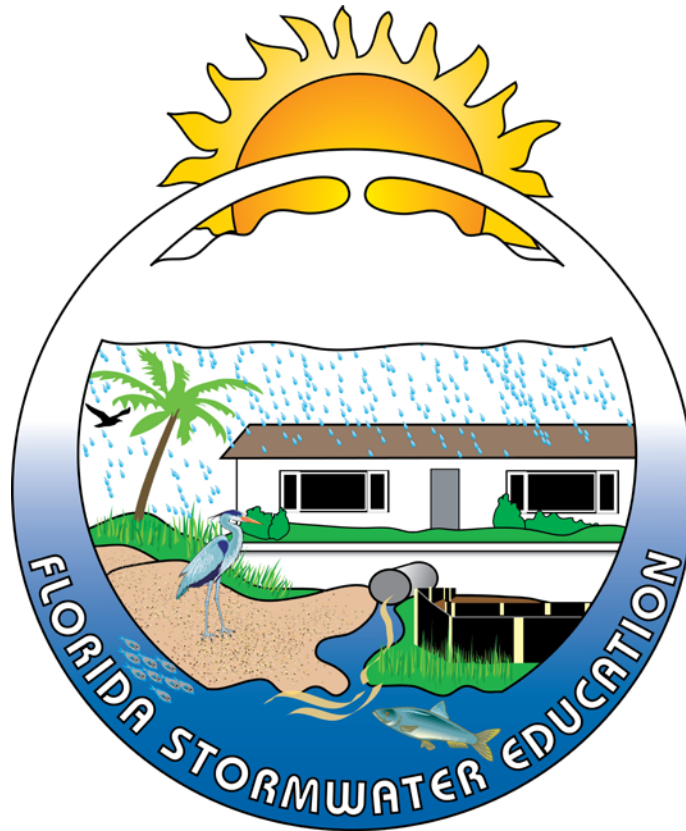


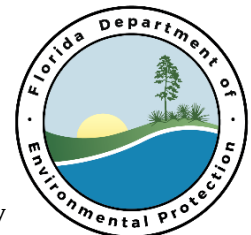


Florida Stormwater Erosion and Sedimentation Control Inspectors Manual

Florida Department of Environmental Protection

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How to Use This Manual

The Florida Stormwater Erosion and Sedimentation Control Inspectors Manual is divided into two tiers that focus on Best Management Practice (BMP) Installers (Tier I) and Qualified BMP Inspectors (Tier II). The classes follow the curriculum provided in the Tier I and Tier II manuals in sequence, and will help individuals improve their knowledge of how to properly manage the impacts from suspended solids, turbidity, nutrients (i.e., nitrogen and phosphorus), and other surface water contaminants.

The Tier I manual and class cover **Chapters 1** through **5**. Tier I provides an introduction to stormwater, erosion, and sedimentation control, and teaches BMP installers and operators how to properly select, install, and maintain BMPs. This class is a prerequisite to the Tier II class.

The Tier II manual and class cover **Chapters 6** through **9**. Tier II provides additional details on information introduced in the Tier I manual along with the applicable regulations, inspection forms, and enforcement procedures necessary for the proper inspection of BMPs.

BMP Installers or Operators should maintain a copy of the Tier I manual for reference. Qualified BMP Inspectors should maintain a copy of both the Tier I and Tier II manuals for reference.

Tier I:
Manual for Best Management Practice (BMP)
Installers

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Chapter 1: Erosion and Sedimentation

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1.1 The Erosion Process and the Water Cycle

Soil erosion is the process by which the land surface is worn away by the action of natural forces such as wind, water, ice, and gravity. It is caused when sediments are detached from the soil mass, transported primarily by flowing water or wind, and eventually deposited as sediment.

Water erosion is generally caused when raindrops falling on bare or sparsely vegetated soil detach soil particles, but it may also be caused directly by flowing water (e.g. uncontrolled dewatering discharges, or stream flow). Water flowing over the ground picks up the particles and carries them. As the runoff gains velocity, it forms channels and detaches more soil particles. This action cuts rills and gullies into the soil, adding to the sediment load.

Wind erosion is also a significant cause of soil loss, especially in peninsular Florida. Winds blowing across unvegetated, disturbed land pick up soil particles and carry them into sensitive areas, and offsite to adjacent areas.¹

Sedimentation is the settling out of soil particles transported by water and wind. It occurs when the velocity of the fluid in which the particles are suspended is slowed to a sufficient degree, and for a sufficient period, to allow the particles to settle out of suspension. Heavier particles such as sand and gravel settle out more rapidly than fine particles such as clay and silt. Sediment deposition is the dominant process in most Florida aquatic systems because most streams have low gradients and low velocities.

¹ Additional information on wind erosion and its control is available from the Natural Resources Conservation Service (NRCS) (formerly the Soil Conservation Service) at <http://soils.usda.gov/>.

Natural or geologic erosion has occurred relatively slowly since the Earth was formed. It is a major factor in creating the Earth as we know it today. The great river valleys of the Florida Panhandle, the rolling farmlands and orchards of the Central Ridge, and the productive estuaries and barrier islands of the coast are all products of geologic erosion and sedimentation. Except for some cases of shoreline and stream channel erosion, natural erosion occurs at a very slow and uniform rate, and is a vital factor in maintaining environmental balance. Geologic erosion produces about 30 % of all sediment in the U.S.

Accelerated erosion is the increased rate of erosion caused primarily by the removal of natural vegetation or alteration of the ground contour. This type of erosion accounts for 70 % of all sediment generated in this country. Farming and construction are the principal causes of accelerated erosion, although any activity that disturbs land can increase the natural erosion rate.

1.2 The Water Cycle

The water cycle is the natural process by which water moves above, along, and through the Earth. Rain falls from clouds to the ground. If the ground is absorbent, water infiltrates into the soil and may flow into a deep geological formation that stores water, known as an aquifer. Water may flow shallowly beneath the ground surface. If the ground surface is a hard material, such as asphalt or concrete, then the water cannot infiltrate into the ground, and instead runs off along the hard surface.

For this reason, rainwater that cannot penetrate the ground and instead flows along the surface is known as runoff, stormwater, stormwater runoff, or surface runoff. This stormwater runoff is the driving force behind the erosion process. Hard surfaces that prevent water from penetrating the ground are known as impermeable or impervious surfaces. Even in well-vegetated areas, some stormwater runoff is natural, as the rate of rainfall exceeds the ground's capacity to absorb the water. However, paved areas and rooftops greatly alter the natural balance between infiltration and runoff, leading to accelerated erosion.

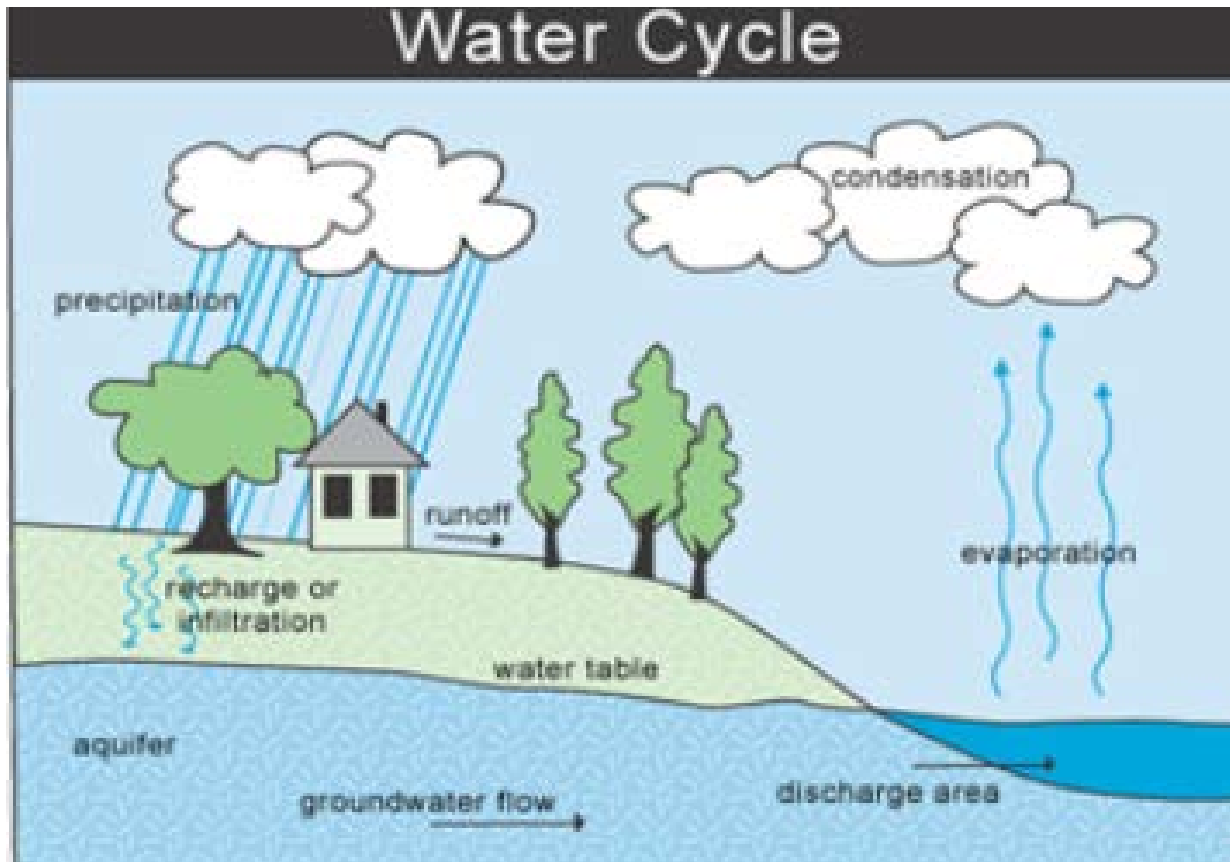


Figure 1.1: The water cycle

1.3 Types of Water Erosion

There are two principal types of water erosion: **overland erosion** and **channel erosion**. Overland erosion occurs on denuded slopes when raindrops splash and run off. Overland erosion is the largest source of sediment during construction activities. It includes the following four processes:

1. **Raindrop erosion** or **splash erosion** results when raindrops dislodge soil particles and splash them into the air. These dislodged particles are then vulnerable to sheet erosion.
2. **Sheet erosion** is caused by shallow sheets of water flowing off the land. These broad, moving sheets of water are seldom the detaching agent, but the flow transports soil particles detached by raindrops. The shallow surface flow rarely moves as a uniform sheet for more than a few feet before concentrating in low spots on the land surface.
3. **Rill erosion** develops as the shallow surface flow begins to concentrate in low spots. The concentrated flow increases in velocity and turbulence, which in

turn causes the detachment and transport of more soil particles. This action cuts tiny, well-defined channels called rills, which are usually only a few inches deep.

4. **Gully erosion** occurs as the flow in rills comes together in larger and larger channels. The major difference between this and rill erosion is size. Stream and channel erosion occurs as the volume and velocity of flow increase significantly to cause the movement of the streambed and bank materials to erode.

1.4 Four Factors Influencing Erosion

Four principal factors determine the inherent erosion potential of an area:

1. *Soil characteristics.*
2. *Vegetative cover.*
3. *Topography.*
4. *Climate (rainfall).*

Although each of these factors is discussed separately, they are inter-related.

1.4.1 Soil Characteristics

Soil properties influence erosion by rainfall and runoff. These properties affect the infiltration capacity (the rate at which water percolates into the ground) and its resistance to detachment and transport by wind or water. These factors include the following:

1. *Soil texture (average particle size and gradation).*
2. *Percentage of organic content.*
3. *Soil structure.*
4. *Soil permeability.*

The most challenging soil types in Florida include those that consist of fine sand and silts. Soils that contain high percentages of silt and very fine sand are generally the most erodible.

As the clay and organic matter content of these soils increases, their erodibility decreases. Clays and organic matter act as a binder of soil particles and reduce erodibility. Clays have a tendency to resist erosion; however, once detached from the soil they are easily transported by water and settle out very slowly, contributing significantly to turbidity problems onsite.

The study of soil characteristics related to soil erodibility is a complex, technical field. **Chapter 2** provides further information about soils.

1.4.2 Vegetative Cover

Vegetative cover plays an extremely important role in controlling erosion:

1. *It shields the soil surface from the impact of falling rain.*
2. *It holds soil particles in place.*
3. *It maintains the soil's capacity to absorb water.*
4. *It slows the velocity of runoff.*
5. *It removes subsurface water through evapotranspiration.*

By sequentially scheduling (phasing) and **limiting the removal of vegetation**, and by **minimizing the extent of the area exposed and duration of exposure**, soil erosion and sedimentation can be significantly reduced. Special consideration should be given to maintaining vegetative cover on areas of high erosion potential, such as erodible soils, steep or long slopes, stormwater conveyances, and streambanks.

1.4.3 Topography

The size, shape, and slope of a watershed influence the amount and rate of runoff. Slope length and gradient are key elements in determining the volume and velocity of runoff and the erosion risks. As both slope length and gradient increase, the velocity and volume of runoff increase, and the erosion potential is magnified. Slope orientation can also be a factor in determining erosion potential.

1.4.4 Climate (Rainfall)

The frequency, intensity, and duration of rainfall are fundamental factors in determining the amount of runoff. As both the volume and the velocity of runoff increase, the capacity of runoff to detach and transport soil particles also increases. When storms are frequent, intense, or of long duration, erosion risks are high. Seasonal changes in rainfall and temperature define the period of the year with the highest risk of erosion.

Land-disturbing activities should be scheduled to take place during periods of low precipitation and low runoff. Exposed areas should be stabilized before the period of high erosion risk. Generally, Florida's wet season occurs from May to November, with a dry season from November to May. Climate information for your area can be obtained from the National Oceanic and Atmospheric Administration (NOAA) or the National Weather Service (NWS).

1.5 Impacts of Erosion and Sedimentation

Normally, runoff builds up rapidly to a peak and then diminishes. Erosion creates excessive quantities of sediment, principally during higher flows. During lower flows, as the velocity of runoff decreases, the transported materials are deposited, only to be picked up by later peak flows. In this way, sediments are carried downstream intermittently and progressively from their source. A study of sedimentation from highway construction and land development in Virginia indicated that 99 % of sediment discharge occurred during periods of high flow that took place during only 3 % of the period of measurement (Vice et al. 1969).

Over 4 billion tons (3.6 billion metric tons [mt]) of sediment reach the ponds, rivers, and lakes of our country each year, and 1 billion tons (0.9 billion mt) of this sediment are carried all the way to the ocean.

Approximately 10 % of this amount is contributed by erosion from land undergoing highway construction or land development (SCS 1980). Although this number may appear to be small compared with the total, it can represent more than half of the sediment load carried by many streams draining small watersheds undergoing development.

Sediment yields in streams flowing from established, urbanized drainage basins range from 200 to 500 tons per square mile per year ($t/mi^2/yr$) (70 to 175 metric tons/square kilometer/year [$mt/km^2/yr$]). In contrast, areas actively undergoing urbanization often have a sediment yield of 1,000 to 100,000 $t/mi^2/yr$ (350 to 3,500 $mt/km^2/yr$) (U.S. Geological Survey [USGS] 1968). Development is begun on 4,000 to 5,000 acres (1,620 to 2,025 hectares [ha]) of land throughout the country every day. This includes development for housing, industrial sites, and highway construction (U.S. Census Bureau 1987). For very small areas, where construction activities have drastically altered or destroyed vegetative cover and the soil mantle, the sediment derived from 1 acre of land may be 20,000 to 40,000 times that obtained from adjacent undeveloped farmland or woodland areas.

1.5.1 Physical Effects of Sedimentation

Sedimentation and turbidity can result in costly damage to waterbodies, wetlands, and private and public lands. The obstruction of stream channels and navigable rivers by masses of deposited sediment reduces hydraulic capacity. This, in turn, causes an increase in flood crests, resulting in flood damage. Sediment fills stormwater conveyances and plugs culverts and stormwater systems, necessitating frequent and costly maintenance.

Municipal and industrial water supply reservoirs lose storage capacity, the usefulness of recreational impoundments is impaired or destroyed, navigable channels must continually be dredged, and the cost of filtering muddy water in preparation for domestic or industrial use becomes excessive. The added expense of water purification in the United States amounts to millions of dollars each year.

1.5.2 Biological Effects of Sedimentation

The biological effects of sedimentation are even more critical. The presence of fine-grained sediments (i.e., clays, silts, and fine sands) in aquatic systems reduces both the kinds and the amounts of living organisms present. Turbidity alters the aquatic environment by screening out sunlight and by changing the rate and the amount of heat radiation. This light reduction inhibits photosynthesis, leading to a decline in aquatic plant growth. Consequently, the food chain is disrupted, and the population of consumer species is reduced.

The elimination or reduction of benthic organisms decreases the number and variety of food sources for fish, further disrupting the food chain and causing fish to either starve or move away. A moderate concentration of sediment can impair fish spawning, while a high concentration clogs the gills of fish and invertebrates. The result may be that clear waterbodies that once supported populations of game fish, such as bass and bream, become muddied and inhabited by more pollution-tolerant species.

Coarser-grained materials also blanket bottom areas and suppress aquatic life found on and in these areas. Where currents are sufficiently strong to move the bed load, the abrasive action of these materials accelerates channel scour caused by, or associated with, higher flood stages induced by sedimentation.

1.6 Erosion and Sediment Hazards Associated with Land Development

Land development activities affect the natural or geologic erosion process by exposing disturbed soils to precipitation and to surface stormwater runoff. The shaping of land for development alters the land cover and the soil in many ways. These alterations often detrimentally affect onsite stormwater patterns and, eventually, offsite stream and streamflow characteristics. As protective vegetation is reduced or removed, earth is excavated, topography is altered, the removed soil material is stockpiled—often without protective cover—the physical properties of the soil itself are changed.

Even small development projects can cause adverse impacts to people and the environment. Uncontrolled erosion and sediment from these areas often cause considerable economic damage to society in general. The hazards associated with development include the following:

1. *A large increase in areas exposed to stormwater and soil erosion.*
2. *Increased volumes of stormwater, accelerated soil erosion and sediment yield, and higher peak flows caused by the following:*
 - a. Removal of existing protective vegetative cover.
 - b. Exposure of underlying soil or geologic formations that are less pervious and/or more erodible than the original soil surface.

- c. Reduced capacity of exposed soils to absorb rainfall because of compaction caused by heavy equipment.
 - d. Enlarged drainage areas caused by grading operations, diversions, and street construction.
 - e. Prolonged exposure of disturbed areas that are left unprotected because of scheduling problems or delayed construction.
 - f. Shortened periods of concentrated surface runoff caused by alterations in steepness, distance, and surface roughness, and by the installation of "improved" storm drainage facilities.
 - g. Increased impervious surfaces such as streets, buildings, sidewalks, and paved driveways and parking lots.
3. *Alteration of the groundwater regime that may adversely affect stormwater systems, slope stability, and the survival of existing or newly established vegetation.*
 4. *Creation of exposures facing south and west that may hinder plant growth because of adverse temperature and moisture conditions.*
 5. *Exposure of subsurface materials that are rocky, acid, dehydrated, or otherwise unfavorable to the establishment of vegetation.*
 6. *Adverse alteration of surface runoff patterns by construction and development.*

1.7 Principles of Erosion and Sediment Control

For an erosion and sediment control program to be effective, it is imperative that provisions for control measures be made in the planning stage. These planned measures, when conscientiously and expeditiously applied during construction, will result in orderly development without environmental degradation and with cost savings.

The **seven principles** listed below should be used to the maximum extent possible. Usually, these principles are integrated into a system of vegetative and structural measures, along with management techniques, that are used in developing a plan to prevent erosion and control sediment. In most cases, a combination of limited grading, limited time of exposure, and the judicious selection of erosion control practices and sediment-trapping facilities are the most practical methods of controlling erosion and the associated production and transport of sediment.

1. Plan the development to fit the particular topography, soils, drainage patterns, and natural vegetation of the site.

Detailed planning should be employed to ensure that roadways, buildings, and other permanent features of the development conform to the natural characteristics of the site. Large graded areas should be located on the most level portion of the site.

Slope length and gradient are key elements in determining the volume and velocity of runoff and its associated erosion. As both slope length and steepness increase, the rate of runoff increases and the potential for erosion is magnified. Where possible, steep vegetated slopes should be left undisturbed. Areas with slope and soils limitations should not be used unless sound conservation practices are employed. For instance, where it is necessary to build on long, steep slopes, the practices of benching, terracing, or constructing diversions should be used. Areas subject to flooding should be avoided or used as part of the stormwater management system. Floodplains should not be used for filling and construction activities since they temporarily store excess runoff, thus helping to avoid erosion and flooding problems downstream.

Erosion control, development, and maintenance costs can be minimized by selecting a site suitable for a specific proposed activity, rather than by attempting to modify a site to conform to that activity. This kind of planning can be more easily accomplished where there is a general land use plan based on a comprehensive inventory of soils, water, and other related resources.

2. Minimize the extent of the area exposed at one time and the duration of exposure.

When land disturbances are required and the natural vegetation is removed, keep the area and the duration of exposure to a minimum. Plan the stages of development so that only the areas that are actively being developed are exposed. All other areas should have a good cover of either temporary or permanent vegetation, or mulch.

Grading should be completed as soon as possible after it has begun. Immediately after grading is completed, a permanent vegetative cover should be established. As cut slopes are made and as fill slopes are brought up to grade, these areas also should be revegetated. This is known as staged revegetation. Minimizing the grading of large or critical areas during the rainy season (the time of maximum erosion potential) reduces the risk of erosion.

3. Apply perimeter control measures to protect the disturbed area from offsite runoff and to prevent sedimentation damage to areas below the development site.

These measures effectively isolate the development site from surrounding properties and, in particular, control sediment once it is produced, thus preventing its transport from the site. Diversions, berms, sediment traps, vegetative filters, and sediment basins are examples of practices to control sediment. Vegetative and structural sediment control measures are either temporary or permanent, depending on whether they will remain in use after development is complete. Generally, sediment is retained by (a) filtering runoff as it flows through an area and

(b) impounding the sediment-laden runoff for a period so that the soil particles settle out. The best way to control sediment, however, is to prevent erosion, as discussed in the fourth principle.

4. Apply erosion control measures to prevent excessive onsite damage.

The use of erosion control measures on a site prevents excessive sediment from being produced. Keep soil covered as much as possible with temporary or permanent vegetation, or with various mulch materials. Special grading methods, such as roughening a slope on the contour or tracking with a cleated bulldozer, may be used.

Other practices include the installation of diversion structures to direct surface runoff from exposed soil and grade stabilization structures to control surface water. These water control devices must prevent "gross" erosion in the form of gullies. Lesser types of erosion, such as sheet and rill erosion, should be prevented, but often scheduling or the large number of measures required makes this impractical. However, when erosion is not adequately controlled, sediment control is more difficult and expensive.

5. Keep runoff velocities low and retain runoff on the site.

The removal of existing vegetative cover and the resulting increase in impermeable surface area during development increase both the volume and velocity of runoff. These increases must be taken into account when providing for erosion control. Keeping slope lengths short and gradients low, and preserving natural vegetative cover, can keep stormwater velocities low and limit erosion hazards.

Runoff from the development site should be safely conveyed to a stable outlet using storm drains, diversions, stable waterways, or similar measures. Consideration should be given to installing stormwater detention structures to prevent flooding and damage to downstream facilities resulting from increased runoff from the site. Conveyance systems should be designed to withstand the velocities of projected peak discharges. These facilities should be operational as soon as possible after the start of construction.

6. Stabilize disturbed areas immediately after the final grade is attained.

Permanent structures, temporary or permanent vegetation, and mulch, or a combination of these measures, should be employed as quickly as possible after the land is disturbed. Temporary stabilization must be initiated within seven days in areas where activity has either permanently or temporarily ceased. Temporary stabilization best management practices (BMPs) can be used when and where it is impractical to establish permanent vegetation. The finished slope of a cut or fill should be stable, and the design should consider ease of maintenance. Stabilize roadways, parking areas, and paved areas with a gravel sub-base whenever possible.

7. Implement a thorough maintenance and follow-up program.

This last principle is vital to the success of the six other principles. A site cannot be effectively controlled without thorough, periodic inspections of the erosion and sediment control practices. These practices must be maintained, just as construction equipment must be maintained and materials checked and inventoried. An example of applying this principle is to start a routine "end of day check" to make sure that all control practices are working properly. At a minimum, BMPs are to be inspected and maintained once every 7 calendar days and within 24 hours of a 0.5-inch or greater storm event. The Construction Generic Permit (CGP) defines a storm event as a rainfall event that results in a measurable amount of rain. A storm event is defined as a separate event when there is at least 4 hours of no rain between periods of rainfall.

1.8 Nutrients and Water Quality Issues

Nutrients are not commonly a concern on inspecting construction sites as that of erosion and sedimentation inspection and under the CGP. However, nutrient losses take place on every construction site throughout Florida, whether a home site, commercial site, or road and bridge construction site. Nutrient pollution is one of the most widespread and costly environmental issues and is caused by excess nitrogen and phosphorus in our air and water. Each element is a natural part of Florida's aquatic ecosystems. Nitrogen is the most abundant element in the air we breathe, and phosphorus supports plant growth on land surfaces as well as in surface waters.

Problems arise when there is too much nitrogen and phosphorus entering our environment from a wide range of sources. Nutrient pollution sources include the following:

- **Stormwater** – Rooftops, sidewalks, and roadways.
- **Agriculture** – Manures, excess fertilizer, and soil erosion.
- **Wastewater** – Sewer and septic tanks.
- **Fossil Fuels** – Electric power generation, industry, transportation, and agriculture.
- **Around the Home** – Fertilizers, yard and pet waste, soaps, detergents, and landscaping.

Excessive nutrient sources are impairing our surface waterbodies, which are normally used for recreation and create the beautiful waterfronts found throughout Florida. Decades of uncontrolled uses of fertilizers, septic tanks, and industrial and agricultural activities in our environment have created serious environmental and health issues, as well as huge impacts on the Florida economy.

Chapter 2: Soils

2.1 Introduction to Soils

2.2 Soil Classification and Properties

2.2.1 Soil Classification

Soil Textures

Organic Matter

Soil Structure

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Soil Hydrologic Group

2.2.2 Soil Properties

Erodibility

Slope

Shrink-Swell Potential

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Wetness

Depth to Bedrock

Flood Vulnerability

2.3 Soil Surveys

2.4 Predicting Soil Loss Using the Revised Universal Soil Loss Equation (RUSLE)

2.1 Introduction to Soils

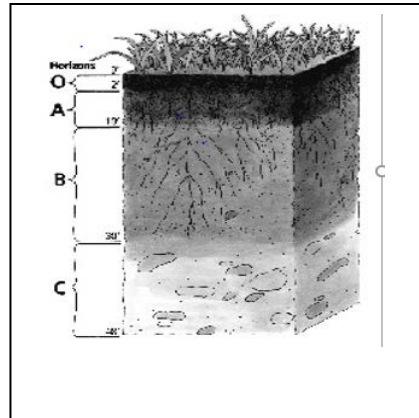
To effectively prevent erosion and minimize sedimentation, a basic understanding of different soil types and their properties is essential. Soils form in response to the interaction of the following five factors:

- 1. Climate** – *Temperature, rainfall, seasons.*
- 2. Topography** – *Flatwoods, depressions, ridges.*
- 3. Organisms** – *Plants, animals, microbes, humans.*
- 4. Parent Material** – *Marine sand, limestone, organic.*
- 5. Time.**

These factors cause physical and chemical changes in the parent material that determine the types of soils found in a location. Soils are developed or deposited in layers. Soils with clearly defined layers are said to be mature. Immature soil lacks well-developed layers. Soils in Florida are generally young, because, geologically, Florida only recently emerged from the sea, allowing less time for these five forces to act on the parent material.

A vertical column of soil, such as might be seen in an excavation or roadside cut, is called a profile. The soil layers in a profile are called **horizons**. They are defined as follows:

O Horizon	Organic layer
A Horizon	Mineral topsoil
E Horizon	Mineral
B Horizon	Subsoil
C Horizon	Parent material
R Horizon	Bedrock material



Soils form in the parent material, known as the C horizon.³ Marine sands, weathered limestone, and organic deposits are the common parent materials found in Florida soils.

A soil is said to mature, or age, as the B horizon accumulates clay. Wetland soils often have an accumulation of organics, iron, and aluminum. These are referred to as spodic horizons and are commonly found in Florida. Soil horizons can differ in chemical and physical properties, such as thickness, texture, color, organic matter, fertility, and pH. **In Florida, clay and muck are the two soils that cause the most problems with turbidity and erosion.**

On a volume basis, average topsoil (the A horizon) is 45 % minerals, 5 % organic matter, and 50 % pore space. With depth, organic matter, porosity, and permeability decrease.

Topsoil has the greatest amount of plant and microbial activity. It is important as a seedbed, as a reservoir for nutrients and water, and in the exchange of gases between the subsoil and atmosphere. The topsoil is the horizon most vulnerable to erosion and human activities.

When possible, stockpiling topsoil or incorporating muck (spodic) soils from other parts of a construction site can improve the viability of vegetation. See **TOPSOILING AND VEGETATION** (in **Chapter 5**) for additional information.

2.2 Soil Classification and Properties

2.2.1 Soil Classification

Soil engineers and agricultural scientists describe the properties of soils differently because their interests are substantially different. Both soil and civil engineers are familiar with the Unified and American Association of State Highway and Transportation Officials (AASHTO) Systems, which focus on the engineering properties of soils. These classifications are based on the physical properties of the soil. Initially, soils are described as either coarse or fine grained. Coarse-grained soils are further described by the degree of sorting of particle sizes. Fine-textured soils

are further distinguished by their liquid and plasticity limits. Particle-size analysis is not usually performed.

In contrast, the U.S. Department of Agriculture (USDA) system of soil classification, used by the agency's NRCS, focuses on the characteristics of soils that are important for agricultural uses, such as texture, organic matter, and nutrient content. A particle-size analysis is necessary before a soil can be classified using the USDA system.

Soil Textures

Soil texture depends on the proportions (by weight) of sand, silt, and clay in a soil—often referred to as the particle size distribution. Table 2.1 lists the USDA particle size classes. A triangle is used to categorize soil textures based on their particle size content (see Figure 2.1).

Table 2.1. USDA particle size classes

Name of Soil Separate	Diameter Limits (millimeters [mm]) USDA Classification
Clay	Less than 0.002
Silt	0.002 – 0.05
Very Fine Sand	0.05 – 0.10
Fine Sand	0.10 – 0.25
Medium Sand	0.25 – 0.50
Coarse Sand	0.50 – 1.00
Very Coarse Sand	1.00 – 2.00

The percentages of sand, silt, and clay in a soil add up to 100. By knowing any 2 components, one can find the texture name for the soil. For example, a soil with 40 % sand and 40 % silt is called a loam. A loam also contains 20 % clay. A sample with 20 % sand and 60 % silt is called a silt loam, while one with 60 % sand and 30 % silt is called a sandy loam.

The Unified and AASHTO classification systems use a different soil particle size than the USDA system to differentiate silt from sand; the former changes the classification at 0.002 mm, the latter at 0.05 mm. This difference is important because the silt and very fine sand particles in this size range are most susceptible to erosion and are therefore of interest in erosion control planning.

Particle size also is important because it affects the ability of a sediment basin to trap soil. The smaller the particle, the larger the basin must be to capture it. Each sediment basin should be designed to capture a certain size particle, called the design particle. If a soils analysis is to be done on a site, the site planner should request that the design particle size be specified as a threshold in the analysis (i.e., specify the percent, by weight, of particles larger or smaller than that size).

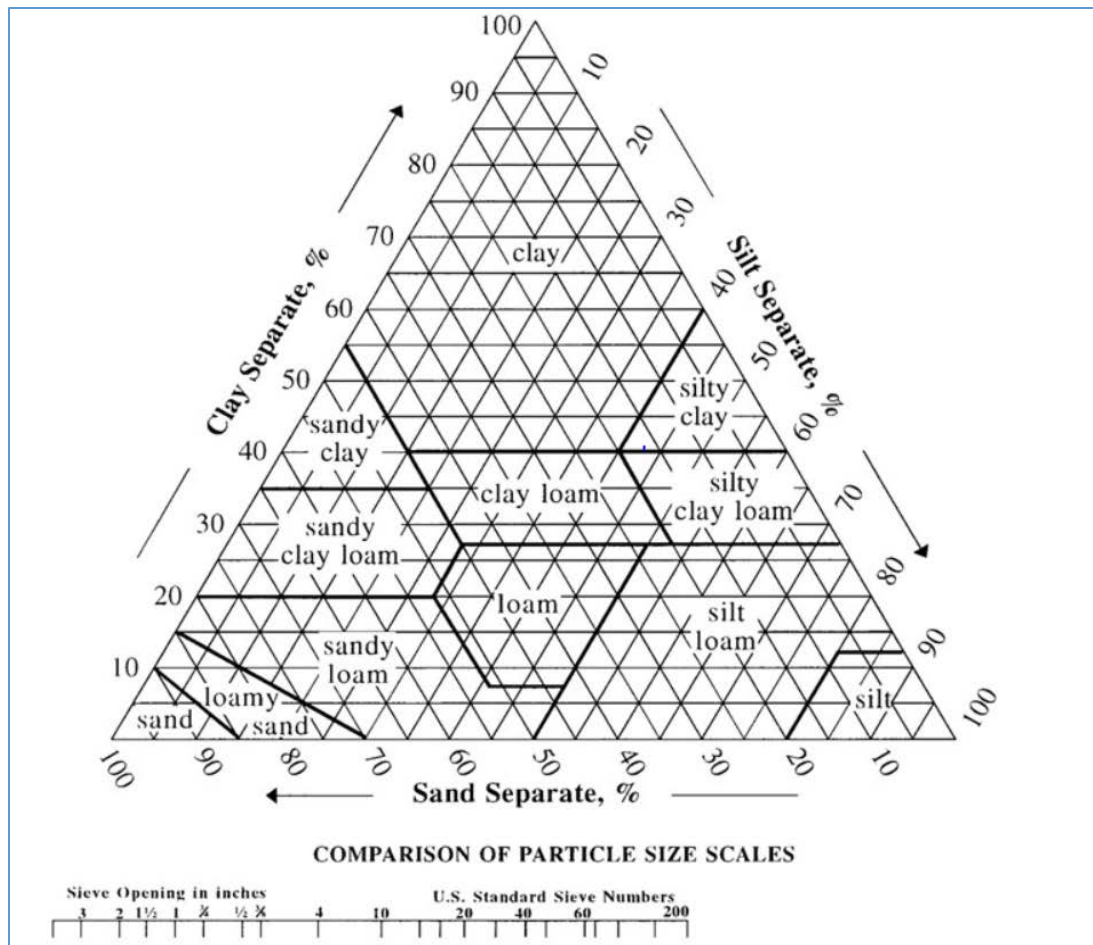


Figure 2.1. Guide to the textural classification of soils

Source: USDA Technical Handbook

Sandy soils generally have a higher permeability than fine-textured soils. The amount of runoff is lower, and since the particles are relatively large (and thus heavy), they are not carried far in any runoff that does occur. Sand particles settle out of runoff at the bottom of a slope or in a channel with a gentle slope. Very fine sand particles, however, behave like silt particles.

Silt is the most important particle size class when soil erodibility is evaluated. The higher the silt content, the more erodible a soil is. Silt-sized particles are small enough to reduce the permeability of a soil and are also easily carried by runoff. Control measures should be designed to prevent the erosion of silt, or at least to contain it onsite.

Clay is the smallest particle size class. A soil with high clay content is quite cohesive—the particles stick together in clumps. Runoff does not pick up clay particles as easily as it does silt. However, once clays are suspended in runoff, they will not settle out until they reach a large, calm waterbody. These very small particles have so low a settling velocity that they are carried

long distances until still water is reached, or until salt water causes them to clump together again in aggregates.

It is easiest to prevent the erosion of sandy soils. Silts are most susceptible to erosion, but they can be recaptured onsite by applying the control measures described in **Chapter 3**. Clays are the most difficult to trap once erosion has occurred, and thus control measures must focus on preventing their erosion in the first place.

Although texture is a principal soil characteristic affecting erodibility, three other characteristics have a strong influence on erosion potential: organic matter, soil structure, and permeability.

Organic Matter

Organic matter within a soil is mostly made up of decomposed plant and animal litter. It consists of colloidal particles as small as and smaller than clay particles. This kind of organic matter helps bind the soil particles together, improves soil structure, and increases permeability and water-holding capacity. Soils with organic matter are less susceptible to erosion and more fertile than soils without organic matter.

On a construction site, where extensive grading has removed the original topsoil and exposed layers of earth with no plant roots growing in them, there is no organic matter. Such subsoils are likely to be more erodible and less fertile than surface soils.

In another sense of the term, organic matter means plant residue or other organic material, applied to the soil surface. Surface-applied mulch reduces erosion by reducing the impact of raindrops, and by absorbing water and reducing runoff. It provides a more hospitable environment for plant establishment, and it eventually decomposes and improves the structure and fertility of the soil. **Chapter 5** describes the uses of mulch in erosion control.

Soil Structure

Soil structure refers to the arrangement of particles in a soil. In an undisturbed soil with established vegetation, organic matter binds the particles into clumps called aggregates, producing what is called a granular structure. This is desirable because permeability and water-holding capacity are increased, and the clumped particles are more resistant to erosion.

The grading and compaction of soils during construction destroy their natural structure, reduce permeability, and increase runoff and erodibility. The direct impact of raindrops on a soil unprotected by mulch or vegetation also breaks up soil aggregates and increases erodibility.

Soil Permeability

Soil permeability refers to the ability of the soil to allow air and water to move through it. **Table 2.2** lists the USDA permeability classes. Soil texture, structure, and organic matter all contribute to permeability. Sites with highly permeable soils absorb more rainfall, produce less runoff, are less susceptible to erosion, and support plant growth more successfully.

Graded areas must meet certain standards of compaction to ensure a stable foundation surface. The infiltration of water into a large area of fill is not desirable because it may reduce the fill's stability. Compaction increases stability, but by lessening the amount of infiltration, soil permeability is reduced and surface runoff and surface erosion increase. When grass is planted on fills and paved diversion ditches are installed midslope to carry away excess runoff, surface erosion is reduced.

Table 2.2. USDA soil permeability classes

Permeability Class	Estimated Inches Per Hour through Saturated, Undisturbed Cores under 1/2-Inch Head of Water
Very Slow	< 0.06
Slow	0.06 – 0.2
Moderately Slow	0.2 – 0.6
Moderate	0.6 – 2.0
Moderately Rapid	2.0 – 6.0
Rapid	6.0 – 20
Very Rapid	> 20

Soil Hydrologic Group

The hydrologic soil group is a direct reflection of the infiltration rate of the soil. The hydrologic soil groups, according to their infiltration and transmission rates, are as follows:

- A. Soils having high infiltration rates even when thoroughly wetted (low runoff potential).*
- B. Soils having moderate infiltration rates when thoroughly wetted.*
- C. Soils having slow infiltration rates when thoroughly wetted.*
- D. Soils having very slow infiltration rates when thoroughly wetted (high runoff potential).*

2.2.2 Soil Properties

The properties of soil at a construction site should be identified for planning purposes. Each soil type has different characteristics, including permeability, infiltration, seasonal wetness, depth to the water table, depth to bedrock, texture, shrink-swell potential, erodibility, and slope.

Variations in the properties of soil affect its ability to support heavy loads, to serve as a medium for wastewater or solid waste disposal, to percolate rainwater, to hold its shape and slope after excavation, or to grow vegetation. These characteristics will ultimately dictate the selection of BMPs at your site. The following sections describe important soil characteristics.

Erodibility

The major soil consideration in controlling erosion and sedimentation is erodibility. An erodibility factor (K) indicates the susceptibility of different soils to the forces of erosion. A soil

survey report includes the K factor for each soil survey area. These K factors are used in the Universal Soil Loss Equation (USLE) to determine soil loss from an area over time because of splash, sheet, and rill erosion. K factors in Florida range from about 0.10 (the lowest erodibility) to about 1.49 (the highest erodibility). K factors are grouped into three general ranges, as follows:

- **0.23 and lower** – *Low erodibility.*
- **0.23 to 0.36** – *Moderate erodibility.*
- **0.36 and up** – *High erodibility.*

The cohesiveness of soil particles varies within different layers of the same soil, causing varying degrees of erodibility at different depths. Therefore, the depth of excavation must be considered in determining soil erodibility on a construction site.

Slope

Slope ranges are recorded in soil surveys, and areas where cuts and fills should be avoided can be identified by studying soil maps. The longer and steeper the slope, the greater the potential for soil loss because of the increased velocity of surface runoff.

Shrink-Swell Potential

Certain soils have clays that shrink when dry and swell when wet. In this situation, special foundations are required to allow for this variation. By consulting the soil survey, soils with these problems can be identified and the necessary precautionary steps can be taken. It should be kept in mind, however, that soil surveys do not always reflect geologic phenomena in the zone beneath the soil; thus, when shrink-swell conditions occur only deep in the soil profile, the soil survey may not be an accurate guide.

Soil Reaction (pH)

Soil survey information on the pH of the individual layers of each soil is useful when planning to establish vegetation on a construction site.

Wetness

The many types of data available in soil surveys include natural soil drainage, depth to seasonal water table, and suitability for winter grading of various kinds of soils. With this information, engineers can make a number of determinations, such as seasonal limits that should be placed on the use of heavy earth-moving machinery and estimates of potential flood hazards or damage to underground structures because of soil wetness.

Depth to Bedrock

Soil surveys indicate bedrock types and in what areas they will be encountered at a depth of less than 5 to 6 feet (1.75 to 2 meters). This information is very helpful in determining suitable locations for stormwater management facilities, or the time and cost of excavation.

Flood Vulnerability

While not a property of soil, knowing the locations of floodprone areas on your site will help provide estimates of where flooding or ponding are most likely to occur and will indicate areas where certain types of soils can be found. The hazards of flooding and ponding are rated in soil surveys, and floodprone areas are shown on soil maps.

2.3 Soil Surveys

Soil surveys are proven to save time and money, and their use results in improved designs, more effective planning, and more accurate preliminary estimates of construction costs. References to soil maps and accompanying supporting data in soil surveys enable developers to determine the soil conditions in proposed construction areas.

Knowing the types of soil, the topography, and surface drainage patterns is beneficial in planning and designing almost any type of land development project and is essential for erosion control planning. In many instances, a major soil-related problem is discovered after a site has been selected and construction is either well under way or in some cases completed. These problems often necessitate delays in construction and ultimately increase the total cost of the project. By consulting a soil survey during the planning process prior to construction, compensating designs can be prepared in advance or alternate sites can be selected.

Soil surveys in Florida are conducted as a joint effort by the NRCS, the Agricultural Experiment Stations of the University of Florida, and the local Soil and Water Conservation Districts. Soil surveys have been published for most Florida counties. Additional soils information may be obtained by contacting the local representative of any of these agencies in your area or at the [NRCS website](http://soils.usda.gov).²

2.4 Predicting Soil Loss Using the Revised Universal Soil Loss Equation (RUSLE)

According to the RUSLE, six major factors affect soil loss, as follows:

$$A = R \times K \times L \times S \times C \times P$$

² <http://soils.usda.gov>.

where:

A = The Soil Loss Factor — An estimated annual average of the soil eroded from the site in an average year.

R = The Rainfall Erosion Index — A measure of erosive force and intensity of rain in a normal year.

K = The Soil Erodibility Factor — A measure of the soil's susceptibility to detachment and transport by rainfall and runoff.

L and S = The Slope Length and the Gradient Factors — The combined effect of slope length and slope gradient.

C – The Vegetative Cover Factor — The ratio of soil loss from land under specified types of cover to the corresponding loss from tilled or disturbed bare soil.

P = The Erosion Control Practices Factor — The selected erosion control practices of the contractor that reduce and control the erosion potential of runoff by reducing the runoff velocity and the tendency of runoff to flow directly downslope.

Resources: University of Florida, Institute of Food and Agricultural Sciences (UF–IFAS), Nutrient Management Series [SS 343](http://edis.ifas.ufl.edu/ss343).³

³ <http://edis.ifas.ufl.edu/ss343>.

Chapter 3: Temporary BMPs for Erosion and Sedimentation Control

- 3.1 Construction Sequencing
- 3.2 Pollution Source Controls on Construction Sites
- 3.3 Stabilized Construction Entrances and Exits
- 3.4 Perimeter Controls
 - 3.4.1 Overview
 - 3.4.2 Silt Fence
 - 3.4.3 Filter Sock – Sediment Retention Fiber Rolls (SRFR) – Wattle
 - 3.4.4 Temporary Diversion Berm
 - 3.4.5 Temporary Fill Diversion
 - 3.4.6 Temporary Slope Drain
 - 3.4.7 Floating Turbidity Barrier
- 3.5 Storm Drain Inlet Protection
- 3.6 Temporary Sediment Trap
- 3.7 Temporary Sediment Basin
- 3.8 Temporary Check Dam

3.1 Construction Sequencing

Definition

Coordinating the construction schedule to minimize the amount of area disturbed at any one time and coordinating land clearing with the installation of erosion control measures.

Purpose

To minimize the amount of disturbed area, thus reducing erosion potential.

Applications

This practice applies to all construction projects. The level of planning and management necessary to minimize erosion and control sedimentation adequately depends on the size, location, and complexity of the construction site.

Planning Considerations

The key to efficient and cost-effective erosion control is to plan construction activities in phases to reduce the erosion potential of the site. By clearing **ONLY** the areas to be developed, only limited areas of land are disturbed, making it much easier to prevent and control erosion than if the entire site were exposed at once. Larger projects should be carried out in phases to minimize the area of exposed soil.

Before site disturbance occurs, perimeter controls, sediment traps, basins, and diversions should be in place to control runoff and capture sediments. Prioritize disturbed areas in the vicinity of

waterbodies, wetlands, steep grades, long slopes, etc., for effective stabilization within seven days of disturbance. Graded areas that will not be worked on should be seeded and mulched immediately, rather than waiting until all project grading is done. A well-planned and well-maintained construction entrance with stabilized construction roads can prevent offsite sedimentation, keep sediments off roads, minimize complaints from neighbors, and reduce future expenses and aggravation.

Land-disturbing activities are best scheduled during periods of low precipitation. Generally, Florida's wet season occurs from May to November with a dry season from November to May. Check with your local water management district or Florida Department of Transportation (FDOT) office for more precise information in your area.

Specifications

The management of construction projects consists of three phases. **Phase 1** is the initial installation of perimeter controls, sediment traps, basins, and diversions prior to site development. **Phase 2** consists of an interim stormwater management plan in which components of the permanent stormwater management system are constructed and connected to the stormwater facilities as the site is developed. **Phase 3** is the finished product and should perform as such.

Phase 1

This is the first construction-related activity to occur on any site. The installation of initial controls shall be discussed at the preconstruction conference. The contractor and the inspector should understand the inspection and maintenance requirements of the specified BMPs, as well as their locations and proper installation procedures.

Offsite runoff should be diverted around the project if stabilized areas, adequate conveyance, and/or protected inlets are available. Sediment traps and basins should be built to receive the anticipated runoff and sediments. A temporary sediment basin in the same location as a permanent stormwater facility makes efficient use of space and simplifies future tasks. Perimeter controls and diversions must be installed to keep sediments onsite and directed into the traps and basins. As clearing and grading progress, temporary seeding and mulching should follow immediately for areas that will not be worked on for a period of seven days or longer.

Phase 2

During this interim phase of the project, the permanent stormwater management system is constructed in conjunction with the other construction activities. Before runoff is directed into it, the system must be properly stabilized. It must also be protected from sedimentation until the completion of the project.

As the stormwater facilities are constructed, they should also be kept free of sediments. Special care must be taken if stormwater ponds are used as temporary sediment basins to ensure the complete removal of accumulated sediments that would reduce stormwater storage volume and cause premature clogging. If possible, design and excavate the sediment basin bottom 6 to 12

inches (15 to 30 centimeters [cm]) higher than the eventual pond bottom. Land disturbance should occur only in areas that are being actively worked. Graded areas should be seeded and mulched immediately if they will not be worked on for a period of 7 days or more.

A regular maintenance program should be in place to ensure that the BMPs are inspected and maintained by the contractor weekly and/or after significant rain events. Any failures should be analyzed to prevent recurrence. Substantial changes to the approved plan must be made or reviewed by the designer and approved by the appropriate regulatory agency.

Phase 3

This is the completed project. The entire stormwater management system should be built according to the approved plans. Substantial deviations from the plan may require revisions by the design professional, reapproval by the regulatory agency, and/or reconstruction by the contractor. The system must also function as designed and in compliance with applicable regulatory criteria. Any previously unforeseen activities that could compromise the function or maintainability of the system should be addressed immediately. The photo below shows a stormwater management system that includes grey and green infrastructure.



3.2 Pollution Source Controls on Construction Sites

Definition

Minimizing nonpoint source pollution from construction sites through good management and "housekeeping" techniques.

Purpose

To reduce the availability of construction-related pollutants that can contaminate runoff water, or to retain pollutants and polluted water onsite.

Applications

This practice applies to all construction projects. The level of planning and management necessary to control nonpoint source pollution adequately depends on the size and complexity of the construction site.

Planning Considerations

Construction activities, by their nature, create many sources of potential pollutants that can contaminate runoff and thus affect the quality of downstream receiving waters. Accelerated erosion and sedimentation caused by land-disturbing activities are the major pollution problems caused by construction.

However, many other potential pollutants are associated with construction activities, such as gasoline, oils, grease, paints, cements, and solvents, to name only a few. Even relatively nontoxic materials such as paper and cardboard are potential pollutants when they are washed into streams and lakes.

The best way to prevent nonpoint source pollution on construction sites is to use good housekeeping practices, which usually entail simply maintaining the site in a neat and orderly condition. Specific practices should be employed to retain runoff and to deal with toxic substances and materials. An overall plan for the control of nonpoint source pollution is advisable so that control measures can be specified and implemented effectively.

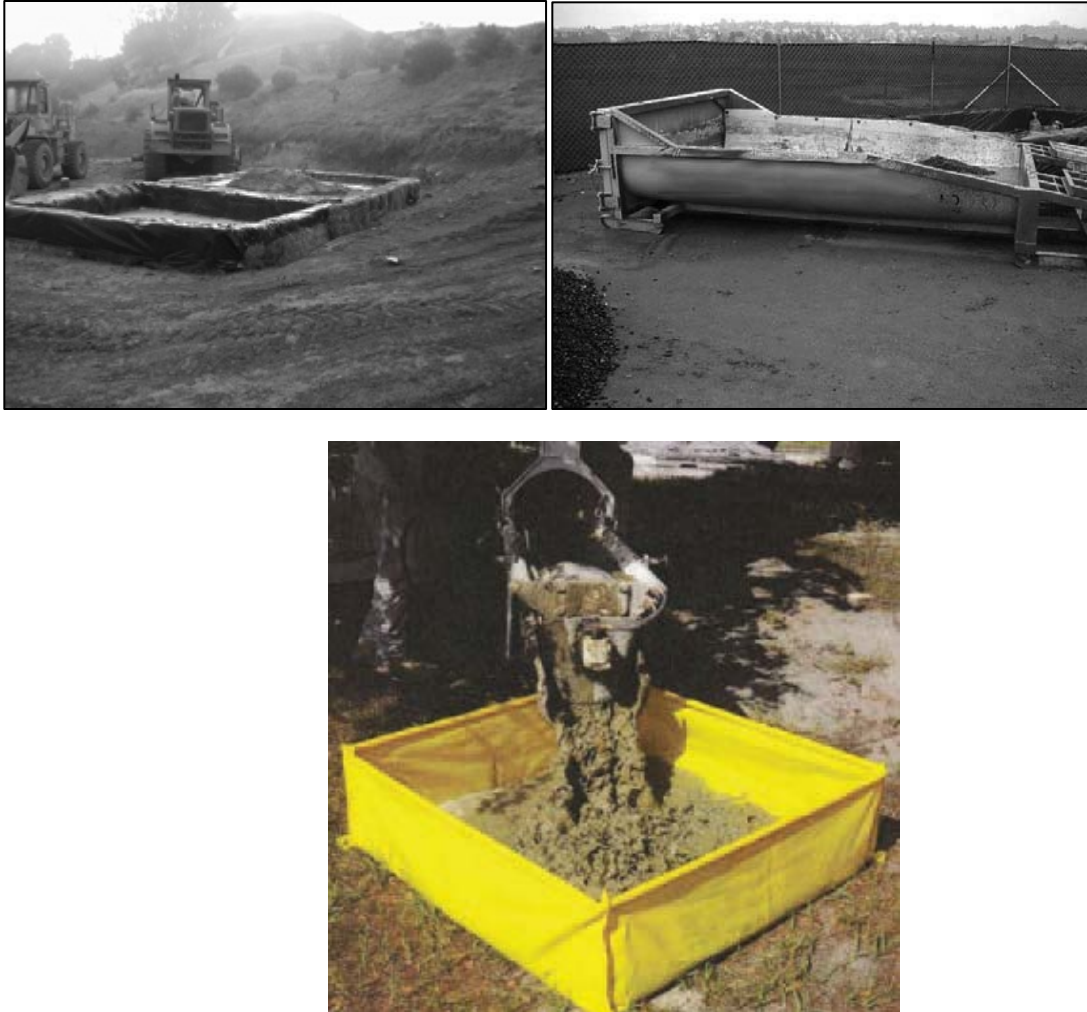
The following 11 elements should be considered in nonpoint source pollution control planning on a construction site:

1. Erosion and Sediment Controls

Practices that minimize erosion and retain sediment onsite are also effective in controlling many other nonpoint source pollutants associated with construction activities. The development and implementation of a good erosion and sediment control plan is a key factor in controlling nonpoint source pollutants other than sediment on a construction site.

