregate, such as TDOT #57, should be applied to minimum depth of 6 inches.

Maintenance and Inspection Points

The structure should be inspected after every rainfall and at least twice a week, and all damages repaired immediately. Any material lost to the stream shall be removed but only after discussion with TDEC staff. The structure should be removed immediately after construction is finished, and the streambed and banks must be stabilized and restored to pre-construction conditions.

References

STREAM PROTECTION PRACTICES

7.44 BIOENGINEERED STREAMBANK STABILIZATION

Definition Bioengineered streambank stabilization is the use of readily available native plant materials to maintain and enhance stream banks; or to prevent, or repair and restore small stream bank erosion problems.

Purpose

- Form a root mat to stabilize and reinforce the soil on the stream bank
- Provide wildlife habitat
- Enhance the appearance of the stream
- Develop the natural stream corridor
- Lower summertime water temperatures providing a healthy aquatic environment

Conditions Where Practice Applies Stream bank stabilization techniques may be required if steep slopes and/or hydrologic patterns deem it necessary.

Planning Considerations Stream bank stabilization without an NRCS approved plan requires authorization from the Tennessee Division of Water Pollution Control and may require authorization from the United States Army Corps of Engineers. For more information, see:

http://www.state.tn.us/environment/permits/arap.shtml.

Design Criteria Bioengineering is a streambank stabilization technique that uses natural materials such as grasses, shrubs, trees, roots and logs to manage stream flow and stabilize the banks. Bioengineering is the preferred method of streambank stabilization and is permitted without notification where no work is done in stream with mechanized equipment; and where the work is done in accordance with an approved bioengineering plan from the United States Department of Agriculture, Natural Resource Conservation Service (NRCS).

Design of streambank stabilization must be performed by a professional experienced in stream design.

A low flow channel shall be provided to convey the smaller storms, and a floodplain shall be included to the extent feasible, given site constraints.

Construction Specifications

Revegetation includes seeding and sodding of grasses in combination with erosion control fabrics, and the planting of woody vegetation (shrubs and trees). Any blankets or matting used within the stream channel shall be jute or other fully biodegradable materials. Floodplain areas can be stabilized with erosion control blankets and/or turf reinforcement mat. Seed or sod used on the streambanks shall be long rooted, native grasses.

Live Stake: Fresh, live cut woody plant cuttings are driven into the ground as stakes, intended to root and grow into mature shrubs that will stabilize soils and restore the riparian zone habitat. Live stakes provide no immediate stream bank stabilization. Only certain species of woody plants will work well for this application. Willow species work best.

Live stakes may also be driven into riprap protected banks to help with permanent stabilization, and improve aesthetics.

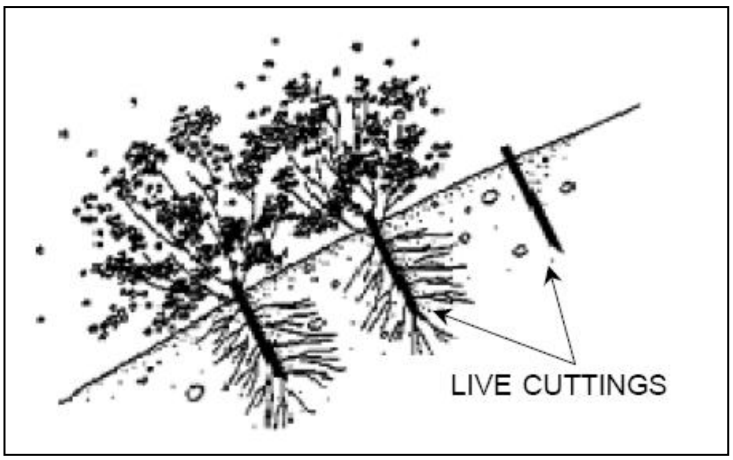


Figure 7.44-1 Live Staking

Live Fascine: Live fascines are sausage-like bundles of live cut branches placed into trenches along the stream bank. They provide immediate protection from erosion when properly used and installed. Willow species work best.