2. Vehicle and Concrete Wash Areas

Vehicles such as dump trucks, concrete trucks, and other construction equipment should **NOT** be washed at locations where the runoff will flow directly into a waterbody or stormwater conveyance system. Special areas should be designated for washing vehicles. Concrete washout areas should be located where the runoff can be collected and removed from the site or collected for drying and reused on site. Concrete washout areas may be constructed onsite by digging a pit and lining it with plastic. Manufactured products and waste disposal companies also are available.



3. Equipment Maintenance and Repair

The maintenance and repair of construction machinery and equipment should be confined to areas specifically designated for that purpose. Such areas should be located and designed so that oils, gasoline, grease, solvents, and other potential pollutants cannot be washed directly into receiving streams, stormwater conveyance systems, or existing and potential well fields. These areas should have adequate waste disposal receptacles for liquid and solid wastes. Maintenance areas should be inspected and cleaned daily.

On a construction site where designated equipment maintenance areas are not feasible, exceptional care should be taken during each individual repair or maintenance operation to prevent potential pollutants from being washed into streams or conveyance systems. Temporary waste disposal receptacles should be provided and emptied as required.

4. Waste Collection and Disposal

A plan should be formulated for collecting and disposing of waste materials on a construction site. It should designate locations for trash and waste receptacles and establish a specific

collection schedule. Methods for the ultimate disposal of waste should be specified and carried out according to applicable local and state health and safety regulations. Special provisions should be made for the collection, storage, and disposal of liquid wastes and toxic or hazardous materials.

Receptacles and other waste collection areas should be kept neat and orderly to the extent possible. Trash cans should have lids, and dumpsters should have covers to prevent rainwater from entering. Waste should not be allowed to overflow a container or accumulate for excessively long periods. Trash collection points should be located where they are least likely to be affected by concentrated stormwater runoff.

5. Demolition Debris Areas

Demolition projects usually generate large amounts of dust with significant concentrations of heavy metals and other toxic pollutants. Dust control techniques should be used to limit the transport of airborne pollutants. However, water or slurry used to control dust should be retained onsite and should not be allowed to run directly into watercourses or stormwater conveyance systems. Demolition debris should be regularly hauled off and disposed of into a permitted Class C and D landfill or recycled.

6. Storage of Construction Materials, Chemical and Hazardous Materials, Etc.

Sites where chemicals, cements, solvents, paints, or other potential water pollutants are to be stored should be isolated in areas where they will not cause runoff pollution. Toxic chemicals and materials, such as pesticides, paints, and acids, should be stored according to the manufacturers' guidelines. Overuse should be avoided, and great care should be taken to prevent accidental spillage. Containers should **NEVER** be washed in or near flowing streams or stormwater conveyance systems.



Groundwater resources should be protected from leaching by placing a plastic mat, tarpaper, or other impervious materials on any areas where toxic liquids are to be opened and stored. Portable storage units are also commercially available for material storage and can be locked at the end of the day.

7. Stockpile Erosion Protection

Soil stockpiles should be protected or adequately covered from stormwater during construction. Simple protection measures include silt fencing or a trench around the base of the stockpile. A tarp or temporary seeding also can provide adequate cover for a soil stockpile. Stockpiles should not be placed near the perimeter of the site, near a waterbody or storm drain inlet, or within 10 feet of an infiltration/exfiltration system.

8. Proper Location of Sanitary Facilities

All sanitary facilities should be located away from curb inlets, wetland areas, nearby streams, or rivers and stormwater swales.

9. Dust Control

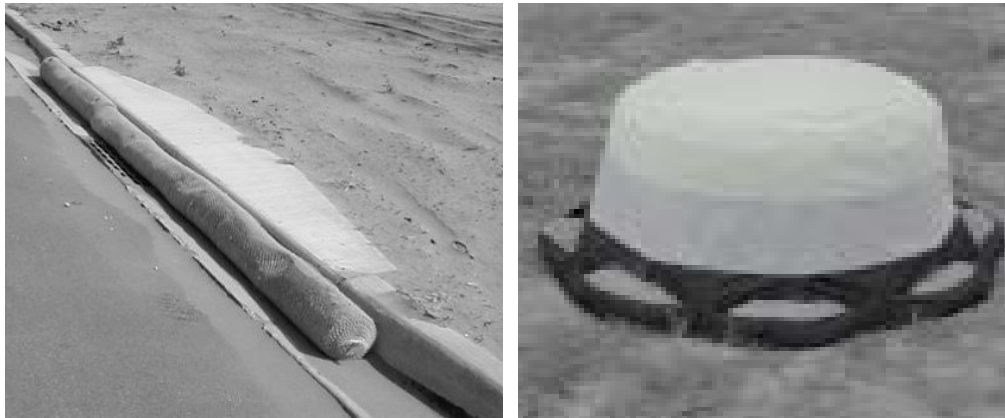
Various types of construction activities generate dust in varying volumes, and road dust causes a concentration of air pollution that can directly affect people who live near an unpaved roadway. To control dust on the job site, FDOT allows the regular use of watering trucks to help control dust. In addition, there are dust control suppression and palliative chemicals designed specifically to abate dust problems on a construction site. Environmentally safe chemicals should always be used; the type of chemical depends on the type of surface involved. The solutions for controlling the problem should be easy to apply, efficient, and cost-effective.

10. Dewatering

The temporary removal of water by well pumps from subsurface formations for mining, quarrying, or construction purposes. See **Chapter 5** for a discussion of dewatering operations.

11. Storm Sewer Inlet Protection

During construction activities, it is important to protect the curb and drop inlets throughout the construction site and the entire project. Otherwise, a very expensive clean-up of the piping and stormwater management system will be required postconstruction (covered further later in this chapter). In the photos below, Geohay (left) is shown covering a curb inlet and a Silt Saver dome (right) is covering a drop inlet.



3.3 Stabilized Construction Entrances and Exits



Definition

A stabilized pad located at points where vehicles enter and leave a construction site.

Purpose

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

Applications

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

Planning Considerations

Construction entrances provide an area where mud can be removed from tires before construction vehicles enter a public road. If the action of the vehicle traveling over the stabilized pad is not sufficient to remove most of the mud, then the tires must be washed before the vehicle enters a public road. If tire washing is provided, provisions must be made to intercept the wash water and trap the sediment before it is carried offsite.

Construction entrances should be used in conjunction with the stabilization of construction roads to reduce the amount of mud picked up by construction vehicles.

Design Criteria

Aggregate Size

If stone is used, FDOT No. 1 Coarse Aggregate, 1 1/2 to 3 1/2 inches (4 to 9 cm), is suggested. Wood chips may be used for single-family residential construction, provided they can be prevented from floating away during a storm event. Manufactured products also are available to

prevent or reduce the amount of sediment tracked onto roadways. If a stabilized exit is not sufficient, street sweeping can be done as an additional measure.

Dimensions

If stone is used, then the aggregate layer must be at least 6 inches (15 cm) thick and must extend the **FULL WIDTH** of the vehicular ingress and egress area. The entrance must be at least 50 feet (20 m) in length. The exit should widen at its connection to the roadway to accommodate the turning radius of large trucks (see **Figure 3.3a**).

Washing

If most of the mud is not removed as vehicles travel over the stone aggregate, then the tires must be washed before the vehicles enter a public road, as illustrated in the photo below. Wash water must be carried away from the entrance to a settling area to remove sediment (see **Figure 3.3b**). A wash rack may also be used to make washing more convenient and effective (see **Figure 3.3c**).



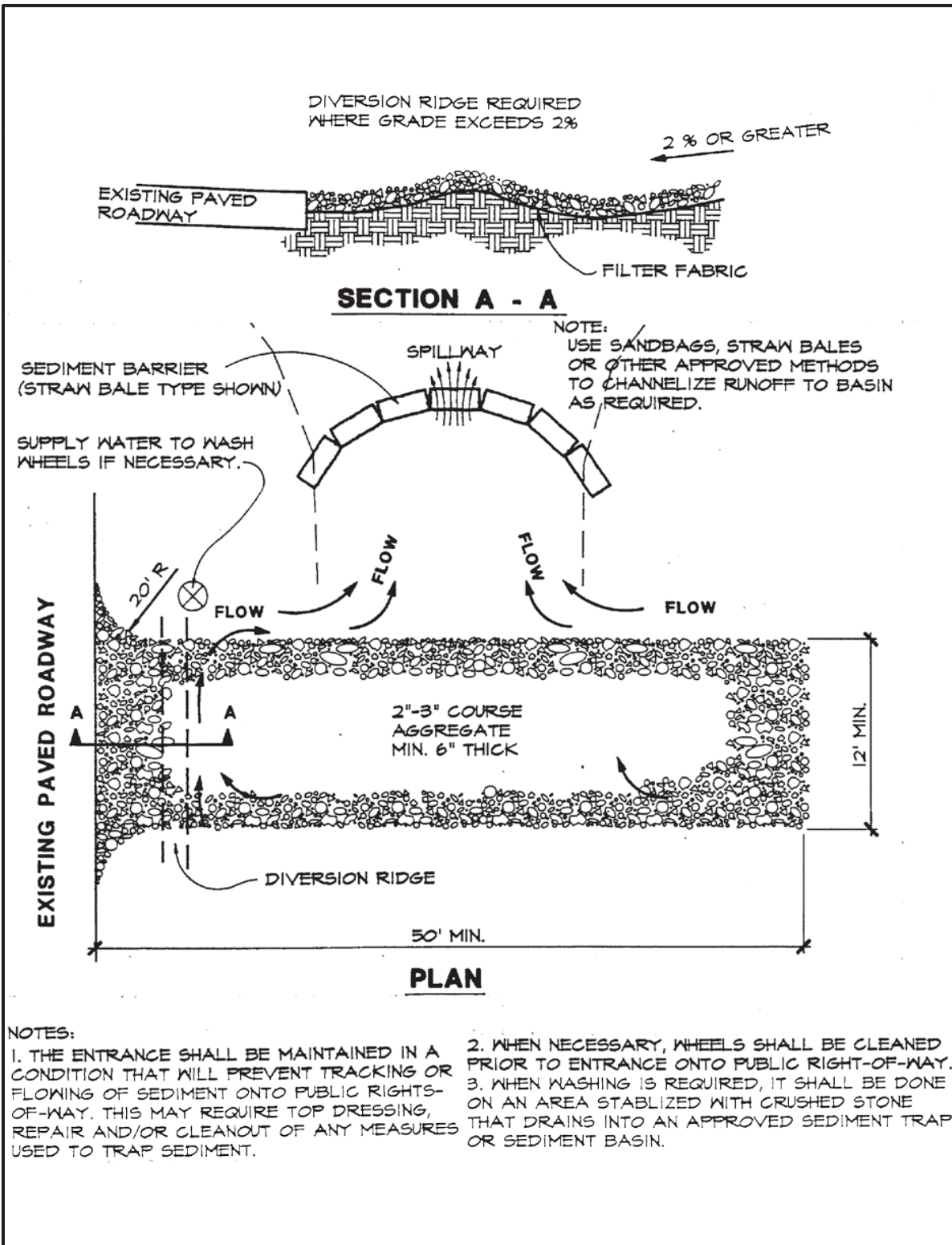


Figure 3.3a. Temporary gravel construction entrance

Source: Erosion Draw

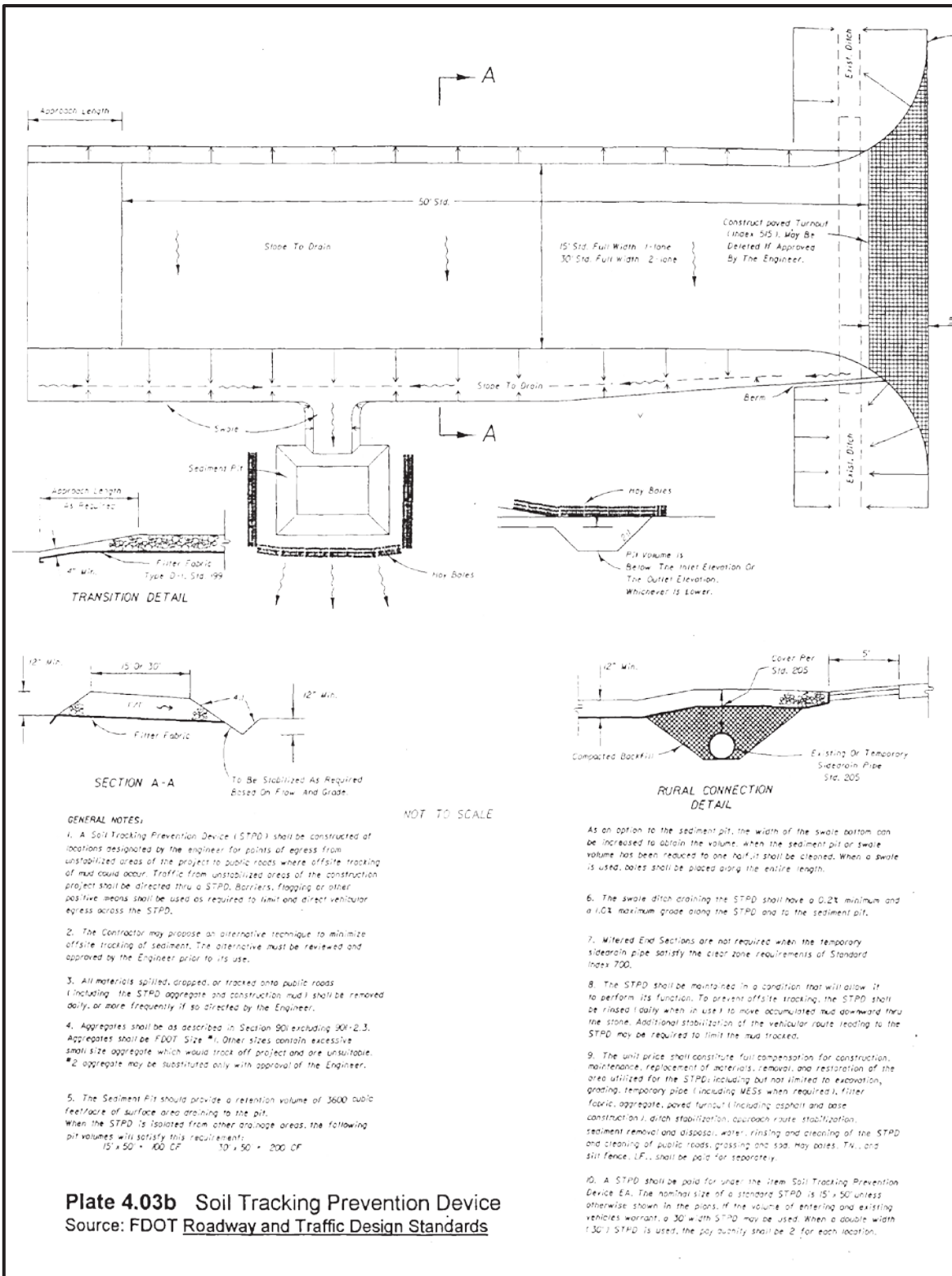


Plate 4.03b Soil Tracking Prevention Device
 Source: FDOT Roadway and Traffic Design Standards

Figure 3.3b. Soil tracking prevention device

Source: FDOT Roadway and Traffic Design Standards

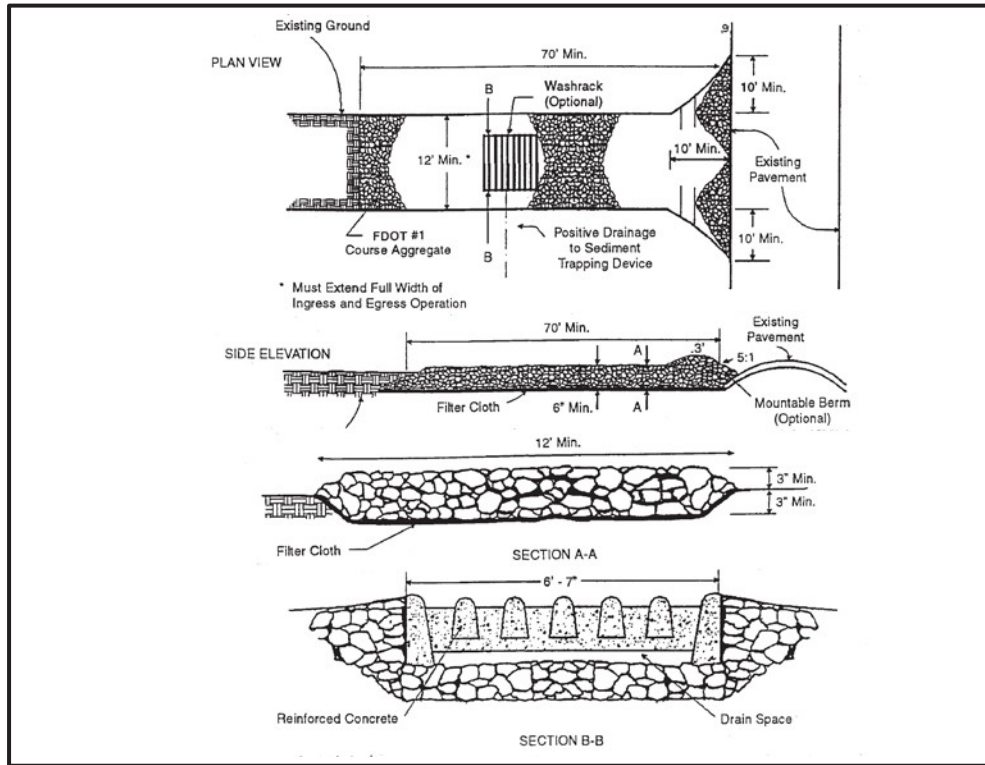


Figure 3.3c. Construction entrance with wash rack

Source: 1983 Maryland Standards for Soil Erosion and Sediment Control

Location

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

Construction Specifications

The entrance area should be cleared of all vegetation, roots, and other objectionable material. A geotextile (shown in the photo at right) should be laid down to improve stability and simplify maintenance when gravel is used. The gravel should then be placed over the geotextile to the specified dimensions.



Maintenance

The stabilized construction exit should be maintained in a condition that will prevent the tracking or flow of mud onto public rights-of-way. This may require periodic maintenance as conditions demand, and the repair and/or clean-out of any structures used to trap sediments. All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately. Look for signs of trucks and trailered equipment "cutting corners" where the construction exit meets the roadway. In the Stormwater Pollution Prevention Plan (SWPPP),

the adjacent roadway should be swept daily when large amounts of soil are hauled in and out of the site.

3.4 Perimeter Controls

3.4.1 Overview

Perimeter controls intercept and detain small amounts of sediment from disturbed areas during construction operations. These measures include silt fences, filter socks, temporary diversion berms, temporary fill diversions, temporary slope drains, and floating turbidity barriers (as illustrated below). They are the last line of defense and one of the most visible and maintenance-intensive BMPs on an active construction site.

These measures reduce the potential for sediment to enter offsite areas such as roadways, storm drains, or adjacent properties. They are used under the following conditions:

1. *Below disturbed areas where erosion would occur in the form of sheet and rill erosion.*
2. *Where the size of the drainage area is no more than 1/4 acre per 100 feet of perimeter control measure, the maximum slope length behind the barrier is 100 feet, and the maximum gradient behind the barrier is 50 % (2:1).*

These measures should be installed before clearing and grading activities begin. They typically remain installed and maintained until the contributing drainage area is stabilized.



Source: Hal Lunsford – Muddy Water Blues Workshop 2018

3.4.2 Silt Fence

Definition

A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts and entrenched. Some silt fence is wire reinforced for support.

Purpose

The purpose of a silt fence is to slow the velocity of water and retain sediment onsite. It is important to understand that regular black woven silt fencing will not stop turbid or fine silty particles from going through the fencing and into an adjacent waterway, causing turbidity and other surface water quality compliance issues. However, some types of silt fencing are "nonwoven" and "performance based," and work much better at removing turbid or fine silty particles while allowing stormwater to pass through.



Applications

A silt fence should only be installed to capture sediment under sheet flow conditions. It should not be installed for channel flow conditions (i.e., ditches, paved ditches, or swales, or in live streams or waterways). Additionally, it is not preferred around drop inlets unless it is reinforced to prevent collapse from water pressure.

Planning Considerations

Silt fences can trap a much higher percentage of suspended sediments than straw bales and are preferable to straw barriers in many cases. The most effective application is to install two parallel silt fences spaced a minimum of three feet apart. The installation and maintenance methods outlined here can improve performance. Silt fences composed of a wire support fence with attached synthetic filter fabric slow the flow rate significantly and have high filtering efficiency. Both woven and nonwoven synthetic fabrics are commercially available. The woven fabrics are generally stronger than the nonwoven fabrics. When tested under acid and alkaline water conditions, most of the woven fabrics increase in strength. There is a variety of reactions among the nonwoven fabrics. The same is true of testing under extensive ultraviolet radiation.

Permeability rates vary regardless of fabric type. While all of the fabrics demonstrate high filtering efficiencies for sandy sediments, there is considerable variation among both woven and nonwoven fabrics when filtering finer silt and clay particles.

Design Criteria

1. *No formal design is required for many small projects and for minor and incidental applications.*
2. *Silt fences shall have an expected usable life of six months. They must be used*

- around perimeters and stockpiles, and at temporary locations where continuous construction changes the earth contour and runoff characteristics.*
3. *Silt fences are limited in application to situations where only sheet or overland flows are expected. They normally cannot filter the volumes of water generated by channel flows, and many fabrics do not have sufficient structural strength to support the weight of water ponded behind the fence line.*
 4. *Types of silt fences vary based on application and are performance based:*
 - a. Standard black silt fence FDOT Type 3 is a woven mesh that traps primarily sands and some silt particles but does not control turbidity.
 - b. BSRF-based strand reinforced fencing comes in two types (Priority 1 and Priority 2). Both are both nonwoven fabrics that trap smaller particles, including sand and finer particles. Priority 1 works best in sloped environments and has a larger stake than Priority 2. Priority 2 works best in level areas and is also used to prevent impacts to sensitive environmental areas adjacent to waterways and wetlands.
 - c. A staked turbidity barrier is an impervious fencing material made like a floating turbidity barrier. It is used in areas where high levels of water may be a problem and the water needs to be diverted to a trap or basin for treatment.
 - d. FDOT Type 1 wire-backed silt fence has nonwoven fabric trenched (according to the same specifications as Type 3) and is clamped with hog rings on the back side to the fencing with post spacing every 10 feet. This type of fencing may be used in lieu of BSRF fencing.

Construction Specifications

Materials

1. *Synthetic filter fabric shall be a pervious sheet of propylene, nylon, polyester, or polyethylene yarn. It shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 °F. to 120 °F. (-17 °C. to 49 °C.).*
2. *The stakes for a silt fence shall be 1 x 2 inches (2.5 x 5 cm) wood (preferred), or equivalent metal with a minimum length of 3 feet (90 cm).*
3. *Wire backed reinforcement for silt fences using standard-strength filter cloth shall be a minimum of 36 inches (90 cm) in height, shall be a minimum of 14 gauge, and shall have a maximum mesh spacing of 6 inches (15 cm) (sometimes referred to as FDOT Type 1 fencing).*

Sheet-Flow Application: Silt Fence

This sediment barrier uses standard-strength or extra-strength synthetic filter fabrics. It is designed for situations in which only sheet or overland flows are expected (see **Figures 3.4a** and **3.4b**):

1. *The height of a silt fence shall not exceed 36 inches (90 cm). Higher fences may impound enough water to cause the structure to fail.*
2. *The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are necessary, filter cloth shall be spliced as described in Item 8 below.*
3. *Posts shall be spaced a maximum of 10 feet (3 m) apart at the barrier location and driven securely into the ground a minimum of 12 inches (30 cm). When extra-strength fabric is used without the wire support fence, post spacing shall not exceed 6 feet (1.8 m).*
4. *A trench shall be excavated approximately 4 inches (10 cm) wide and 4 inches (10 cm) deep along the line of posts and upslope from the barrier.*
5. *When standard-strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch (25 mm) long, tie wires, or hog rings. The wire shall extend into the trench a minimum of 2 inches (5 cm) and shall not extend more than 36 inches (90 cm) above the original ground surface.*
6. *The standard-strength filter fabric shall be stapled or wired to the fence, and 8 inches (20 cm) of the fabric shall be extended into the trench. The fabric shall not extend more than 36 inches (90 cm) above the original ground surface.*
7. *When extra-strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In this case, the filter fabric is stapled or wired directly to the posts with all other provisions of Item 6 applying.*
8. *When attaching 2 silt fences together, place the end post of the second fence inside the end post of the first fence. Rotate both posts at least 180 degrees in a clockwise direction to create a tight seal with the filter fabric. Drive both posts into the ground and bury the flap (see **Figure 3.4b**).*
9. *The trench shall be backfilled and the soil compacted over the filter fabric.*
10. *The most effective application consists of a double row of silt fences spaced a minimum of 3 feet apart, so that if the first row collapses it will not fall on the second row. Wire or synthetic mesh may be used to reinforce the first row (see **Figure 3.4c**).*

11. When used to control sediments from a steep slope, silt fences should be placed away from the toe of the slope for increased holding capacity (see **Figure 3.4d**).
12. Silt fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

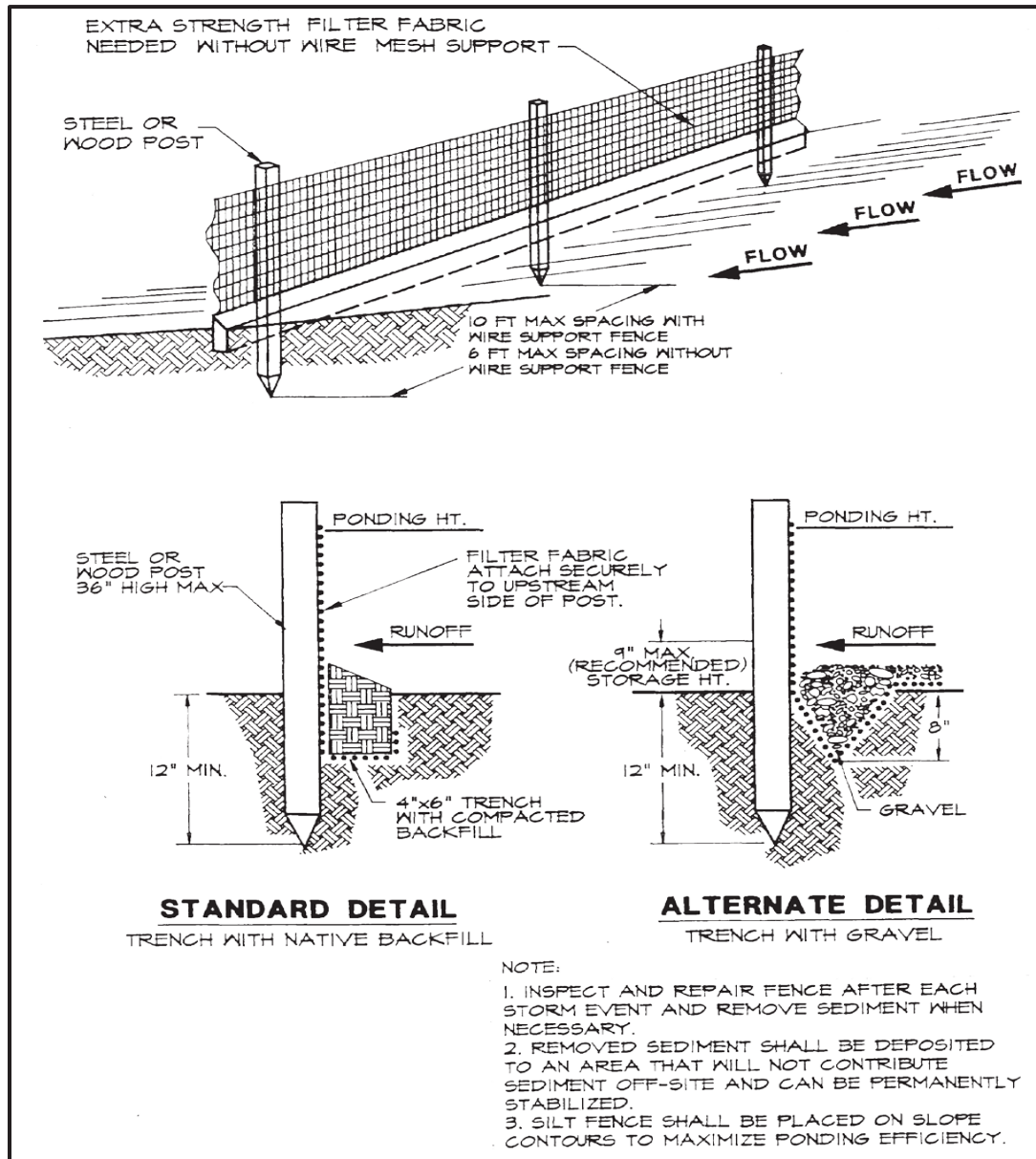


Figure 3.4a. Silt fence

Source: Erosion Draw

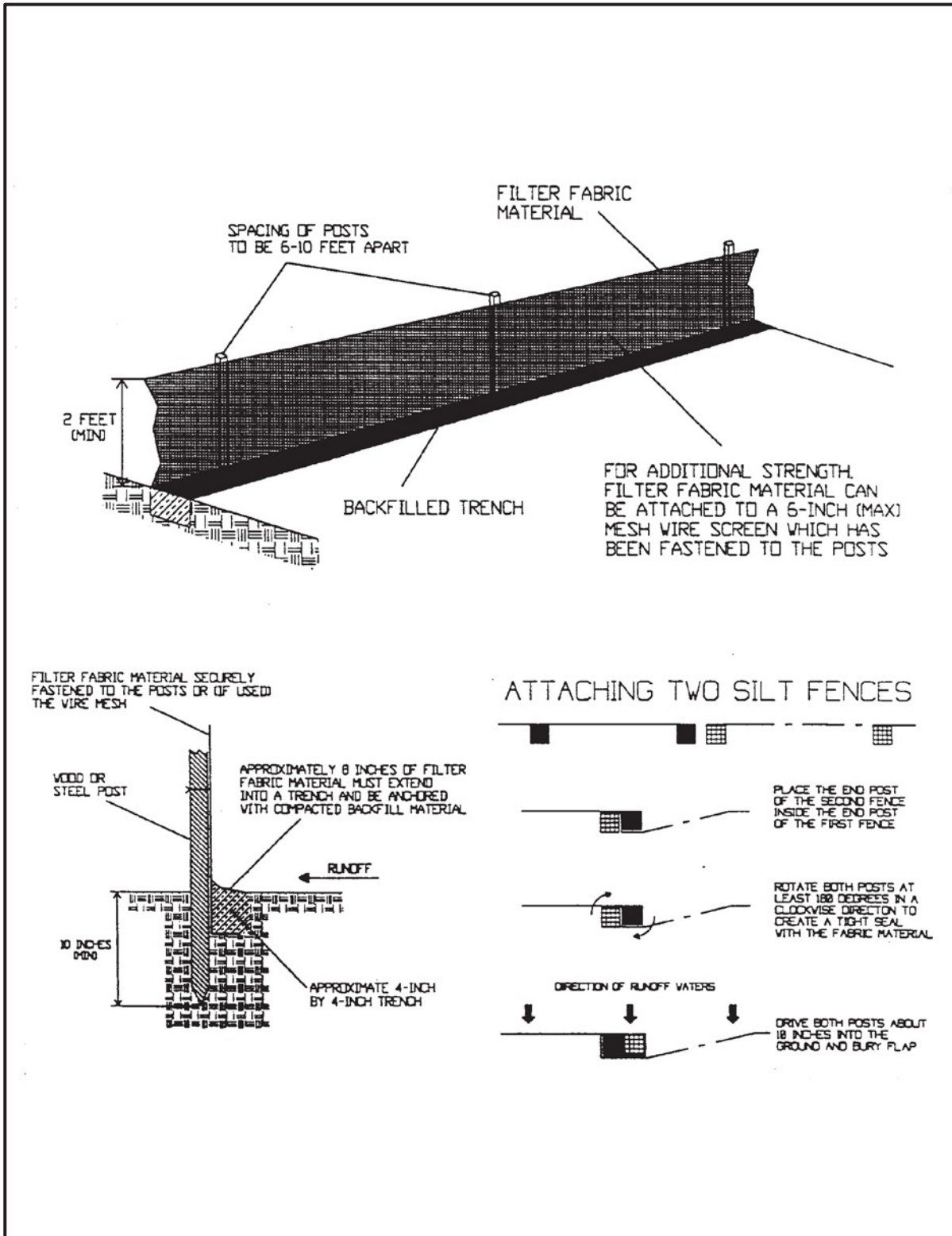


Figure 3.4b. Installing a filter fabric silt fence

Source: HydroDynamics, Inc.

Maintenance

1. Silt fences shall be inspected within 24 hours after each 1/2-inch rainfall event and at least once a week (every 7 calendar days according to the CGP). Any required repairs shall be made immediately.
2. Should the fabric on a silt fence decompose or become ineffective before the end of the expected usable life and the barrier is still necessary, the fabric shall be replaced promptly. Normal life expectancy of silt fence is 6 months.
3. Sediment deposits should be removed when deposits reach approximately one-half the height of the barrier.
4. Any sediment deposits remaining in place after the silt fence is no longer required shall be dressed to conform with the existing grade, prepared, and seeded.

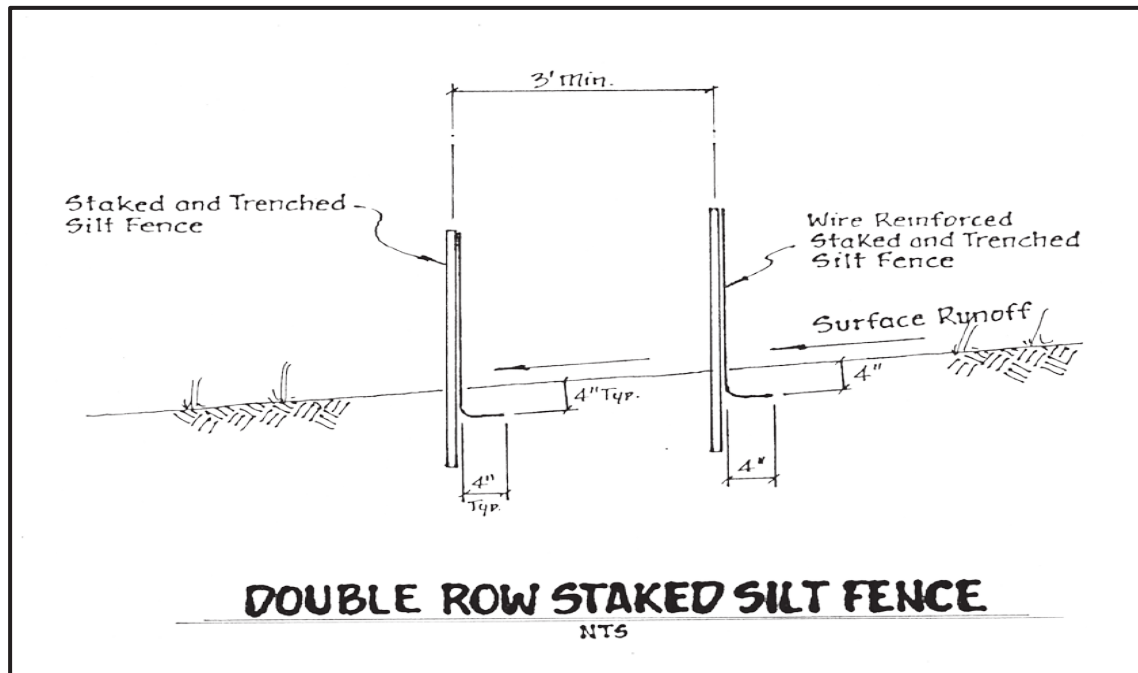


Figure 3.4c. Double row staked silt fence

Source: Reedy Creek Improvement District

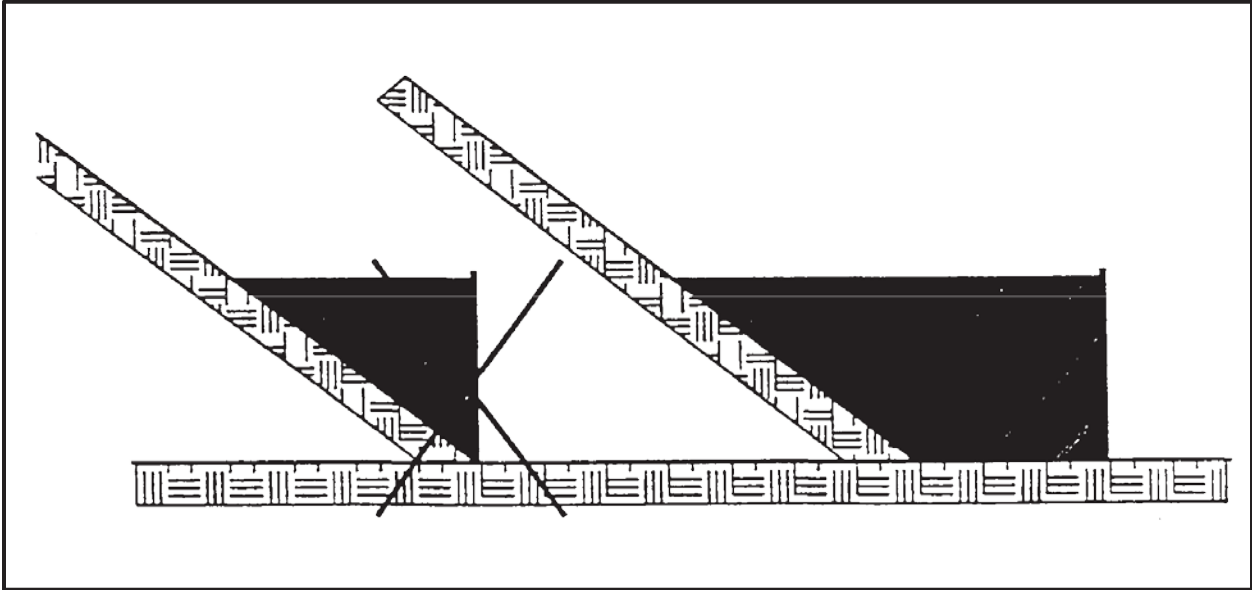


Figure 3.4d. Proper placement of a silt fence at the toe of a slope

Source: HydroDynamics, Inc.

3.4.3 Filter Sock – Sediment Retention Fiber Rolls (SRFR) – Wattle

Definition

A filter sock, referred to as SRFR or wattles, is a three-dimensional, tubular sediment control and stormwater runoff filtration device, encapsulated within a flexible containment material used in sediment and flow control applications. It is used for the perimeter control of sediment and soluble pollutants.

Purposes

1. *To trap sediment and soluble pollutants by filtering runoff water as it passes through the fiber matrix, allowing the deposition of suspended solids.*
2. *To decrease the velocity of sheet flows and low- to moderate-level channel flows.*
3. *To slow and spread runoff, reducing sediment entering retention ponds, lakes, and other waterbodies.*



Applications

1. *Site perimeters.*
2. *Below disturbed areas where erosion would occur in the form of sheet and rill erosion.*
3. *Above and below exposed and erodible slopes.*
4. *Around curb and drop inlets.*
5. *Along the toe of stream and channel banks.*
6. *Where the size of the drainage area is no more than 1/4 acre per 100 feet (1.3 ha/100 m) of silt fence length, the maximum slope length behind the barrier is 100 feet (30 m), and the maximum gradient behind the barrier is 50 % (2:1).*
7. *Around sensitive trees where the trenching of a silt fence is not beneficial for tree survival or may unnecessarily disturb established vegetation.*
8. *In areas where it is necessary to minimize the obstruction of wildlife movement and migration.*

Planning Considerations

A filter sock can be easily implemented as a BMP within a treatment train onsite. The filter sock is installed on top of the soil and does not require soil disturbance for installation and removal. A filter sock contains organic material that can be direct seeded at the time of application to provide greater stability and filtration capacity once vegetation is established. The mesh socks are biodegradable or photodegradable and can be left onsite after construction activity. Filter sock performance depends on ground surface contact and may not be suitable for an extremely bumpy or rocky land surface or steep slopes.

Design Criteria

1. *No formal design is required for many small projects and for minor and incidental applications.*
2. *Filter socks shall have an expected usable life of 9 months. They are applicable in ditch lines, around drop inlets, and at temporary locations where continuous construction changes the earth contour and runoff characteristics, and where low or moderate flows (not exceeding 1 cubic foot per second [cfs]) (0.03 cubic meters per second [m^3/sec]) are expected.*
3. *Filter socks also are applicable where sheet or overland flows are expected. They can be used in channel flow applications to slow the water and allow sediment to settle out of suspension.*

Construction Specifications

Materials

1. *A synthetic filter sock shall be a photodegradable or biodegradable mesh netting material providing a minimum of 9 months of expected usable life at a temperature range of 0 °F. to 120 °F. (-17 °C. to 49 °C.).*
2. *The media within the filter sock shall contain composted material suitable for removing solids and soluble pollutants from stormwater runoff.*
3. *Socks are available in 9-, 12-, 18-, and 24-inch diameters for a variety of applications and may be stacked for increased storage capacity.*
4. *Posts for the filter sock shall be 2 x 2 inches (2.5 x 5 cm) wood (preferred), or equivalent metal with a maximum height of 3 feet.*

Installation

1. *Posts shall be spaced a maximum of 10 feet (3 m) apart at the barrier location and driven securely into the ground on either side of the sock. Install a minimum of 8 inches (20 cm) in clay soils or 12 inches (30 cm) for sandy soils. For use on pavement, heavy concrete blocks or rock bags shall be used behind the filter socks for stabilization.*
2. *When joining two filter socks together, overlap the two sections by about a foot. Drive a stake into the ground through each filter sock.*
3. *Filter socks shall be removed or cut open when they have served their useful purpose, and organic material spread out. However, this should not be done before the upslope area is permanently stabilized.*
4. *Filter socks shall not be used in perennial, ephemeral, or intermittent streams.*

Maintenance

1. *Filter socks shall be inspected at least once per week and within 24 hours of each 1/2 inch or greater rainfall event. Replacements and repairs must be made within a maximum of 7 days.*
2. *Sediment deposits should be removed when deposits reach approximately one-half the height of the barrier.*

3.4.4 Temporary Diversion Berm

Definition

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

Purposes

1. *To divert storm runoff from higher drainage areas away from unprotected slopes to a stabilized outlet.*
2. *To divert sediment-laden runoff from a disturbed area to a sediment-trapping facility.*

Applications

Wherever stormwater runoff must be temporarily diverted to protect disturbed slopes or retain sediments onsite during construction. These structures generally have a life expectancy of 18 months or less.



Planning Considerations

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

If the berm is going to remain in place for longer than 30 days, it is very important that it be established with temporary or permanent vegetation. The slope behind the berm is also an important consideration. The berm must have a positive grade to ensure drainage, but if the slope is too great, precautions must be taken to prevent erosion from high-velocity flow behind the berm.

This practice is considered economical because it uses material available onsite and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the berm with vegetation.

As specified here, this practice is intended to be temporary. However, with more stringent design criteria, it can be made permanent in accordance with **DIVERSION (Chapter 8)**.

Design Criteria

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

Drainage Area

The maximum allowable drainage area is 5 acres (2 ha).

Dimensions

The minimum allowable height measured from the upslope side of the berm is 18 inches (45 cm). The top width shall be a minimum of 2 feet (60 cm) with a minimum base width of 4½ feet (1.4 m) (see **Figure 3.4e**).

Side Slopes

3:1 or flatter.

Grade

The channel behind the berm shall have a positive grade to a stabilized outlet. If the channel slope is less than or equal to 2%, no stabilization is usually required. If the slope is greater than 2%, the channel shall be stabilized in accordance with **STORMWATER CONVEYANCE CHANNEL** (see **Chapter 8**).

Outlet

1. *The diverted runoff, if free of sediment, must be released through a stabilized outlet or channel.*
2. *Sediment-laden runoff must be diverted and released through a sediment-trapping facility.*

Construction Specifications

1. *Whenever feasible, the berm should be built before construction begins on the project.*
2. *The berm should be adequately compacted to prevent failure.*
3. *Temporary or permanent seeding and mulch shall be applied to the berm within 15 days of construction.*
4. *The berm should be located to minimize damage by construction operations and traffic.*

Maintenance

The berm shall be inspected after every storm and repairs made to the berm, flow channel, and outlet, as necessary. Approximately once a week, whether a storm has occurred or not, the berm shall be inspected and repairs made if needed. Damage caused by construction traffic or other activity must be repaired before the end of each working day.

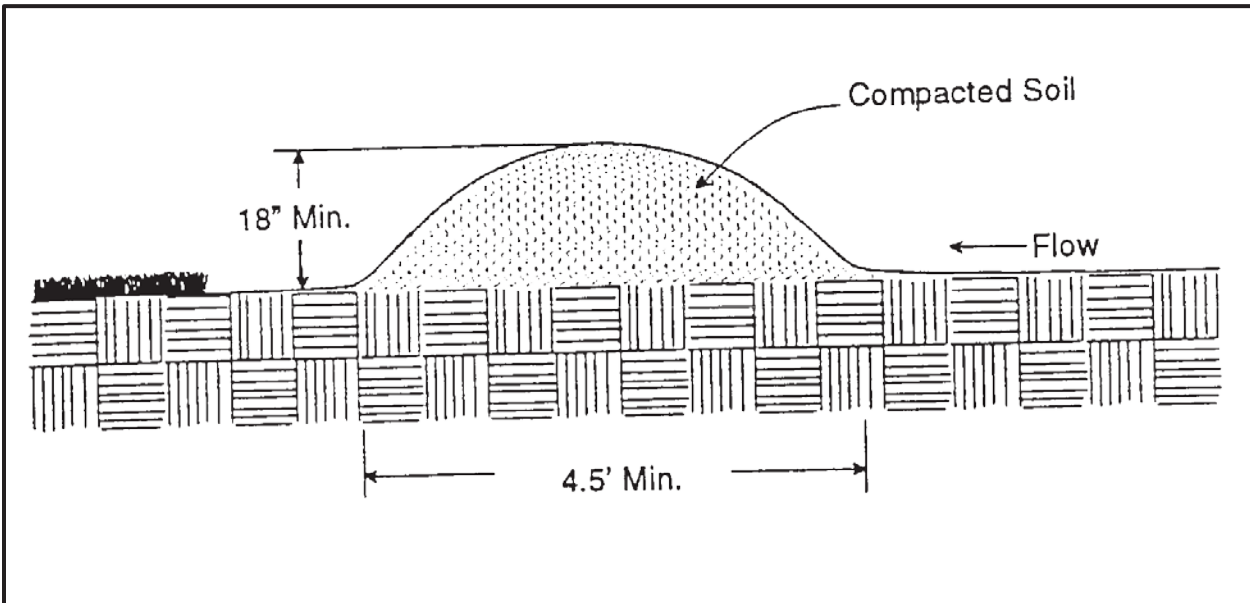


Figure 3.4e. Temporary diversion berm

Source: Virginia Division of Soil and Water Conservation (DSWC)

3.4.5 Temporary Fill Diversion

Definition

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

Purpose

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

Applications

Where the drainage area at the top of an active earth fill slopes toward the exposed slope and where continuous fill operations make the use of a **DIVERSION (Chapter 8)** unfeasible. This temporary structure should remain in place for less than one week.

Planning Considerations

One important principle of erosion and sediment control is to keep stormwater runoff away from exposed slopes. This is often accomplished by installing a berm, diversion, or paved ditch at the top of a slope to carry the runoff away from the slope to a stabilized outlet or downdrain. In general, these measures are installed after the final grade has been reached. On cuts, the measures

may be installed at the beginning, since the work proceeds from the top and the measures have little chance of being covered or damaged. On fills, the work proceeds from the bottom to the top and the elevation changes daily. It is therefore not feasible to construct a compacted berm or permanent diversion that may be covered by the next day's activity.

The temporary fill diversion is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed. This measure can be carried out using a motor grader or one of the smaller bulldozers. To shape the diversion, the piece of machinery used may run near the edge of the fill with its blade tilted to form the channel, as described in **Figure 3.4f**. This work should be done at the end of the working day and should provide a channel with a berm on the lower side to protect the slope. Wherever possible, the temporary diversion should be sloped to direct water to a stabilized outlet. If the runoff is diverted over the fill itself, the practice may cause more problems than it solves by concentrating water at a single point.

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

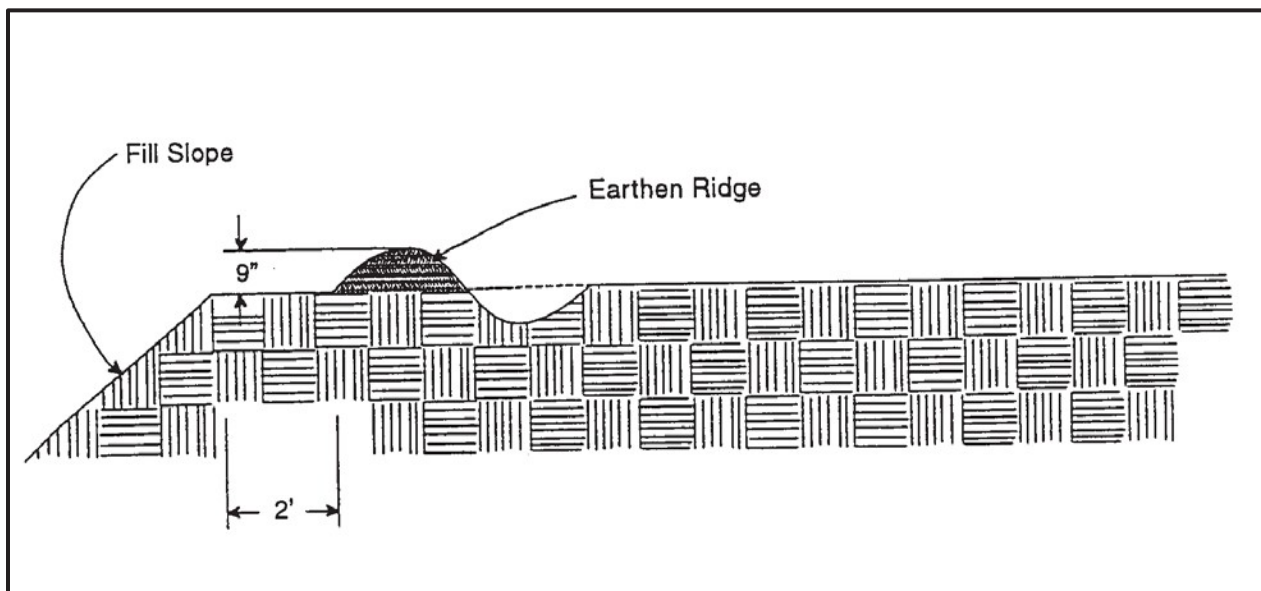


Figure 3.4f. Temporary fill diversion

Source: Virginia DSWC

Design Criteria

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

Drainage Area

The maximum allowable drainage area is 5 acres (2 ha).

Height

The minimum height of the supporting ridge shall be 9 inches (23 cm) (see **Figure 3.4f**).

Grade

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

Outlet

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

Construction Specifications

- 1. The diversion shall be constructed at the top of the fill at the end of each workday as needed.*
- 2. The diversion shall be located at least 2 feet (60 cm) inside the top edge of the fill (see **Figure 3.4f**).*
- 3. The supporting ridge of the lower side shall be constructed with a uniform height along its entire length.*

Maintenance

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

3.4.6 Temporary Slope Drain

Definition

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

Purpose

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

Application

On cut or fill slopes before permanent stormwater drainage structures are installed.



Planning Considerations

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

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

Design Criteria

Drainage Area

The maximum allowable drainage area per drain is 5 acres (2 ha).

Flexible Conduit

1. *The slope drain shall consist of heavy-duty flexible material designed for this purpose. The diameter of the slope drain shall be equal over its entire length. Reinforced hold-down grommets shall be spaced at 10-foot (3 m) maximum intervals.*
2. *Slope drains shall be sized according to the specifications in **Table 3.1**.*

Overside Drain

For small flows and/or short slopes, an open top chute may be used in place of a pipe (see **Figure 3.4g**).

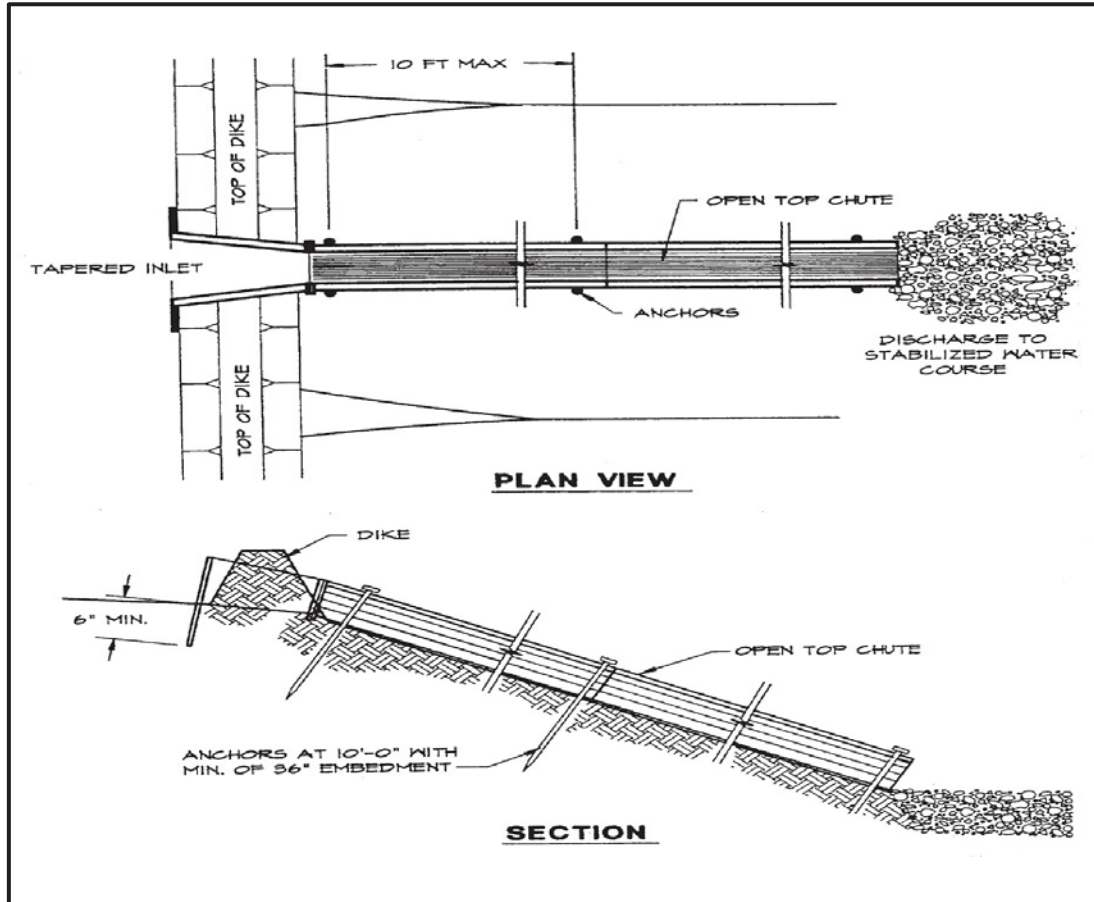


Figure 3.4g. Overside drain

Source: Erosion Draw

Table 3.1. Size of slope drain

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

Entrance Sections

The entrance to the slope drain shall consist of a standard FDOT "Flared End-Section for Metal Pipe Culverts." Extension collars shall consist of 12 inch (30 cm) long corrugated metal pipe. Watertight fittings shall be provided (see **Figures 3.4h** and **3.4i**).

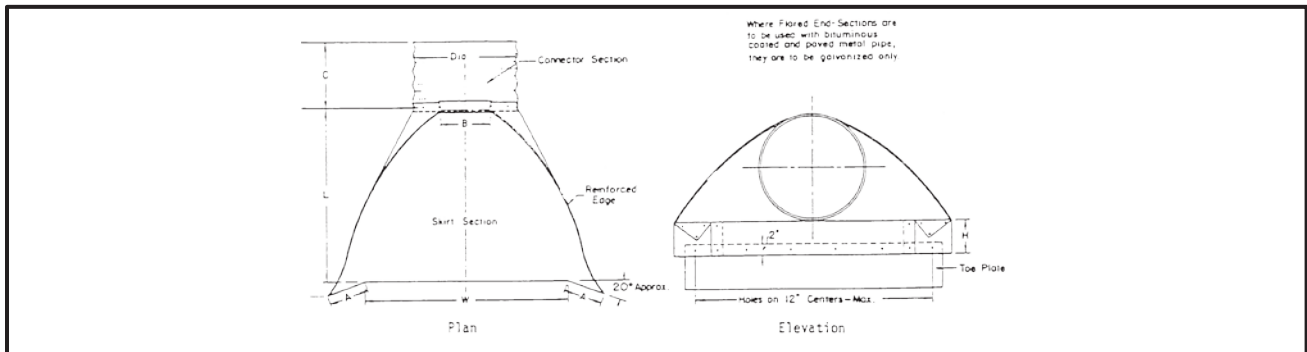


Figure 3.4h. Flared end section schematic

Source: Virginia Department of Highways and Transportation (DH&T) Road Designs and Standards



Soft-armored ditch using polyacrylamide (PAM) and jute fabric.

Source: Applied Polymer Systems, Inc., 2018

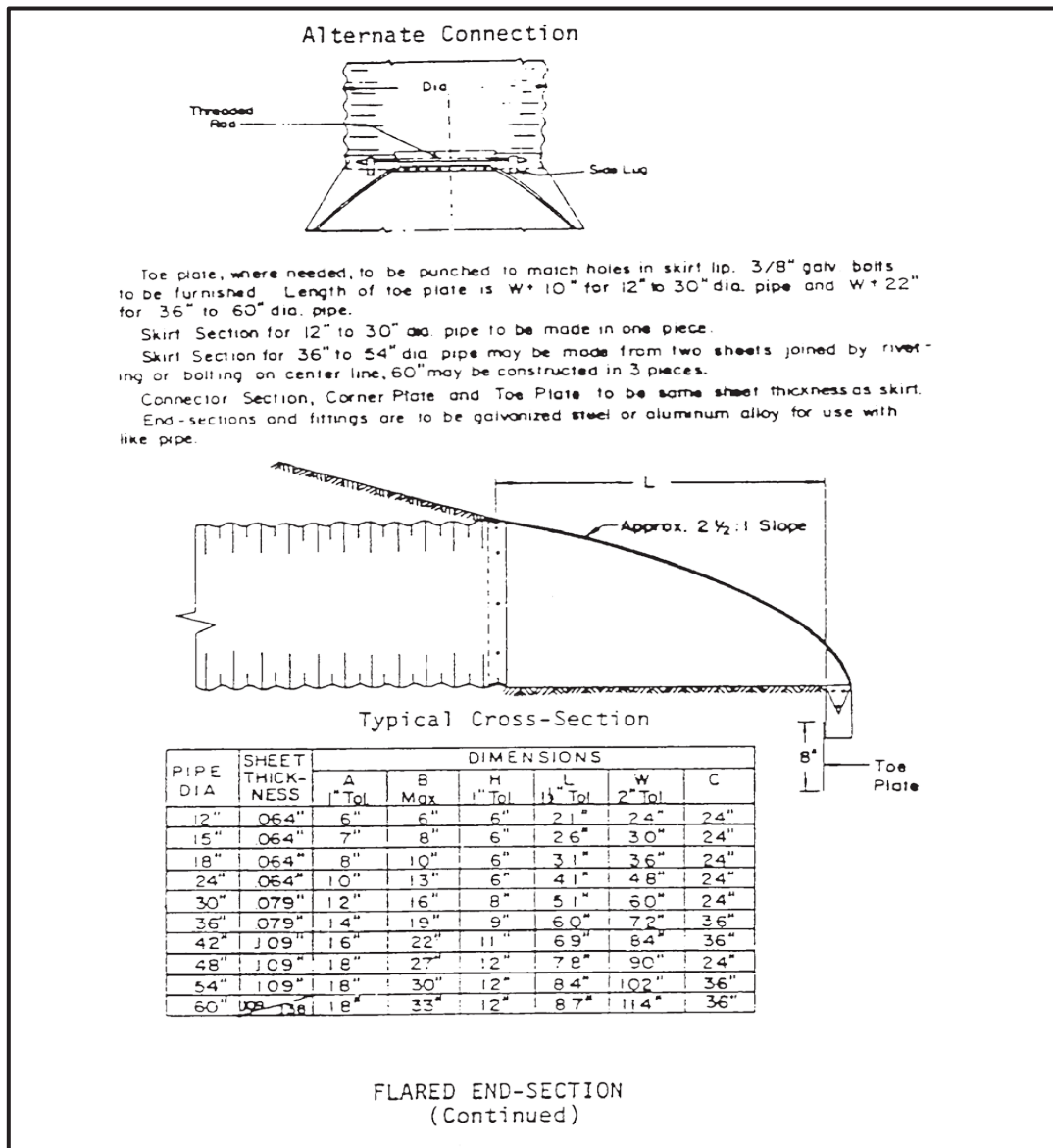


Figure 3.4i. Flared end section specifications

Source: Virginia DH&T Road Designs and Standards

Berm Design

1. An earthen berm shall be used to direct stormwater runoff into the temporary slope drain and shall be constructed according to **DIVERSION** (in Chapter 8) (see **Figure 3.4j**).
2. The height of the berm at the center line of the inlet shall be equal to the diameter of the pipe (D) plus 6 inches (15 cm). Where the berm height is greater than 18 inches (45 cm) at the inlet, it shall be sloped at the rate of 3:1 or flatter to connect with the remainder of the berm (see **Figure 3.4j**).

Outlet Protection

The outlet of the slope drain shall be protected from erosion according to **OUTLET PROTECTION** (in **Chapter 8**) (see **Figure 3.4k**).

Construction Specifications

1. The measure shall be placed on undisturbed soil or well-compacted fill.
2. The entrance section shall slope toward the slope drain at the minimum rate of 1/2 inch per foot (4 cm/m).
3. The soil around and under the entrance section shall be hand-tamped in 8-inch (20 cm) lifts to the top of the berm to prevent piping failure around the inlet.
4. The slope drain shall be securely staked to the slope at the grommets provided.
5. The slope drain sections shall be securely fastened together and have watertight fittings.

Maintenance

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

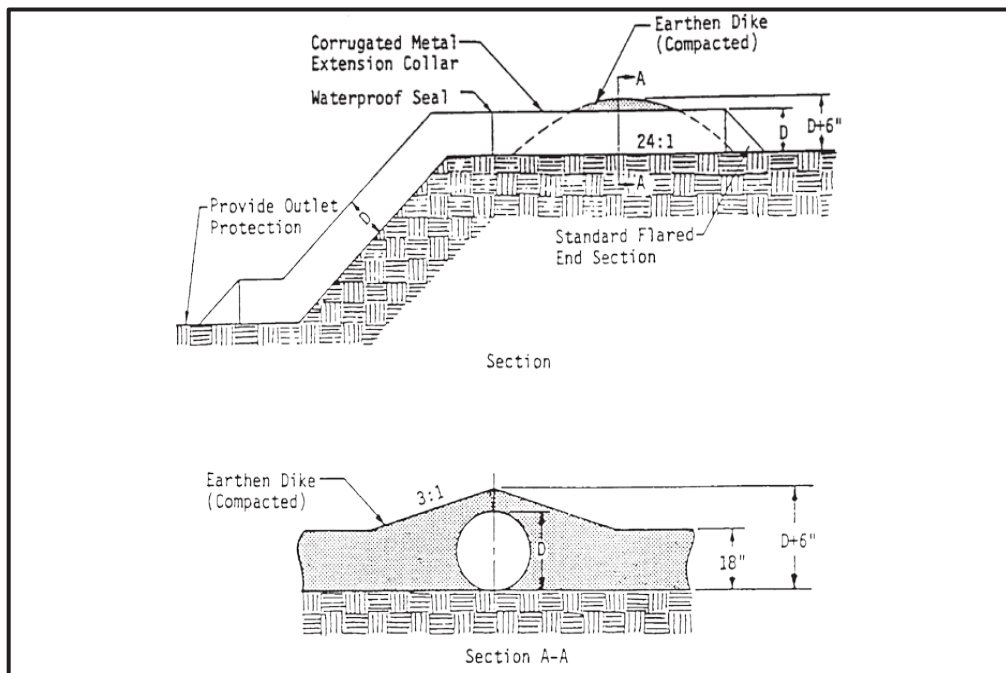


Figure 3.4j. Temporary slope drain

Source: Virginia Soil and Water Conservation Commission (SWCC)

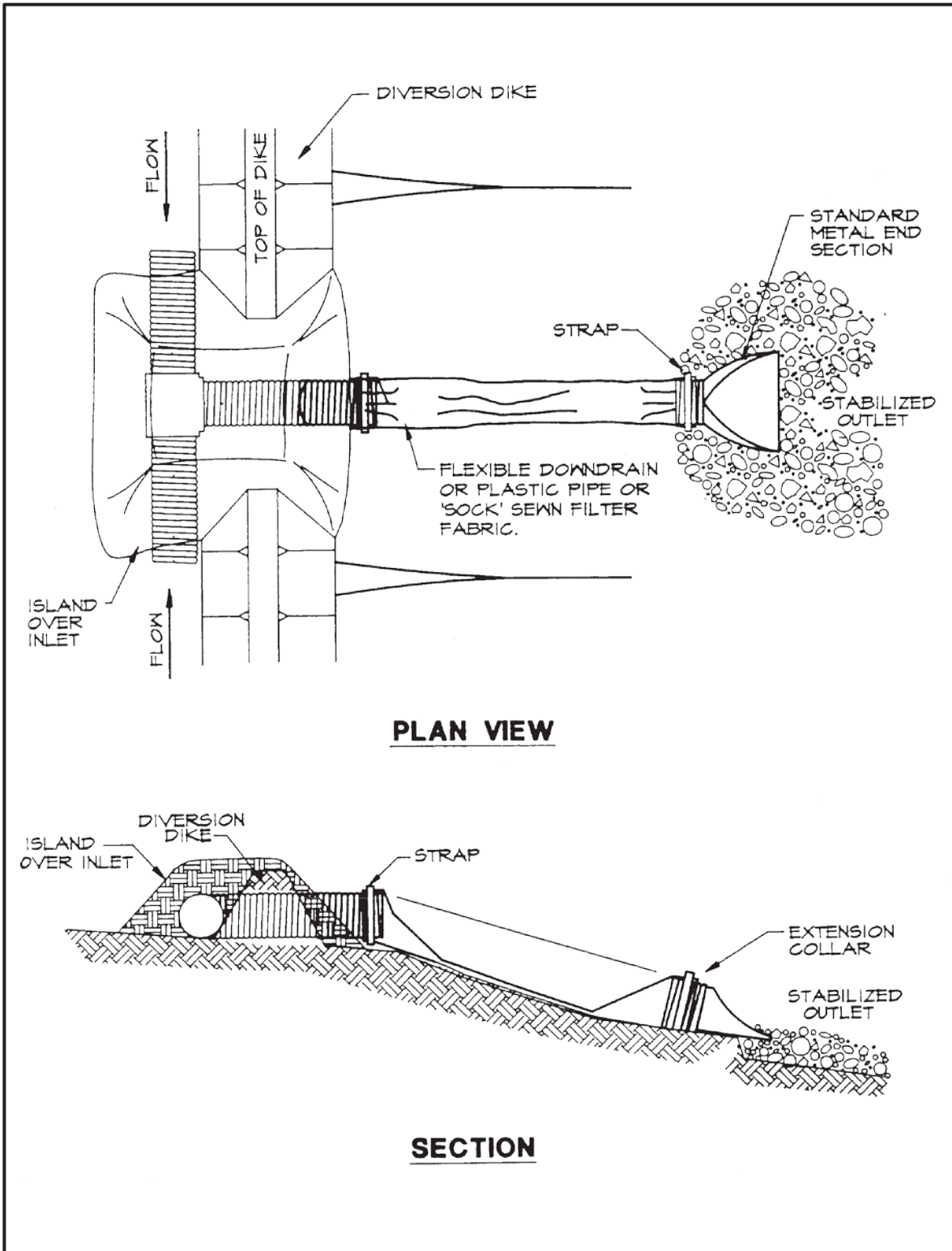


Figure 3.4k. Slope drain

Source: Erosion Draw

3.4.7 Floating Turbidity Barrier

Definition

A floating geotextile material that minimizes sediment transport from a disturbed area adjacent to or within a waterbody.

Purpose

To provide sedimentation protection for a watercourse from upslope land disturbance where conventional erosion and sediment controls cannot be used, or from dredging or filling in a watercourse.



Application

Applicable to nontidal and tidal watercourses where intrusion into a watercourse by construction activities has been permitted and subsequent sediment movement is unavoidable.

Planning Considerations

Soil loss into a watercourse results in the long-term suspension of sediment. In time, the suspended sediment may travel long distances and affect widespread areas. A turbidity curtain is designed to deflect and contain sediment within a limited area and provide enough residence time so that soil particles will fall out of suspension and not travel to other areas.

Turbidity curtain types must be selected based on the flow conditions in the waterbody, whether a flowing channel, lake, pond, or tidal watercourse. The specifications in this measure pertain to minimal and moderate flow conditions where the velocity may reach 5 feet (1.5 m) per second (or a current of approximately 3 knots). For situations where there are greater flow velocities or currents, a qualified engineer and product manufacturer should be consulted.

Consideration must also be given to the direction of water movement in channel flow situations. Turbidity curtains are not designed to act as water impoundment dams and cannot be expected to stop the flow of a significant volume of water. They are designed and installed to trap sediment, not to halt the movement of water itself. In most situations, turbidity curtains should not be installed across channel flows.

In tidal or moving water conditions, provisions must be made to allow the volume of water contained within the curtain to change. Since the bottom of the curtain is weighted and external anchors are frequently added, the volume of water contained within the curtain will be much greater at high tide vs. low tide, and measures must be taken to prevent the curtain from submerging.

In addition to allowing slack in the curtain to rise and fall, water must be allowed to flow through the curtain, if the curtain is to remain in roughly the same place and maintain the same shape. Normally, this is achieved by constructing part of the curtain from a heavy, woven filter fabric. The fabric allows the water to pass through the curtain but retains the sediment particles.

Consideration should be given to the volume of water that must pass through the fabric and sediment particle size when specifying fabric permeability.

Sediment that has been deflected and settled out by the curtain **may be removed** if so directed by the onsite inspector or the permitting agency. However, the probable outcome of the procedure must be considered—**will it create more of a sediment problem by the resuspension of particles and by accidental dumping of the material through the equipment involved?**

It is, therefore, recommended that the soil particles trapped by a turbidity curtain only be removed if there has been a significant change in the original contours of the affected area in the watercourse. Regardless of the decision made, soil particles should always be allowed to settle for a minimum of 6 to 12 hours before their removal by equipment or before the removal of a turbidity curtain.

It is imperative that the intended function of the other controls in this chapter, to keep sediment out of the watercourse, should be the strategy for every erosion control plan. However, when proximity to the watercourse makes successfully mitigating sediment loss impossible, the use of a turbidity curtain during land disturbance is essential.

Under no circumstances shall permitted land-disturbing activities create violations of water quality standards!

Design Criteria

1. *Type I configuration (see **Figure 3.4l**) should be used in protected areas where there is no current and the area is sheltered from wind and waves.*
2. *Type II configuration (see **Figure 3.4l**) should be used in areas where there may be low to moderate current running (up to 2 knots or 3.5 feet [1 m] per second) and/or wind and wave action can affect the curtain.*
3. *Type III configuration (see **Figure 3.4m**) should be used in areas where considerable current (up to 3 knots or 5 feet [1.5 m] per second) may be present, where tidal action may be present, and/or where the curtain may be subject to wind and wave action.*
4. *Turbidity curtains should extend the entire depth of the watercourse whenever it is not subject to tidal action and/or significant wind and wave forces. This prevents silt-laden water from escaping under the barrier, scouring and resuspending additional sediments.*
5. *In situations with tidal and/or wind and wave action, the curtain should never be so long as to touch the bottom. There should be a minimum 1-foot (30 cm) gap between the weighted lower end of the skirt and the bottom at mean low water. The movement of the lower skirt over the bottom because of tidal reverses or wind and wave action on the flotation system may fan and stir*

- sediments already settled out.*
6. *In situations with tidal and/or wind and wave action, it is seldom practical to extend a turbidity curtain lower than 10 to 12 feet (3 to 4 m) below the surface, even in deep water. Curtains that are installed deeper than this will be subject to very large loads with resulting strain on the curtain materials and mooring system. In addition, a curtain installed in this manner can "billow up" toward the surface under the pressure of the moving water, resulting in an effective depth that is significantly less than the skirt depth.*
 7. *Turbidity curtains should be located parallel to the direction of flow of a moving body of water. **They should not be placed across the main flow of a significant body of moving water.***
 8. *When sizing the length of the floating curtain, allow an additional 10 % to 20 % variance in the straight-line measurements. This will allow for measuring errors, make installation easier, and reduce stress from potential wave action during high winds.*
 9. *An attempt should be made to avoid an excessive number of joints in the curtain; a minimum continuous span of 50 feet (15 m) between joints is a good rule of thumb.*
 10. *To maintain stability, a maximum span of 100 feet (30 m) between anchor or stake locations is also a good rule to follow.*
 11. *The ends of the curtain, both floating upper and weighted lower, should extend well up into the shoreline, especially if high-water conditions are expected. The ends should be secured firmly to the shoreline to fully enclose the area where sediment may enter the water.*
 12. *When there is a specific need to extend the curtain to the bottom of the watercourse in tidal or moving water conditions, a heavy, woven, pervious filter fabric may be substituted for the normally recommended impervious geotextile. This creates a "flow-through" medium that significantly reduces the pressure on the curtain and helps to keep it in the same relative location and shape during the rise and fall of tidal waters.*
 13. ***Figure 4.4m** shows the typical alignments of turbidity curtains. The number and spacing of external anchors may vary depending on current velocities and potential wind and wave action; the manufacturer's recommendations should be followed.*
 14. *Be certain that the type, location, and installation of the barrier are as shown on the approved plan and permit. Additional permits may be required in*

navigable waterways, especially when the barrier creates an obstruction.

Construction Specifications

Materials

1. Barriers should be a bright color (yellow or "international" orange are recommended) that will attract the attention of nearby boaters.
2. The curtain fabric must meet the minimum requirements.
3. Seams in the fabric shall be either vulcanized welded or sewn and shall be impervious.
4. Flotation devices shall be flexible, buoyant units contained in an individual flotation sleeve or collar attached to the curtain. Buoyancy provided by the flotation units shall be sufficient to support the weight of the curtain and maintain a freeboard of at least 3 inches (8 cm) above the water surface level (see **Figure 3.4n**).
5. Load lines must be fabricated into the bottom of all floating turbidity curtains. Types II and III must have load lines also fabricated into the top of the fabric. The top load line shall consist of woven webbing or vinyl-sheathed steel cable and shall have a break strength in excess of 10,000 pounds (4.5 metric tonnes [mt]). The supplemental (bottom) load line shall consist of a chain incorporated into the bottom hem of the curtain of sufficient weight to serve as ballast to hold the curtain in a vertical position. Additional anchorage shall be provided as necessary. The load lines shall have suitable connecting devices that develop the full breaking strength for connecting to load lines in adjacent sections (see **Figures 3.4l** and **3.4m**, which portray this orientation).
6. External anchors may consist of 2 x 4 inch (5 x 10 cm) or 2 1/2 inch (6 cm) minimum diameter wooden stakes, or 1.33 pounds per linear foot (2 kilograms [kg]/m) steel posts when Type I installation is used. For Type II or Type III installations, bottom anchors should be used.
7. Bottom anchors must be sufficient to hold the curtain in the same position relative to the bottom of the watercourse without interfering with the action of the curtain. The anchor may dig into the bottom (grappling hook, plow, or fluke-type) or may be weighted (mushroom-type) and should be attached to a floating anchor buoy via an anchor line. The anchor line then runs from the buoy to the top load line of the curtain. When used with Type III installations, these lines must contain enough slack to allow the buoy and curtain to float freely with tidal changes without pulling the buoy or curtain down, and they must be checked regularly to make sure they do not become entangled with

debris. As previously noted, anchor spacing varies with current velocity and expected wind and wave action; the manufacturer's recommendations should be followed (see the orientation of external anchors and anchor buoys for tidal installation in **Figure 3.4m**).



Source: enviro-usa.com

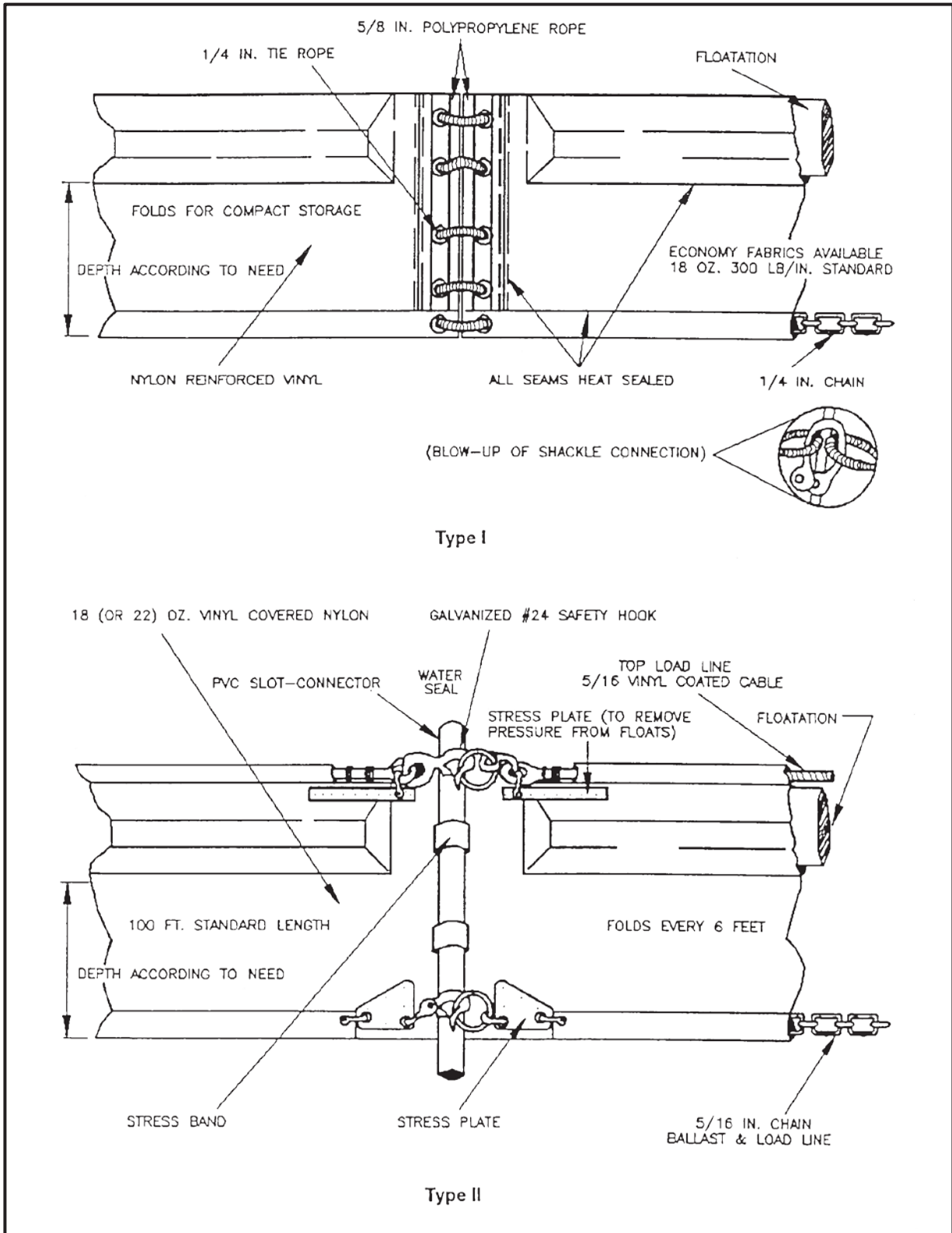


Figure 3.4l. Type I and II floating turbidity barriers

Source: American Boom and Barrier Corporation

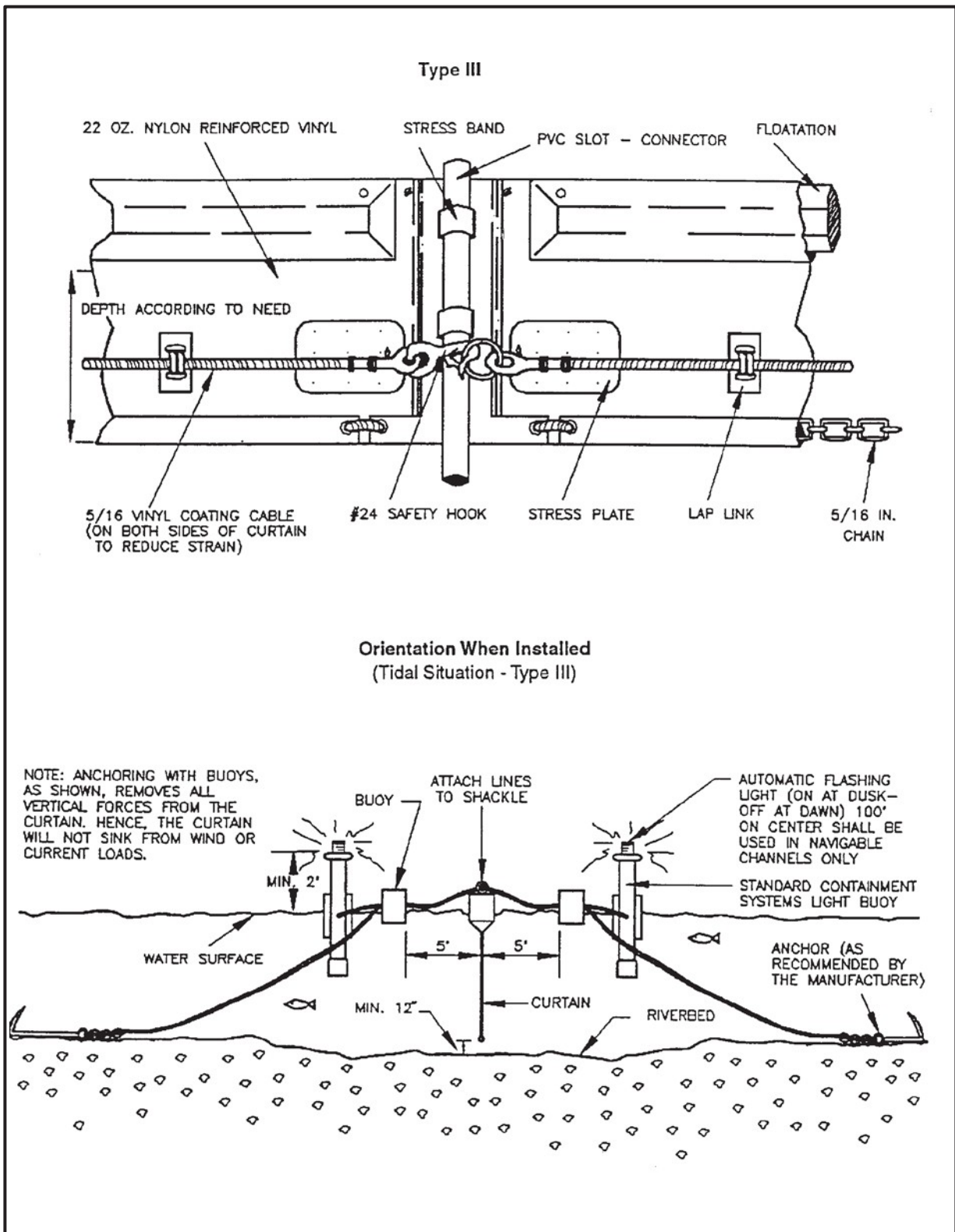


Figure 3.4m. Type III floating turbidity barrier

Source: American Boom and Barrier Corporation and Virginia Department of Transportation (DOT) Standard Sheets

Installation

1. *In the calm water of lakes or ponds (Type I installation), it is usually sufficient to merely set the curtain end stakes or anchor points (using anchor buoys if bottom anchors are employed), then tow the curtain **in the furled condition** out and attach it to these stakes or anchor points. Following this, any additional stakes or buoyed anchors required to maintain the desired location of the curtain may be set and these anchor points made fast to the curtain. **Only then** should the furling lines be cut to let the curtain skirt drop.*
2. *In rivers or in other moving water (Type II and III installations), it is important to set all the curtain anchor points. Care must be taken to ensure that the anchor points have sufficient holding power to retain the curtain under the expected current conditions, before putting the furled curtain into the water. Anchor buoys should be employed on all anchors to prevent the current from submerging the flotation at the anchor points. If the moving water into which the curtain is being installed is tidal and will subject the curtain to currents in both directions as the tide changes, it is important to provide anchors on both sides of the curtain for two reasons, as follows:*

- a. *Curtain movement will be minimized during tidal current reversals.*
- b. *The curtain will not overrun the anchors or pull them out when the tide reverses.*

When the anchors are secure, the furled curtain should be secured to the upstream anchor point and then sequentially attached to each next downstream anchor point until the entire curtain is in position. At this point, and before unfurling, the "lay" of the curtain should be assessed and any necessary adjustments made to the anchors. Finally, when the desired location is achieved, the furling lines should be cut to allow the skirt to drop.

3. ***Always attach anchor lines to the flotation device, not to the bottom of the curtain.*** *The anchor line attached to the flotation device on the downstream side will provide support for the curtain. Attaching the anchors to the bottom of the curtain could cause the curtain to fail prematurely because of the stresses imparted on the middle section of the curtain.*
4. *There is an exception to the rule that turbidity curtains should not be installed across channel flows: when there is a danger of creating a silt buildup in the middle of a watercourse, thus blocking access or creating a sandbar. Curtains have been used effectively in large areas of moving water by forming a very long-sided, sharp "V" to deflect clean water around a work site, confine a large part of the silt-laden water to the work area inside the "V," and direct much of the silt toward the shoreline. Care must be taken, however, not to install the curtain perpendicular to the water current.*

5. See **Figure 3.4n** for typical installation layouts.
6. The effectiveness of the barrier can be increased by installing 2 parallel curtains, separated at regular intervals by 10 feet (3 m) long wooden boards or lengths of pipe.

Maintenance

1. The developer/owner shall be responsible for maintaining the filter curtain for the duration of the project to ensure the continuous protection of the watercourse.
2. Should repairs to the geotextile fabric become necessary, repair kits are normally available from the manufacturer; the manufacturer's instructions must be followed to ensure the adequacy of the repair.

Removal

1. Care should be taken to protect the skirt from damage as the turbidity curtain is dragged from the water.
2. The site selected to bring the curtain ashore should be free of sharp rocks, broken cement, debris, etc., to minimize damage when hauling the curtain over the area.
3. If the curtain has a deep skirt, it can be further protected by running a small boat along its length with a crew installing furling lines before attempting to remove the curtain from the water.
4. When the curtain is no longer required as determined by the inspector, the curtain and related components shall be removed in a manner that minimizes turbidity. Sediment shall be removed and the original depth (or plan elevation) restored before removing the curtain. The remaining sediment shall be sufficiently settled before the curtain is removed. Any spoils must be taken to an upland area and stabilized.

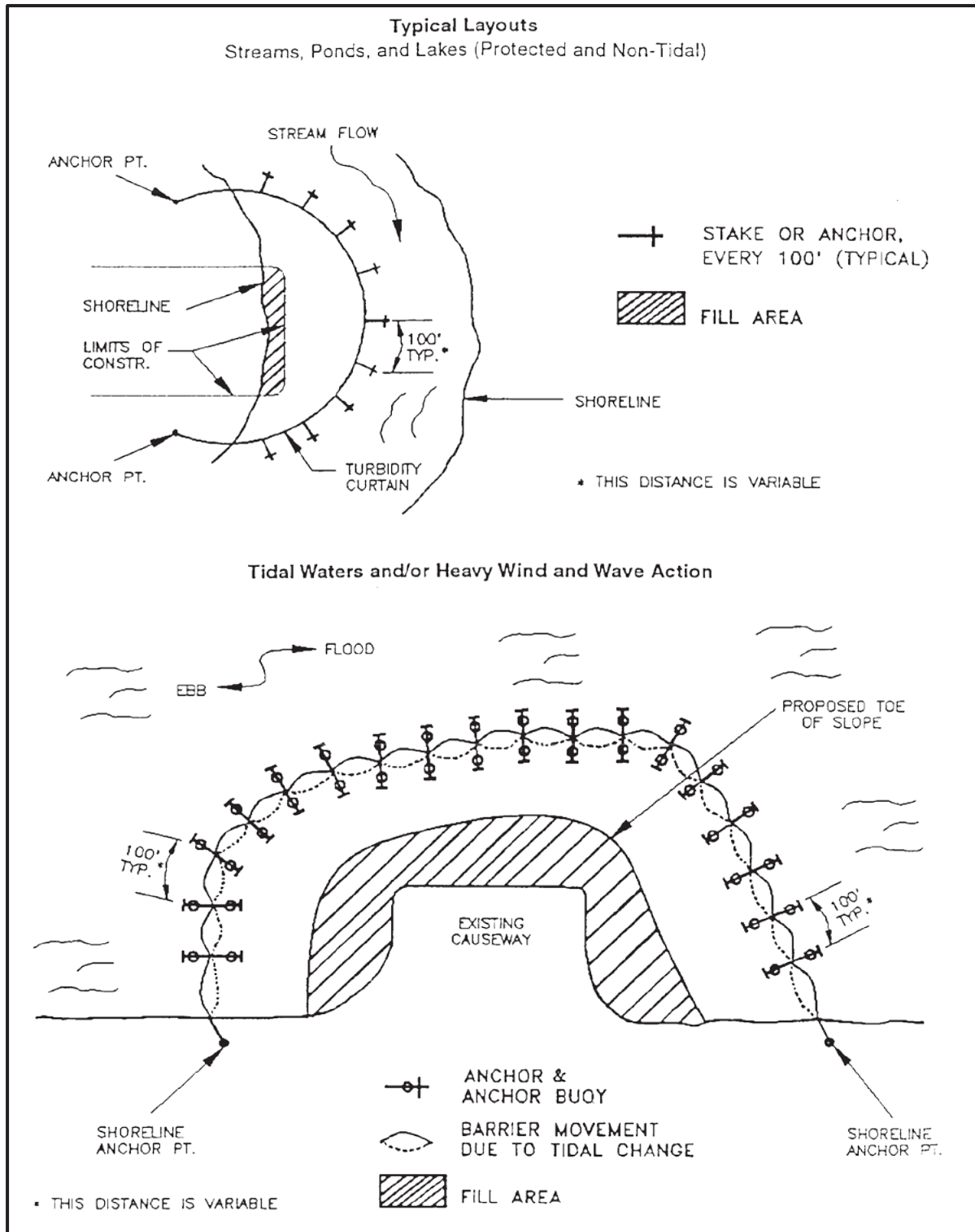


Figure 3.4n. Typical installation layouts

Source: FDOT Roadway and Traffic Design Standards

3.5 Storm Drain Inlet Protection

Definition

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

Purpose

To prevent sediment from entering stormwater conveyance systems before the disturbed area is permanently stabilized.

Application

Where storm drain inlets are to be made operational before the permanent stabilization of the disturbed drainage area. Different types of structures are used for different conditions (see **Figures 3.5a through 3.5j**).

Planning Considerations

Storm sewers that are made operational before their drainage area is stabilized can convey large amounts of sediment to receiving waters. In the case of extreme sediment loading, the storm sewer itself may clog and lose most of its capacity. To avoid these problems during construction activities, it is essential to prevent sediment from entering the system at the inlets.

There are several types of inlet filters and traps, which have different applications depending on the site conditions and type of inlet. Choices for inlet protection should take into consideration the frequency of maintenance required and the manpower costs of replacement.

Note that these various inlet protection devices are for drainage areas of **less than 1 acre (0.4 ha)**. Runoff from large, disturbed areas should be routed through a **TEMPORARY SEDIMENT TRAP** (discussed later in this chapter).

Design Criteria

1. *The drainage area shall be no greater than 1 acre (0.4 ha).*
2. *The inlet protection device shall be constructed to facilitate the cleanout and disposal of trapped sediment and to minimize interference with construction activities.*
3. *The inlet protection devices shall be constructed so that any resultant ponding or stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.*
4. **Figures 3.5a through 3.5j** show the specific design criteria for each particular inlet protection device.

Construction Specifications

Fabric Drop Inlet Sediment Filter

1. *The fabric shall be cut from a continuous roll to avoid joints.*
2. *Stakes shall be 2 x 4 inch (5 x 10 cm) wood (preferred) or equivalent metal with a minimum length of 3 feet (90 cm) (see **Figure 4.5a**).*
3. *Staples shall be of heavy-duty wire at least 1/2 inch (13 mm) long.*
4. *Stakes shall be spaced around the perimeter of the inlet a maximum of 3 feet (90 cm) apart and securely driven into the ground a minimum of 8 in (20 cm). A frame of 2 x 4 inch (5 x 10 cm) of wood shall be constructed around the top of the stakes for proper stability.*
5. *A trench shall be excavated approximately 4 in (10 cm) wide and 4 in (10 cm) deep around the outside perimeter of the stakes (see Figure 4.5b).*
6. *The fabric shall be stapled to the wooden stakes, and 8 inches (20 cm) of the fabric shall be extended into the trench. The height of the filter barrier shall be a minimum of 15 inches (38 cm) and shall not exceed 18 inches (45 cm).*
7. *The trench shall be backfilled and the soil compacted over the fabric.*



Source: Auburn University



Source: LakeCountyOhio.gov

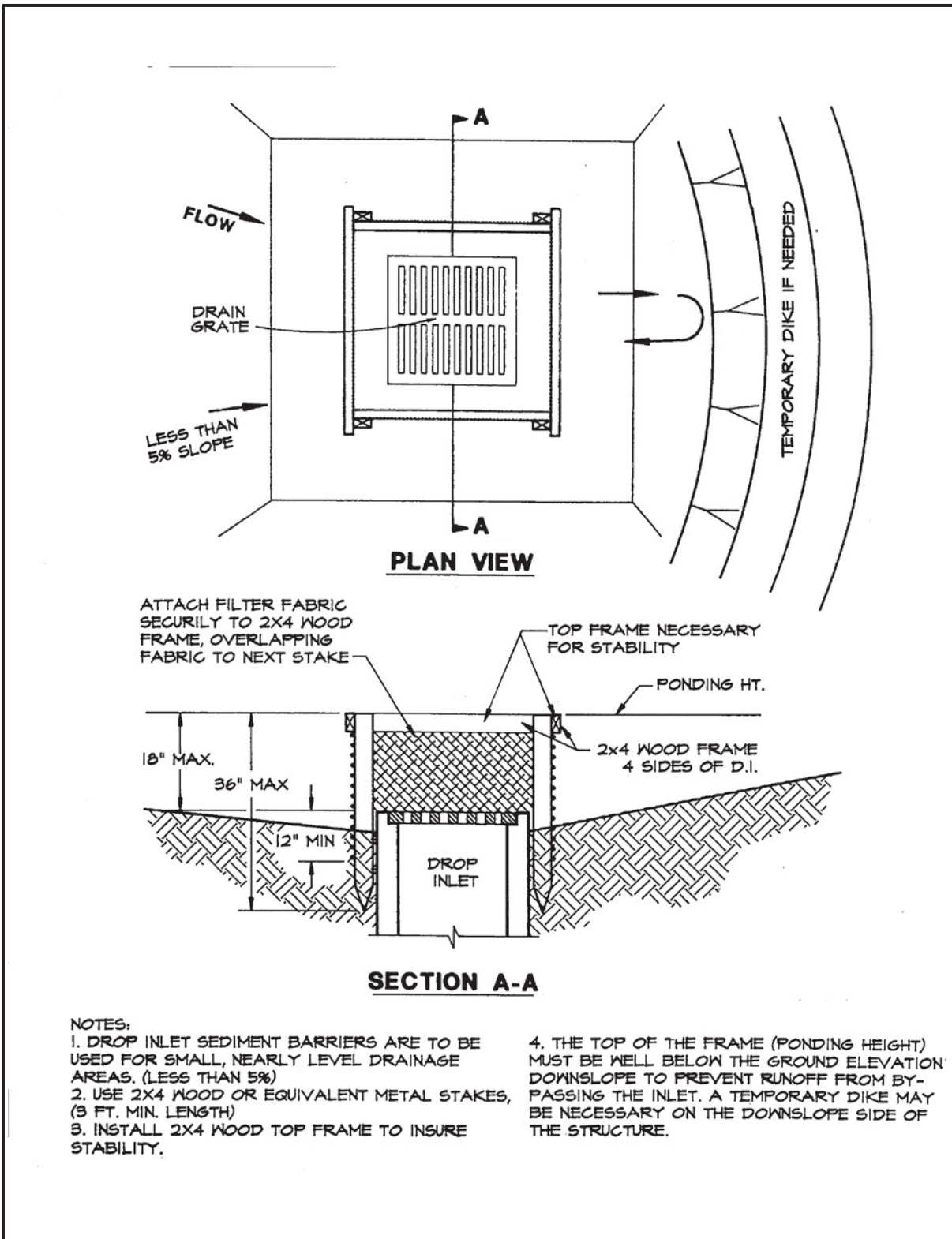


Figure 3.5a. Silt fence drop inlet sediment barrier

Source: Erosion Draw

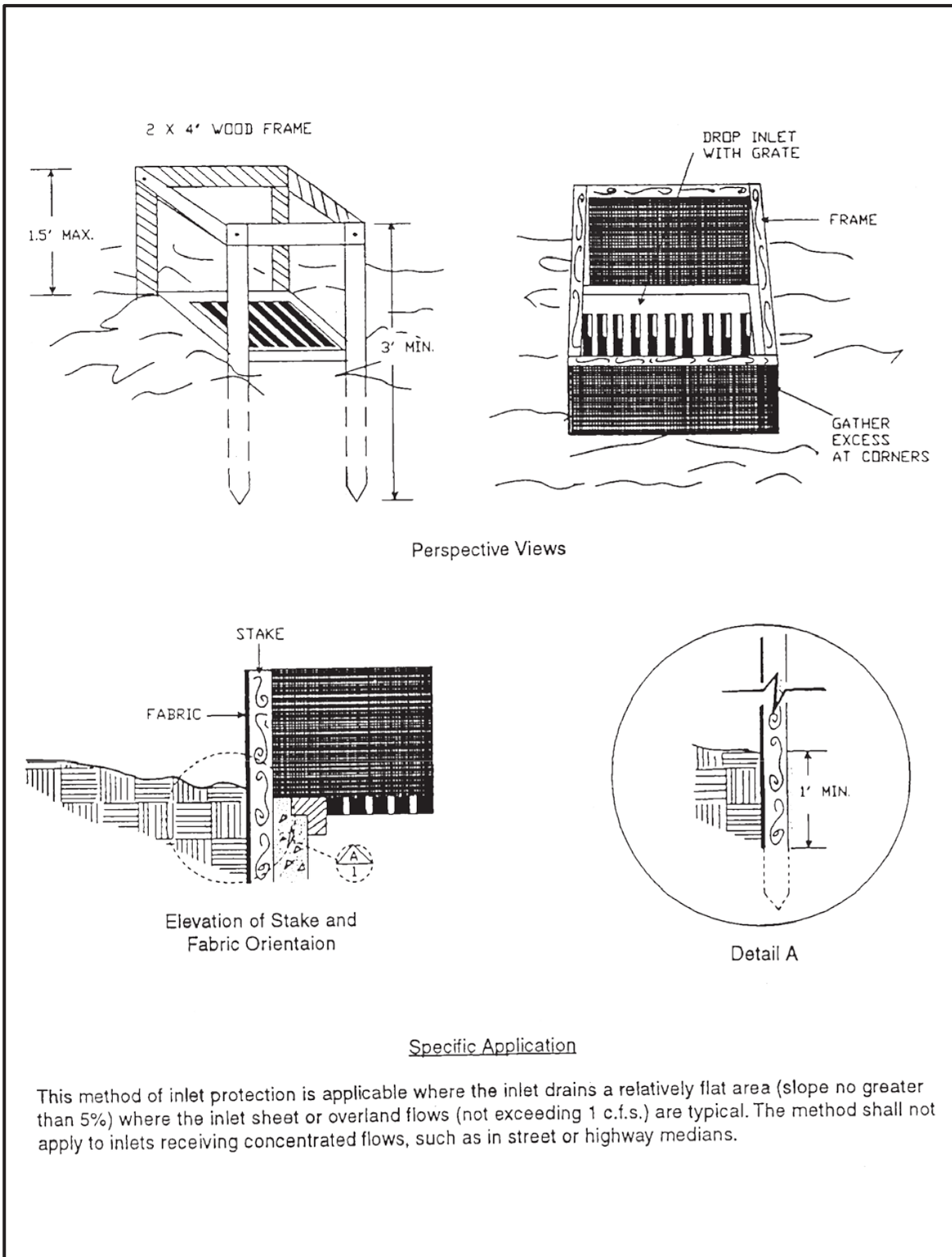


Figure 3.5b. Filter fabric drop inlet sediment filter

Source: North Carolina Erosion and Sediment Control Manual

Gravel and Wire Mesh Drop Inlet Sediment Filter

1. Wire mesh shall be laid over the drop inlet so that the wire extends a minimum of 1 foot (30 cm) beyond each side of the inlet structure. Hardware cloth or comparable wire mesh with 1/2-inch (13 mm) openings shall be used. If more than 1 strip of mesh is necessary, the strips shall be overlapped at least 1 foot (30 cm).
2. FDOT No. 1 Coarse Aggregate (1.5 to 3.5 inches) (4 to 9 cm) stone shall be placed over the wire mesh, as shown in **Figure 3.5c**. The depth of the stone shall be at least 12 inches (30 cm) over the entire inlet opening. The stone shall extend beyond the inlet opening at least 18 inches (45 cm) on all sides (see **Figure 3.5c**).
3. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned, and replaced.