Live fascines create very little site disturbance as compared to other systems and works especially well when combined with surface covers such as jute mesh or coir fabrics.

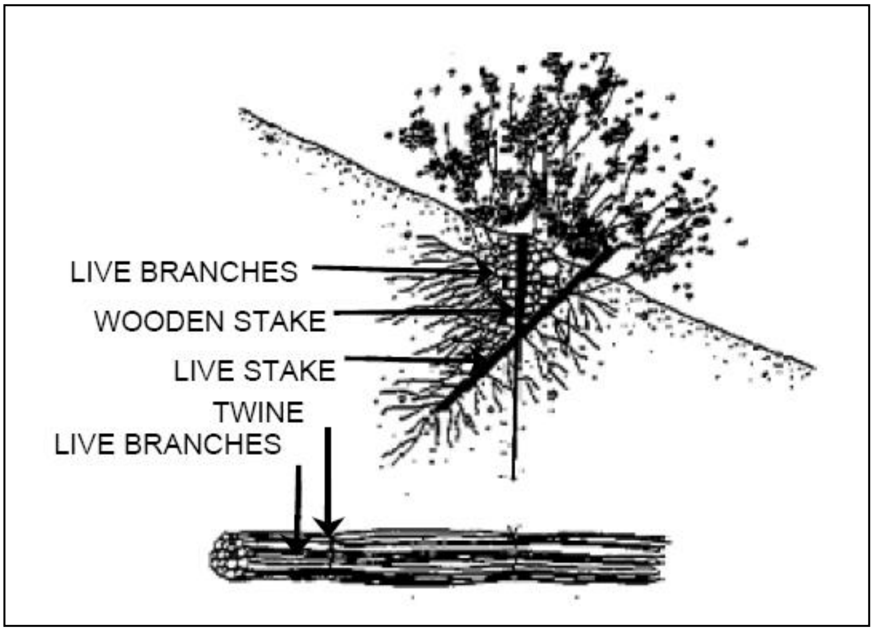


Figure 7.44-2 Live Fascines

Brushmattress: A combination of living units that forms an immediate protective surface cover over the stream bank. Living units used include live stakes, live fascines and a mattress branch cover (long, flexible branches placed against the bank surface).

Brushmattresses require a great deal of live material, are complicated as well as expensive to evaluate, design, and install.

Brushmattresses capture sediment during flood conditions, produce habitat rapidly and quickly develop a healthy riparian zone.

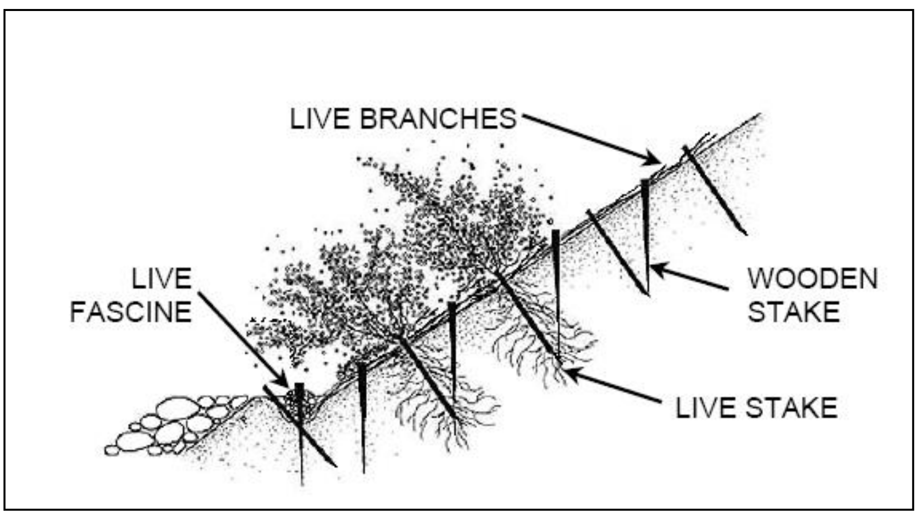


Figure 7.44-3 Brush Mattress

Live Cribwall: A rectangular framework of logs or timbers, rock and woody cuttings. This requires a great deal of assessment and understanding of stream behavior. Cribwalls can be complicated and expensive if a supply of wood is not available.