Source: Ecoturf.net

- NOTE:** This filtering device above has no overflow mechanism. Therefore, ponding is likely, especially if sediment is not removed regularly. This type of device must **NEVER** be used where overflow may endanger an exposed fill slope. Consideration should also be given to the possible effects of ponding on traffic movement, nearby structures, working areas, adjacent property, etc.
4. The filtering system shown below uses rock gabion tube, which may enhance the flow-through for a fabric drop inlet filter.



RocSoxx for drop inlet protection
Source: RocSoxx, LLC

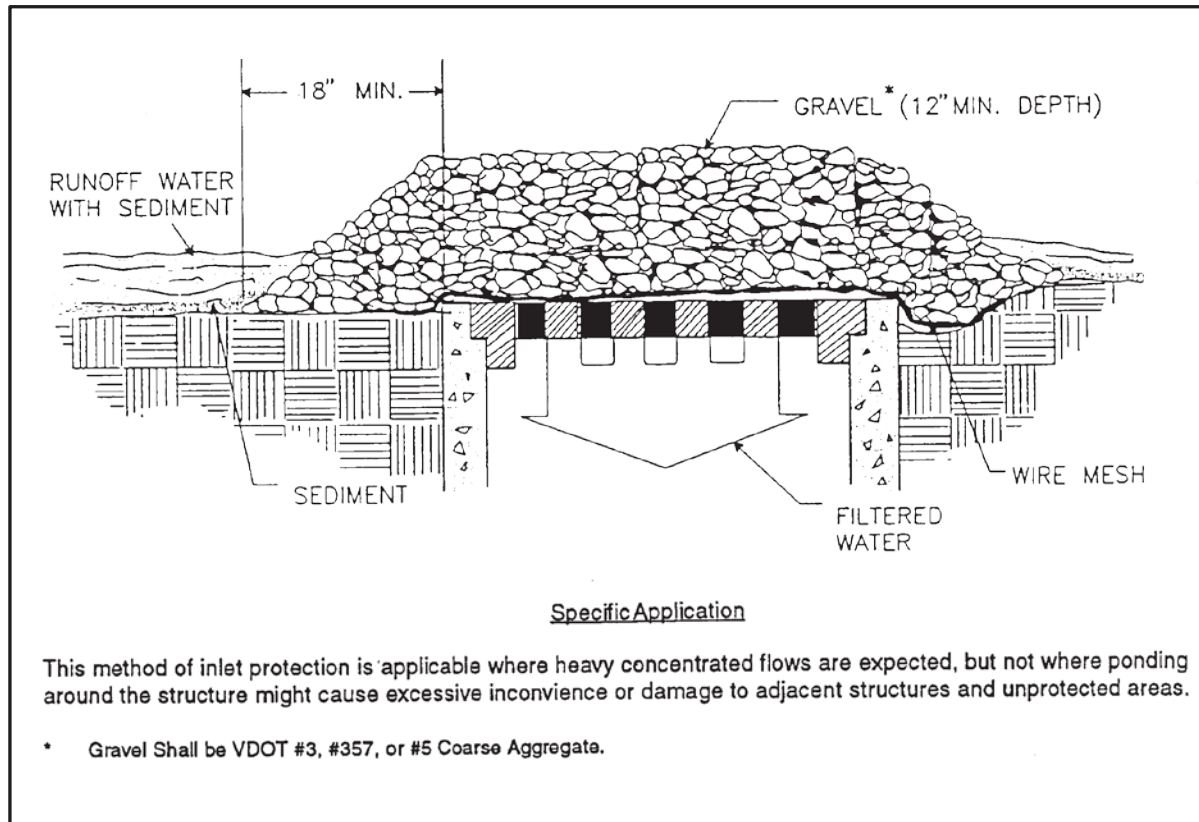


Figure 3.5c. Gravel and wire mesh drop inlet sediment filter

Source: Virginia DSWC

Block and Gravel Drop Inlet Sediment Filter

1. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, with the ends of adjacent blocks abutting. The height of the barrier can be varied, depending on design needs, by stacking combinations of 4-, 8-, and 12-inch-wide (10, 20, and 30 cm) blocks. The barrier of blocks shall be at least 12 inches (30 cm) high and no greater than 24 inches (60 cm) high.
2. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Hardware cloth or comparable wire mesh with 1/2-inch (13 mm) openings shall be used (see **Figure 3.5d**).
3. Stone shall be piled against the wire to the top of the block barrier. Suitable coarse aggregate shall be used (see **Figure 3.5d**).
4. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned, and replaced.

5. As a very temporary alternative, pervious burlap bags filled with gravel may be placed around the inlet, provided there are no gaps between the bags (see **Figure 4.5e**).
6. Either of these two practices may be installed on pavement or bare ground.

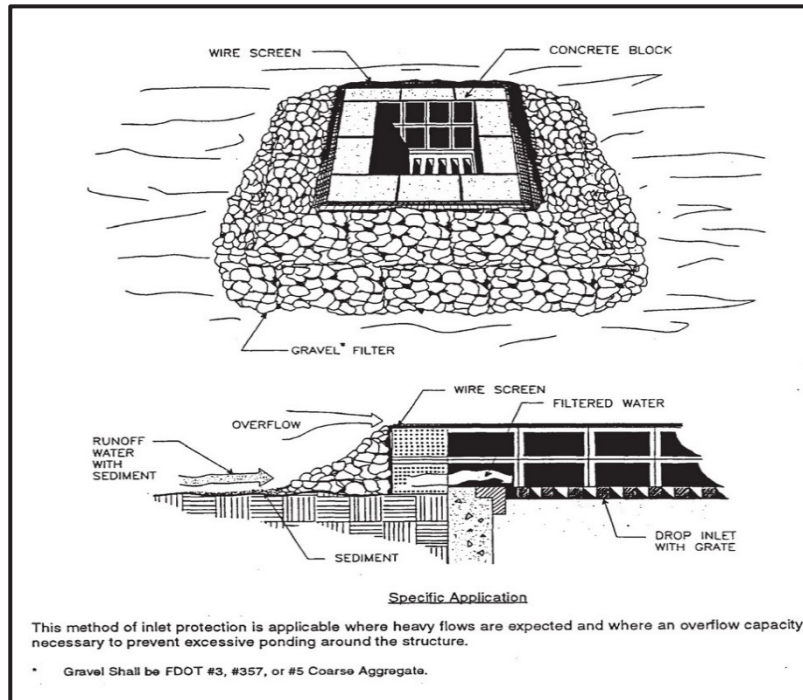


Figure 3.5d. Block and gravel drop inlet sediment filter

Source: Michigan Soil Erosion and Sedimentation Control Guidebook

Sod Drop Inlet Sediment Filter

1. Soil shall be prepared and sod installed according to the specifications in **Chapter 4**.
2. Sod shall be placed to form a turf mat covering the soil for a distance of 4 feet (1.2 m) from each side of the inlet structure (see **Figure 3.5e**).



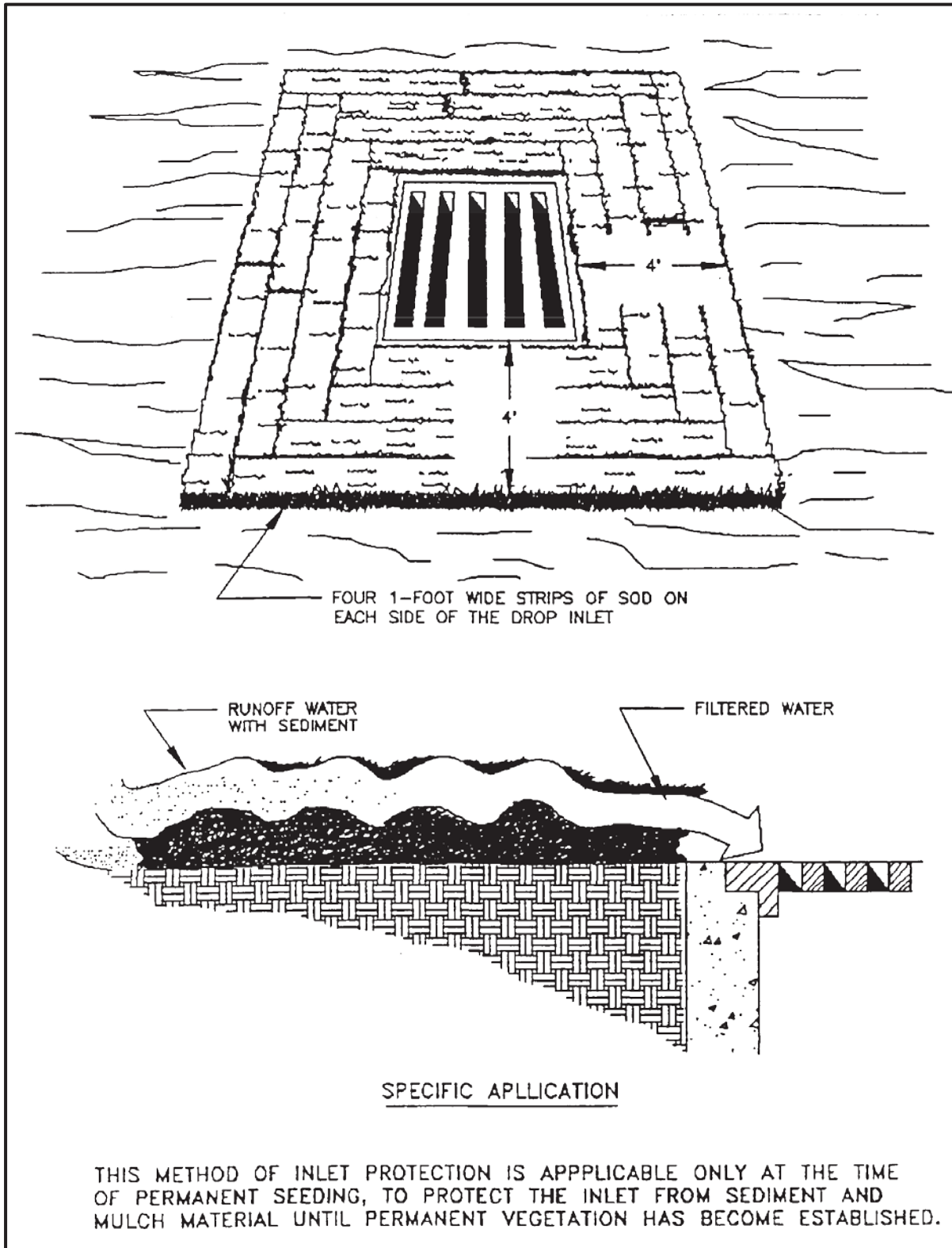


Figure 3.5e. Sod drop inlet sediment filter

Source: Virginia DSWC

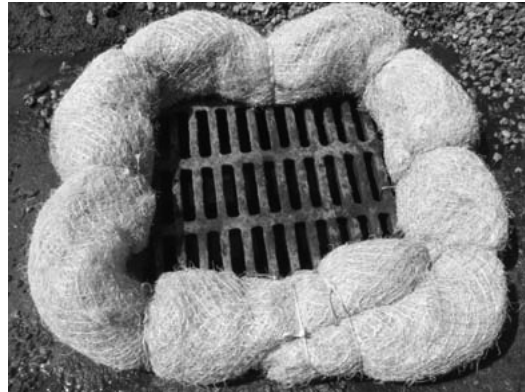
Prefabricated Drop Inlet Internal Filter Bag

1. Remove the grate over the catch basin and insert the filter device, then replace the grate to hold the device in position.
2. When sediments have accumulated to within 1 foot (30 cm) of the grate, the filter insert must be removed by a front-end loader or forklift. The filter may be discarded and replaced, or it may be emptied, cleaned, and reused.



Filter Sock Drop Inlet Filter

1. The filter sock should be placed around the entire circumference of the drop inlet and should allow for at least 1 foot of overlap on either side of the opening being protected.
2. Under low-flow conditions, a 9- or 12-inch sock diameter should suffice.
3. Sediment will collect around the outside of the filter sock and should be removed when the sediment reaches one-half of the sock height.



Prefabricated Drop Inlet External Filter

1. Place the device over the inlet. If the inlet has a grate, the device shall be secured to the grate by means of a long toggle bolt. If the grate is not present, the device shall be bolted directly to the concrete.
2. Sediments shall be removed when they have accumulated to within 1 foot (30 cm) of the top of the device. The filter fabric elements shall be cleaned or replaced at that time.

NOTE: This segment does not constitute a product endorsement.



Source: Silt Saver



Geohay can be used for drop inlet protection.

Source: Geohay

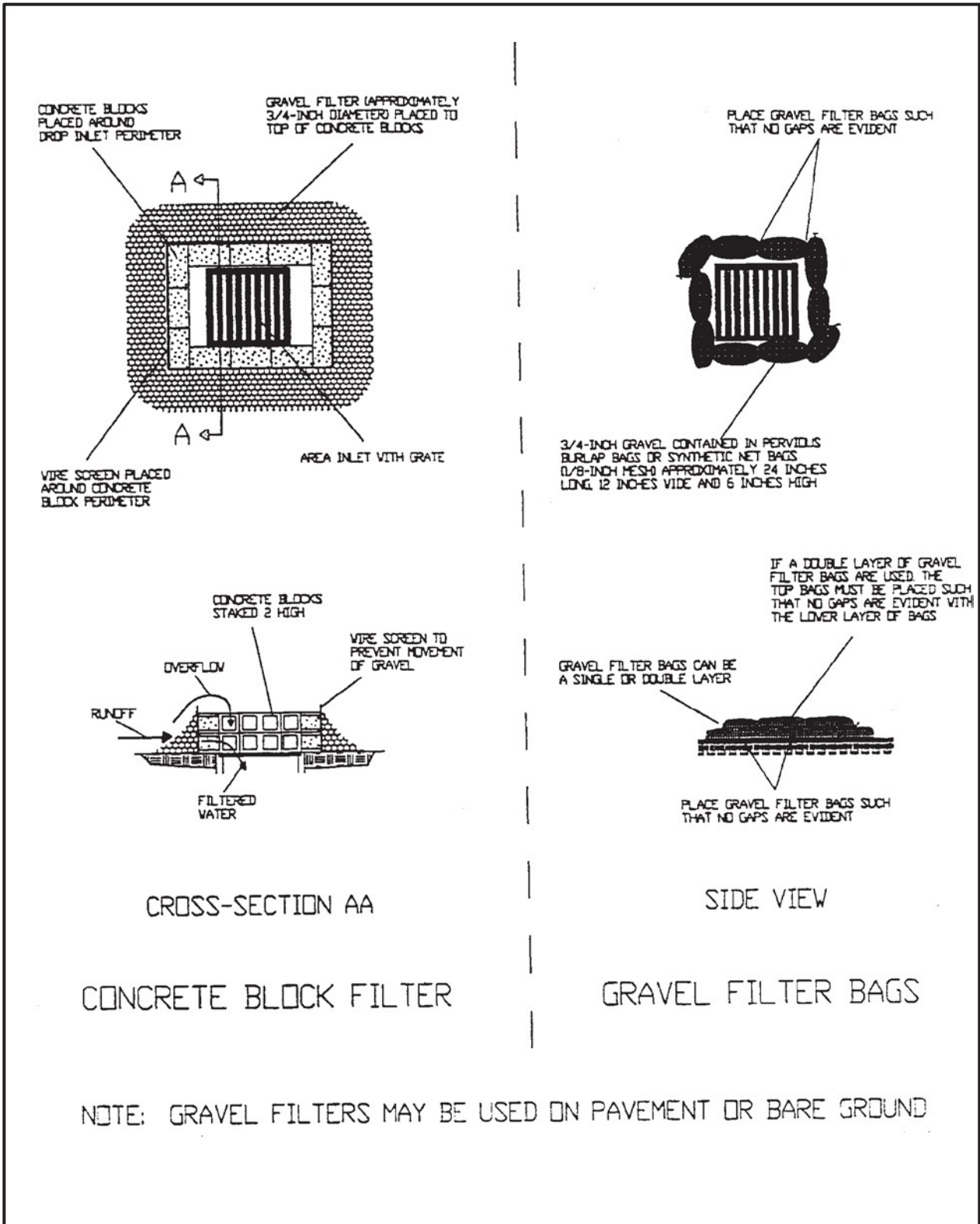


Figure 3.5f. Gravel filters for area inlets

Source: Hydro Dynamics, Inc.

Gravel Curb Inlet Sediment Filter

1. Hardware cloth or comparable wire mesh with 1/2 inch (13 mm) openings shall be placed over the curb inlet opening so that at least 12 inches (30 cm) of wire extends across the top of the inlet cover and at least 12 inches (30 cm) of wire extends across the concrete gutter from the inlet opening (see **Figure 3.5g**).
2. Stone shall be piled against the wire to anchor it against the gutter and inlet cover and to cover the inlet opening completely. FDOT No. 1 Coarse Aggregate shall be used.
3. An overflow weir can be constructed of 2 x 4 inch (5 x 10 cm) boards to lessen ponding from this practice (see **Figure 3.5h**).
4. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the block, cleaned, and replaced.

Block and Gravel Curb Inlet Sediment Filter

1. Two concrete blocks shall be placed on their sides abutting the curb at either side of the inlet opening (see **Figure 3.5i**).
2. A 2 x 4-inch (5 x 10 cm) board shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.
3. Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks (see **Figure 3.5j**).
4. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Hardware cloth with 1/2-inch (13 mm) openings shall be used.
5. FDOT No. 1 Coarse Aggregate shall be piled against the wire to the top of the barrier.
6. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the block, cleaned, and replaced.
7. As an alternative, gravel-filled burlap bags may be stacked tightly around the curb inlet (see **Figures 3.5k and 3.5l**).

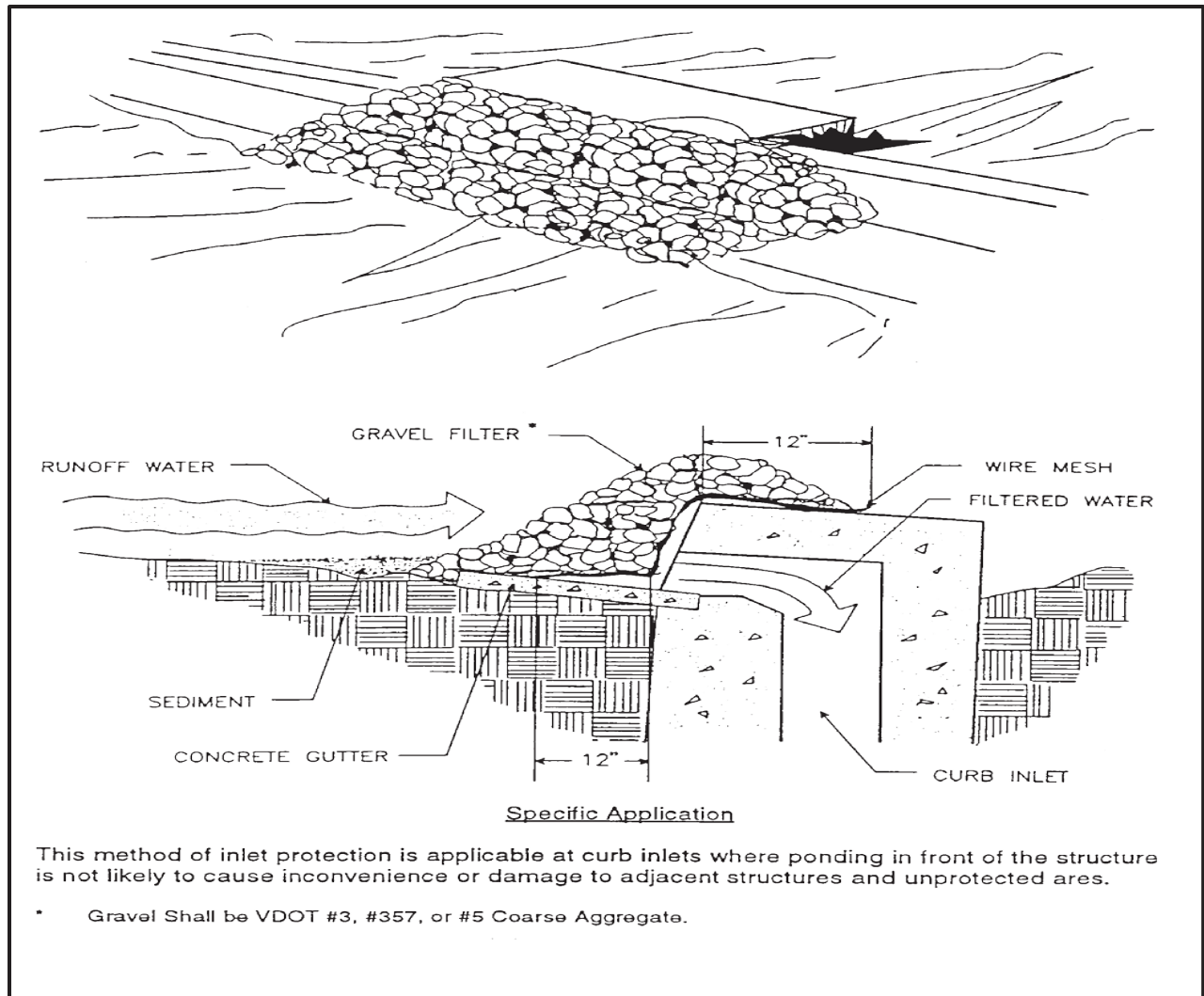


Figure 3.5g. Gravel curb inlet sediment filter

Source: Virginia DSWC

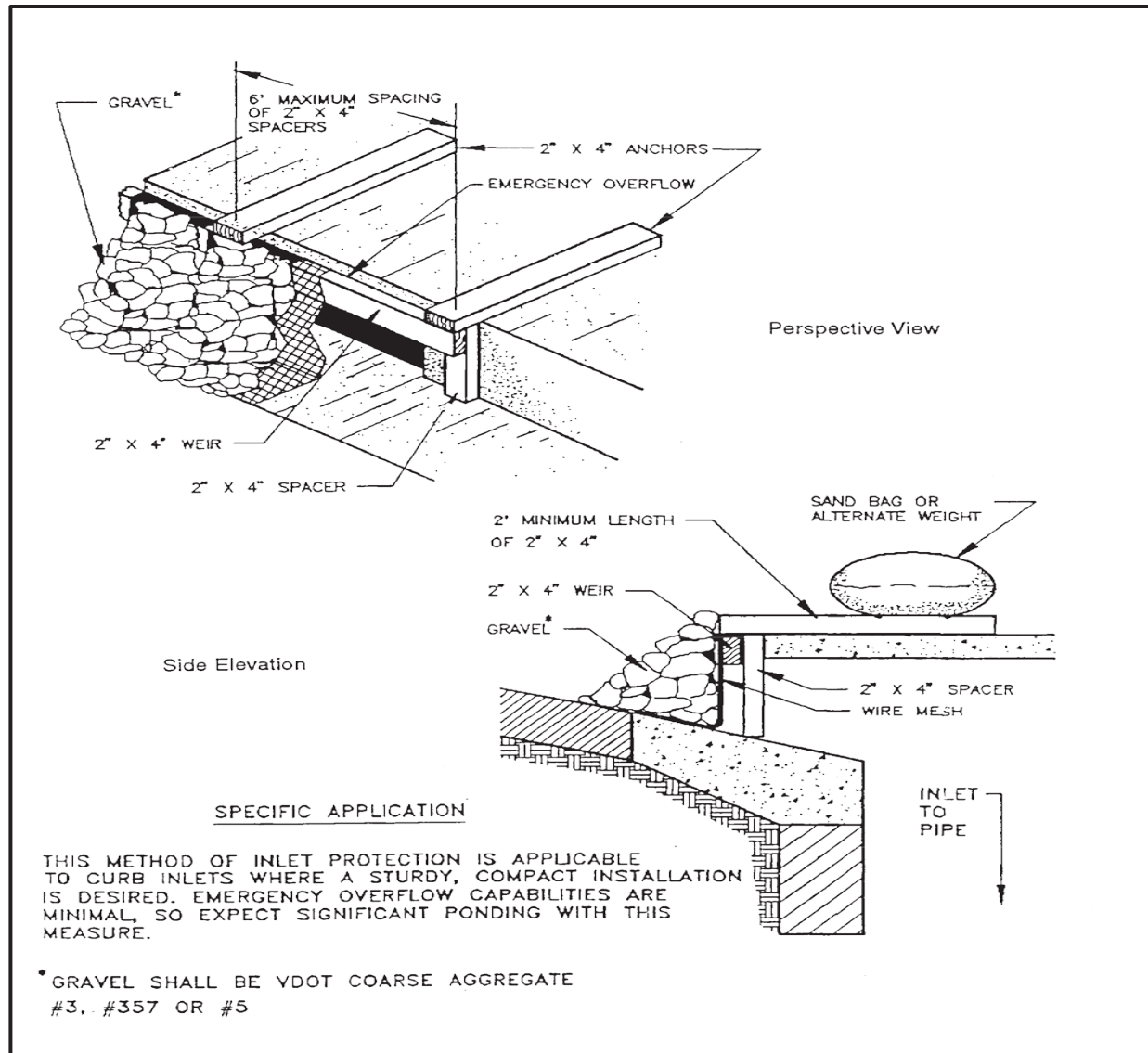


Figure 3.5h. Gravel curb inlet sediment filter with overflow weir

Source: Maryland Standards and Specifications for Soil Erosion and Sediment Control

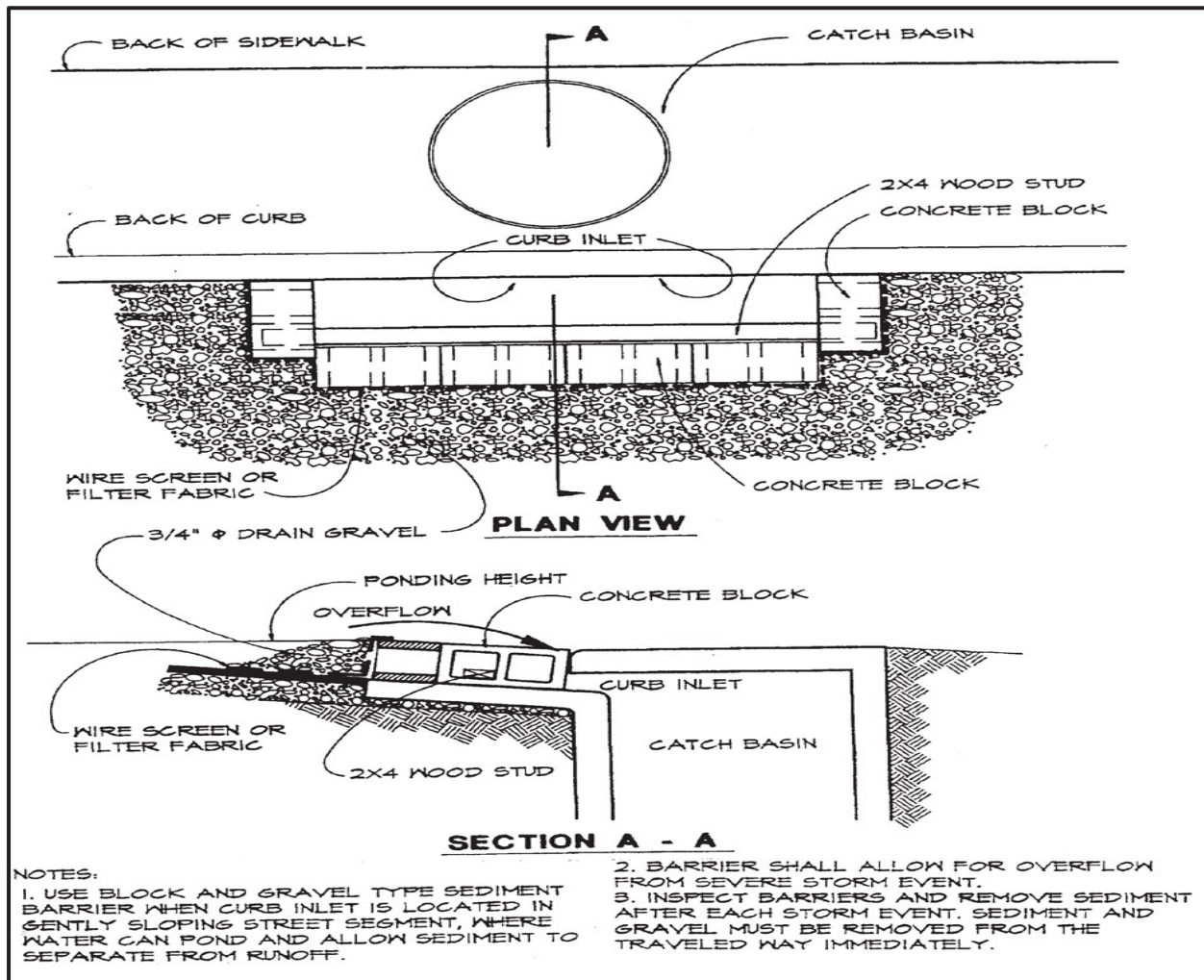


Figure 3.5i. Block and gravel curb inlet sediment barrier

Source: Erosion Draw

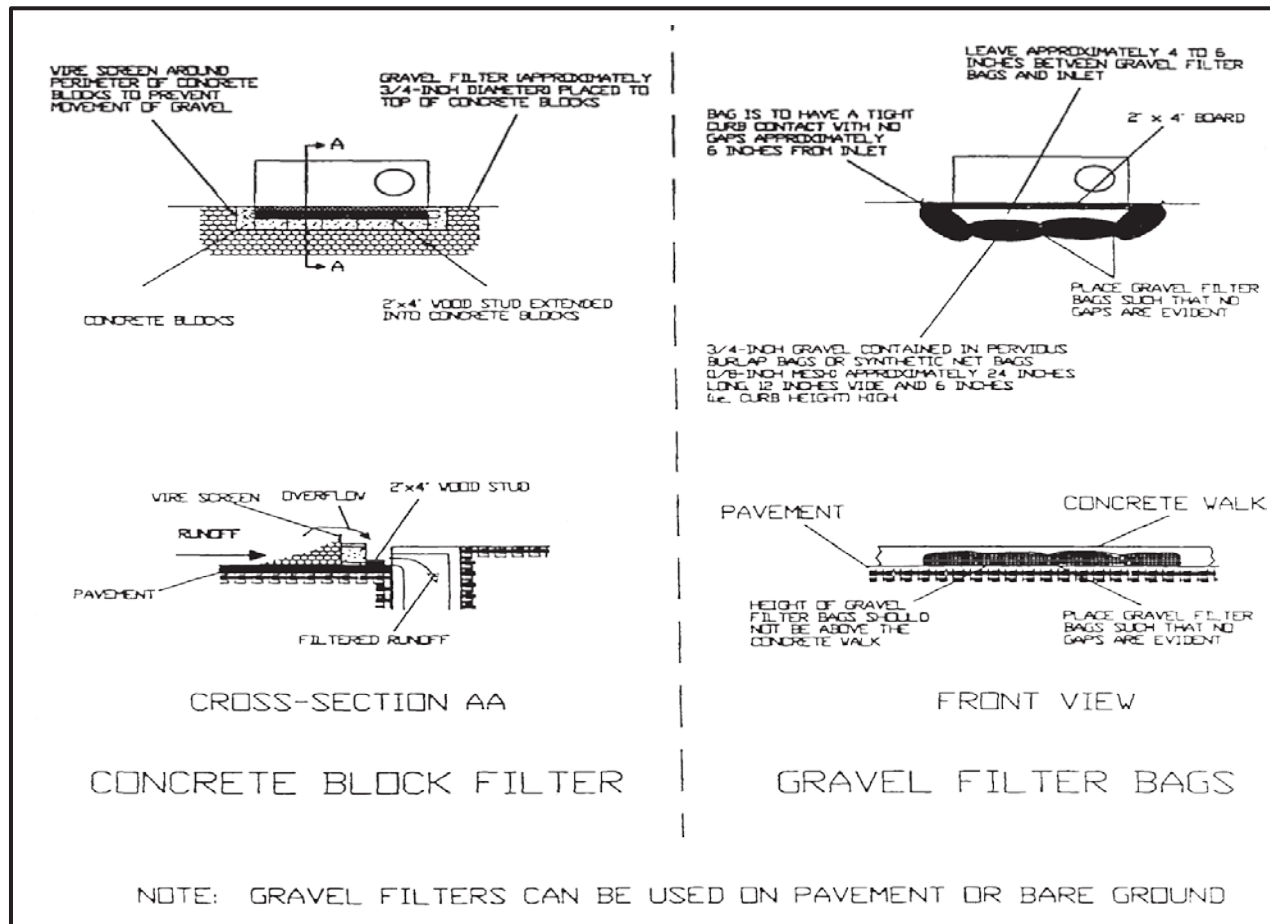


Figure 3.5j. Curb inlet gravel filters

Source: HydroDynamics, Inc.

Curb and Gutter Sediment Barrier

1. Place gravel-filled burlap bags on gently sloping street segments according to the spacing chart (see **Figure 3.5m**).
2. Place two or more bags at each interval in a manner that provides maximum support.
3. When stacking several bags high, leave a one-bag gap to provide an overflow spillway (see **Figure 3.5m**).
4. Sediments must be removed after each rain event.



Maintenance

1. The structure shall be inspected after each rain and repairs made as needed. Most rock bags break down quickly because of sunlight and may be required to be changed out every 14 days to prevent rocks from entering inlets.
2. The sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one-half of the design depth of the trap. The removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.
3. Structures shall be removed and the area stabilized when the remaining drainage area has been properly stabilized.

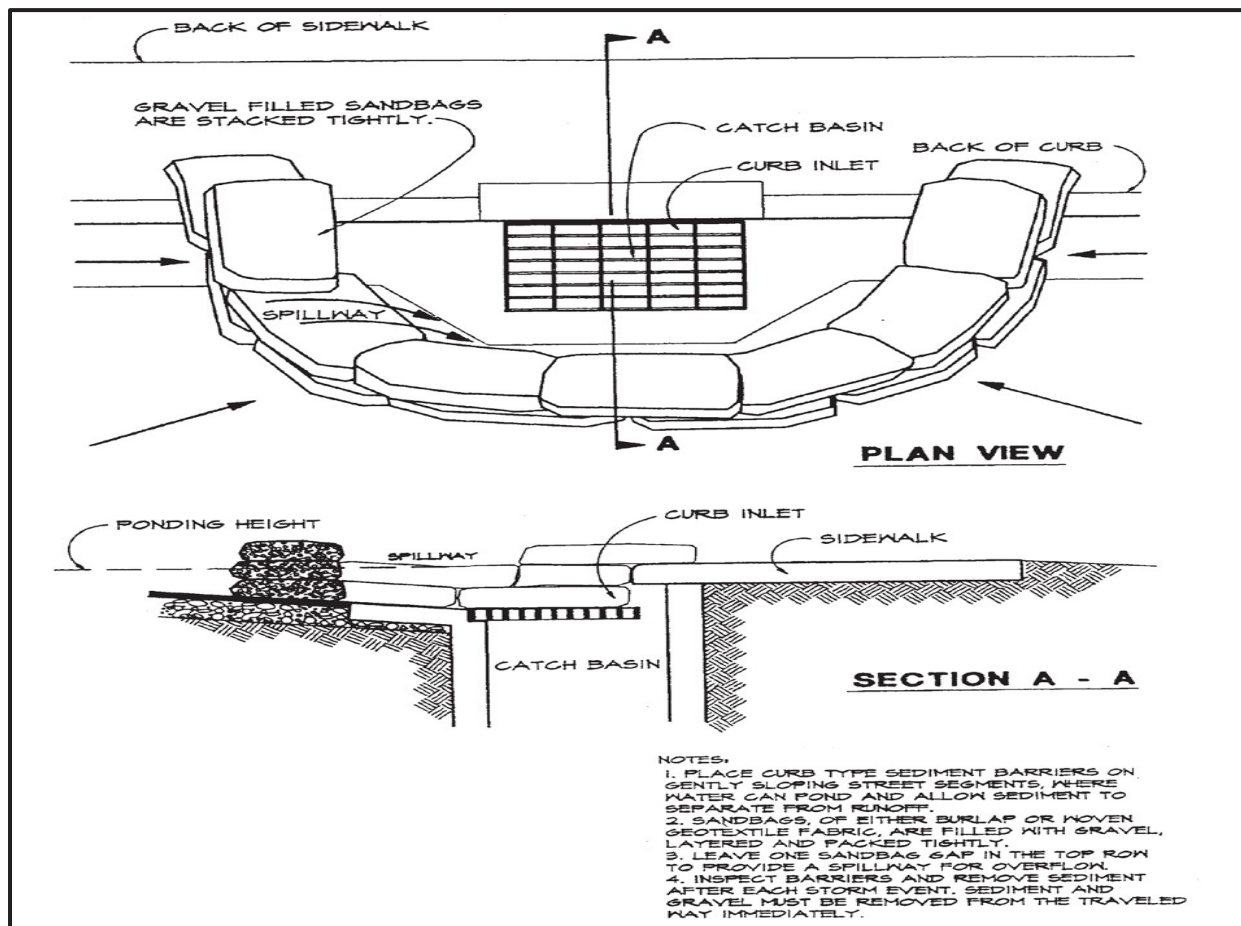


Figure 3.5k. Curb inlet sediment barrier

Source: Erosion Draw

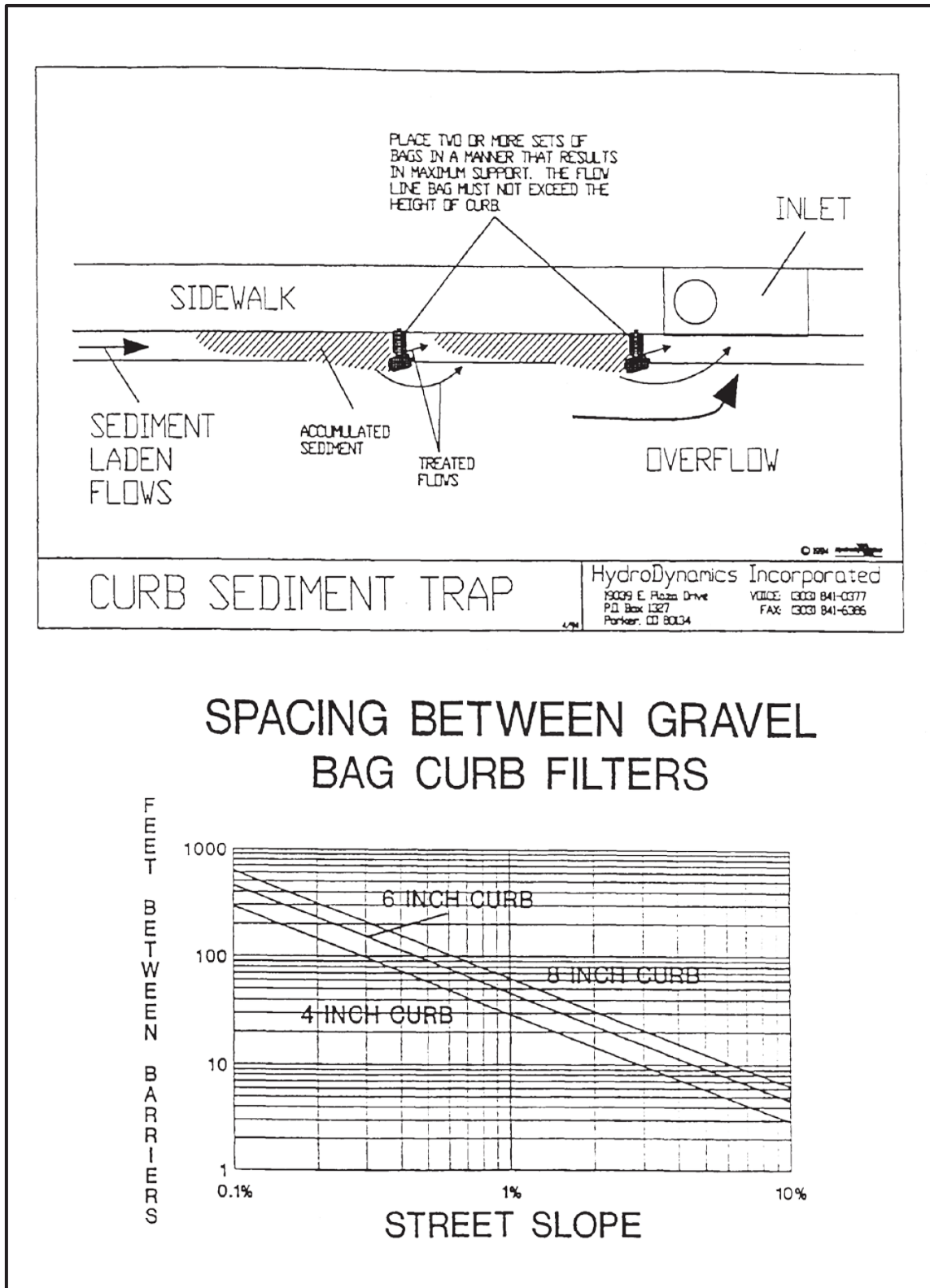


Figure 3.5l. Gravel bag curb sediment filters

Source: HydroDynamics, Inc.

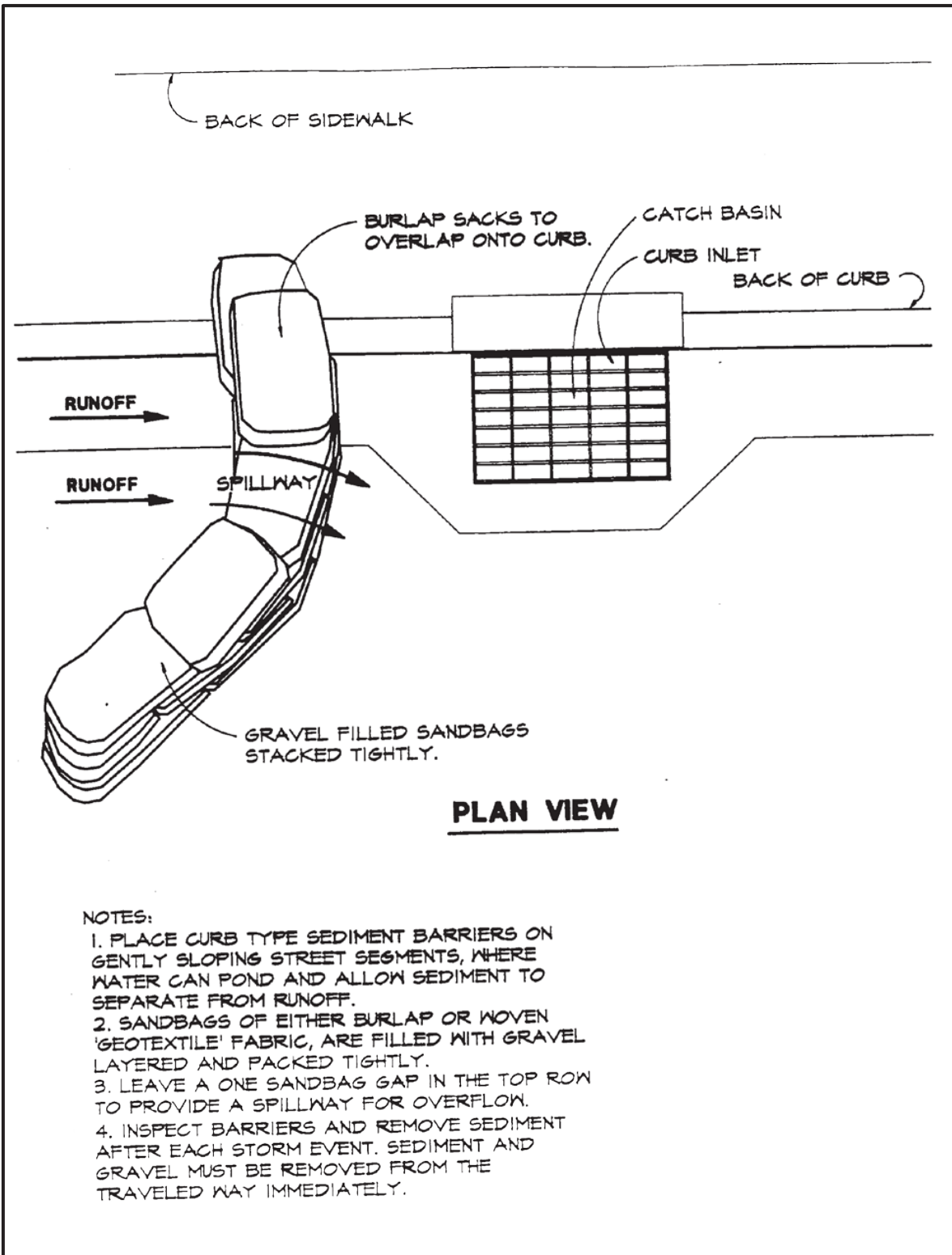


Figure 3.5m. Curb and gutter sediment barrier

Source: Erosion Draw

3.6 Temporary Sediment Trap

Definition

A small, temporary ponding area formed by excavation and/or an embankment across a drainageway.

Purpose

To detain sediment-laden runoff from small disturbed areas long enough to allow most of the sediment to settle out, thus protecting drainageways, properties, and rights-of-way from sedimentation.



Applications

1. A sediment trap is usually installed in a drainageway, at a storm drain inlet, or at other points of discharge from a disturbed area.
2. It is installed below drainage areas of 5 acres (2 ha) or less.
3. It is installed where the sediment trap will be used less than 18 months.
4. The sediment trap may be constructed either independently or in conjunction with **TEMPORARY DIVERSION BERM** (discussed earlier in this chapter).

Planning Considerations

The sediment trap should be located to obtain the maximum storage benefit from the terrain, to make clean out and disposal of the trapped sediment easier, and to minimize interference with construction activities.

Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than 5 acres (2 ha), see **TEMPORARY SEDIMENT BASIN** (discussed later in this chapter).

Sediment must be periodically removed from the trap. Plans should detail how this sediment is to be disposed of, such as by use in fill areas onsite or removal to an approved offsite dump.

Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Design Criteria

Trap Capacity

The sediment trap must have an initial storage volume of 134 cubic yards, or 3,600 cubic feet per acre (252 m³/ha) of drainage area, measured from the low point of the ground to the crest of the gravel outlet. Sediment should be removed from the basin when the volume is reduced by one-half.

For a natural basin, the volume may be approximated as follows:

$$V = 0.4 \times A \times D$$

where:

V = The storage volume in cubic feet (ft³).

A = The surface area of the flood area at the crest of the outlet, in square feet (ft²).

D = The maximum depth, measured from the low point in the trap to the crest of outlet, in feet.

Excavation

If excavation is necessary to attain the required storage volume, the side slopes should be no steeper than 2:1.

Embankment Cross-Section

The maximum height of the sediment trap embankment shall be 5 feet (1.5 m) as measured from the low point. **Table 3.2** lists the minimum top widths (W) and outlet heights (Ho) for various embankment heights (H). The side slopes of the embankment shall be 2:1 or flatter.

Table 3.2. Minimum top width (W) and outlet height (Ho) required for sediment trap embankment according to height of embankment (feet)

H	Ho	W
2.0	1.0	2.0
2.5	1.5	2.5
3.0	2.0	2.5
3.5	2.5	3.0
4.0	3.0	3.0
4.5	3.5	4.0
5.0	4.0	4.5

Outlet

The outlets shall be designed, constructed, and maintained so that sediment does not leave the trap and erosion of the outlet does not occur. A trap may have several different outlets, with each outlet conveying part of the flow based on the criteria below. The combined outlet capacity shall

be sufficient for the drainage area. For example, a 12-foot (3.6 m) earth outlet, adequate for 2 acres (0.8 ha), and a 12-inch (30 cm) pipe outlet, adequate for 1 acre (0.4 ha), could be used for a 3-acre (1.2 ha) drainage area.

There are four types of outlets for sediment traps. Each sediment trap is named according to the type of outlet that it has. Each type has different design criteria and will be discussed separately. The types are as follows:

1. **An earth outlet sediment trap** consists of a basin formed by excavation and/or an embankment. The trap has a discharge point over or cut into natural ground. The outlet width (feet) shall be equal to 6 times the drainage area (acres). If an embankment is used, the crest shall be at least 1 foot (30 cm) below the top of the embankment. The outlet shall be free of any restriction to flow. The earthen embankment shall be seeded with temporary or permanent vegetation (see **Chapter 4**) within 7 days of construction (see **Figure 3.6a**).
2. **A pipe outlet sediment trap** consists of a basin formed by an embankment, or an excavation and an embankment. The outlet for the trap is through a perforated riser and a pipe through the embankment. The outlet pipe and riser shall be made of corrugated metal. The riser diameter shall be the same or a larger diameter than the pipe. The top of the embankment shall be at least 1 1/2 feet (45 cm) above the crest of the riser. At least the top two-thirds of the riser shall be perforated with 1/2-inch (13 mm) diameter holes spaced 8 inches (20 cm) vertically and 10 to 12 inches (25 to 30 cm) horizontally. All pipe connections shall be watertight (see **Figure 3.6b**). Select the pipe diameter from the specifications listed in **Table 3.3**.

Table 3.3. Minimum pipe diameter for pipe outlet sediment trap according to maximum size of drainage area

Minimum Pipe Diameter in Inches (cm)	Maximum Drainage Area in Acres (ha)
12 (30 cm)	1 (0.4 ha)
18 (45 cm)	2 (0.8 ha)
21 (53 cm)	3 (1.2 ha)
24 (60 cm)	4 (1.6 ha)
30 (75 cm)	5 (2.0 ha)

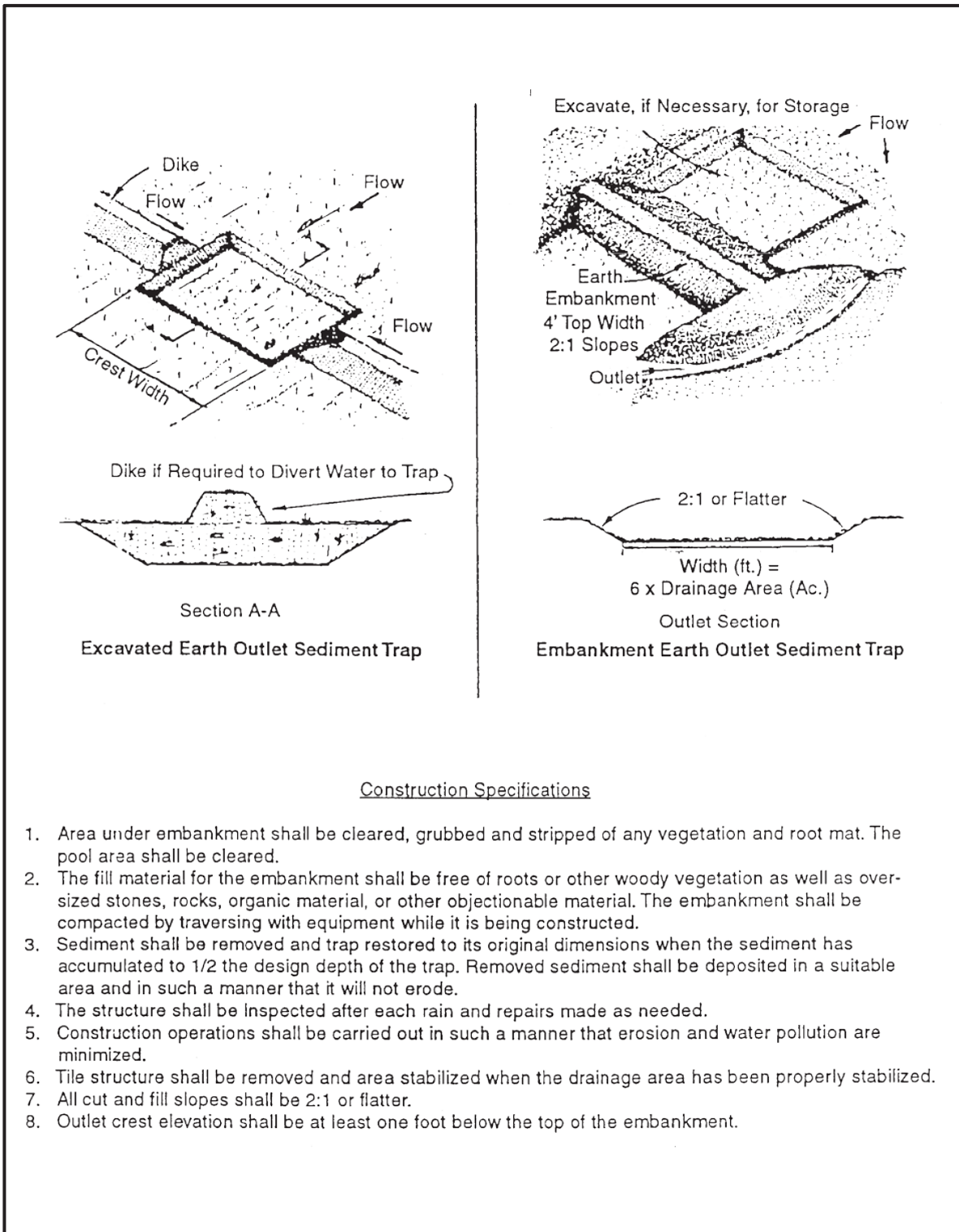


Figure 3.6a. Earth outlet sediment trap

Source: NRCS

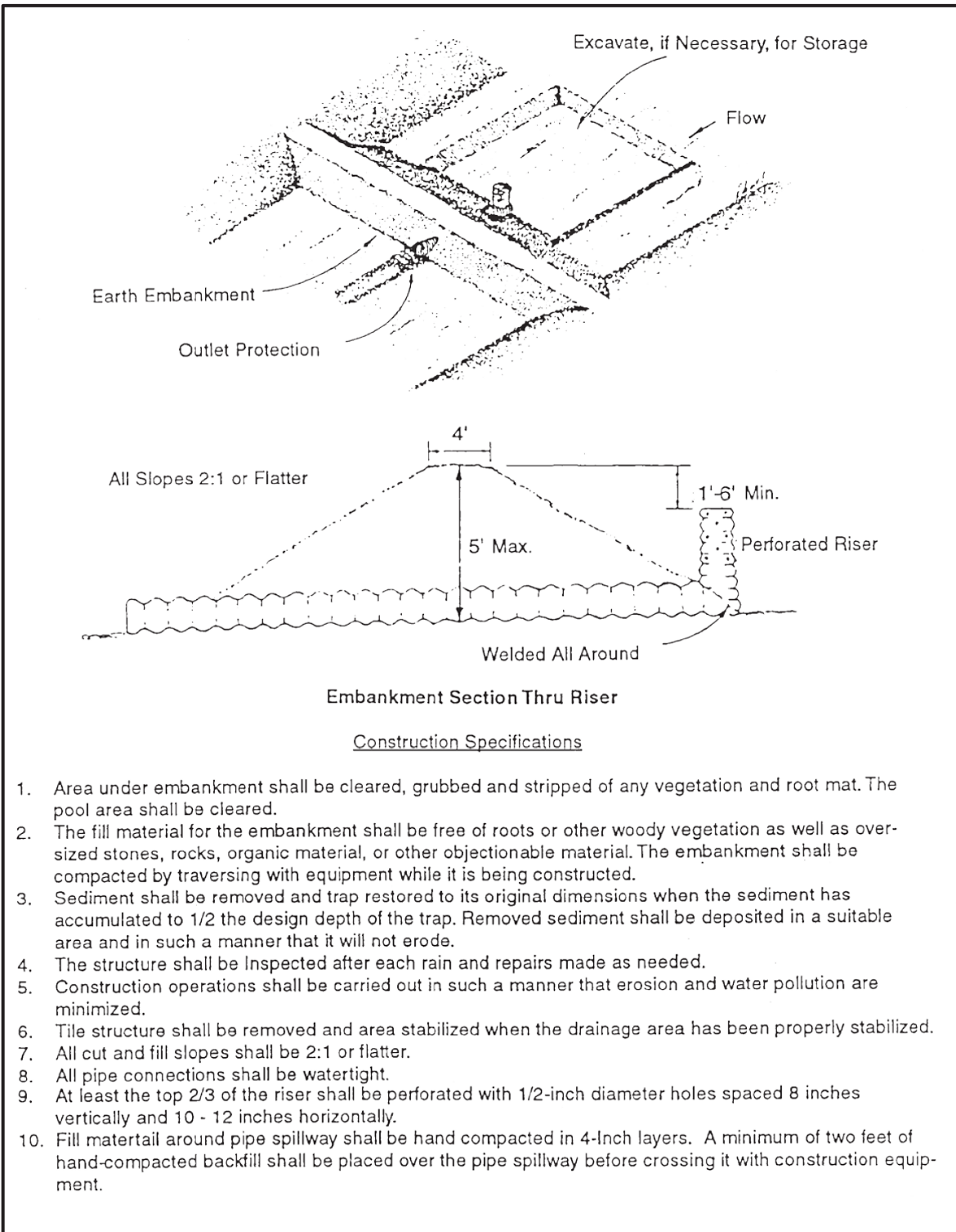


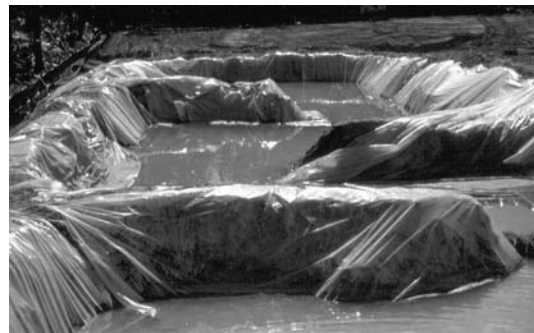
Figure 3.6b. Pipe outlet sediment trap

Source: NRCS

3. **A stone outlet sediment trap** consists of a basin formed by an embankment or excavation and an embankment. The outlet for the sediment trap shall consist of a crushed stone section of the embankment located at the low point in the basin. The minimum length of the outlet shall be 6 feet times the acreage of the drainage area (4.5 m x ha). The crest of the outlet must be at least 1 foot (30 cm) below the top of the embankment, to ensure that the flow will travel over the stone and not the embankment. The outlet shall be constructed of FDOT No. 1 size crushed stone (see **Figure 3.6c**).
4. **A storm inlet sediment trap** consists of a basin formed by excavation or natural ground that discharges through an opening in a storm drain inlet structure. This opening can either be the inlet opening or a temporary opening made by omitting bricks or blocks in the inlet. The trap shall be between 1 and 2 feet (30 to 60 cm) deep, measured from the low point of the inlet. A yard drain inlet or an inlet in the median strip of a dual highway would use the inlet opening for an outlet (see **Figure 3.6d**). A curb inlet would require a temporary opening (see **Figure 3.6e**). The trap should be out of the roadway to avoid interference with construction. Placing the trap on the opposite side of the opening and diverting water from the roadway to the trap is one means of accomplishing this.
5. **Other Applications.** At times, a small trap may be constructed in a drainage channel using the culvert for a road crossing. Gravel-filled bags may be used if there are no gaps in the installation (see **Figures 3.6f** and **3.6g**). In larger traps, baffles may be required to ensure adequate flow length and prevent short-circuiting).

Construction Specifications

1. The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. To facilitate cleanout, the pool area should be cleared.
2. Fill material for the embankment shall be free of roots or other woody vegetation, organic material, large stones, and other objectionable material. The embankment should be compacted in 8-inch (20 cm) layers by traversing it with construction equipment.
3. The earthen embankment shall be seeded with temporary or permanent vegetation (see **Chapter 4**) within 15 days of construction.



4. *Construction operations shall be carried out so that erosion and water pollution are minimized.*
5. *The structure shall be removed and the area stabilized when the upslope drainage area has been stabilized.*

Maintenance

1. *Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one-half the design volume of the trap. Sediment removed from the basin shall be deposited in a suitable area and in such a manner that it will not erode.*
2. *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 outlet should be checked to ensure that its center is at least 1 foot (30 cm) below the top of the embankment.*

Removal

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

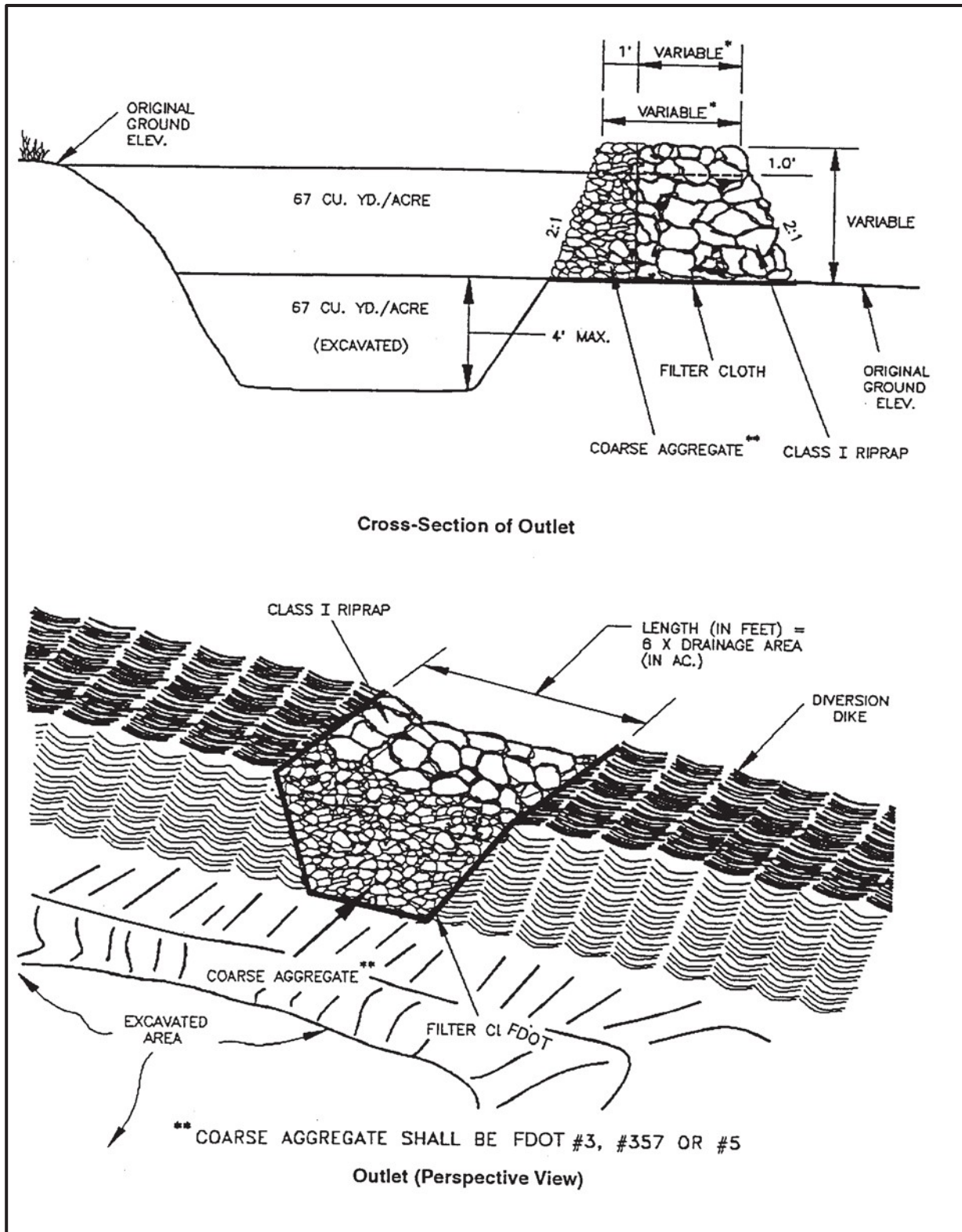


Figure 3.6c. Stone outlet sediment trap

Source: NRCS

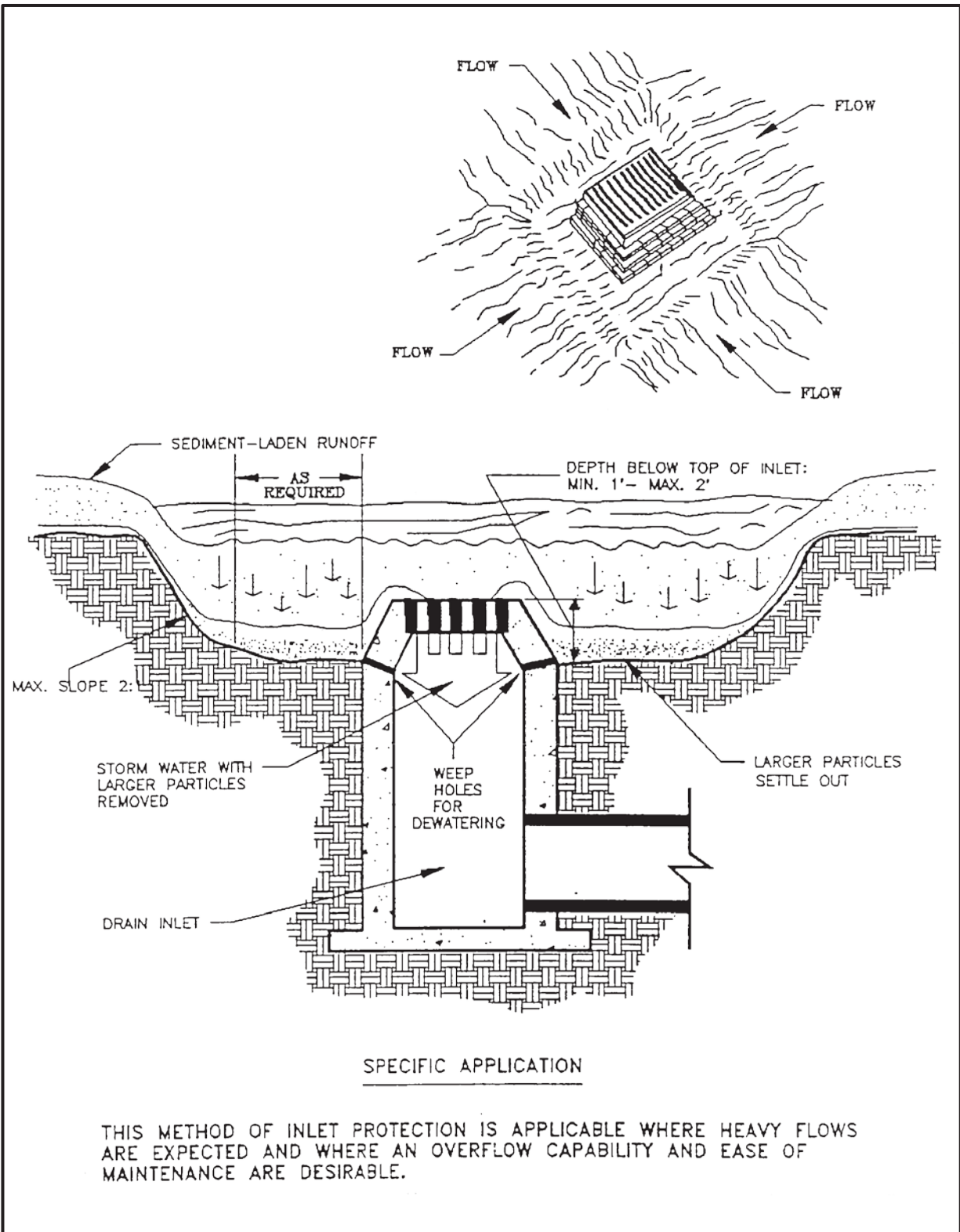


Figure 3.6d. Excavated drop inlet sediment trap

Source: Michigan Soil Erosion and Sedimentation Control Guidebook

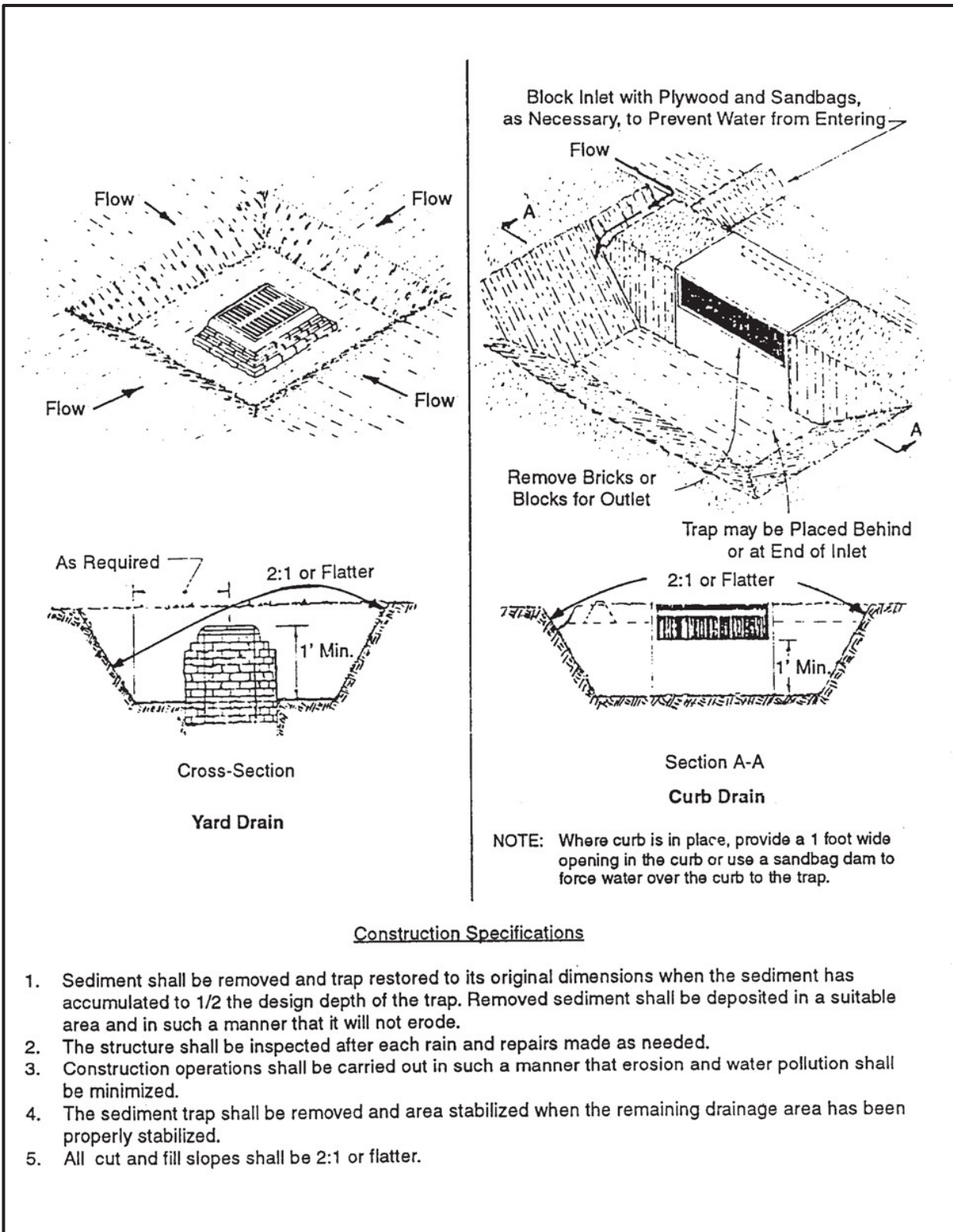


Figure 3.6e. Storm inlet sediment trap

Source: NRCS

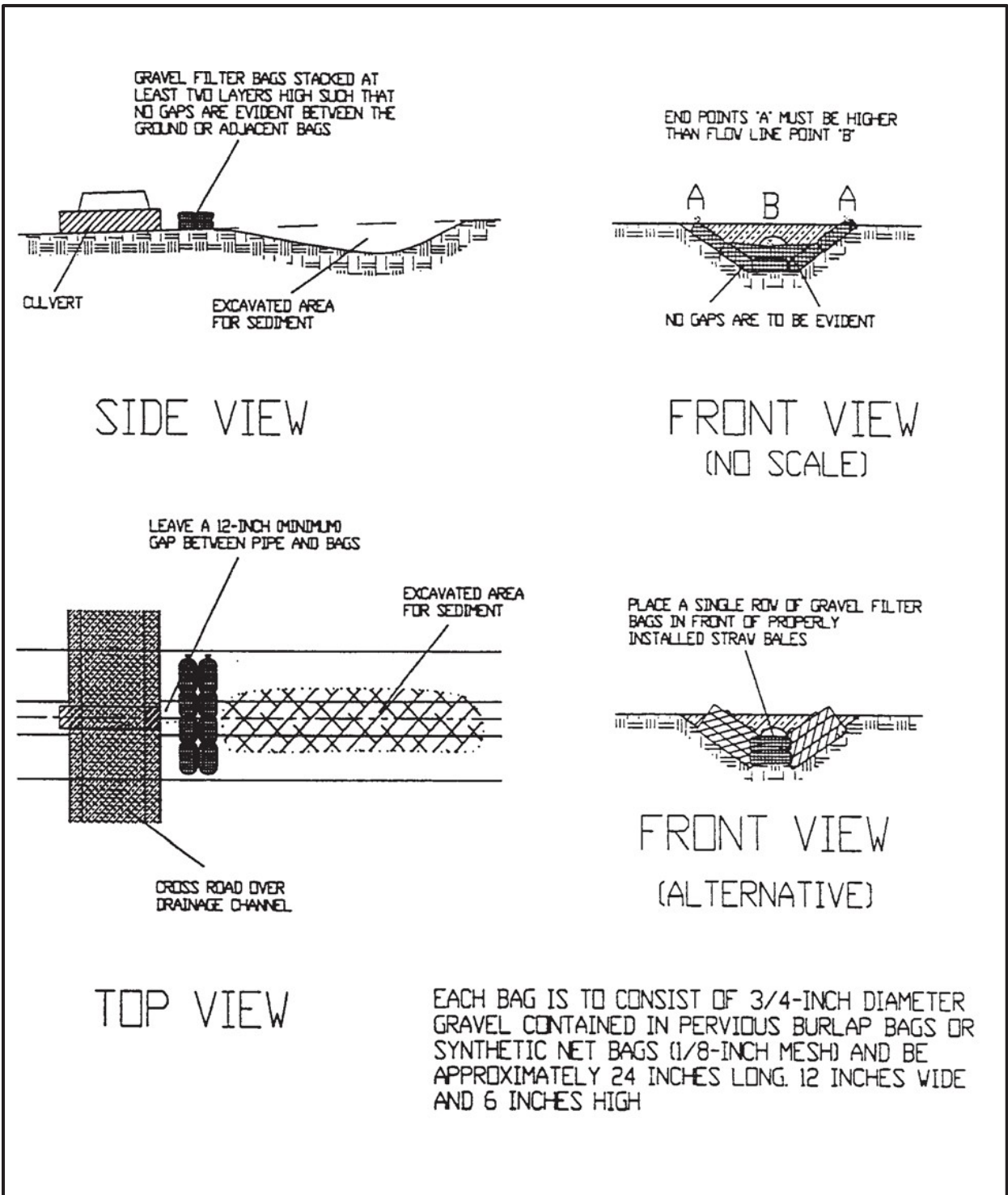


Figure 3.6f. Small sediment trap located in a stormwater conveyance channel

Source: HydroDynamics, Inc.

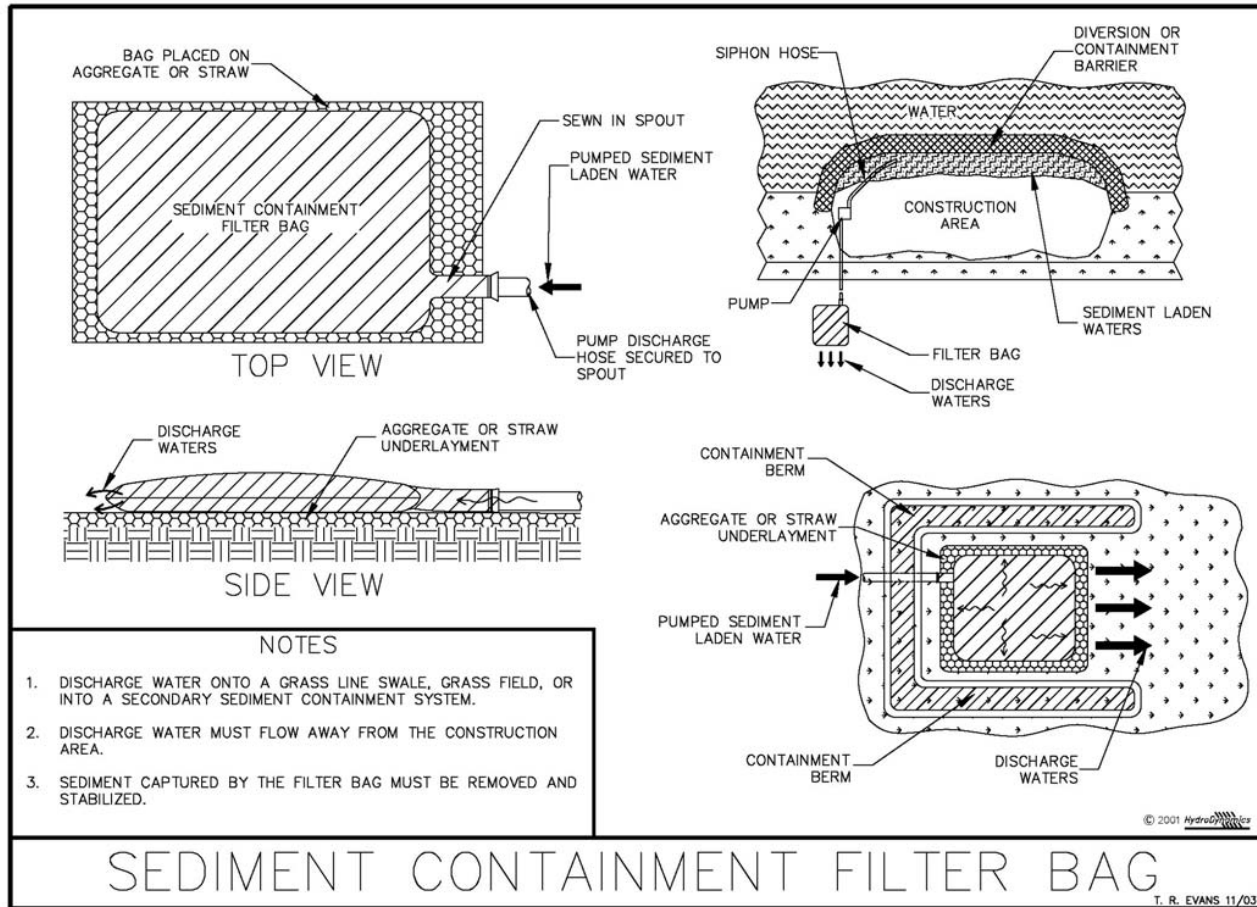


Figure 3.6g. Sediment containment filter bag

3.7 Temporary Sediment Basin

Definition

A temporary basin with a controlled stormwater release structure, formed by constructing an embankment of compacted soil across a drainageway.

Purpose

To detain sediment-laden runoff from disturbed areas long enough for most of the sediment to settle out.

Applications

According to the 2015 CGP requirements, drainage basins with 10 or more disturbed acres at one time, a temporary (or permanent) sediment or wet detention basin providing 3,600 cubic feet of storage per acre drained must be provided until the final stabilization of the site. Also, the *2013 Florida Designer and Reviewer Manual* should be reviewed as required by the CGP.

There must be sufficient space and appropriate topography for the construction of a temporary impoundment. These structures are limited to a useful life of 18 months unless they are designed as permanent ponds by a qualified professional engineer.

Planning Considerations

Effectiveness

Sediment basins are at best only 70 % to 80 % effective in trapping the sediment that flows into them. Therefore, they should be used together with erosion control practices such as temporary seeding, mulching, diversion berms, etc., to reduce the amount of sediment. Anionic polyacrylamides used with jute fabric panels can be used to enhance sediment removal. Faircloth skimmers can be attached to the overflow structure to remove only the cleanest water at the surface, increasing the removal of sediments prior to discharge.

Location

To improve the effectiveness of the basin, it should be located to intercept the largest possible amount of runoff from the disturbed area. The best locations are generally low areas and natural drainageways below disturbed areas. Drainage into the basin can be improved using diversion berms and ditches. The basin must not be installed in a live stream but should be located to trap sediment-laden runoff **BEFORE** it enters the stream. The basin should not be located where its failure would result in the loss of life, damage to adjacent properties, or interruption of the use of public utilities or roads.

Multiple Use

Sediment basins may be designed as permanent structures to remain in place after construction is completed. Always leave the bottom of a sediment basin 6 to 12 inches higher than the eventual bottom of a retention basin. This will ensure the removal of accumulated fine sediments that could prematurely clog the retention basin. Wherever these structures are to become permanent,

or if they exceed the size limitations of the design criteria, they must be designed as permanent ponds by a qualified professional engineer. Permanent ponds are beyond the scope of this BMP.

Design Criteria

Maximum Drainage Area

Unless the structure is designed as a permanent pond by a Florida-licensed Professional Engineer, the maximum allowable drainage area into the basin shall be 150 acres (61 ha).

Basin Capacity

The design capacity of the basin must be at least 134 cubic yards or 3,600 cubic feet per acre (252 m³/ha) of drainage area measured from the bottom of the basin to the crest of the principal spillway (riser pipe). Sediment should be removed from the basin when the volume of the basin has been reduced to 55 cubic yards per acre (104 m³/ha) of drainage area. The elevation of the sediment cleanout level should be calculated and clearly marked on the riser. In no case shall the sediment cleanout level be higher than 1 foot (30 cm) below the top of the riser (see **Figure 3.7a**).

Basin Shape and Baffles

To improve the sediment-trapping efficiency of the basin, the effective flow length must be twice the effective flow width. This basin shape may be attained by properly selecting the site of the basin, excavating, or using baffles (see **Figure 3.7b**), as referenced in the *2013 Designer and Reviewer Manual*.

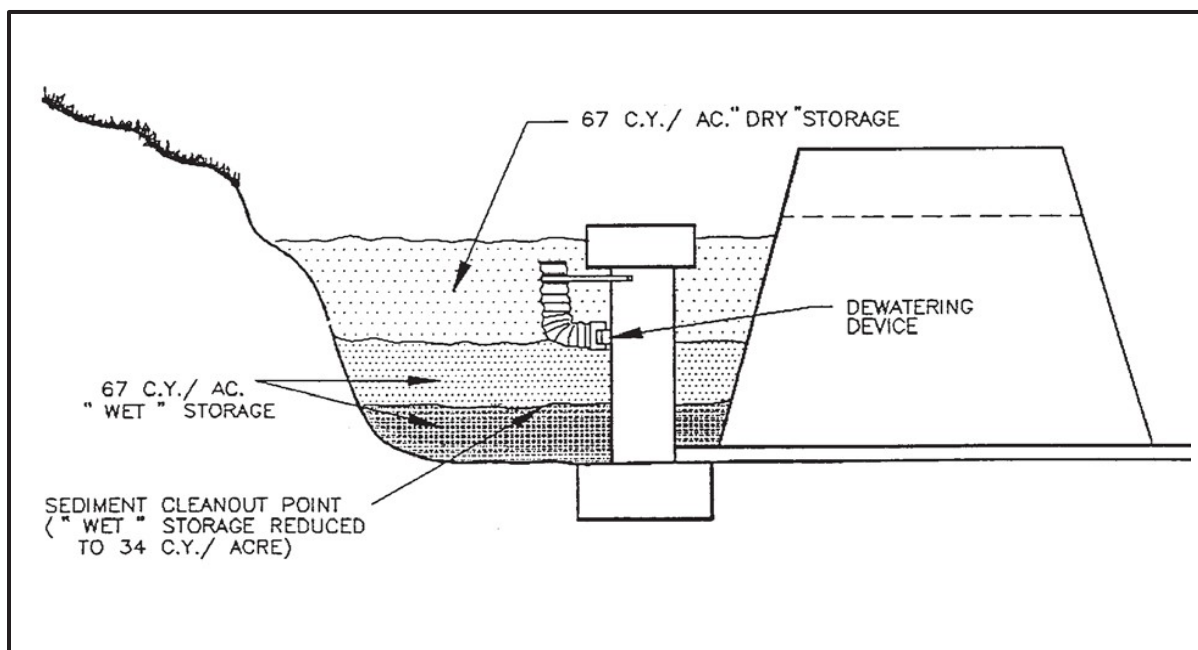


Figure 3.7a. Sediment basin storage volumes

Source: Virginia DSWC

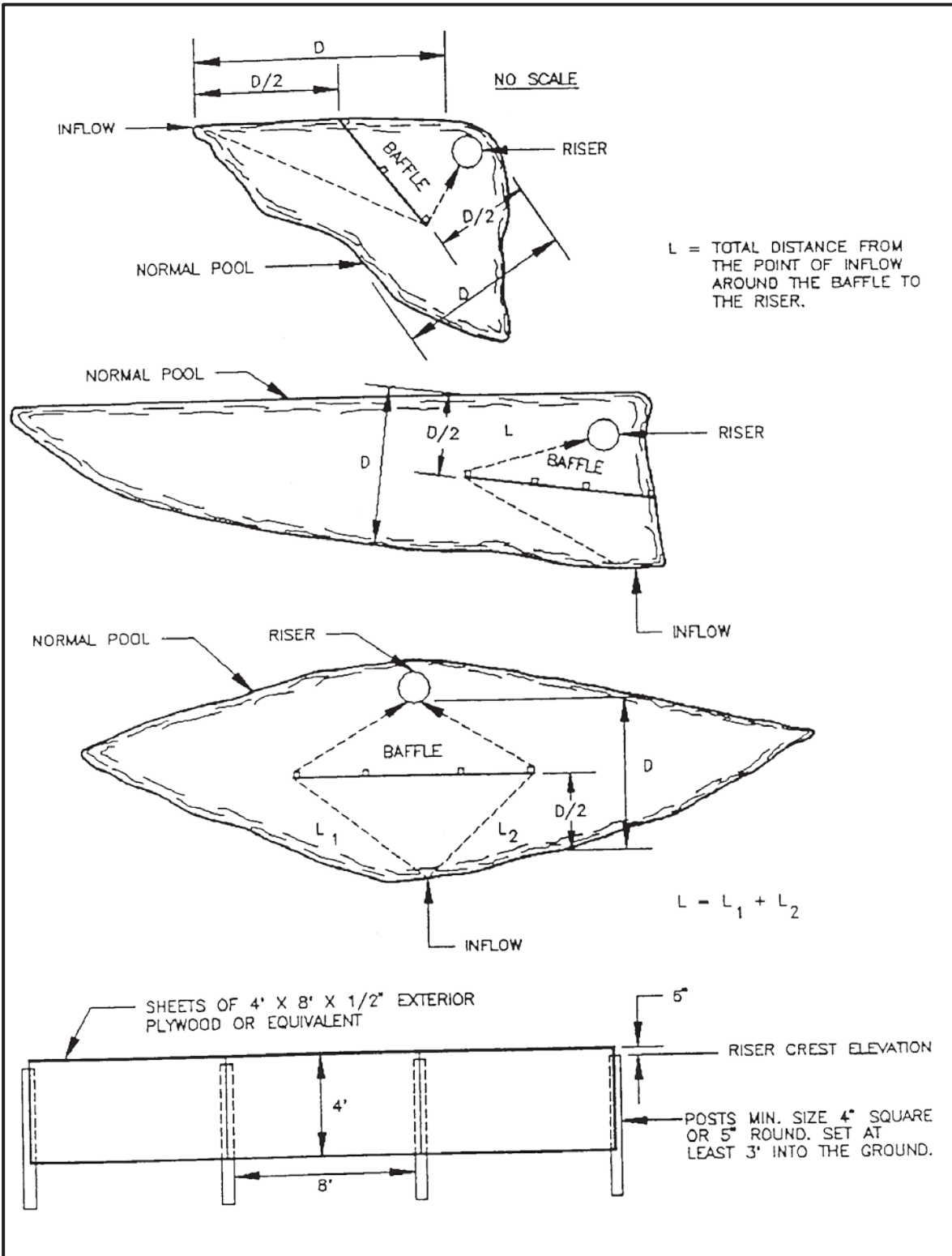


Figure 3.7b. Sample plan view of baffle locations in sediment basins

Embankment Cross-Section

The embankment must have a minimum top width of 8 feet (2.5 m). The side slopes must be 2:1 or flatter. The embankment may have a maximum height of 10 feet (3 m) if the side slopes are 2:1. If the side slopes are 2.5:1 or flatter, the embankment may have a maximum height of 15 feet (4.5 m).

Spillway Design

The outlets for the basin may consist of a combination of principal and emergency spillways or a principal spillway alone. In either case, the outlet(s) must pass the peak runoff expected from the drainage area for a 10-year storm without damage to the embankment of the basin. Runoff computations shall be based on the soil cover conditions expected to prevail during the life of the basin.

The spillways designed by the procedures contained in this BMP will **NOT** necessarily result in any reduction in the peak rate of runoff. If a reduction in peak runoff is needed, the appropriate hydrographs should be generated to choose the basin and outlet sizes.

To increase the efficiency of the basin, the spillway(s) must be designed to maintain a permanent pool of water between storm events.

Principal Spillway

The principal spillway shall consist of a solid (nonperforated), vertical pipe or box of corrugated metal or reinforced concrete joined by a watertight connection to a horizontal pipe (barrel) extending through the embankment, with an outlet beyond the downstream toe of the fill. If the principal spillway is used in conjunction with an emergency spillway, the principal spillway shall have a minimum capacity of 0.2 cfs per acre (0.015 m³/sec per ha) of drainage area when the water surface is at the crest of the emergency spillway. If no emergency spillway is used, the principal spillway must be designed to pass the entire peak flow expected from a 10-year storm. See the *2013 Florida Designer and Reviewer Manual* for design details.

Design Elevations

If the principal spillway is used together with an emergency spillway, the crest of the principal spillway shall be a minimum of 1 foot (30 cm) below the crest of the emergency spillway. If no emergency spillway is used, the crest of the principal spillway shall be a minimum of 3 feet (90 cm) below the top of the embankment (see **Figure 3.7c**). In either case, a minimum freeboard of 1 foot (30 cm) shall be provided between the design high water and the top of the embankment.



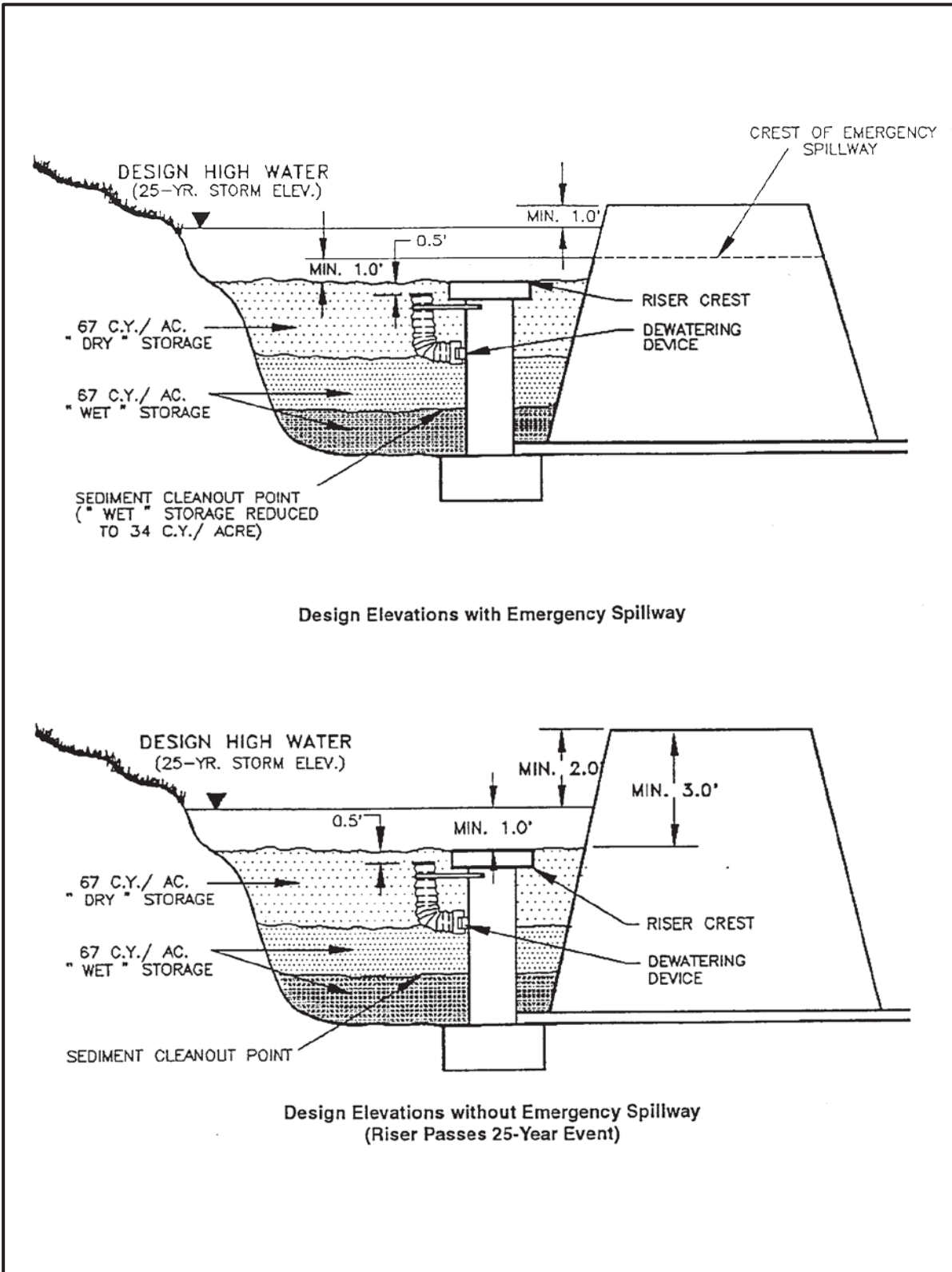


Figure 3.7c. Sediment basin schematic elevations

Source: Virginia DSWC

Antivortex Device and Trash Rack

An antivortex device and trash rack shall be attached to the top of the principal spillway to improve the flow of water into the spillway and prevent floating debris from being carried out of the basin. The antivortex device shall be of the concentric type (see **Figure 3.7c**).

Dewatering

Dewatering shall be done in a way that removes the relatively clean water without removing any of the sediment that has settled out and without removing any appreciable quantities of floating debris. As a minimum, provisions shall be made to dewater the basin down to the sediment cleanout elevation. This can be accomplished by providing a hole at the maximum sediment retention elevation (see **Figure 3.7c**). The dewatering hole shall be no larger than 4 inches (10 cm) in diameter. **Chapter 5** outlines other means of dewatering.

It is also advantageous (but not required) to provide for the dewatering of trapped sediment before cleanout. Basin underdrains are generally installed for this purpose.

Base

The base of the principal spillway must be firmly anchored to prevent it from floating. If the riser of the spillway is greater than 10 feet (3 m) in height, computations must be made to determine the anchoring requirements. As a minimum, a factor of safety of 1.25 shall be used (downward forces = 1.25 x upward forces).

For risers 10 feet (3 m) or less in height, the anchoring may be done in one of the two following ways:

1. *A concrete base 18 inches (45 cm) thick and twice the width of the riser diameter shall be used and the riser embedded 6 inches (15 cm) into the concrete (see **Figure 3.7e** and the 2013 Florida Designer and Reviewer Manual).*
2. *A square steel plate, being a minimum of 1/4 inch (6.5 mm) thick and having a width equal to twice the diameter of the riser, shall be welded to the base of the riser. The plate shall then be covered with 2 1/2 feet (76 cm) of stone, gravel, or compacted soil to prevent flotation.*

Barrel

The 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 connection between the riser and the barrel must be watertight. The outlet of the barrel must be protected to prevent the erosion or scour of downstream areas.

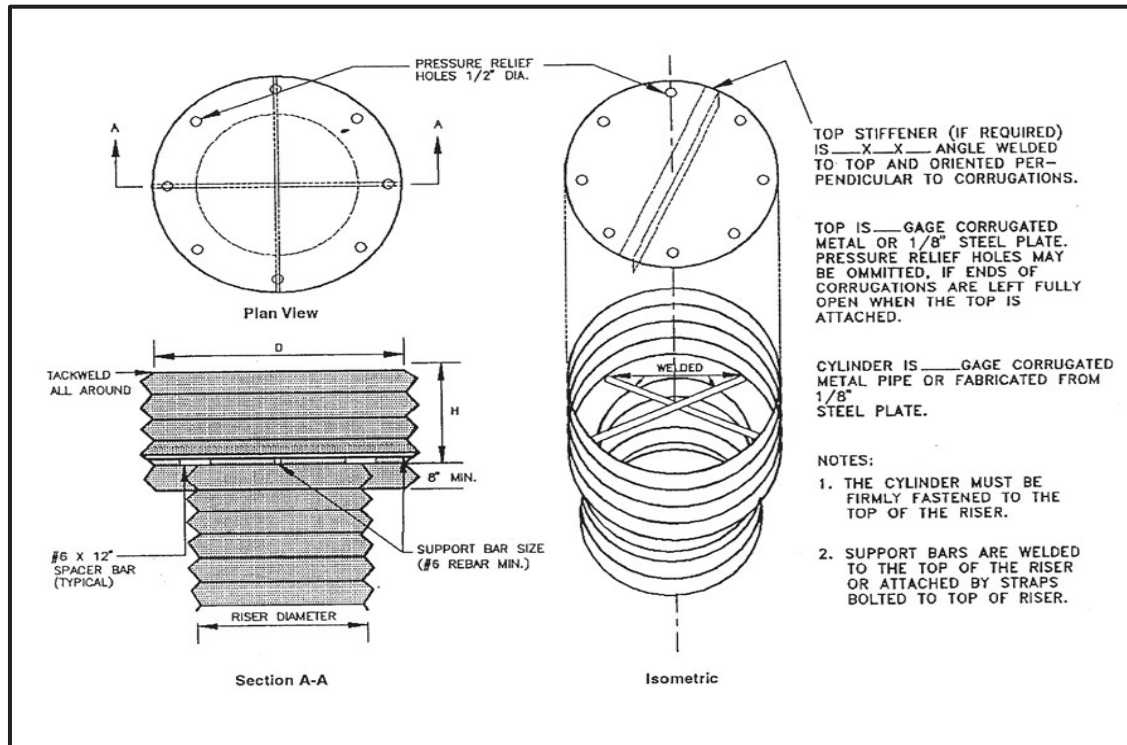


Figure 3.7d. Antivortex device design

Source: NRCS

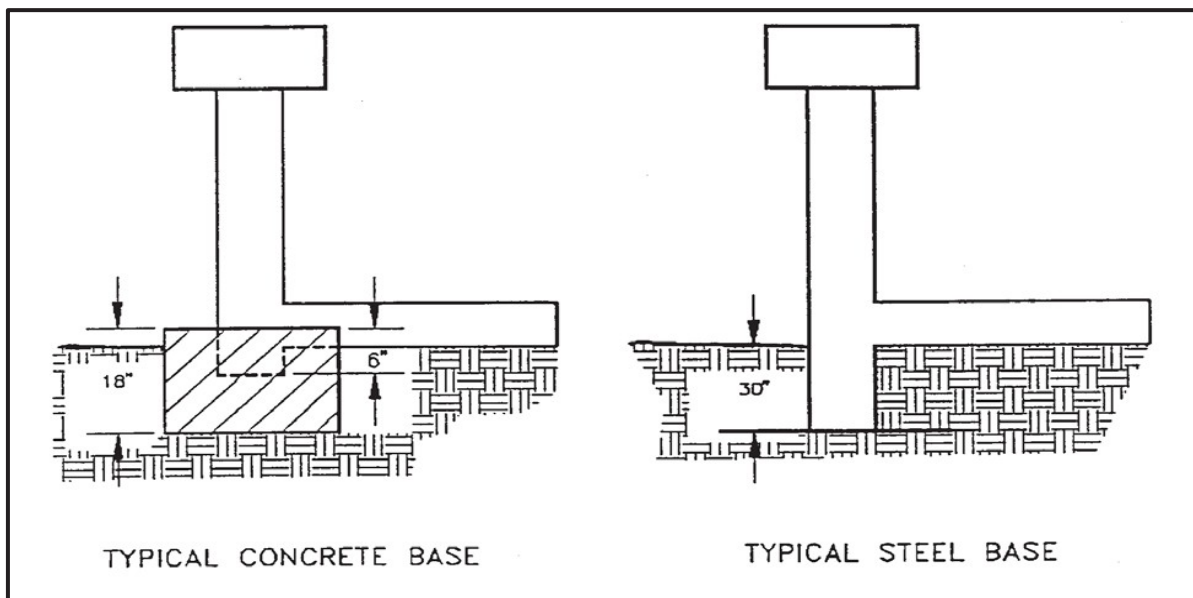


Figure 3.7e. Riser pipe conditions

Source: Virginia DSWC

Floating Skimmer

The floating skimmer, or "Faircloth Skimmer," is widely used throughout the southeastern U.S. and is approved by the EPA and many southeastern states. If correctly installed and sized, it improves sediment trapping efficiency by regulating the filling and draining of the basin better than conventional methods using perforated risers or stone. A floating skimmer works best on small basins sized for the entire catchment, less than half or three quarters of an acre (preferably less), because of the difficulty and expense of construction and maintenance—particularly sediment removal in large basins requiring equipment (usually a dragline) that can reach into a wide area. The skimmer orifice has a constant head that causes the basin to fill—creating conditions for gravity settling—and then drain slowly at a constant rate from near the surface. If possible, locate the basin outside a watercourse or stream to avoid disturbing the natural channel (and avoiding restabilization) and reduce the drainage area to the basin and therefore the size of the basin.

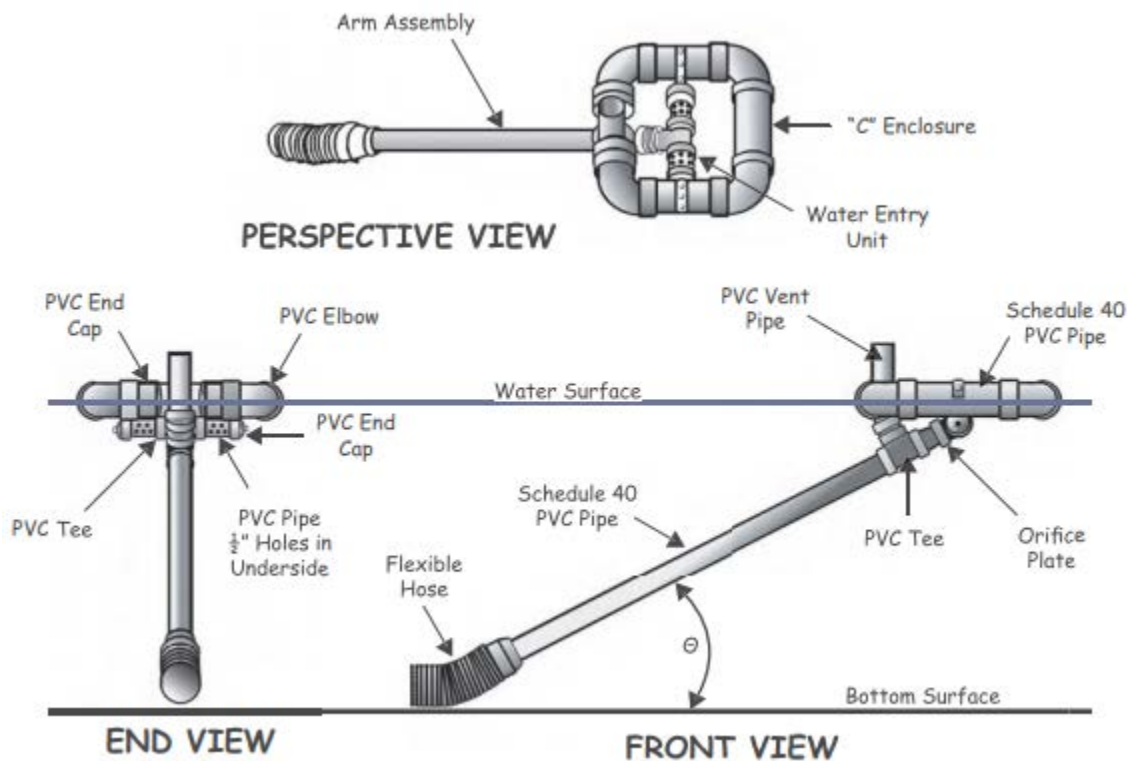


Figure 3.7f. Floating Skimmer

Source: Schematic from Pennsylvania Erosion and Sediment Control Manual 2000

Antiseep Collars

Antiseep collars shall be used on the 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 (3 m).
2. The embankment has a low silt-clay content (Unified Soil Classes SM or GM) and the barrel is greater than 10 inches (25 cm) in diameter.