Benefits include developing a natural stream bank or upland slope appearance after is has begun to grow and provides excellent habitat for a variety of fish, birds, and animals. It is very useful where space is limited on small, narrow stream corridors.

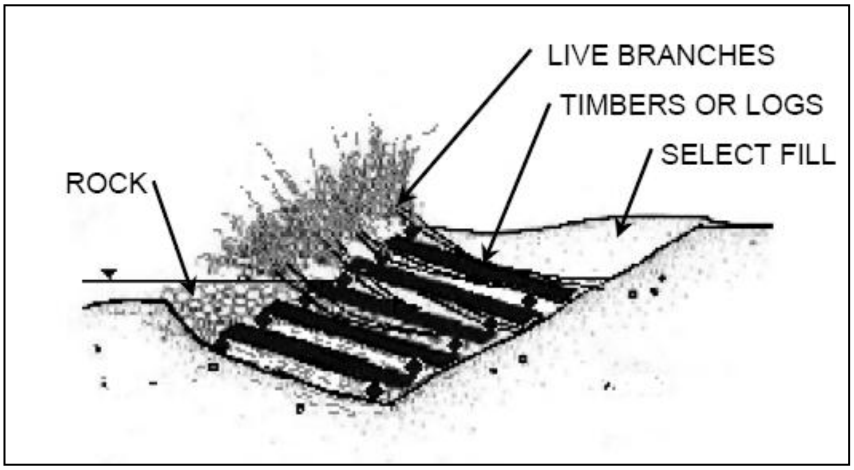


Figure 7.44-4 Live Cribwall

Branchpacking: Process of alternating layers of live branches and soil, incorporated into a hole, gully, or slumped-out area in a slope or streambank. There is a moderate to complex level of difficulty for construction.

Branchpacking produces an immediate filter barrier, reducing scouring conditions, repairing gully erosion and providing habitat cover and bank reinforcement. This is one of the most effective and inexpensive methods for repairing holes in earthen embankments along small stream sites.

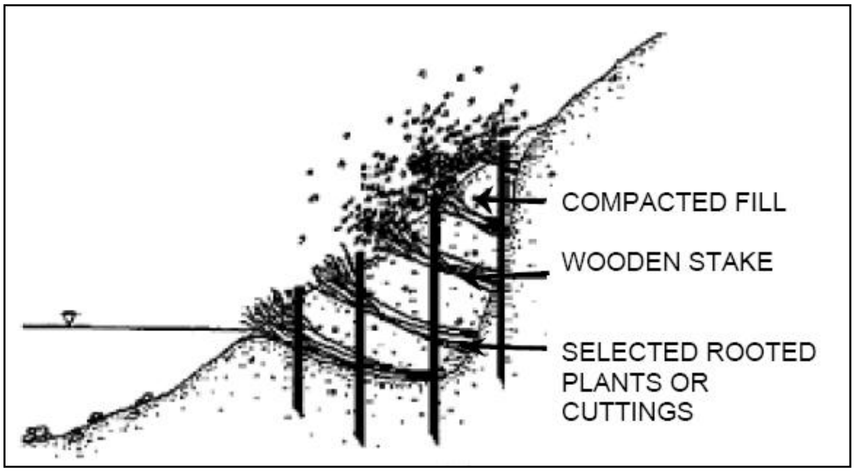


Figure 7.44-5 Branchpacking

Maintenance and Inspection Points

During restoration activities, inspect construction to ensure that sediment control and erosion controls are installed and functioning.

Check for germination or seedling emergence.

The banks should be inspected after every high-water event, fixing gaps in the vegetative cover at once with structural materials or new plants, and mulching if necessary. Fresh cuttings from other plants may be used for repairs.