The antiseep collars shall be installed within the saturated zone. The maximum spacing between collars shall be 14 times the projection of the collar above the barrel. Collars shall not be closer than 2 feet (60 cm) to a pipe joint. Collars should be placed sufficiently far apart to allow space for hauling and compacting equipment. Connections between the collars and the barrel shall be watertight (see **Figure 3.7g** and the 2013 Florida Designer and Reviewer Manual).



Source: Auburn University

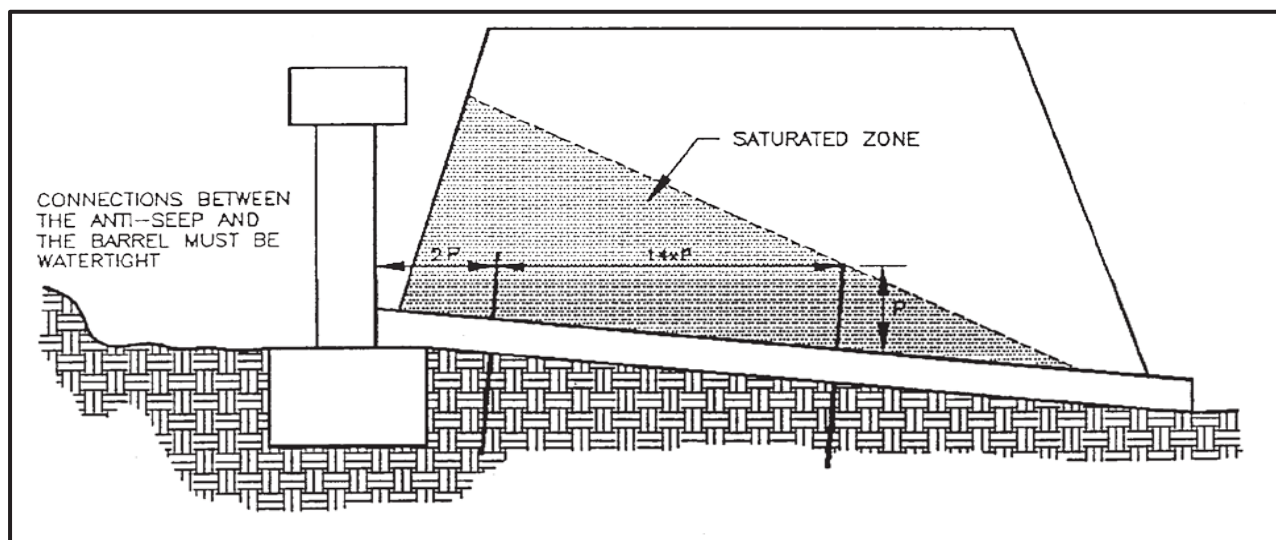


Figure 3.7g. Location of antiseep collars

Source: Virginia DSWC

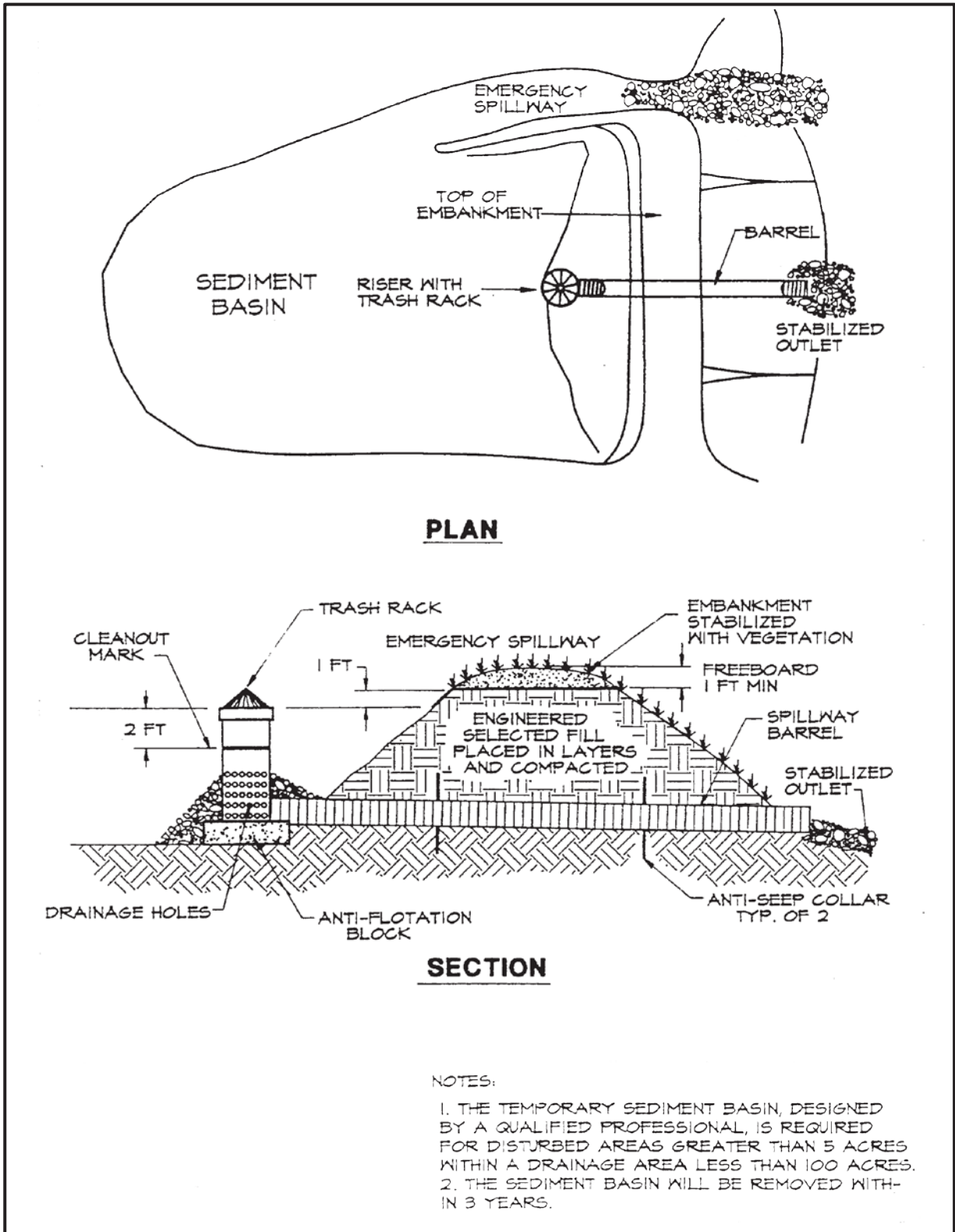


Figure 3.7h. Sediment basin

Source: Erosion Draw

Emergency Spillway

The emergency spillway shall consist of an open channel constructed next to the embankment over undisturbed material or properly compacted fill. The spillway shall have a control section at least 20 feet (6 m) in length. The control section is a level portion of the spillway channel at the highest elevation in the channel (see **Figure 3.7h**). The primary spillway and the emergency spillway shall both discharge to stabilized outlets (see **Figure 3.7i**).

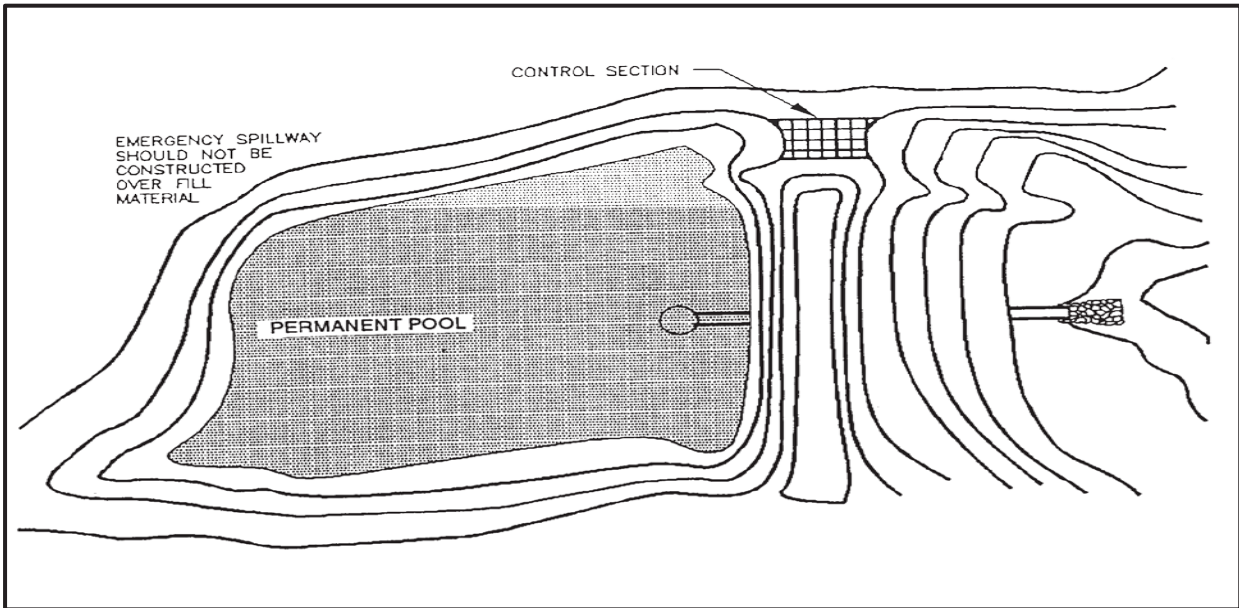


Figure 3.7i. Emergency spillway

Source: Virginia DSWC

Capacity

The emergency spillway shall be designed to carry the peak rate of runoff expected from a 10-year storm, minus any reduction because of the flow through the principal spillway.

Design Elevations

The design high water through the emergency spillway shall be at least 1 foot (30 cm) below the top of the embankment. The crest of the emergency spillway channel shall be at least 1 foot (30 cm) above the crest of the principal spillway.

Location

The emergency spillway channel shall be located to avoid fill material. If constructed on fill, the fill will be properly compacted in lifts. The channel shall be located to avoid sharp turns or bends. The channel shall return the flow of water to a defined channel downstream from the embankment.

Maximum Velocities

The maximum allowable velocity in the emergency spillway channel depends on the type of lining used. For nonerodible linings, such as concrete or asphalt paving and riprap, design velocities may be increased. However, the emergency spillway channel shall return the flow to the natural channel at a noneroding velocity.

Stabilization of the Embankment and Basin

The embankment of the sediment basin shall be temporarily seeded within 15 days after its completion, as described in **TEMPORARY SEEDING** (see **Chapter 4**). If excavation is required in the basin, side slopes should not be steeper than 2:1 (based on the 2013 *Florida Designer and Reviewer Manual*).

Cleanout

Sediment shall be removed from the basin when the capacity is half full or reduced to 55 cubic yards per acre (104 m³/ha) of drainage area. This elevation should be clearly marked, preferably on the riser. Plans for the sediment basin shall state the methods for disposing of sediment removed from the basin. Possible alternatives include the use of the material in fill areas onsite or removal to an approved offsite dump.

Final Removal

Sediment basin plans shall show the final disposition of the sediment basin after the upstream drainage area is stabilized. The plans shall specify methods for the removal of excess water lying over the sediment, the stabilization of the basin site, and the disposal of any excess material. Sediment shall not be flushed into the stream or drainageway.

Safety

Sediment basins are attractive to children and can be very dangerous. Therefore, they should be fenced or otherwise made inaccessible to people or animals unless this is deemed unnecessary because of the remoteness of the site or other circumstances. Strategically placed signs around the impoundment reading "**DANGER—QUICKSAND**" should also be installed. In any case, local ordinances and regulations regarding health and safety must be adhered to.

Construction Specifications

Site Preparation

Areas under the embankment and any structural works shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other objectionable material. To facilitate cleanout and restoration, the pool area (measured at the top of the principal spillway) shall be cleared of all brush and trees.

Cutoff Trench

For earth fill embankments, a cutoff trench shall be excavated along the center line of the dam. The minimum depth shall be 2 feet (60 cm). The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 4 feet (1.2 m), but wide enough to allow the 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 and compacting operations.

Embankment

The fill material shall be taken from approved borrow areas. It shall be clean mineral soil, free of roots, woody vegetation, oversized stones, rocks, or other objectionable material. Areas on which the fill is to be placed shall be scarified prior to the placement of fill. The fill material should contain sufficient moisture so that it can be formed by hand into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. Fill material will be placed in 6- to 8-inch (15 to 20 cm) continuous layers over the entire length of the fill. 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 1 wheel or tread track of the equipment, or by using a compactor. 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 compactors are used for compaction, the overbuild may be reduced to not less than 5 %.

Principal Spillway

The riser of the principal spillway shall be securely attached to the barrel by a watertight connection. The barrel and riser shall be placed on a firm, compacted soil foundation. The base of the riser shall be firmly anchored according to design criteria to prevent floating. Pervious material such as sand, gravel, or crushed stone shall not be used as backfill around the barrel or antiseep collars. Fill material shall be placed around the pipe in 4-inch (10 cm) layers and compacted by hand at least to the same density as the embankment. A minimum of 2 feet (60 cm) of fill shall be hand compacted over the barrel before crossing it with construction equipment.

Emergency Spillway

The emergency spillway should not be constructed over fill material. Design elevations, widths, and entrance and exit channel slopes are critical to the successful operation of the spillway and should be adhered to closely during construction.

Vegetative Stabilization

The embankment and emergency spillway of the sediment basin shall be stabilized with temporary vegetation within seven days of the completion of the basin, as described in **TEMPORARY SEEDING** (see **Chapter 4**).

Erosion and Sediment Control

The construction of the sediment basin shall be carried out so that erosion and water pollution are minimized downstream.

Final Disposal

When **temporary** structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposits should be leveled or otherwise disposed of according to the approved pollution control plan.

Maintenance

The embankment of the basin should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The emergency spillway should be checked regularly to ensure that its lining is well established and erosion resistant. The basin shall be checked after each runoff-producing rainfall for sediment cleanout. When the sediment reaches the cleanout level mark, it shall be removed and properly disposed of.

Information to Be Submitted for Approval

Sediment basin designs and construction plans submitted for review to the appropriate regulatory agency shall include the following:

1. *Specific location of the dam.*
2. *Plan view of the dam, storage basin, and emergency spillway.*
3. *Cross-sections and profiles of the dam, principal spillway, and emergency spillway.*
4. *Details of pipe connections, riser to pipe connection, riser base, antiseep collars, trash rack, and antivortex device.*
5. *Runoff calculations for a 10-year frequency storm.*
6. *Storage computations:*
 - a. Total required.
 - b. Total available.
 - c. Level of sediment at which cleanout shall be required, to be stated as the distance from the riser crest to the sediment surface.
7. *Calculations showing the design of the pipe and emergency spillway.*

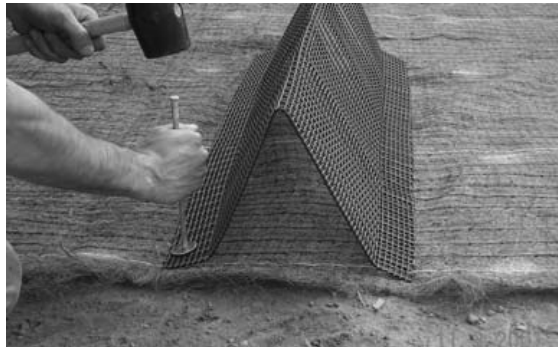
3.8 Temporary Check Dam

Definition

A small, temporary dam constructed across a swale or stormwater conveyance channel.

Purpose

To reduce the velocity of concentrated stormwater flows, thus reducing the erosion of the swale or ditch. This practice also traps small amounts of sediment generated in the ditch itself. These sediments require periodic removal. However, this is not a sediment-trapping practice and should not be used as such.



Applications

This practice is limited to use in small, pen channels that drain 10 acres (4 ha) or less and should not be used in a live stream. It is especially applicable to sloping sites where the gradient of waterways is close to the maximum for a grass lining. Some specific applications include the following:

1. *Temporary ditches or swales that, because of their short length of service, cannot receive a nonerodible lining but still need some protection to reduce erosion.*
2. *Permanent ditches or swales that for some reason cannot receive a permanent, nonerodible lining for an extended period.*
3. *Either temporary or permanent ditches or swales that need protection during the establishment of grass linings.*

Planning Considerations

Temporary check dams can be constructed of stone, filter socks, or a variety of prefabricated products.

Construction Specifications

No formal design is required for a temporary check dam; however, a number of criteria should be adhered to. The drainage area of the ditch or swale being protected should not exceed 10 acres (4

ha). The maximum height of the check dam should be 2 feet (60 cm). The center of the check dam must be at least 6 inches (15 cm) lower than the outer edges (see **Figure 3.8a**). The maximum spacing between the dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam (see **Figure 3.8a**).



Stone check dams should be constructed of FDOT No. 1 Coarse Aggregate (1 1/2 to 3 1/2 inches) (4 to 9 cm) stone. The stone should be placed according to the configuration shown in **Figure 3.8b**. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the ends (see **Figure 3.8b**).

Filter socks are temporary barriers to contain sediment on vertical construction lots as well as to slow water velocity. The compost socks come in a range of diameters, including 8, 12, 18, and 24 inches, and are considered a Type 2 sediment containment system on vertical sites.

Prefabricated materials are discussed in the *2013 Florida Designer and Reviewer Manual*, as geosynthetic barriers such as Geohay and other filter barriers.

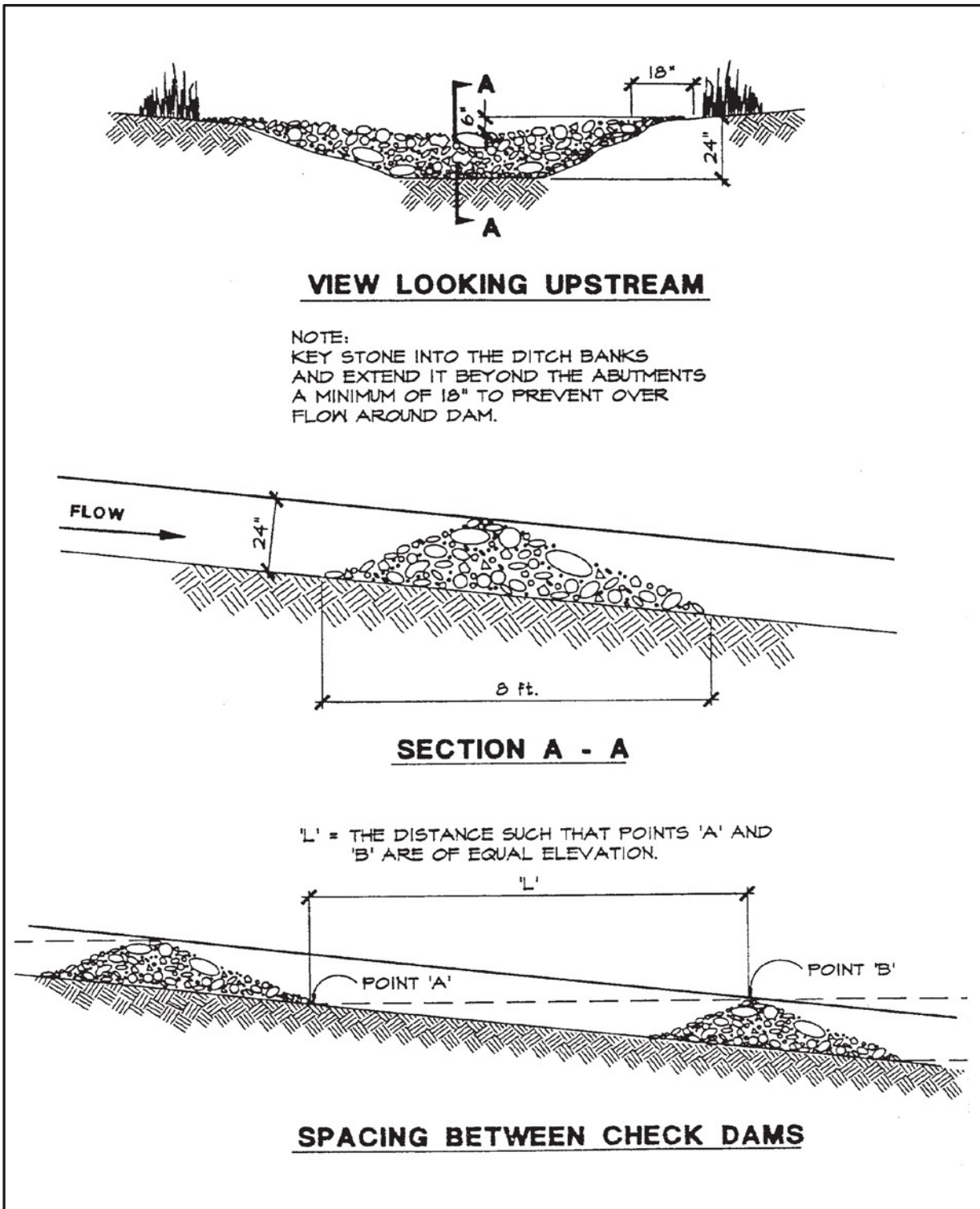


Figure 3.8a. Rock check dam

Source: Erosion Draw

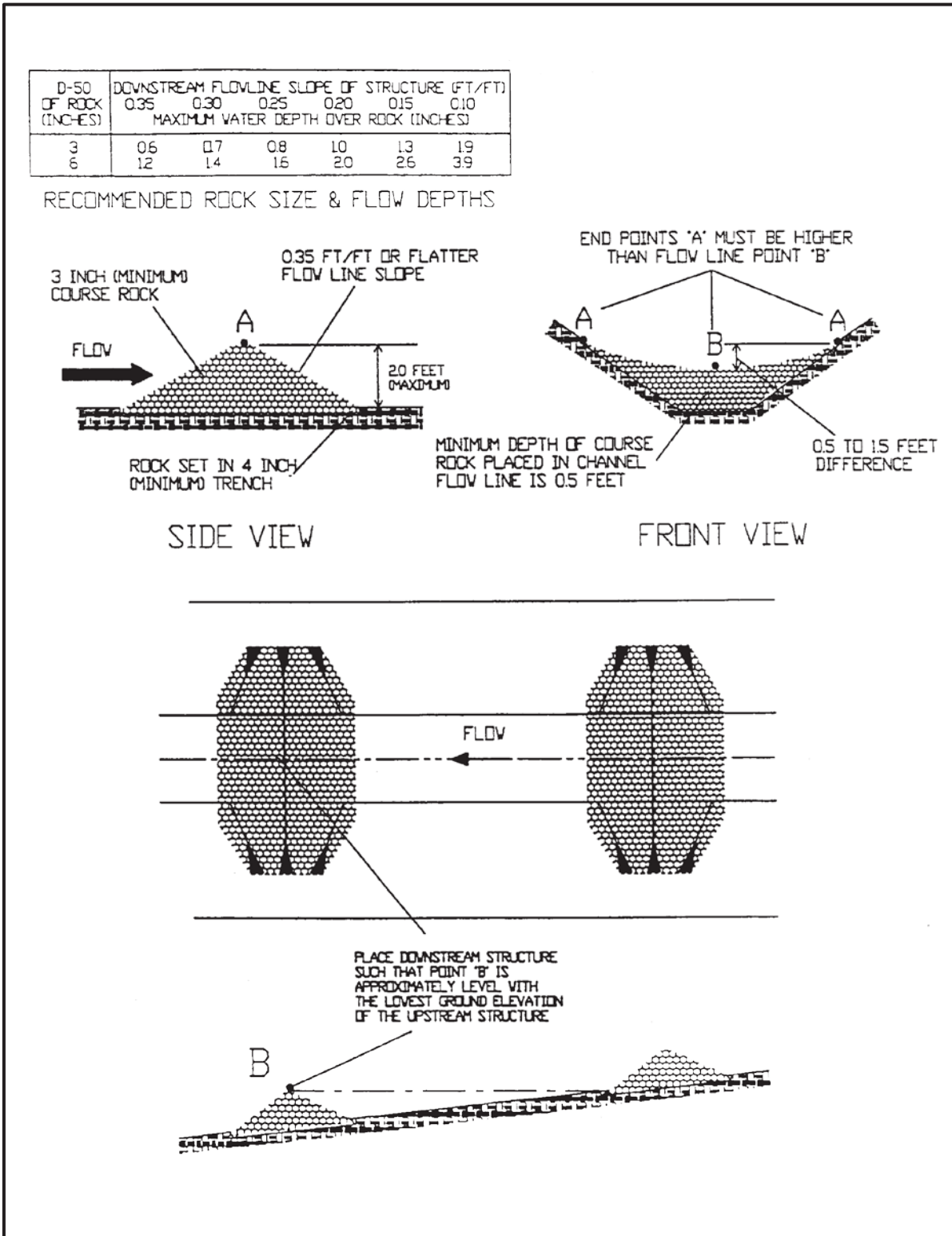


Figure 3.8b. Rock check dam details

Source: Hydro-Dynamics, Inc.

Maintenance

Check dams should be checked for sediment accumulation after each significant rainfall. Sediment should be removed when it reaches one-half of the original height or before.

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

Removal

Check dams must be removed when their useful life has been completed. In temporary ditches and swales, check dams should be removed and the ditch filled in when it is no longer needed. In permanent structures, check dams should be removed when a permanent lining can be installed. In grass-lined ditches, check dams should be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams should be seeded and mulched or sodded (depending on velocity) immediately after the dams are removed.

If stone check dams are used in grass-lined channels that will be mowed, care should be taken to remove all the stone from the dam when the dam is removed. This should include any stone that has washed downstream.

Chapter 4: BMPs—Vegetation for Erosion Control

- 4.1 Introduction
- 4.2 Surface Roughening
- 4.3 Topsoiling
- 4.4 Temporary Seeding
- 4.5 Permanent Seeding
- 4.6 Sodding
- 4.7 Mulching
- 4.8 Trees, Shrubs, Vines, and Ground Covers
- 4.9 Tree Preservation and Protection
- 4.10 Vegetative Streambank Stabilization

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4.1 Introduction

The most efficient and cost-effective form of erosion control is prevention. The most cost-effective, environmentally friendly, and aesthetically pleasing form of prevention is through the use of vegetation. Success depends on the proper application, installation, and maintenance of vegetative BMPs, such as those described in this chapter.

4.2 Surface Roughening

Definition

Providing a rough soil surface with horizontal depressions created by operating a tillage implement or other suitable implement on the contour, or by leaving slopes in a roughened condition by not fine-grading them.

Purposes

1. *To aid in the establishment of vegetative cover with seed.*
2. *To reduce runoff velocity and increase infiltration.*
3. *To reduce erosion and provide for sediment trapping.*

Applications

1. *All slopes steeper than 3:1 require surface roughening if they are to be stabilized with vegetation. Acceptable methods include stair-step grading, grooving, furrowing, or tracking.*
2. *Areas with grades less steep than 3:1 should have the soil surface lightly roughened and loosened to a depth of 2 to 4 inches (5 to 10 cm) prior to*

seeding.

3. *Areas that have been graded but will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.*

Specifications

Cut Slope Applications for Areas that Will Not Be Mowed

1. *Cut slopes with a gradient steeper than 3:1 shall be stair-step graded or grooved (see **Figures 4.1a** and **4.1b**).*
2. *Stair-step grading may be carried out on any material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading. The ratio of the vertical cut distance to the horizontal distance shall be less than 1:1, and the horizontal portion of the "step" shall slope toward the vertical wall. Individual vertical cuts shall not be more than 30 inches (75 cm) on soft soil materials and not more than 40 inches (100 cm) in rocky materials.*
3. *Grooving consists of using machinery to create a series of ridges and depressions that run perpendicular to the slope (on the contour). Grooves may be made with an appropriate implement that can be safely operated on the slope and that will not cause undue compaction. Suggested implements include discs, tillers, spring harrows, and the teeth on a front-end loader bucket. Such grooves shall not be less than 3 inches (8 cm) deep or more than 15 inches (38 cm) apart.*

Fill Slope Applications for Areas that Will Not Be Mowed

Fill slopes with a gradient steeper than 3:1 shall be grooved or allowed to remain rough as they are constructed. The options are as follows:

1. *Groove according to Item 2, above.*
2. *As lifts of the fill are constructed, soil and rock materials may be allowed to fall naturally onto the slope surface (see **Figure 4.1a**).*

Colluvial materials (soil deposits at the base of slopes or from old streambeds) shall not be used in fills, as they flow when saturated. At no time shall slopes be bladed or scraped to produce a smooth, hard surface.

Cuts, Fills, and Graded Areas that Will Be Mowed

Mowed slopes should not be steeper than 3:1. Excessive roughness is undesirable where mowing is planned. These areas may be slightly roughened with shallow grooves, such as those that remain after tilling, disking, harrowing, raking, or the use of a cultipacker-seeder. The final pass of any such tillage implement shall be on the contour (perpendicular to the slope). Grooves formed by such implements shall not be less than 1 inch (2.5 cm) deep and not more than 12 inches (30 cm) apart. Fill slopes that are left rough as constructed may be smoothed with a dragline or pickchain to facilitate mowing.

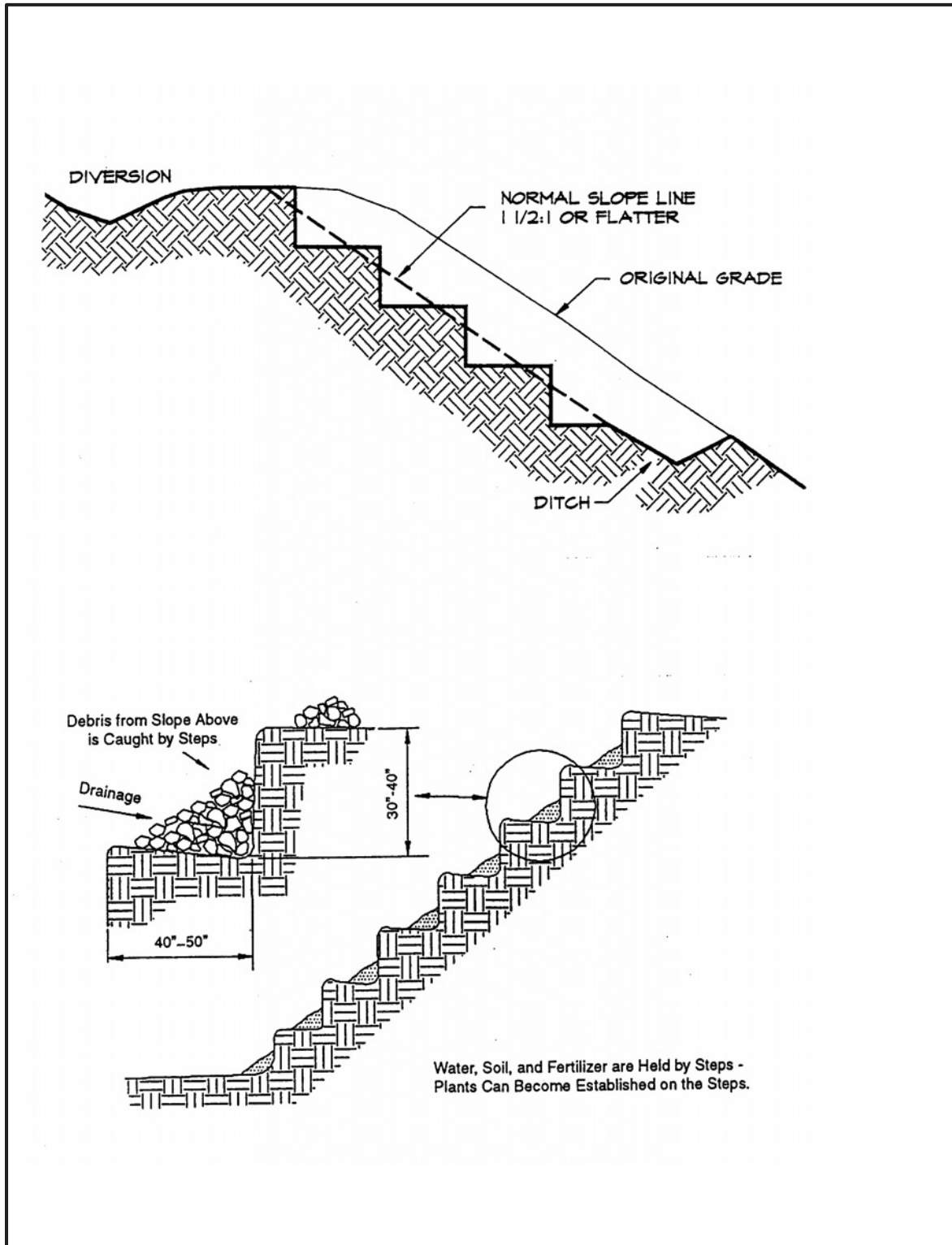


Figure 4.1a. Stair-stepped slope

Source: Virginia DSWC; Erosion Draw

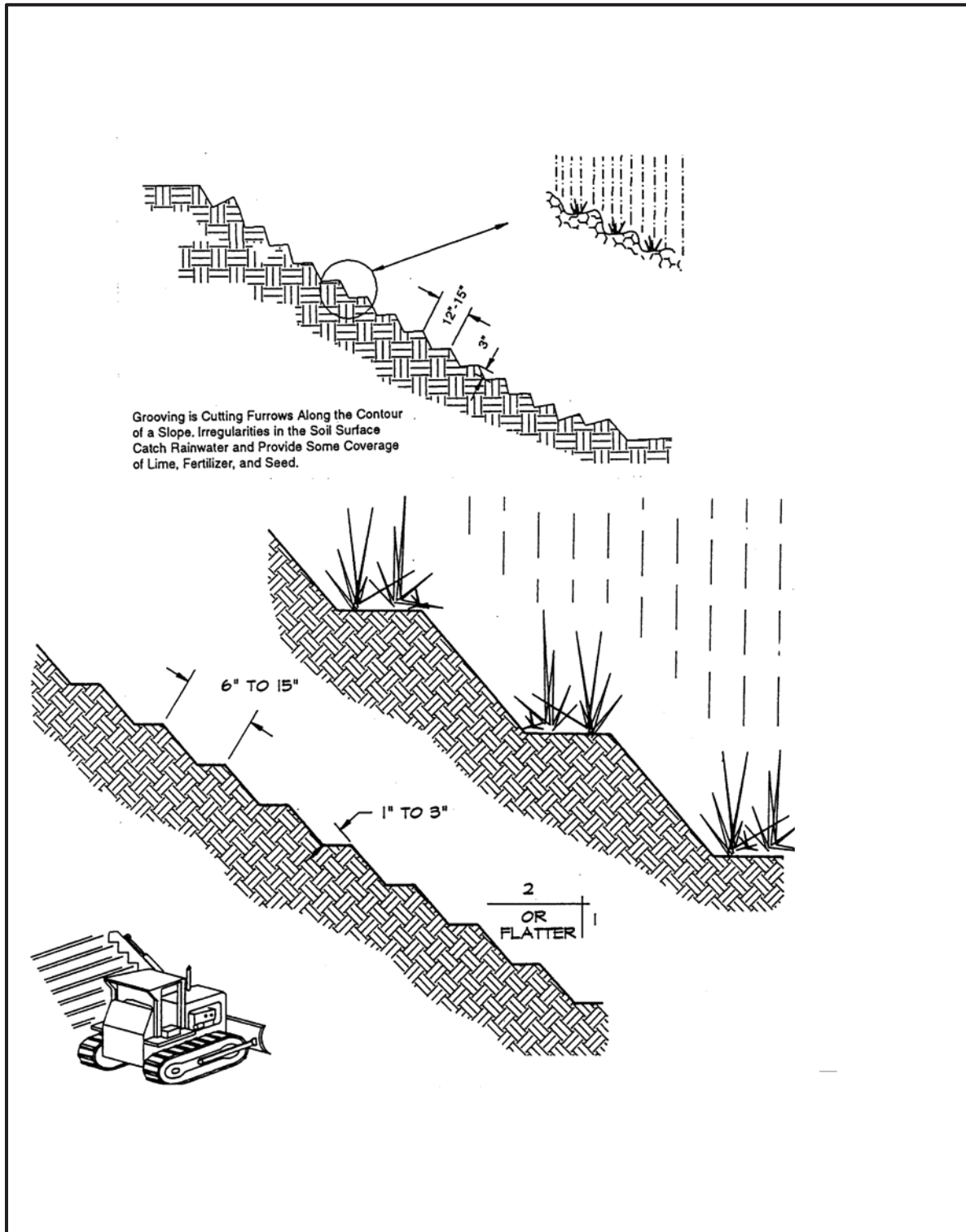


Figure 4.1b. Grooved or serrated slope

Source: Erosion Draw

Terracing

Bench terraces consist of one or more diversions placed along a slope to slow and intercept the flow of water. The diversions are constructed either along the contour or sloping gradually to a stabilized waterway. The bench or channel should be at least 6 feet (2 m) wide to allow the use of mowing equipment (see **Figure 4.1c**).

Roughening with Tracked Machinery

Roughening with tracked machinery on clayey soils is not recommended unless no other alternatives are available. This practice unduly compacts the surface soil. Sandy soils do not compact severely and may be tracked. Tracking is not as effective as the other roughening methods described in this chapter.

When tracking is the chosen technique for surface roughening, it shall be done by operating tracked machinery up and down the slope to leave horizontal depressions in the soil. There should be as few passes of the machinery as possible to minimize compaction (see **Figure 4.1d**).

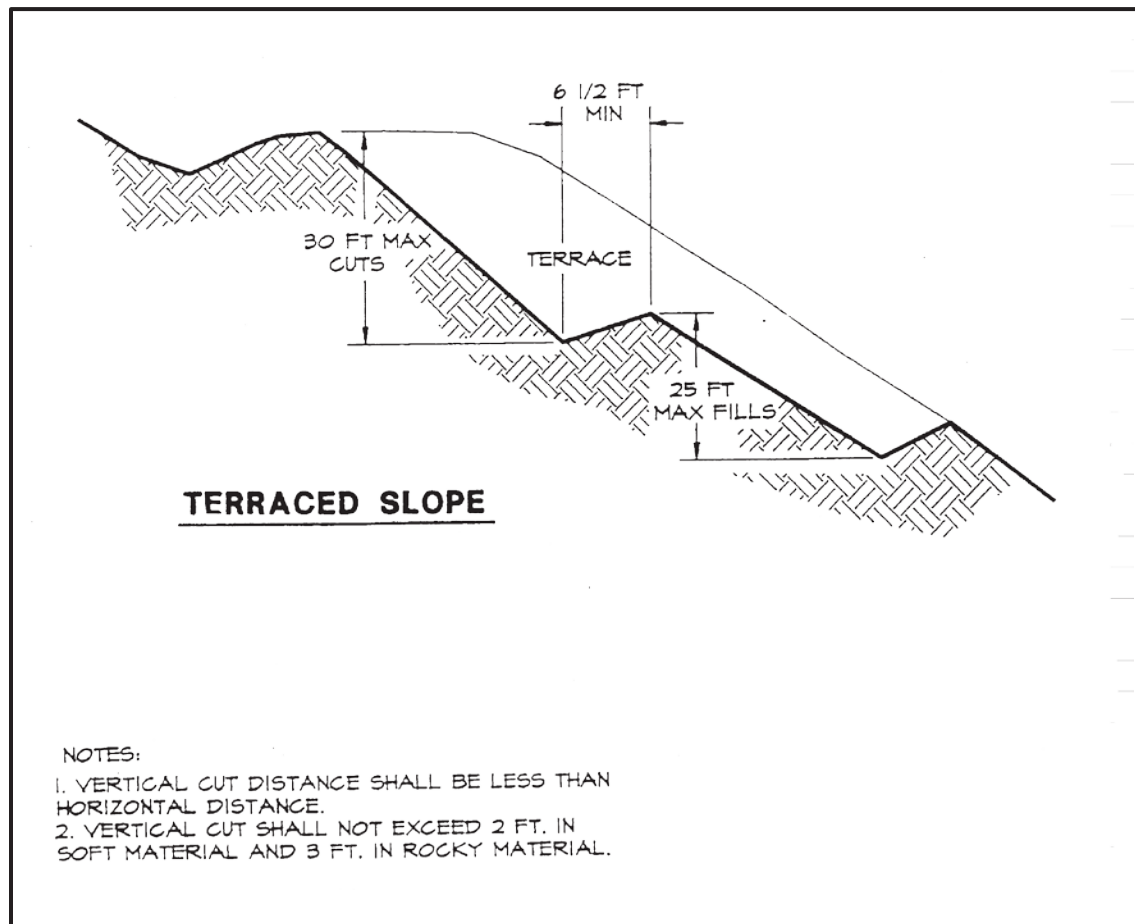


Figure 4.1c. Terraced slope

Source: Erosion Draw

Seeding

Roughened areas shall be seeded and mulched as soon as possible to obtain optimum seed germination and seedling growth.

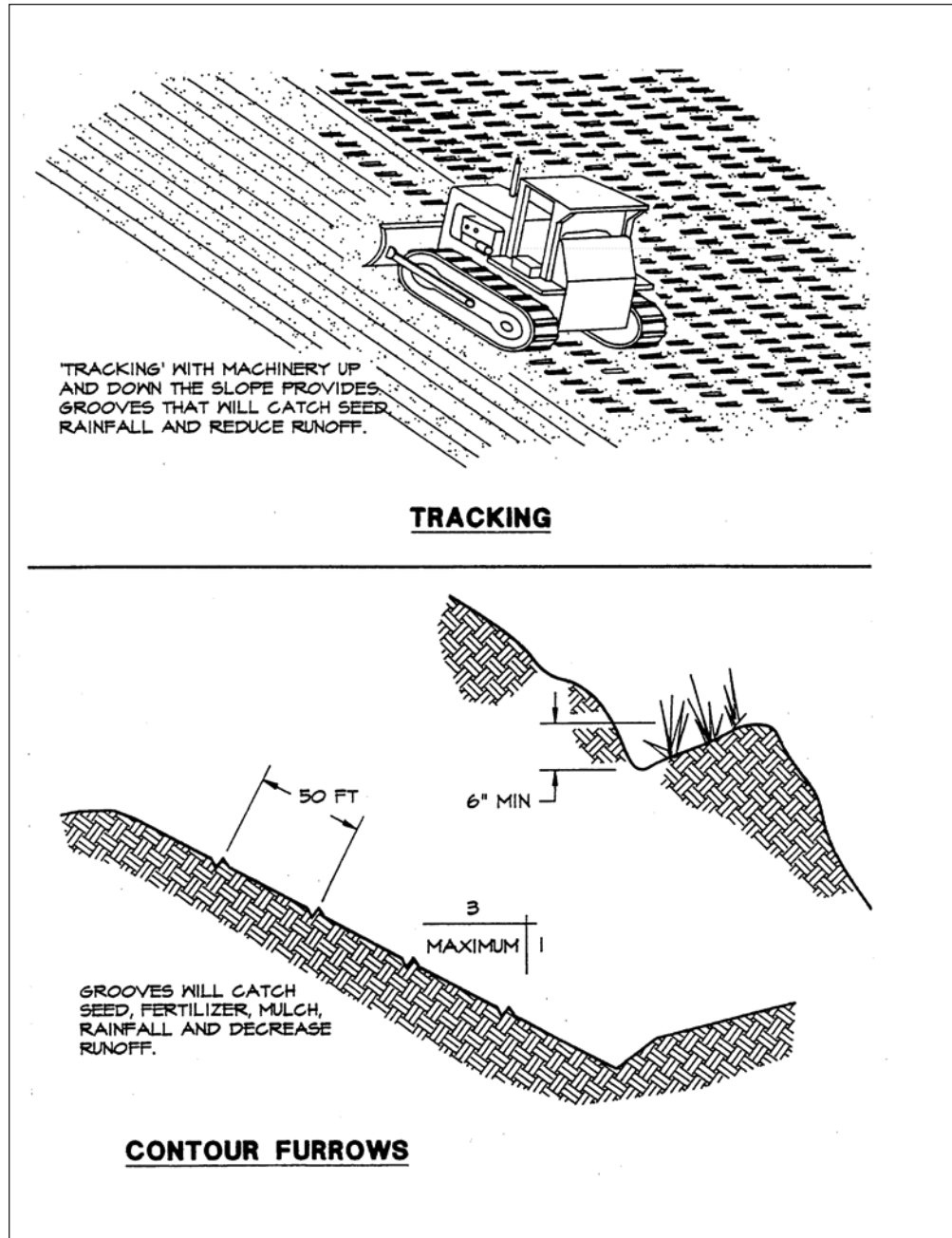


Figure 4.1d. Roughening with tracked machinery

Source: Erosion Draw

4.3 Topsoiling

Definition

Methods of preserving and using topsoil to enhance final site stabilization with vegetation.

Purpose

To provide a suitable growth medium for final site stabilization with vegetation.

Applications

1. *Where either the preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium.*
2. *Where the subsoil or existing soil presents the following problems:*
 - a. The texture, pH, or nutrient balance of the available soil cannot be modified by reasonable means to provide an adequate growth medium.
 - b. The soil material is too shallow to provide an adequate root zone and to supply the necessary moisture and nutrients for plant growth.
 - c. The soil contains substances potentially toxic to plant growth.
3. *Where high-quality turf is desirable to withstand intense use or meet aesthetic requirements.*
4. *Where ornamental plants will be established.*
5. *Only on slopes that are 2:1 or flatter.*

Specifications

Materials

A field evaluation of the site should be made to determine if there is sufficient surface soil of good quality to justify stripping. The topsoil should be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). It should be free of debris, trash, stumps, rocks, roots, and noxious weeds, and should be able to support healthy plant growth.

Soil Testing

Once topsoil is stockpiled, random soil samples should be taken throughout the stockpile, mixed together, and a composite sample sent for testing to the University of Florida Institute of Food and Agricultural Sciences (UF–IFAS) in Gainesville, FL. The results of the testing will provide information on the conditioners and amendments that may need to be added to the topsoil.

Stripping

Stripping should be confined to the immediate construction area. A 4- to 6-inch (10 to 15 cm) stripping depth is common, but depth may vary depending on the particular soil. All perimeter berms, basins, and other sediment controls shall be in place prior to stripping.

Stockpiling Topsoil

Topsoil shall be stockpiled so that natural drainage is not obstructed and no offsite sedimentation occurs. Stockpiles should be planned so as not to interfere with any of the construction operations. They can also act as barriers to shield the construction site from the neighborhood and adjacent landowners, and can help to reduce the amount of dust and noise coming from the site.

The side slopes of the stockpile shall not exceed 2:1. A perimeter berm with gravel outlet, silt fence, or equivalent barrier shall surround all topsoil stockpiles. Temporary seeding of stockpiles shall be completed within 7 days of the formation of the stockpile, or in areas where the stockpile will not be graded for more than 7 days, in accordance with **TEMPORARY SEEDING** (discussed in this chapter).

Site Preparation Prior to and Maintenance During Topsoiling

Before topsoiling, establish needed erosion and sediment control practices such as diversions, grade stabilization structures, berms, level spreaders, waterways, and sediment basins. These practices must be maintained during topsoiling. The following guidelines should be used for site preparation and maintenance:

1. ***Grading*** – *Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.*
2. ***Liming*** – *Where the pH of the subsoil is 6.0 or less, or the soil is composed of heavy clays, agricultural limestone shall be spread in accordance with the soil test or the vegetative establishment practice being used.*
3. ***Bonding*** – *After the areas to be topsoiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by disking or scarifying to a depth of at least 2 inches (5 cm) to ensure bonding of the topsoil and subsoil.*

Applying Topsoil

Topsoil shall not be placed while in a muddy condition, when the subgrade is excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed sodding or seeding. The topsoil shall be uniformly distributed to a minimum compacted depth of 2 inches (5 cm) on 3:1 or steeper slopes, and 4 inches (10 cm) on flatter slopes. Any irregularities in the surface resulting from topsoiling or other operations shall be corrected to prevent the formation of depressions or water pockets.

The topsoil should be compacted enough to ensure good contact with the underlying soil and a level seedbed for the establishment of high-maintenance turf. However, undue compaction is to be avoided, as it increases runoff velocity and volume, and deters seed germination. In areas that are not going to be mowed, the surface should be left rough, as described in **Surface Roughening** (discussed in this chapter).

Soil Sterilants

No sod or seed shall be placed on soil that has been treated with soil sterilants until enough time has elapsed to permit the toxic materials to dissipate.

4.4 Temporary Seeding

Definition

The establishment of temporary vegetative cover on disturbed areas by seeding with appropriate, rapidly growing annual plants to protect exposed soils.

Purposes

- 1. To reduce erosion and sedimentation by stabilizing disturbed areas that will not be brought to final grade within seven days or longer.*
- 2. To reduce problems associated with mud and dust production from bare soil surfaces during construction.*

Applications

Where exposed soil surfaces are not to be fine graded for periods of seven days or longer. Such areas include denuded areas, soil stockpiles, berms, dams, the sides of sediment basins, and temporary road banks.

Specifications

Prior to seeding, install necessary erosion control practices such as berms, waterways, and basins.

Plant Selection

Select plants appropriate to the season, region, and site conditions. Consult with your local Agricultural Extension Service agent, county, Florida Department of Environmental Protection (DEP), water management district, or FDOT office. See the *2013 Florida Designer and Reviewer Manual*.

Seedbed Preparation

To control erosion on bare soil surfaces, plants must be able to germinate and grow. Seedbed preparation is essential. **A UF–IFAS soil test should be carried out** to determine liming and fertilization requirements. In the absence of a soil test, the following guidelines apply:

1. **Liming** – Where soils are known to be highly acid (pH 6.0 and lower), lime should be applied at the rate of 2 tons of pulverized agricultural limestone per acre.
2. **Fertilizer** – Shall be applied as 217.5 pounds per acre (5 pounds/1,000 square feet) (504 kg/ha) of 50 % slow-release 10-20-20 or equivalent. Lime and fertilizer shall be incorporated into the top 2 to 4 inches (5 to 10 cm) of the soil. If quick-release nitrogen is used, apply 2 to 3 weeks after seed has sprouted.
Note P Rule – Only if required per soil test. Also, remember to check with the local municipality regarding its fertilizer ordinances, which place limits on amounts and types applied, and the timing or season.
3. **Surface Roughening** – If the area has been recently loosened or disturbed, no further roughening is required. When the area is compacted, crusted, or hardened, the soil surface shall be loosened by disking, raking, harrowing, or other acceptable means (see **SURFACE ROUGHENING** in this chapter).
4. **Tracking** – Tracking with bulldozer cleats is most effective on sandy soils. This practice often causes the undue compaction of the soil surface, especially in clayey soils, and does not aid plant growth as effectively as other methods of surface roughening.

Seeding

Seed shall be evenly applied with a cyclone seeder, drill, cultipacker-seeder, or hydroseeder. Small grains shall be planted no more than 1 inch deep. Grasses and legumes shall be planted no more than 1/4 inch (6 mm) deep.

Mulching

1. Mulch should usually be applied to reduce damage from water runoff or wind erosion, and to improve moisture conditions for seedlings. Mulching without seeding should be considered for very short-term protection. The use of mulch is a judgment based on the time of seeding and conditions of individual sites. When used, mulch shall be applied according to **MULCHING** (in this chapter).
2. Seedings made on slopes more than 3:1, or on adverse soil conditions, or during excessively hot or dry weather, shall be mulched according to **MULCHING** (in this chapter).
3. Seedings made during optimum spring and summer seeding dates, with favorable soil and site conditions, may not require mulch.

Reseeding

Areas that fail to establish enough vegetative cover to prevent rill erosion will be filled in with proper topsoil and reseeded as soon as they are identified.

4.5 Permanent Seeding

Definition

The establishment of perennial vegetative cover on disturbed areas by planting seed.

Purposes

1. *To reduce erosion and decrease sediment yield from disturbed areas.*
2. *To permanently stabilize disturbed areas in a manner that is economical and adaptable to the site conditions, and that allows the selection of the most appropriate plant materials.*

Applications

1. *Disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil.*
2. *Rough-graded areas that will not be brought to final grade for a year or more.*

Specifications

Selection of Plant Materials

1. *The selection of plant materials is based on climate, topography, soils, land use, and planting season. To determine which plant materials are best adapted to a specific site, see A Guide for Roadside Vegetation Management, by Dr. Jason Farrell, Dr. Bryan Unruh, and Jason Kruse, 2012 edition.*
2. *There are appropriate seeding mixtures for various site conditions in Florida. These mixtures are designed for general use and are known to perform well on the sites described. Adhere to these mixtures whenever feasible. Please contact your local Agricultural Extension Service for further guidance specific to your area of the county or counties. Also, check your construction plans to see if a specific seed or seeds have already been selected by the design engineer.*

Seedbed Requirements

Vegetation should not be established on slopes that are unsuitable because of inappropriate soil texture, poor internal structure or internal drainage, a high volume of overland flow, or excessive steepness, until measures have been taken to correct these problems.

To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. **The existing soil must meet the following criteria:**

1. *Enough fine-grained material to maintain adequate moisture and nutrient supply.*
2. *Sufficient pore space to permit root penetration. A bulk density of 1.2 to 1.5 indicates that sufficient pore space is present. A fine granular or crumblike structure is also favorable.*
3. *Sufficient depth to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans shall be 12 inches (30 cm) or more, except on slopes steeper than 2:1, where the addition of soil is not feasible.*
4. *A favorable pH range for plant growth. If the soil is so acid that a pH range of 6.0 to 7.0 cannot be attained by the addition of pH-modifying materials, then the soil is unsuitable for plant roots.*
5. *Freedom from toxic amounts of materials harmful to plant growth.*
6. *Freedom from excessive quantities of roots, branches, large stones, large clods of earth, or trash of any kind. Clods and stones may be left on slopes steeper than 3:1 if they are to be hydroseeded.*

If any of the above criteria cannot be met—i.e., if the existing soil is too coarse, dense, shallow, acid, or contaminated to foster vegetation—then topsoil should be applied in accordance with **TOPSOILING** (discussed in this chapter). The necessary mechanical erosion and sediment control practices **will be installed prior to seeding**. Grading will be carried out according to the approved plan. Surfaces will be roughened in accordance with **SURFACE ROUGHENING** (discussed in this chapter).

Soil Conditioners

To modify the texture, structure, or drainage characteristics of a soil, the following materials **may** be added to the soil:

1. **Peat** shall be sphagnum moss peat, hypnum moss peat, reed-sedge peat, or peat humus, from freshwater sources. Peat shall be shredded and conditioned in storage piles for at least 6 months after excavation.
2. **Sand** shall be clean and free of toxic materials.
3. **Vermiculite** shall be horizontal grade and free of toxic substances.
4. **Composted manure** shall be stable or cattle manure not containing undue

amounts of straw or other bedding materials or toxic chemicals. Phosphorus shall be limited to soil test recommendations.

5. ***Thoroughly rotted sawdust*** shall be 6 pounds of nitrogen added to each cubic yard (3.5 kg/m³) and shall be free of stones, sticks, and toxic substances.

Lime and Fertilizer

Lime and fertilizer needs should be determined by soil tests. Soil samples should always be collected and sent to the UF–IFAS Soil Testing Laboratory so it can perform the appropriate soil analysis.

***SPECIAL NOTE:** Please check with the local municipality for specific fertilizer ordinances that may limit the type and timing of fertilizer applied.

Information on the Soil Testing Laboratory is available from county Agricultural Extension Service agents. Under unusual conditions where it is not possible to obtain a soil test, the following soil amendments will be applied:

- ***LIME:***
 - 2 tons per acre finely ground agricultural or dolomitic limestone (90 pounds per 1,000 square feet) (4.48 t/ha).
- ***FERTILIZER:***
 - **Mixed Grasses and Legumes:** 150 pounds per acre of 5-25-10 (3.5 pounds per 1,000 square feet).
 - **Legume Stands Only:** 150 pounds per acre of 5-20-10 (3.5 pounds per 1,000 square feet).
 - **Grass Stands Only:** 870 pounds per acre of 5-5-10 (1.12 t/ha) and 57 pounds of 38-0-0 in spring (1.3 pounds per 1,000 square feet); 220 pounds per acre of 10-5-10 and 57 pounds of 38-0-0 in fall (1.3 pounds per 1,000 square feet).

Other fertilizer formulations may be used, provided they supply the same amounts and proportions of plant nutrients.

Lime and fertilizer shall be incorporated into the top 4 to 6 inches (10 to 15 cm) of the soil by disking or other means. When applying lime and fertilizer with a hydroseeder, apply to a rough, loose surface.

Seeding

1. ***Certified seed*** should be used for all permanent seeding whenever possible.

2. **Legume seed** should be inoculated with the inoculant appropriate to the species. The seed of lespedezas, crown vetch, and clovers should be scarified to promote uniform germination.
3. **Apply seed uniformly** with a cyclone seeder, drill, cultipacker-seeder, or hydroseeder on a firm, friable seedbed. The maximum seeding depth should be 1/4 inch.
4. During **hydroseeding or applying Hydraulic Erosion Control Products (HECP)**, to avoid seed damage, it is recommended that if a machinery breakdown of 30 minutes to 2 hours occurs, 50 % more seed should be added to the tank, based on the proportion of the slurry remaining in the tank. Beyond 2 hours, a full rate of new seed may be necessary.
5. Often hydroseeding contractors prefer not to apply lime in their rigs, as it is abrasive. In inaccessible areas, lime may have to be applied in pelletized or liquid form, separately. The rates of wood fiber should be according to the manufacturer specifications. If none exist, then the minimum rate should be 3,000 pounds per acre. Application rates typically increase as the slope increases. Surface roughening is particularly important when hydroseeding, as a roughened slope provides some natural coverage of lime, fertilizer, and seed.
6. **Legume inoculants** should be used by the date indicated on the container. When dry seeding, use 4 times the manufacturer's recommended application rate, and use 10 times the recommended rate of inoculant when hydroseeding.

Mulching

All permanent seeding must be mulched immediately upon the completion of seed application (refer to the extended discussion in **MULCHING** below).

Maintenance of New Seedings

1. **Irrigation** – New seedings should be supplied with adequate moisture. Supply water as needed, especially late in the season, in abnormally hot or dry weather, or on adverse sites. Water application rates should be controlled to prevent runoff. Inadequate amounts of water may be more harmful than no water.
2. **Reseeding** – Inspect seeded areas for failure and make necessary repairs and reseedings within the same season, if possible:
 - a. If vegetative cover is inadequate to prevent rill erosion, overseed and fertilize in accordance with soil test results.

- b. If a stand has less than 40 % cover, re-evaluate the choice of plant materials and quantities of lime and fertilizer. Re-establish the stand following seedbed preparation and seeding recommendations, omitting lime and fertilizer in the absence of soil test results. **NOTE:** If vegetation has failed to grow, the soil must be tested to determine if acidity or nutrient imbalances are responsible.

3. **Fertilization** – *Seedlings should be fertilized 1 year after planting to ensure proper stand density:*

- a. To established all-grass stands, apply 300 pounds per acre of 15-0-15 or 15-2-15 slow release (6.7 pounds per 1,000 square feet) between August 15 and November 15 (the first fall following seeding).
- b. To legume-and-grass stands or pure legume stands, apply 150 pounds per acre of 0-20-20 (3.5 pounds per 1,000 square feet) in early May, or between August 15 and October 15.
- c. Generally, a stand of vegetation or grassing is not determined to be fully established until soil cover has been maintained for 1 full year from the date of planting. Disturbed areas that are to be stabilized with perennial or permanent vegetation must be seeded or planted within 7 days after final grade is achieved, unless temporary stabilization is applied.
- d. Final stabilization is defined as a uniform perennial vegetative cover with a density of growth of at least 70 % or greater for all paved areas.
- e. Always check with the local municipality for specific fertilizer ordinances that may limit the type and timing of the application fertilizers.

4.6 Sodding

Definition

Stabilizing fine-graded disturbed areas by establishing permanent grass stands with sod.

Purposes

1. *To establish permanent turf immediately.*
2. *To prevent erosion and damage from sediment and runoff by stabilizing the soil surface.*
3. *To reduce the production of dust and mud associated with bare soil surfaces.*
4. *To stabilize drainageways where concentrated overland flow will occur.*

Applications

1. *Disturbed areas that require immediate vegetative covers, or where sodding is preferred to other means of grass establishment.*

2. *The following locations are particularly suited to stabilization with sod:*
 - a. Slopes and buffer strips.
 - b. Waterways and swales, especially around drop inlets.
 - c. Residential or commercial lawns where quick use or aesthetics are factors.

Specifications

Soil Preparation

1. *Prior to soil preparation, areas to be sodded shall be brought to final grade in accordance with the approved plan. These operations should leave as much topsoil as possible or replace the topsoil to a depth of 4 inches (10 cm) (see **Figure 4.2a**).*
2. *Soil tests should be carried out to determine the exact requirements for lime. They may be conducted by the state Soil Testing Laboratory at the University of Florida or a reputable commercial laboratory. Information on state soil tests is available from county Agricultural Extension Service agents. When a soil test is not carried out, **pulverized agricultural limestone** may be added at a rate of 100 pounds per 1,000 square feet (2 tons/acre).*
3. *Before sod is laid, the soil surface shall be clear of trash, debris, roots, branches, stones, and clods more than 2 inches (5 cm) in length or diameter. Sod shall not be applied to gravel or other nonsoil surfaces.*
4. *Any irregularities in the soil surface resulting from topsoil or other operations shall be filled or leveled to prevent the formation of depressions or water pockets.*
5. *Areas to be topsoiled and the topsoil used shall fulfill the requirements of **TOPSOILING** (in this chapter). No sod shall be spread on soil that has been treated with soil sterilants until enough time has elapsed to permit the dissipation of toxic materials.*
6. *PAM application prior to laying sod can increase water retention rates, increase rates of survival, improve soil moisture, and improve the effectiveness of fertilization. Refer to manufacturer specifications for rates of application.*

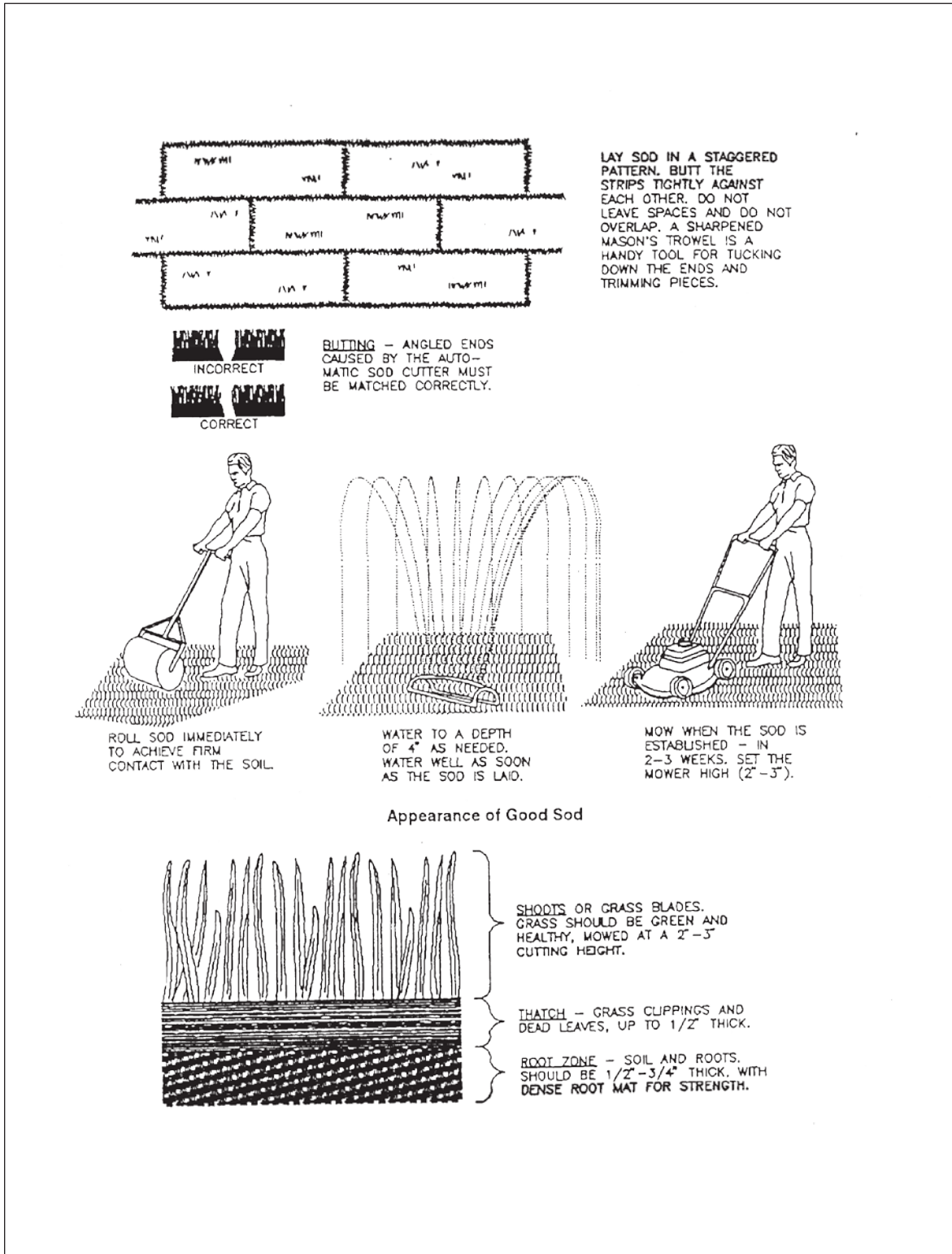


Figure 4.2a. Sodding

Source: Virginia DSWC

Sod Quality

1. Sod should be free of weeds and undesirable coarse weedy grasses. If possible, **Certified** or **Approved** turfgrass sod should be used.
2. Sod should be machine cut at a uniform soil thickness of 3/4 inch (20 mm), plus or minus 1/4 inch (6 mm), at the time of cutting. This thickness shall exclude shoot growth and thatch.
3. Pieces of sod should be cut to the supplier's standard width and length, with a maximum allowable deviation in any dimension of 5 %. Torn or uneven pads are not acceptable.
4. Standard-size sections of sod should be strong enough to support their own weight and retain their size and shape when suspended from a firm grasp on one end of the section.
5. Sod should not be cut or laid in excessively wet or dry weather.
6. Sod should be harvested, delivered, and installed within 36 hours.

Installation

Solid Sodding

1. Irrigate areas to be sodded with a minimum of 1/2 inch (13 mm) of water, unless recent rains have provided an equivalent amount of moisture (see **Figure 4.2b**).
2. The first row of sod shall be laid in a straight line, with subsequent rows placed parallel to and butting tightly against each other. Lateral joints shall be staggered to promote more uniform growth and strength. Care shall be exercised to ensure that the sod is not stretched or overlapped and that all joints are butted tightly to prevent voids that would dry out the roots.
3. On slopes of 3:1 or greater, or wherever erosion may be a problem, sod shall be laid with staggered joints and secured by pegging or other approved methods. Sod shall be installed with the length perpendicular to the slope (on the contour). Begin laying sod at the bottom of the slope and work uphill. On very steep slopes, the use of ladders facilitates the work and prevents damage to the sod.

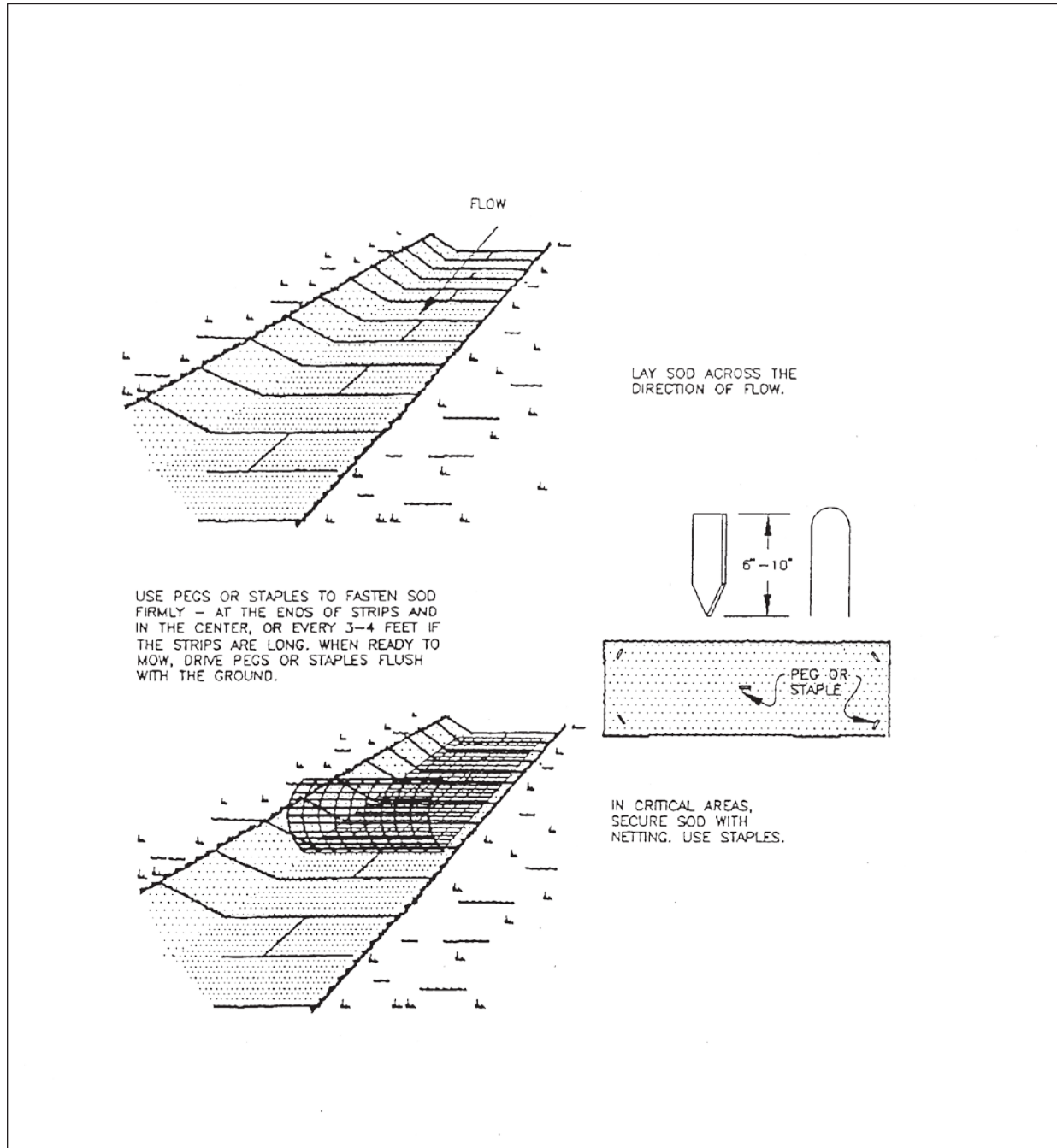


Figure 4.2b. Sodding swales and waterways

Source: Virginia DSWC

4. *Surface water flow cannot always be diverted from the face of the slope, but a capping strip of heavy jute or erosion netting, properly secured, along the crown of the slope provides extra protection against the lifting and undercutting of sod. The same technique is used to fortify sod in water-carrying channels and other critical areas. Use wire staples to anchor heavy jute or erosion netting in channels.*
5. *As the sodding of clearly defined areas is completed, sod should be rolled or tamped to provide firm contact between roots and soil.*
6. *After rolling, sod shall be irrigated deeply enough that the underside of the sod pad and the soil 4 inches (10 cm) below the sod are thoroughly wet.*
7. *During the first week, in the absence of adequate rainfall, watering shall be performed as often as necessary to maintain moist soil to a depth of at least 4 inches (10 cm).*
8. *The first mowing shall not be attempted until the sod is firmly rooted, usually after 2 to 3 weeks. No more than one-third of the grass leaf should be removed at any one cutting.*
9. *Two to 4 weeks after sod is laid, fertilize at an application rate of 300 pounds per acre or 6.7 pounds per 1,000 square feet with 15-0-15 or 15-2-15 slow release.*

Spot Sodding

1. *Spot sodding is the planting of plugs or blocks, a minimum of 4 inches (10 cm) in diameter or square, of sod at measured intervals. The plugs or blocks should be placed 1 foot (30 cm) apart.*
2. *Sod spots in a row should be placed alternately and not directly opposite sod spots in adjacent rows.*
3. *Fit the plugs or blocks tightly into the prepared holes and tamp them firmly into place.*
4. *Irrigate deeply enough that the underside of the sod spot and the soil 4 inches (10 cm) below the sod are thoroughly wet.*

Strip Sodding

1. *Areas to be strip sodded should be fertilized, limed, prepared, and smoothed as in solid sodding.*

2. Lay the strips end to end in rows 1 to 1 1/2 feet (30 to 45 cm) apart, with the strips a minimum of 2 to 4 inches (5 to 10 cm) wide.
3. Roll or tamp the strips thoroughly to create firm contact between roots and soil.
4. Irrigate deeply enough that the underside of the strips and the soil 4 inches (10 cm) below the strips are wet.

Sodded Swales and Waterways

1. Care should be taken to prepare the soil adequately in accordance with this specification. The sod type shall consist of plant materials able to withstand the designed velocity (see **STORMWATER CONVEYANCE CHANNEL** in **Chapter 6**).
2. Sod strips in swales and waterways shall be laid perpendicular to the direction of flow. Care should be taken to butt the ends of the strips tightly.
3. After rolling or tamping, sod shall be pegged or stapled to resist washout during the establishment period. Chicken wire, jute, or other netting may be pegged over the sod for extra protection in critical areas.
4. All other specifications for this practice shall be adhered to when sodding a swale or waterway.

Maintaining Established Sod

1. After the first week, sod shall be watered as necessary to maintain adequate moisture in the root zone and prevent dormancy.
2. Apply lime and fertilizer under a regular program based on soil tests and on the use and general appearance of the vegetative cover. In the absence of a soil test, apply 1 to 2 tons per acre (45 to 90 pounds/1,000 square feet) (2.24 to 4.48 t/ha) of finely ground agricultural limestone every 3 years. Apply 300 pounds per acre (6.7 pounds/1,000 square feet) of 15-0-15 or 15-2-15 slow-release fertilizer in the spring and fall.
3. Mow to control weeds, improve the appearance of the vegetative cover, and reduce fire hazard, as necessary. In general, the coarser the leaf texture of the grass, the higher it should be cut. Continuous, close mowing results in a loss of vigor and reduced stand. No more than one-third of the grass leaf should be removed in any mowing.

4.7 Mulching

Definition

The application of plant residues or other suitable materials to the soil surface.

Purposes

1. *To prevent erosion by protecting the soil surface from raindrop impacts and reducing the velocity of overland flow.*
2. *To foster the growth of vegetation by increasing available moisture and providing insulation against extreme heat and cold.*

Applications

1. *Areas that have been permanently seeded should be mulched immediately after seeding.*
2. *Areas that cannot be seeded because of the season should be mulched to temporarily protect the soil surface. An organic mulch (not wood fiber alone) shall be used, and the area should then be seeded as soon as feasible in spring.*
3. *Mulch shall be used together with plantings of trees, shrubs, or certain ground covers that do not provide adequate soil stabilization by themselves.*
4. *Mulch shall be used in conjunction with the temporary seeding operations specified in **TEMPORARY SEEDING** (in this chapter).*
5. *Mulches used in areas of concentrated flows or frequent inundation shall be properly anchored to prevent them from floating away.*

Specifications

Types of Mulches

1. **Organic Mulches** – Organic mulches may be used in any area where mulch is required, subject to the restrictions noted in **Table 4.1**. Select mulch material based on site requirements, the availability of materials, and the availability of labor and equipment. The table lists the most commonly used organic mulches. Other materials, such as peanut hulls and cotton burs, may also be used.

Mulch materials shall be spread uniformly, by hand or machine. When spreading straw by hand, divide the area to be mulched into approximately 1,000-square-foot sections and place 70 to 90 pounds (1 1/2 to 2 bales) (30 to 40 kg) of straw in each section, to facilitate uniform distribution.

2. **Nets, Mats, and Blankets** – Nets may be used alone on level areas, on slopes

no steeper than 3:1, and in waterways, as specified in **STORMWATER CONVEYANCE CHANNEL** (see **Chapter 6**). When mulching is done in late fall or during June, July, or August, **or** where soil is highly erodible, net should only be used in conjunction with an organic mulch such as straw. When net and organic mulch are used together, the net should be installed over the mulch, except when the mulch is wood fiber. Wood fiber may be sprayed on top of the installed net. Excelsior binders are protective mulches and may be used alone on erodible soils and throughout the year.

Jute net shall be heavy, uniform cloth woven of single jute yarn, which if 36 to 48 inches (90 to 120 cm) wide shall weigh an average of 1.2 pounds per linear yard (0.6 kg/m). Other products designed to control erosion shall conform to the manufacturer's specifications and should be applied in accordance with the manufacturer's instructions, provided those instructions are at least as stringent as this specification. Examples of these products include Erosionet, Holdgro, Weedchek, and Curlex. (**NOTE:** The use of trade names does not constitute a product endorsement by DEP). In no case shall these products cover less than 30 % of the soil surface.

Table 4.1. Organic mulch materials and application rates

Source: Virginia SWCC

Mulches	Rate Per Acre	Rate Per 1,000 Square Feet	Notes
Straw	2 tons	70 – 90 pounds.	Free from weeds and coarse matter. Must be anchored. Spread with mulch blower or by hand.
Wood Fibers	0.5 – 1.0 tons	25 – 50 pounds	Fibers 1.5-inch minimum length. Do not use alone in winter or during hot, dry weather. Apply as slurry.
Wood Chips	4 – 6 tons	185 – 275 pounds	Free of coarse matter. Air dried. Treat with 12 pounds nitrogen per ton. Do not use in fine turf areas. Apply with mulch blower or chip handler, or by hand.
Shredded Bark Chips	50 – 70 cubic yards	1 – 2 cubic yards	Free of coarse matter. Air dried. Do not use in fine turf areas. Apply with mulch blower or chip handler, or by hand.

3. Hydraulic (Chemical) Mulches – Chemical mulches may be used alone only in the following situations:

- Where no other mulching material is available.
- In conjunction with temporary seeding when mulch is not required for that practice.
- From May 1 to June 15 and September 15 to October 15, provided they are used on areas with slopes no steeper than 4:1 that have been roughened in accordance with **SURFACE ROUGHENING** (in this chapter).

Installation

Prior to mulching, the following activities should be carried out:

1. *As required, shape and grade the waterway, channel, slope, or other area to be protected.*
2. *Remove all rocks, clods, or debris larger than 2 inches in diameter that will prevent contact between the net and the soil surface.*
3. *Lime and fertilizer should be incorporated and the surface roughened as needed. Seed should be applied prior to mulching, except in the following cases:*
 - a. *Where seed is to be applied as part of a hydroseeder slurry containing wood fiber mulch.*
 - b. *Where seed is to be applied following a straw mulch spread during the winter months.*
 - c. *Where a hydroseeder slurry is applied over straw.*

Mulch Anchoring

Straw mulch must be anchored immediately after spreading to prevent windblow. The other organic mulches listed in **Table 4.1** do not require anchoring. The following methods of anchoring straw may be used:

1. **Mulch Anchoring Tool** – *A tractor-drawn implement is used to punch mulch into the soil surface. This method provides maximum erosion control with straw. It is limited to use on slopes no steeper than 3:1, where equipment can operate safely. Machinery shall be operated on the contour.*
2. **Liquid Mulch Binders** – *The application of liquid mulch binders and tackifiers should be heaviest at the edges of areas and at the crests of ridges and banks, to prevent windblow. Binders should be applied uniformly over the rest of the area. They may be applied after mulch is spread or may be sprayed into the mulch as it is being blown onto the soil. Applying straw and binder together is the most effective method.*
3. **Rolled Erosion Control Products (RECP)** – *Lightweight nets may be stapled over the mulch. The nets shall be secured by stakes, staples, or pins according to the manufacturer's recommendations (see **Figure 4.3a** for details).*

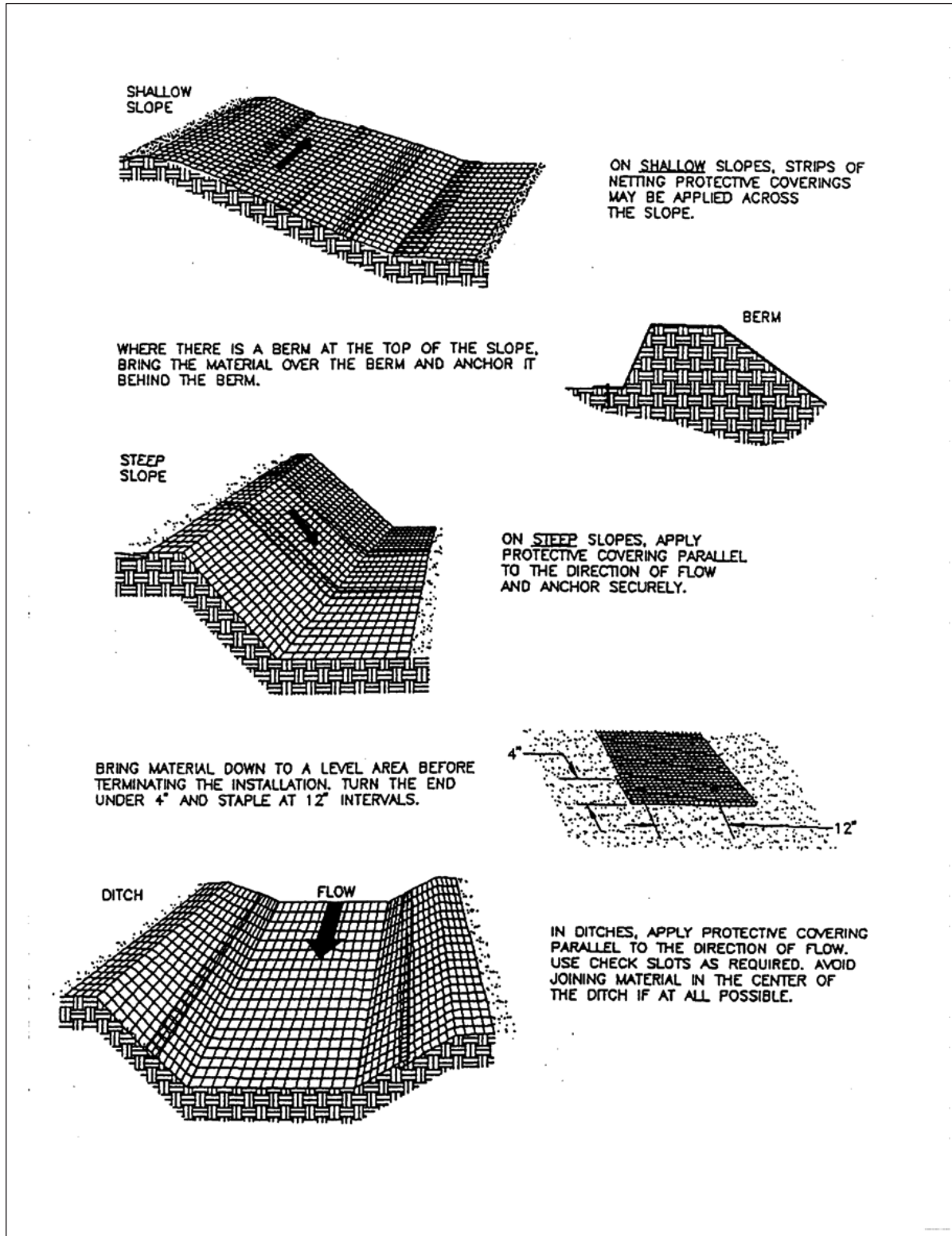


Figure 4.3a. Typical orientation of Treatment 1 – Soil stabilization blanket

Source: Adapted from Ludlow Products Brochure

Laying Nets, Mats, and Blankets

Nets, mats, and blankets should be installed according to the manufacturer's instructions, provided these are at least as stringent as the following general recommendations (see **Figure 4.3b**):

1. *Start laying the net from the top of the channel or the top of the slope and unroll downgrade.*
2. *Allow the net to lie loosely on the soil—**DO NOT STRETCH**.*
3. *To secure the net, the upslope ends should be buried in a slot or trench no less than 6 inches (15 cm) deep. Tamp earth firmly over the net. Staple the net every 12 inches (30 cm) across the top end. Staple patterns should be per the manufacturer specifications for the use of the RECP. The edges shall be stapled every 3 feet (90 cm). Where 2 strips of net are laid side by side, the adjacent edges shall be overlapped 3 inches (8 cm) and stapled together. Staples shall be placed down the center of net strips at 3-foot (90 cm) intervals. **DO NOT STRETCH** the net when applying staples.*
4. *To join strips, insert a new roll of net in the trench, as with the upslope ends of the net. Overlap the end of the previous roll 18 inches (45 cm), turn under 6 inches (15 cm), and staple across the end of the roll just below the anchor slot and at the end of the turned-under net every 12 inches (30 cm) (see **Figures 4.3g** and **4.3h**).*
5. *At the bottom of slopes, lead the net out onto a level area before anchoring. Turn the ends under 6 inches (15 cm), and staple across the ends every 12 inches (30 cm).*
6. *On highly erodible soils and on slopes steeper than 4:1, erosion check slots should be made every 15 feet (4.5 m). Insert a fold of net into a 6-inch (15 cm) trench and tamp firmly. Staple at 12-inch (30 cm) intervals across the downstream portion of the net.*
7. *After installation, stapling, and seeding, the net should be rolled to **ensure firm contact between the net and soil**.*

Maintenance

All mulches should be inspected periodically, particularly after rainstorms, to check for rill erosion. Where erosion is observed, areas should be inspected and mulch restaked to ensure contact with the soil. The net should be inspected after rainstorms for dislocation or failure. If washouts or breakage occur, reinstall the net as necessary after repairing damage to the slope. Inspections should take place until the grass is firmly established. Where mulch is used in conjunction with ornamental plantings, inspect periodically throughout the year to determine if mulch is maintaining coverage of the soil surface. Repair as needed.

Source: Virginia DOT

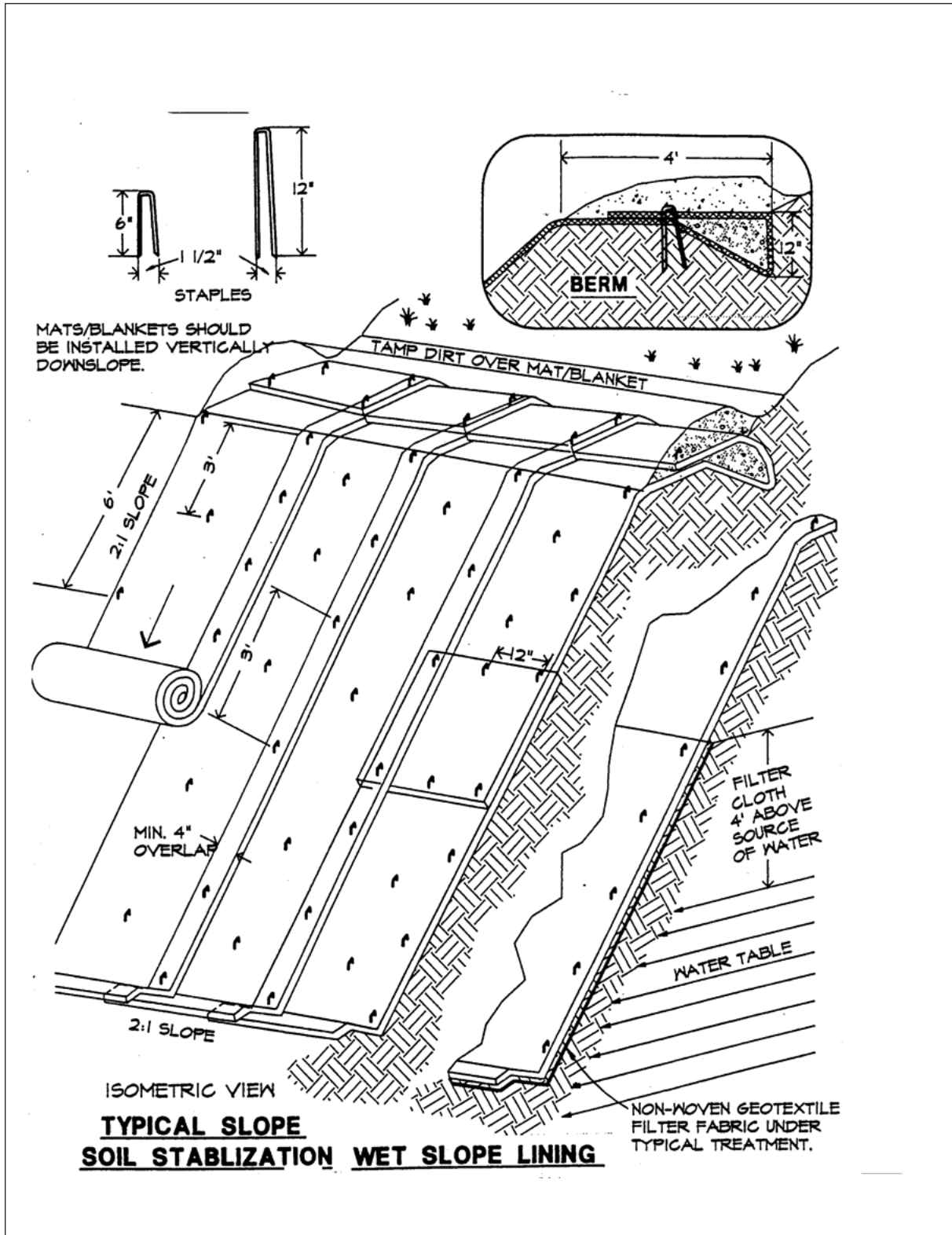


Figure 4.3c. Erosion blankets and turf reinforcement mats – Slope installation

Source: Erosion Draw

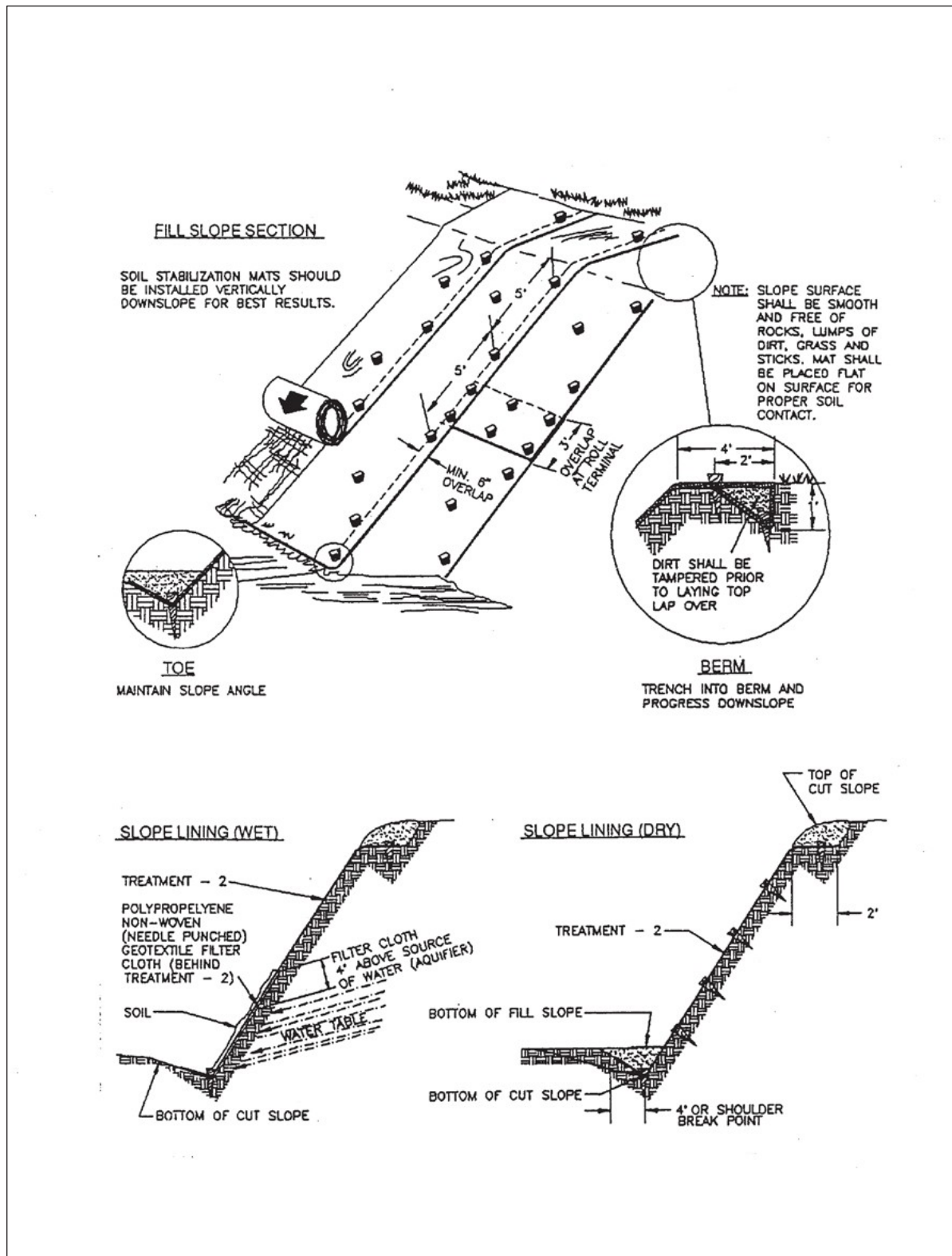


Figure 4.3d. Typical Treatment 2 – Soil stabilization matting slope installation

Source: Virginia DOT

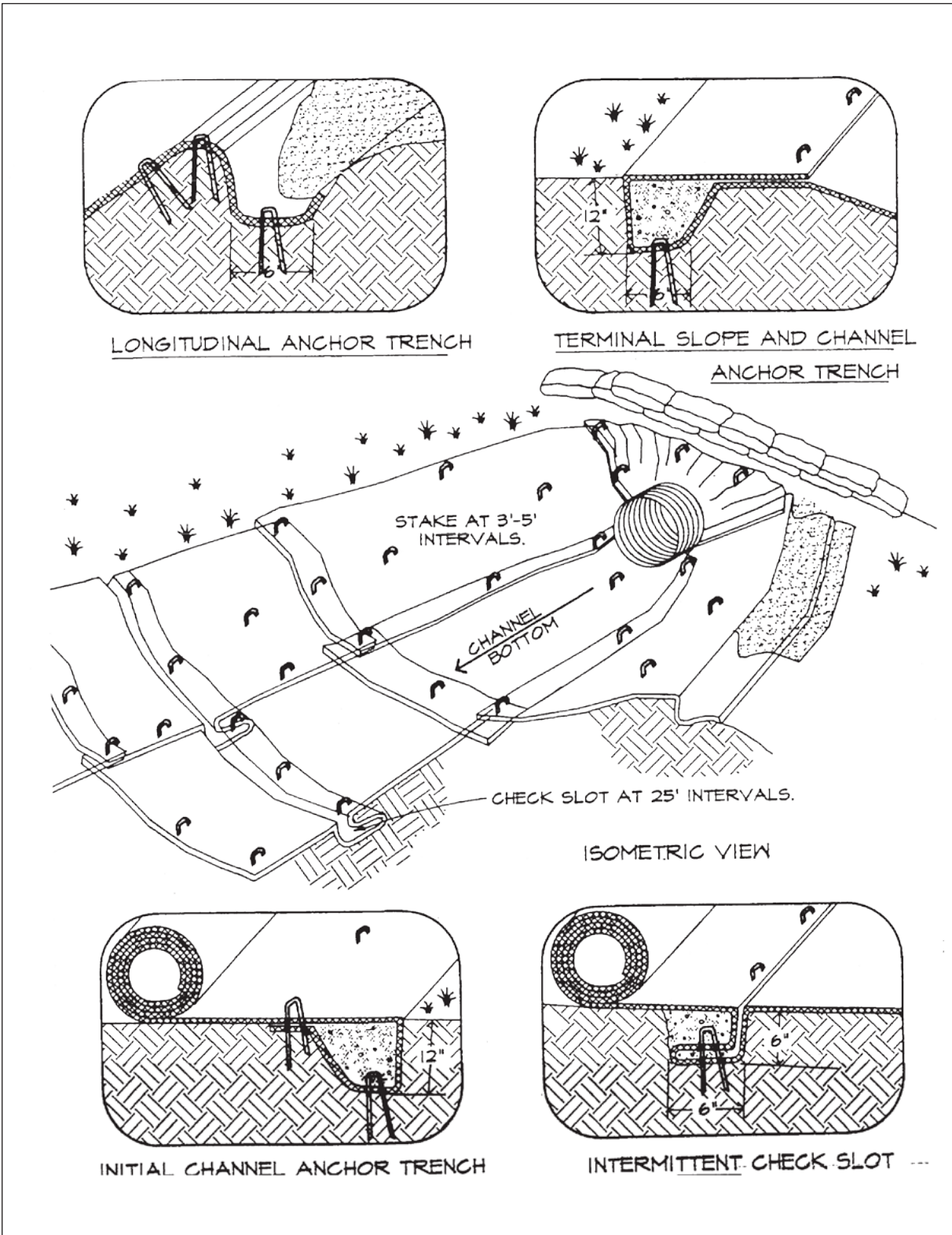


Figure 4.3e. Erosion blankets and turf reinforcement mats – Channel installation

Source: Erosion Draw

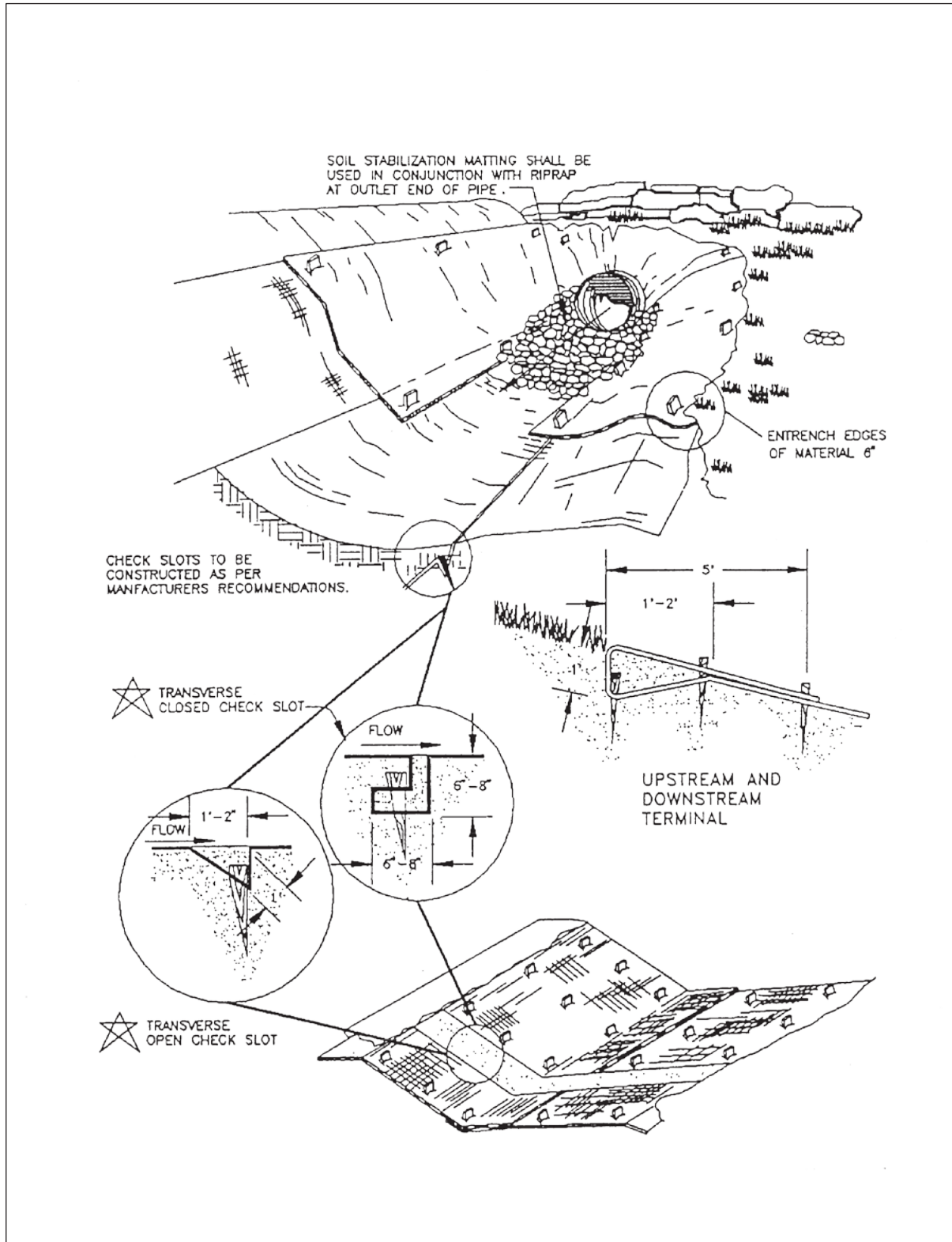


Figure 4.3f. Typical Treatment 2 – Soil stabilization matting installation

Source: Virginia DOT

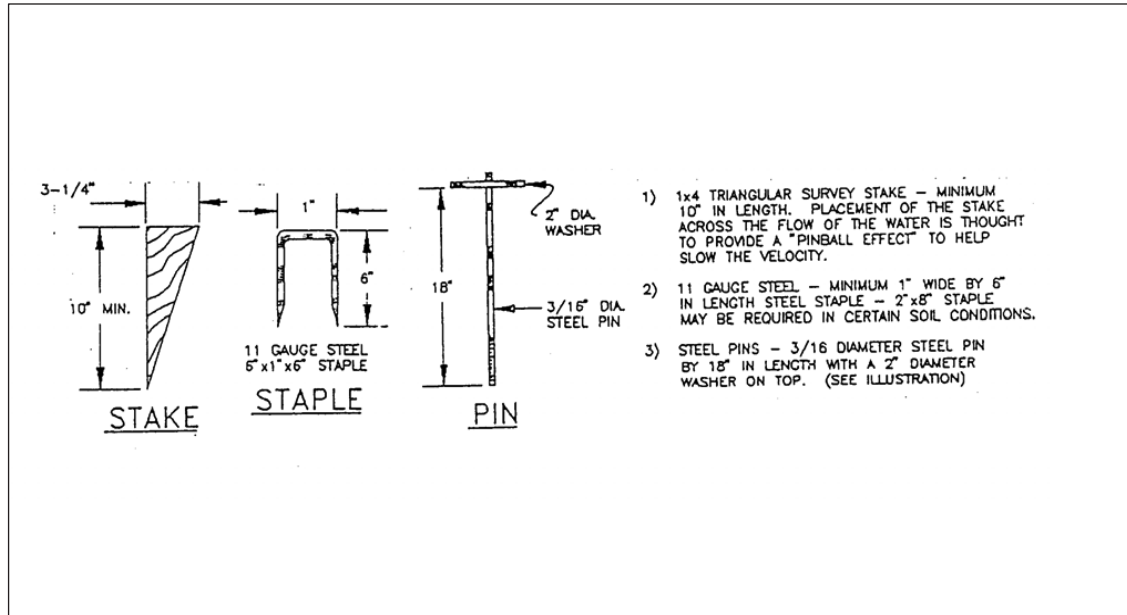


Figure 4.3g. Stakes, staples, and pins for the installation of soil stabilization matting

Source: Product literature from Greenstreak, Inc.

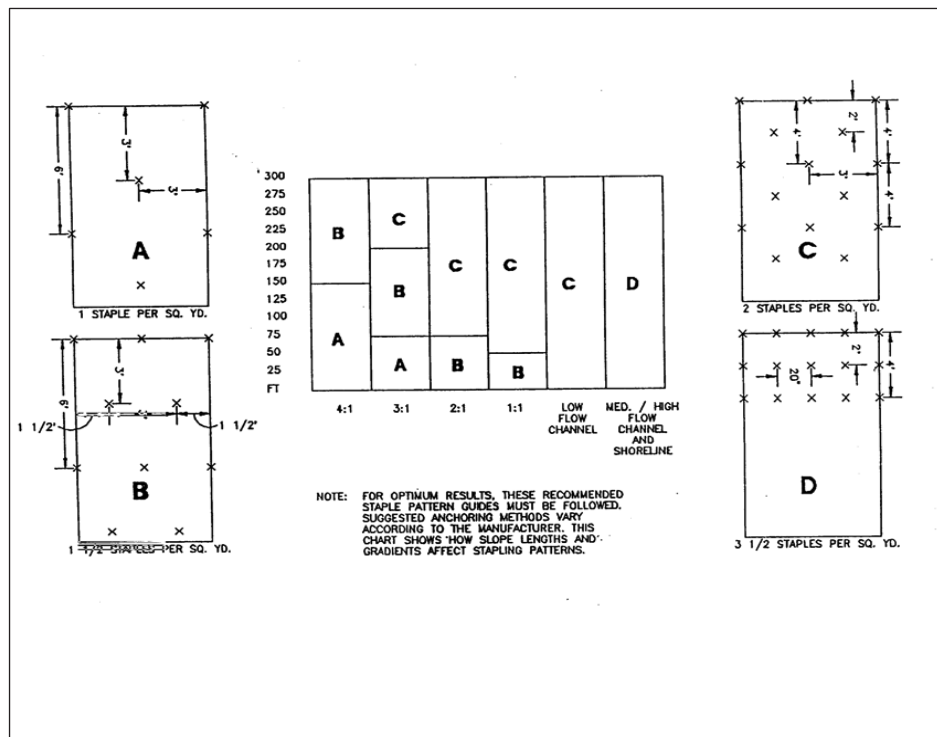


Figure 4.3h. General staple pattern guide and recommendation for Treatment 2 – Soil stabilization matting

Source: Product literature from North American Green

4.8 Trees, Shrubs, Vines, and Ground Covers

Definition

Stabilize disturbed areas by establishing vegetative cover with trees, shrubs, vines, or ground covers. Trees in particular provide many additional benefits (see **Figure 4.4a**).

Purposes

1. *To aid in stabilizing soil in areas where vegetation other than turf is preferred.*
2. *To provide food and shelter for wildlife where wildlife habitat is desirable.*

Applications

1. *On steep or rocky slopes, where mowing is not feasible.*
2. *Where ornamentals are desirable for landscaping purposes.*
3. *In areas where turf maintenance is difficult, such as shady areas.*
4. *Where woody plants are desirable for soil conservation, or to establish wildlife habitats.*
5. *As a traffic-control measure to direct people, vehicles, and equipment to or from an area, or to control access to an area.*

Specifications

Types of Tree Plantings

1. **Bare-rooted seedlings** – Trees to be planted as bare-rooted seedlings should be handled **only while dormant** in winter, or after leaf fall in autumn, with January being the optimum planting month (see **Figure 4.4b** for planting instructions).

When stabilizing the disturbed areas between tree plantings, do not use grasses or legumes that will overshadow the new seedlings. Where possible, a circle of mulch around the seedlings will help them compete successfully with herbaceous plants.

2. **Transplants (balled-and-burlapped and container-grown trees)** – Late fall through winter (November to February) is the preferred time for planting both deciduous and evergreen trees throughout Florida (see **Figure 4.4c**).

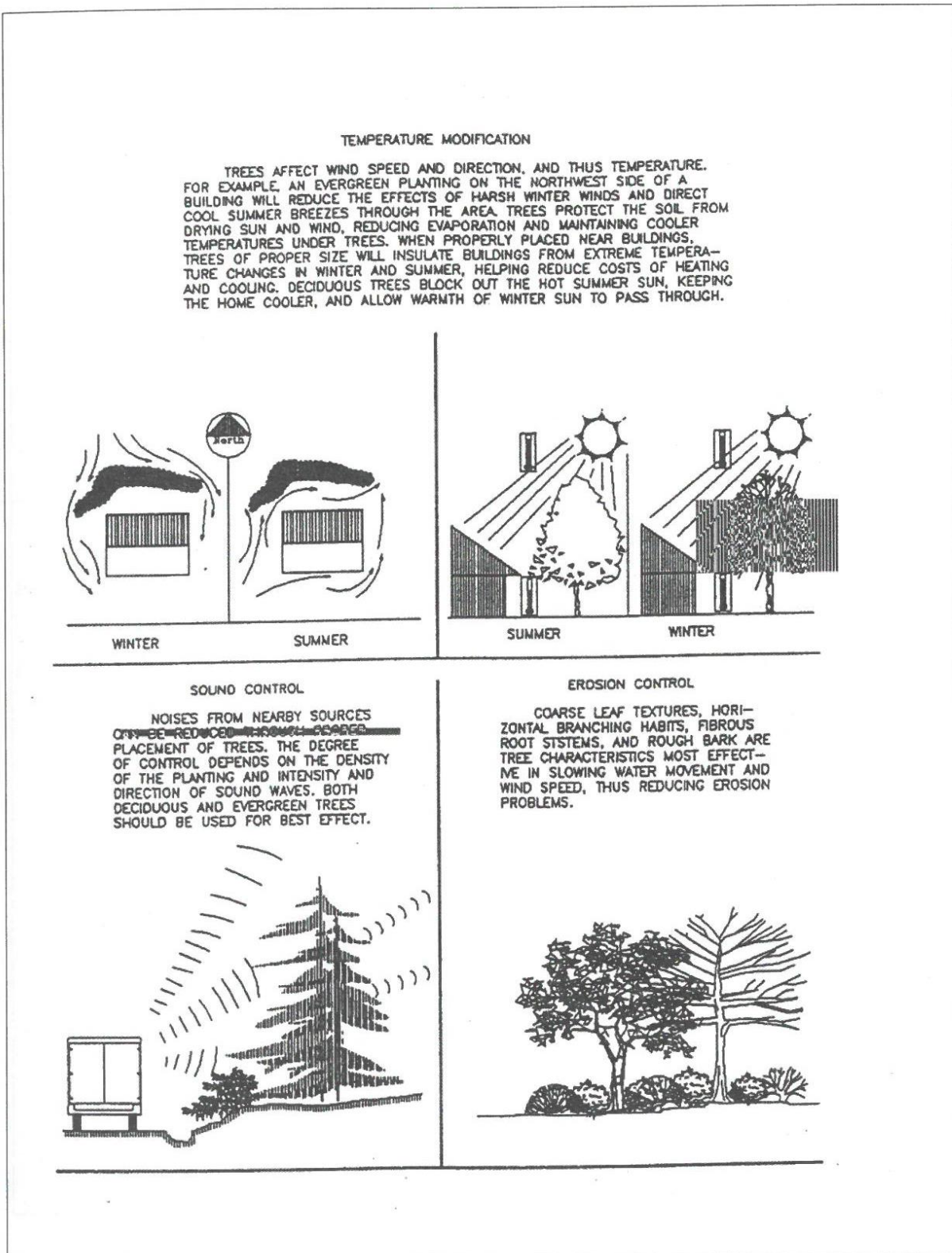
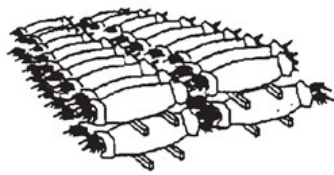


Figure 4.4a. Benefits of trees

Source: Virginia DSWC



CARE OF SEEDLINGS UNTIL PLANTED

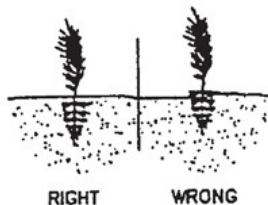
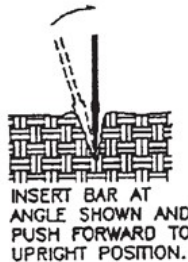
SEEDLINGS SHOULD BE PLANTED IMMEDIATELY. IF IT IS NECESSARY TO STORE MOSS-PACKED SEEDLINGS FOR MORE THAN 2 WEEKS, ONE PINT OF WATER PER PKG. SHOULD BE ADDED. IF CLAY-TREATED, DO NOT ADD WATER TO PKG. PACKAGES MUST BE SEPERATED TO PROVIDE VENTILATION TO PREVENT "HEATING". SEPARATE PACKAGES WITH WOOD STRIPS AND STORE OUT OF THE WIND IN A SHADED, COOL (NOT FREEZING) LOCATION.



CARE OF SEEDLINGS DURING PLANTING

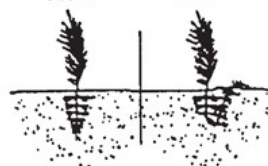
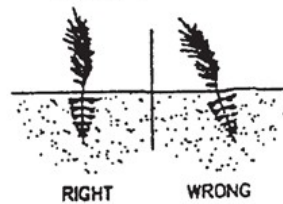
WHEN PLANTING, ROOTS MUST BE KEPT MOIST UNTIL TREES ARE IN THE GROUND. DO NOT CARRY SEEDLINGS IN YOUR HAND EXPOSED TO THE AIR AND SUN. KEEP MOSS-PACKED SEEDLINGS IN A CONTAINER PACKED WITH WET MOSS OR FILLED WITH THICK MUDDY WATER. COVER CLAY-TREATED SEEDLINGS WITH WET BURLAP ONLY.

HAND PLANTING



DON'T EXPOSE ROOTS TO AIR DURING FREEZE OR PLANT IN FROZEN GROUND.

PLANT SEEDLINGS UPRIGHT - NOT AT AN ANGLE.



DO NOT BEND ROOTS SO THAT THEY GROW UPWARDS OUT OF THE GROUND.

ALWAYS PLANT IN SOIL - NEVER LOOSE LEAVES OR DEBRIS. PACK SOIL TIGHTLY.



Figure 4.4b. Planting bare root seedlings

Source: Virginia Department of Forestry

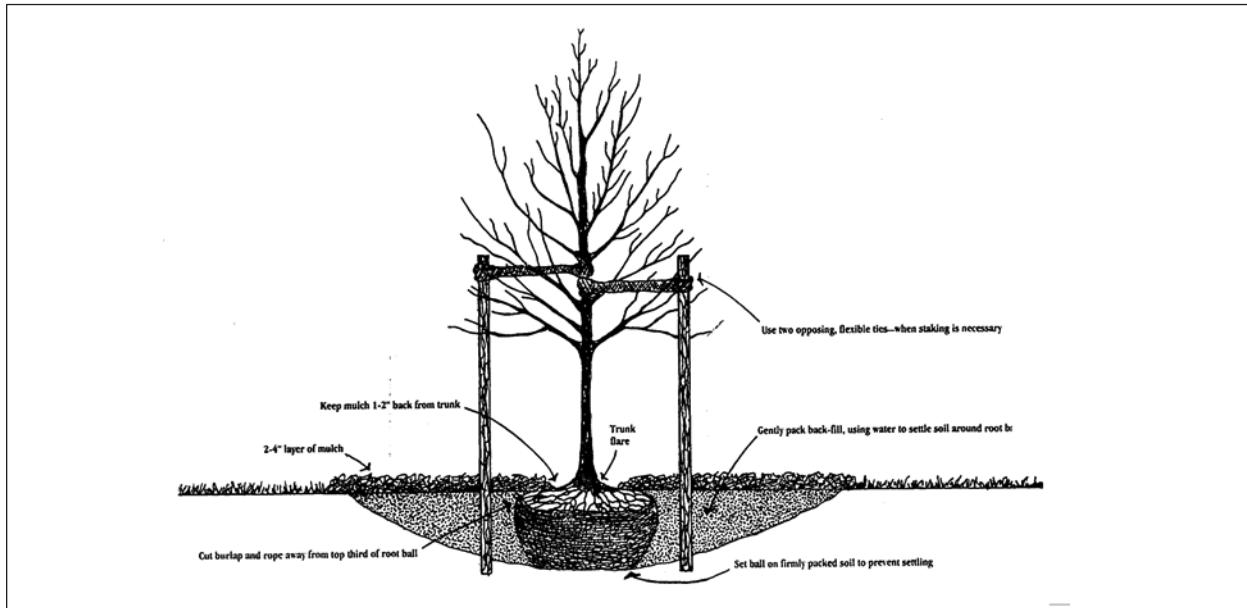


Figure 4.4c. Planting balled-and-burlapped and container-grown trees

Source: International Society of Arbiculture

Installation

1. **Tree preparation** – In digging a tree for transplant, as much of the root system as possible should be conserved, particularly the fine roots. Soil adhering to the roots should be damp when the tree is dug and kept moist until planting. The soil ball should be 12 inches (30 cm) in diameter for each inch (2.5 cm) of trunk diameter. The tree should be carefully excavated and the soil ball wrapped in burlap and tied with rope. The use of a mechanical tree spade is also acceptable. Tree foliage should be protected from heat, wind, and chemical damage during transport.
2. **Site preparation** – The planting hole should be dug three times as wide as the root ball and only as deep as the root ball for proper placement of the root ball. The final level of the root ball's top should be level with the ground surface (see **Figure 4.4d**).

As the hole is dug, topsoil should be kept separate from subsoil. If possible, discard the subsoil and replace it with good topsoil. If topsoil is unavailable, improve the subsoil by mixing in one-third by volume of peat moss or well-rotted manure.

Heavy or poorly drained soils are not good growth media for trees. When it is necessary to transplant trees into such soils, extra care should be taken. Properly installed drain tile will improve drainage.

3. **Setting the tree** – The depth of planting must be close to the original depth.

*The tree may be set just a few inches higher than in its former location, especially if the soil is poorly drained. **DO NOT** set the tree lower than before. Soil to be placed around the root ball should be moist but not wet.*

Set the tree in the hole and remove the rope and the top one-third of the burlap that holds the root ball. Do not break the soil of the root ball. Fill the hole with soil halfway and tamp firmly around the root ball. Add water to settle the soil and eliminate air pockets. When the water has drained, fill the hole the remainder of the way and tamp as before.

*Use extra soil to form a shallow basin around the tree, somewhat smaller than the diameter of the root ball, to hold water when the tree is irrigated (see **Figure 4.4d**). **NOTE:** In colder climates, level the ground and eliminate these basins when winter sets in, as ice forming in the basin might injure the trunk.*

- 4. **Supporting the tree** – If the tree is grown and dug properly, staking for support is not necessary in most landscape situations. If wind is a concern, trees may be supported by two stakes with wide, flexible tie straps. Stakes may also be used to protect plantings from vandalism or mower damage (see **Figure 4.4d**).*
- 5. **Watering** – The soil around the tree should be thoroughly watered after the tree is set in place. When the soil becomes dry, the tree should be watered deeply but not too often. Mulching around the base of the tree helps to prevent the roots from drying out.*

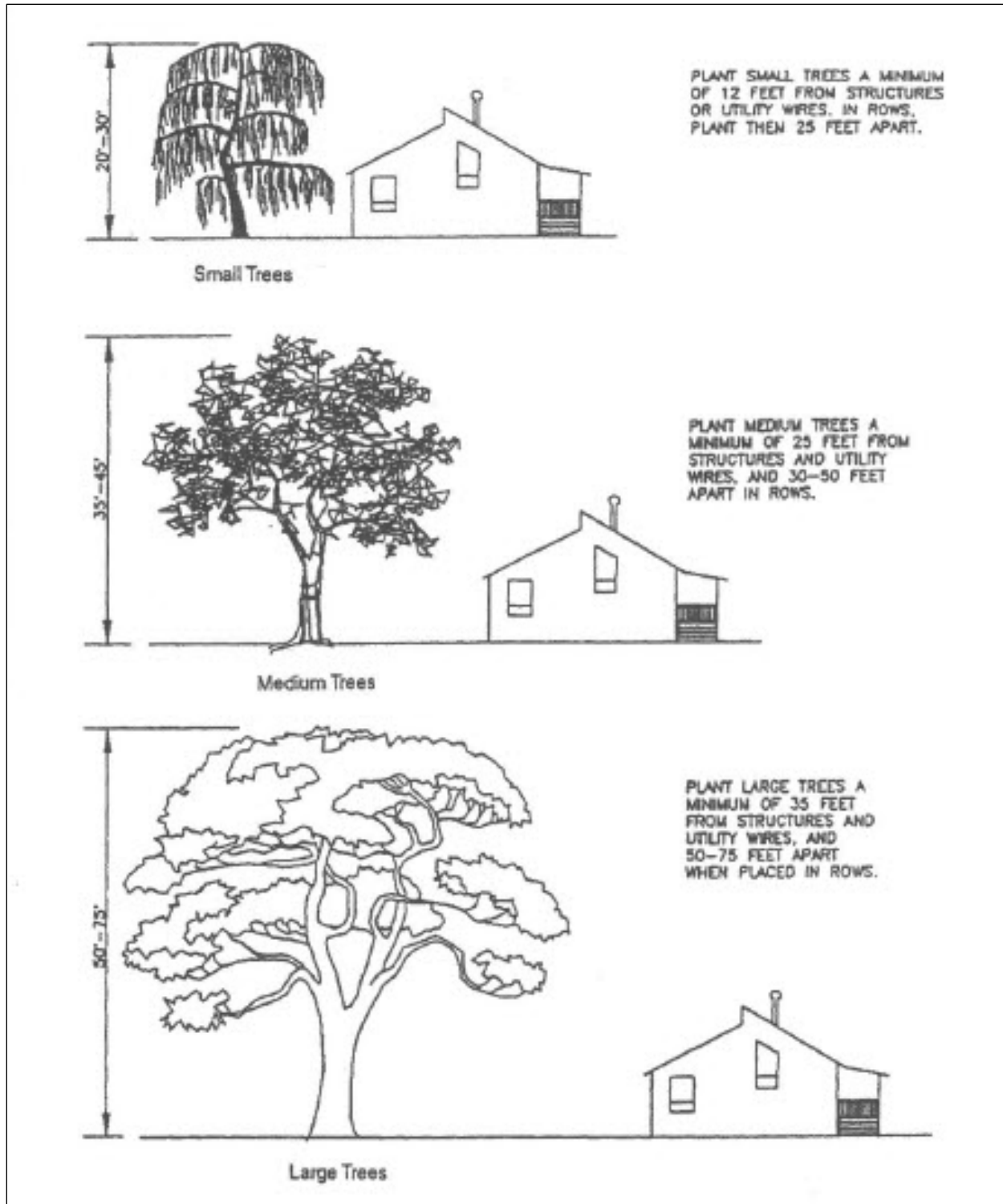


Figure 4.4d. Spacing trees for safety and effective landscaping

Source: Virginia DSWC

Maintenance

Like all plants, trees require water and fertilizer to grow. Ideally, young trees should receive an inch of water each week for the first two years after planting. When rain does not supply this need, the tree should be watered deeply but not more often than once per week.

Transplanted trees should be fertilized 1 year or so after planting. There are many sophisticated ways to supply fertilizer to trees, but some simple methods are adequate. The best material for small trees is well-rotted stable manure, if it can be obtained. Add it annually as a 2-inch (5 cm) layer of mulch around the tree. If chemical fertilizers are to be used, a formulation such as 10-8-6 or 10-6-4 is preferred. Use about 2 pounds per inch (350 grams [g]/cm) of trunk diameter measured 4 feet (1.2 m) from the ground. For example, if the trunk diameter at 4 feet (1.2 m) is 5 inches (13 cm), apply 10 pounds (4.5 kg) of fertilizer.

Fertilizer must come in contact with the roots to benefit the tree. A simple way to ensure this is to make holes in the tree's root area with a punchbar, crowbar, or auger. The holes should be 18 inches (45 cm) deep, spaced about 2 feet (60 cm) apart, and located around the drip line of the tree. Distribute the necessary fertilizer evenly into these holes and close the holes with the heel of a shoe or by filling with topsoil or peat moss. Fertilize trees in late fall or in early spring, before leaves emerge.

NOTE: For evergreens, use half the recommended amount of chemical fertilizer **OR** use only organic fertilizers such as cottonseed meal, bone meal, or manure.

Planting and Maintaining Shrubs

Follow the general procedure for tree planting when planting shrubs. The proper pruning, watering, and application of fertilizer every 3 years or so will keep shrubs healthy. Maintain the mulch cover or turf cover surrounding the shrubs. A heavy layer of mulch reduces weeds and retains moisture.

Planting and Maintaining Vines and Ground Covers

Low-growing plants that sprawl, trail, spread, or send out runners come in many leaf types, colors, and growth habits. Some are suitable only as part of a maintained landscape, and some can stabilize large areas with little care. In addition to stabilizing disturbed soil, vines and ground covers can perform the following functions:

1. *Maintain cover in heavily shaded areas where turf will not thrive.*
2. *Provide attractive cover that does not need mowing.*
3. *Help to define traffic areas and control pedestrian movement. People are more likely to walk on the grass than on a thick bed of ivy or a prickly planting of juniper.*

Table 1.80c of the *Florida Development Manual* lists the characteristics of some commonly used vines and ground covers suitable for Florida. Information on others is available from nursery professionals.

Like shrubs and trees, ground covers are best planted in spring. Container-grown plants can be planted throughout the growing season if adequate water is provided.

Site Preparation

Ground covers naturally grow very close together, competing for space, nutrients, and water, and thus the soil for planting ground covers should be well-prepared. A well-drained soil high in organic matter is best. The entire area should be spaded, disked, or rototilled to a depth of 6 to 8 inches. Two to 3 inches of organic material, such as good topsoil, peat, or well-composted manure, should be spread over the entire area. Apply 9 to 18 pounds per 1,000 square feet (440 to 880 kg/ha) of 10-10-10 fertilizer and incorporate the organic material and fertilizer into the soil before planting.

If the area to be planted is very large or it is impractical to prepare the entire area, individual planting holes one-third larger and deeper than the plant root ball should be dug. If the soil is not suitable for plant growth, it is best to blend a batch of planting medium. A good mixture consists of 1:1 or 2:1 sandy loam soil and peat, composted manure, or other well-rotted organic material with 10 pounds of 10-10-10 fertilizer and 20 pounds of lime per cubic yard (6 kg/m³ fertilizer and 12 kg/m³ lime) of soil mix. Lime should not be used for acid-loving plants such as camellias, azaleas, or blueberries.

Planting

1. *Space plants according to the type of plant and the extent of covering desired. Set small plants as close as 4 to 6 inches (10 to 15 cm) apart. Medium-size plants such as ivy, pachysandra, and periwinkle should be planted on 1-foot centers; large plants such as juniper can be spaced on 3-foot (90 cm) centers. **Table 4.2** lists the area that approximately 100 plants will cover when set at various distances apart.*

Table 4.2. Planting distance and area covered by 100 plants

Planting Distance (inches)	Area Covered (square feet)
4	11
6	25
8	44
10	70
12	120
18	225
24	400
36	900
48	1,600

2. *The following steps will help ensure good plant growth:*

- a. Make the plantings on the contour.
- b. Dig the holes one-third larger than the plant root ball.
- c. Plant at the same level that the plants grew.
- d. Use good topsoil or soil mixture with a lot of organics.
- e. Fill the hole one-third to one-half full, shake the plants to settle soil among the roots, and then water. Finish filling the hole, firm slightly, and again settle with water.
- f. Leave a saucer-shaped depression around the plant to hold water.
- g. Water thoroughly and regularly.

Mulching

The soil between trees and shrubs must be planted with cover vegetation or mulched. When establishing ground covers, it is not desirable to plant species that will compete strongly with the ground cover or make maintenance difficult. A thick, durable mulch such as shredded bark or wood chips is recommended to prevent erosion and reduce weed problems. Pre-emergent herbicides may be necessary where weeding is not practical.

On slopes where erosion may be a problem, jute net or excelsior blankets may be installed prior to planting, and the plants tucked into the soil through slits in the net. Such plants should be put in a staggered pattern to minimize erosion.

Maintenance

Trim old growth as needed to improve the appearance of ground covers. Most need once-a-year trimming to promote growth. Maintain mulch cover by adding mulch where needed. Fertilize as described above every three to four years.

4.9 Tree Preservation and Protection

Definition

The protection of desirable trees from mechanical and other injury during land-disturbing and construction activities.

Purpose

To ensure the survival of desirable trees where they will be effective for erosion and sediment control, watershed protection, landscape beautification, dust and pollution control, noise reduction, shade, and other environmental benefits while the land is being converted from forest to urban-type uses or being redeveloped. Local tree preservation requirements may be more stringent than described below. Refer to local ordinances for area-specific requirements found in

each city and county Land Development Regulation (LDR) or Land Development Plan (LDP), which specifically guides all development activities under a specific jurisdiction.

Application

Treed areas subject to land-disturbing activities.

Specifications

1. **Identification and Retention** – Groups of trees and individual trees selected for retention shall be accurately located on the plan and designated as "tree(s) to be saved." Individual specimens that are not part of a tree group shall also have their species and diameter noted on the plan.
2. **Critical Root Zone (CRZ)** – A CRZ should be identified for each tree or group of trees to be saved. A CRZ takes into account the root area needed to preserve the tree. Because of their key role in supplying the tree with water, nutrients, and support, roots must be protected to ensure tree health after construction. Contrary to popular belief, a tree's roots extend far beyond the drip line, occupying from 2 to 10 times the area of the canopy.⁴ In addition, tree roots typically grow very shallowly, mostly in the upper 3 feet of soil.⁵ Because the size of a tree's drip line can be highly variable, the CRZ method uses the diameter of the trunk to determine the area of roots required to preserve a tree. Calculating the CRZ is simple: 1 foot from the trunk (in each direction) for each inch of the diameter of the tree (measured approximately at chest height)⁶ (see **Figure 4.9a**).
3. **Limits of Disturbance (LOD)** – The LOD should be located outside the CRZ of any tree to be retained, encroaching on no more than one-third of the CRZ⁷ for any tree to be saved and no closer than 8 feet to the trunk of these trees (see **Figure 4.5a**). (Exceptions can be made for palms, which benefit from the typical CRZ but can tolerate disturbance to 90 % or more of their root zone and allow impacts to within 2 feet of the trunk.)⁸ If the limits of clearing will impact more than one-third of the CRZ or come closer than 8 feet to any given tree, the tree should be removed unless otherwise directed by a Certified Arborist or other tree care professional. The edge of the CRZ for all trees to be retained, adjusted as necessary so it does not overlap with the LOD, is referred to as the tree conservation area (TCA).
4. **Marking** – Before construction and before the preconstruction conference, the TCA shall be visibly marked with stakes, ribbon, pin flags, or similar means. The limits of the TCA will correspond to the LOD in that area. Any trees

⁴ Matheny and Clark 1998, p. 16.

⁵ Harris, Clark, and Matheny 1999, p. 36.

⁶ Matheny and Clark 1998, p. 74.

⁷ Matheny and Clark 1998.

⁸ <http://hort.ifas.ufl.edu/woody/palms.html>.

within the TCA (outside the LOD) that are to be removed because of poor health or close proximity to the LOD should be marked with paint or flagging.

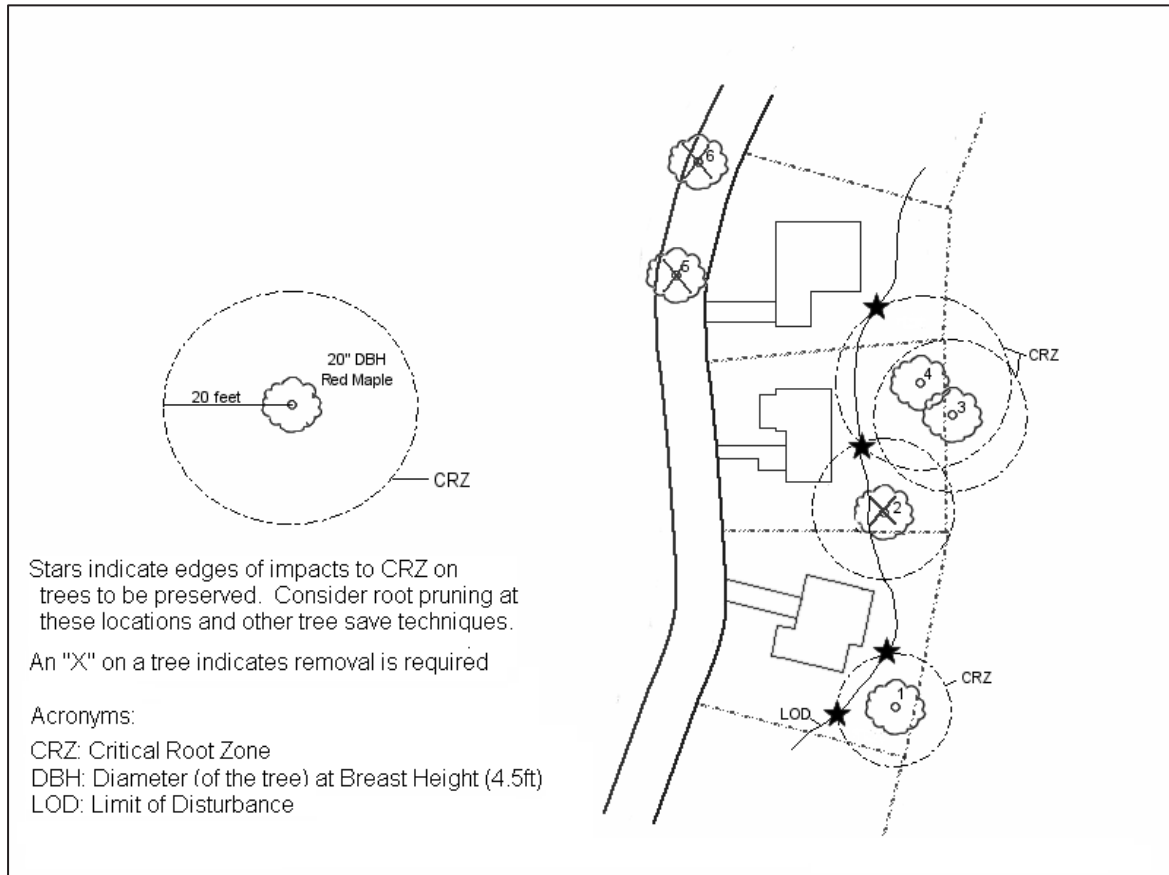


Figure 4.5a. Determining the CRZ and TCA

DEP 2006. The left side of the figure depicts a CRZ for an individual tree, calculated by establishing a 1-foot radius for each inch in diameter of the tree at diameter breast height (DBH), which corresponds to 4.5 feet above the ground.

Trees 1, 3, and 4 have CRZs that can largely be preserved during development; therefore, the CRZ remaining outside the LOD is designated as a TCA. The stars designate the starting and stopping points for root pruning and protective fencing. (Protective fencing should be extended farther if construction equipment could approach the tree from the sides or the back of the lot.)

Tree 2 is outside the LOD but more than 30 % of its CRZ will be impacted by the development. Therefore, the tree needs to be removed so it does not become a hazard. Trees 5 and 6 are within the LOD and will be removed.

5. **Preconstruction Conference** – Tree preservation and protection measures should be discussed at a preconstruction conference, including the location of the TCA and any trees within it that have to be removed. The CRZ should be reviewed with the contractor as it applies to a specific project.
6. **Root Pruning** – After the TCA has been agreed on at the preconstruction conference, the perimeter of the TCA shall be root pruned with a vibratory plow or similar device (**Figure 4.5b**). If a trencher is used for root pruning, all cut roots 1 inch and greater in diameter must then be hand pruned to ensure

- smooth cuts. Root pruning prevents crushing or other damage to roots in the construction zone, giving the trees to be retained the best chances for survival.
7. **Equipment Operation and Storage** – Heavy equipment, vehicular traffic, or stockpiles of any construction material, including topsoil, shall not be permitted in the TCA. Trees being removed shall not be felled, pushed, or pulled into trees being retained. Equipment operators shall not clean any part of their equipment by slamming it against the trunks of trees to be retained.
 8. **Fires** – Fires shall not be permitted within 100 feet (30 m) from the drip line of any trees to be retained. Fires shall be limited in size to prevent adverse effects on trees and kept under surveillance.
 9. **Storage and Disposal of Toxic Materials** – No toxic materials shall be stored closer than 100 feet (30 m) to the drip line of any trees to be retained. Paint, acid, nails, gypsum board, wire, chemicals, fuels, and lubricants shall not be disposed of so as to injure vegetation.
 10. **Fencing and Armoring (Figure 4.5b)** – Any device may be used that will effectively protect the roots, trunk, and tops of trees retained onsite. However, trees to be retained within 40 feet (12 m) of a proposed building or excavation shall be protected by fencing. Personnel must be instructed to honor protective devices. The following devices are only suggestions and are not intended to exclude the use of other devices that will protect the trees to be retained:
 - a. **Orange Construction Fence** – Standard 48 inch (1.2 m) high fence to be placed at the limits of the clearing/TCA line on standard steel posts set 6 feet (1.8 m) apart.
 - b. **Board Fence** – Board fencing consisting of 4-inch (10 cm) square posts set securely in the ground and protruding at least 4 feet (1.2 m) above the ground shall be placed at the limits of clearing with a minimum of 2 horizontal boards between posts.
 - c. **3-Strand Wire Fence** – Posts with a minimum size of 2 inches (5 cm) square or 2 inches (5 cm) in diameter set securely in the ground and protruding at least 4 feet (1.2 m) above the ground, with 3 rows of wire with strips of colored surveyor's flagging tied securely to the string at intervals no greater than 3 feet (90 cm).
 - d. **Earth Berms** – Temporary earth berms shall be constructed according to the specifications for a **Temporary Diversion Berm** (see **PERIMETER CONTROLS** in **Chapter 4**), with the base of the berm on the tree side located along the limits of clearing. Earth berms may not be used for this purpose if their presence conflicts with drainage patterns.
 - e. **Additional Trees** – Additional trees may be left standing as protection between

the trunks of the trees to be retained and the limits of clearing. However, for this alternative to be used, the trunks of the trees in the buffer must be no more than 6 feet (1.8 m) apart to prevent equipment and material from passing through the buffer. These additional trees shall be re-examined prior to the completion of construction and either given sufficient treatment to ensure survival or removed.

- f. **Trunk Armoring** – A tree trunk can be armored with burlap wrapping and 2-inch (5 cm) studs wired vertically no more than 2 inches (5 cm) apart to a minimum height of 5 feet (1.5 m) encircling the trunk. This alternative should only be used in situations where heavy machinery will be working close to a tree to be retained. If this method of protection is used, the CRZ will still require protection. Do not nail trunk armoring to a tree. Fencing and armoring devices and any other tree protection measures shall be in place before any site clearing, excavation, or grading begins; shall be kept in good repair for the duration of construction activities; and shall be the last items removed during the final cleanup after the completion of the project.

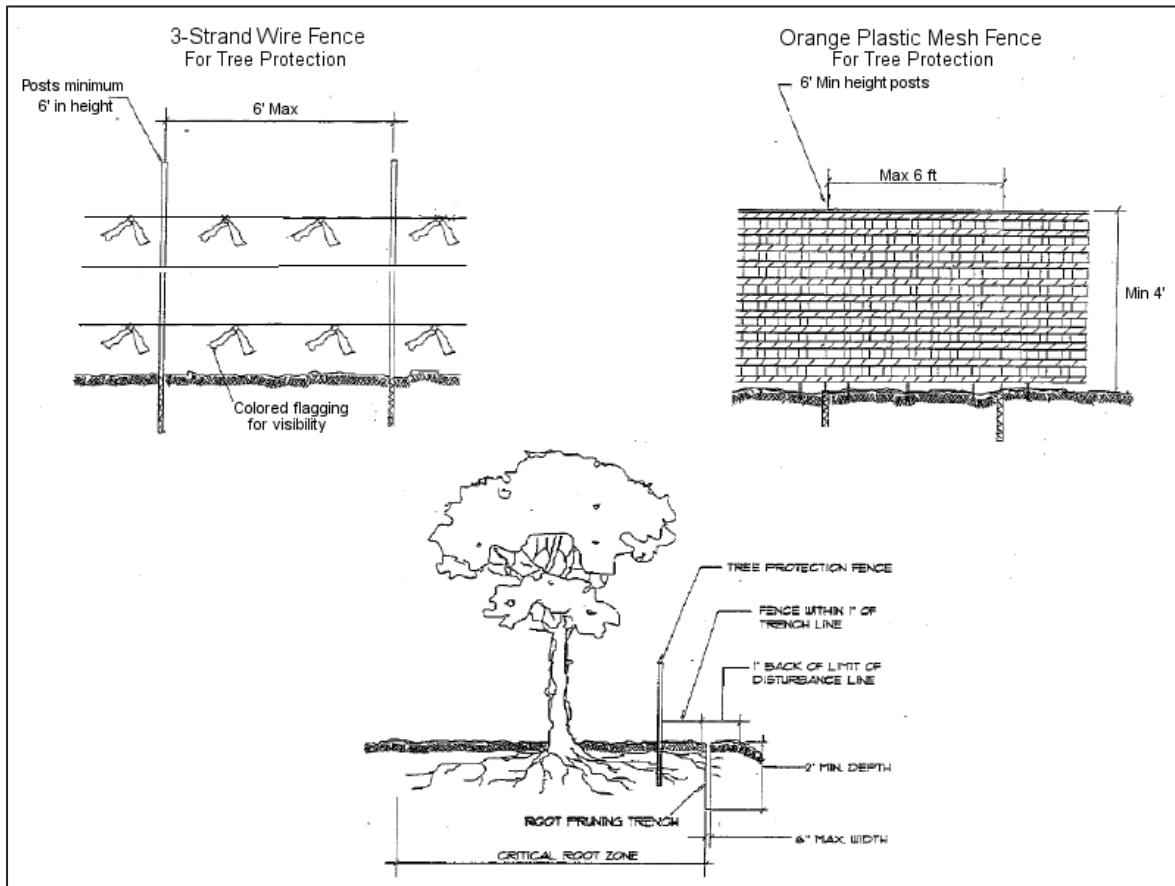


Figure 4.5b. Tree conservation area protection practices

Source: Montgomery County, Maryland, 1992

11. Trenching and Tunneling (see Figure 4.5c):

- a. Trenching shall be done as far away from the trunks of trees as possible, preferably outside the branches or crown spreads of trees, to reduce the amount of root area damaged or killed by these activities.
- b. Wherever possible, trenches should avoid large roots or root concentrations. This can be accomplished by curving the trench or by tunneling under large roots and areas of heavy root concentration.
- c. Tunneling under an individual specimen that does not have a large taproot may be preferable to trenching beside it. Tunneling is more expensive initially, but it usually causes less soil disturbance and physiological impact on the root system. The extra cost may offset the potential costs of tree removal and replacement should the tree die.
- d. When trenching, the roots in the trench shall not be left exposed to the air. They shall be covered with soil as soon as possible or protected and kept moistened with wet burlap or peat moss until the trench or tunnel can be filled.
- e. Inside the trench, the ends of damaged and cut roots shall be cut off smoothly with pruning shears or a chainsaw.⁹
- f. Trenches and tunnels shall be filled as soon as possible. Air spaces in the soil shall be avoided by careful filling and tamping.
- g. Peat moss or other suitable material shall be added to the fill material as an aid to inducing and developing new root growth.
- h. The tree shall have mulch placed on top of the CRZ to the extent practical to conserve moisture and prevent competition from herbaceous plants.
- i. If a large part of the root system has been damaged or killed, an irrigation plan shall be implemented to ensure the tree receives adequate water. Irrigation should occur weekly and should be substantial enough to wet the top 2 feet of soil in the CRZ or the amount equivalent to a 1-inch rain event.¹⁰

⁹ Pruning shears or chainsaw are specified because construction personnel may otherwise opt to use ditching or other equipment, which tears rather than cuts. Torn roots create a healing problem and are a source of pathogens for trees. American National Standards Institute (ANSI) A300 Best Management Practices – Tree Pruning, p. 24 – "Wound dressings are used primarily for cosmetic purposes, and neither are required nor recommended in most cases."

¹⁰ <http://hort.ifas.ufl.edu/woody/maintenance.html>.

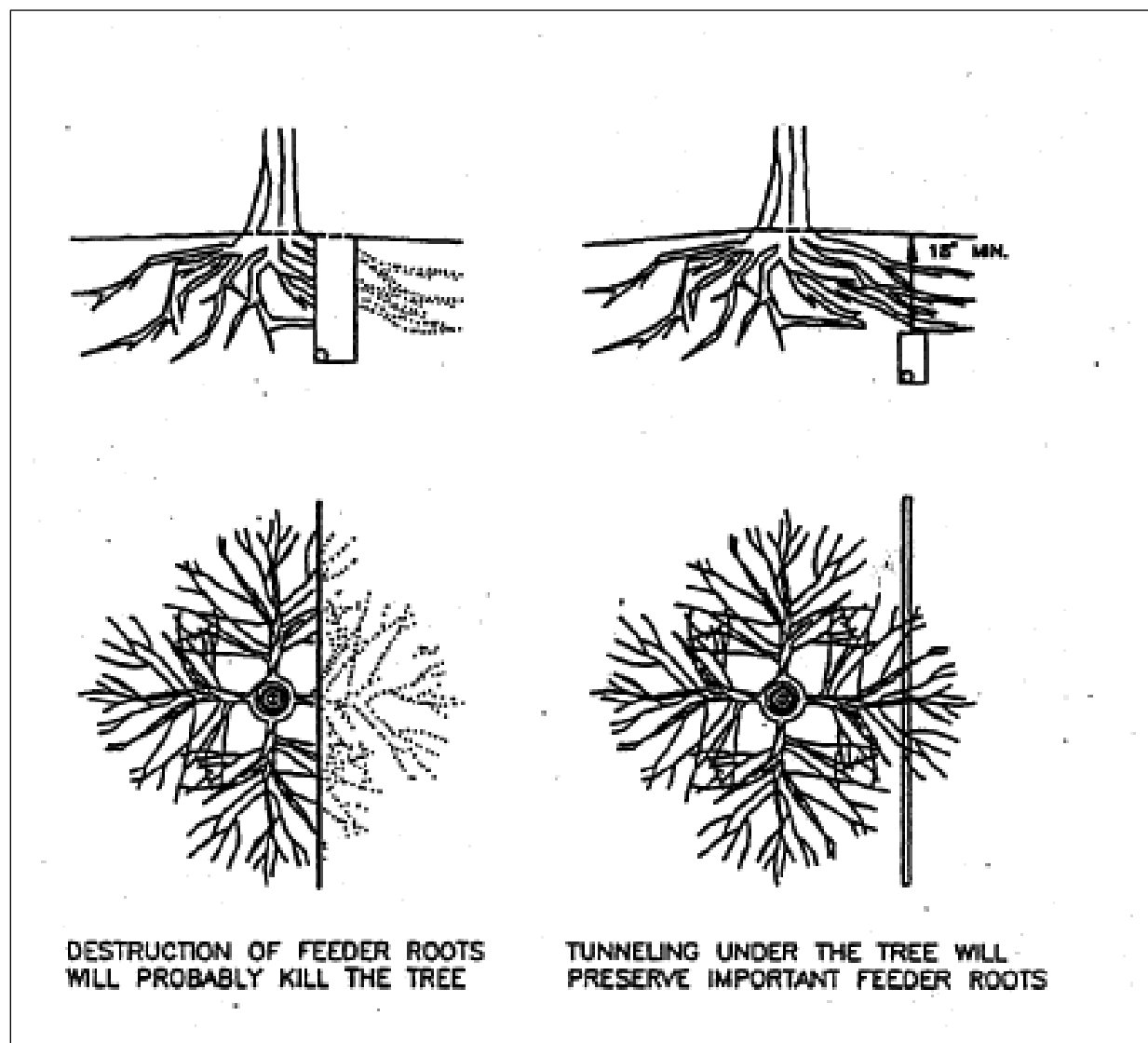


Figure 4.5c. Trenching vs. tunneling

Source: Pirone 1979

- 12. Removal and Replacement of Damaged Trees** – If a tree is identified and marked to be retained but is damaged seriously enough that survival and normal growth are impossible, it shall be removed. If replacement is desirable and/or required, the replacement tree shall be of the same or a similar species, 2- to 2-1/2 inch (5 to 6 cm) caliper balled-and-burlapped nursery stock.
- 13. Clean-Up** – Clean-up after a construction project can be a critical time for tree damage. Trees protected throughout the development operation are often destroyed by carelessness during the final cleanup and landscaping. Fences and barriers shall be removed last, after everything else is cleaned up and carried away.
- 14. Maintenance** – Despite precautions, some damage to protected trees may occur. In such cases, the following guidelines should be followed:
- a. **Irrigation** – Damage to trees or tree roots is often accompanied by a reduced ability to obtain needed water. The implementation of an irrigation plan for damaged trees, including trees with significant pruning or root loss, will help to ensure the trees' survival. Irrigation should occur weekly and should be substantial enough to wet the top 2 feet of soil in the CRZ or the amount equivalent to a 1-inch rain event.¹¹
 - b. **Repairing Damage** –
 - i. Any damage to the crown, trunk, or root system within the TCA of any tree retained onsite shall be repaired immediately.
 - ii. A Certified Arborist or equivalent landscape professional shall perform or oversee all tree repair activities.
 - iii. Damaged roots shall immediately be cut off cleanly inside the exposed or damaged area. Moist peat moss, burlap, or topsoil shall be spread over the exposed area.
 - iv. If the bark of a tree branch appears to be substantially damaged, prune the branch back to the collar. If the bark of the trunk appears to be substantially damaged, leave the remaining bark intact and contact a Certified Arborist for advice on treating the injury.
 - v. All tree limbs damaged during construction or removed for any reason shall be cut off above the collar at the preceding branch junction (see **Figure 4.5d**).
 - vi. Care for serious injuries shall be prescribed by a Certified Arborist or other tree care specialist.

¹¹ <http://hort.ifas.ufl.edu/woody/maintenance.html>.

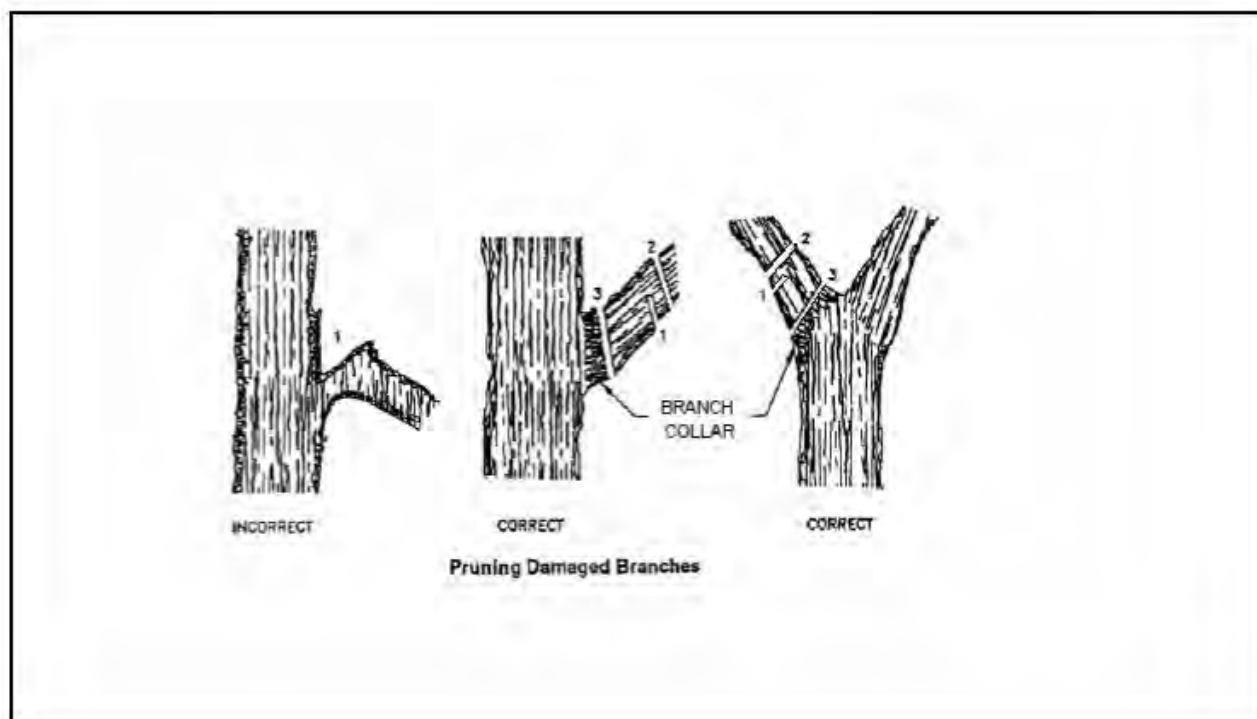


Figure 4.5d. Proper pruning technique

Source: DEP 2006

4.10 Vegetative Streambank Stabilization

Definition

The use of vegetation in stabilizing streambanks.

Purpose

To protect streambanks from the erosive forces of flowing water.

Applications

Along banks in creeks, streams, and rivers subject to erosion from excess runoff. This practice is generally applicable where bankfull flow velocity does not exceed 5 feet per second (1.5 m/sec) and soils are erosion resistant. Above 5 feet per second (1.5 m/sec), structural measures are generally required. This practice does not apply where tidal conditions are present.

Planning Considerations

A primary cause of stream channel erosion is the increased frequency of bankfull flows, often resulting from upstream development. Most natural stream channels are formed with a bankfull capacity to pass the runoff from a storm with a 1 1/2 to 2-year recurrence interval. In a typical urbanizing watershed, however, stream channels are subject to a three to fivefold increase in the frequency of bankfull flows. As a result, stream channels that were once parabolic in shape, with their banks covered with vegetation, are transformed into wide channels with barren banks.

In recent years, many structural measures have evolved to strengthen and protect the banks of rivers and streams. These methods, if employed correctly, immediately ensure satisfactory protection for the banks. However, such structures may be expensive to build and maintain, and frequently contribute to downstream velocity problems. Without constant upkeep, they are exposed to progressive deterioration by natural agents. The materials used often prevent the re-establishment of native plants and animals, especially when the design is executed according to standard cross-sections, which ignore the natural variation of a stream system. Very often these structural measures diminish the appearance of a site.

In contrast, the use of living plants in conjunction with structures has many advantages. The degree of protection, which may be low to start with, increases as the plants grow and spread. The repair and maintenance of structures is unnecessary where self-maintaining streambank plants are established. The protection provided by natural vegetation is more reliable and effective where the cover consists of natural plant communities that are native to the site. Planting vegetation is less damaging to the environment than installing structures. Vegetation also provides habitat for fish and wildlife and is aesthetically pleasing. Plants provide erosion protection to streambanks by absorbing stream velocity, binding soil in place with a root mat, and covering the soil surface when high flows tend to flatten vegetation against the banks. For these reasons, vegetation should always be considered first.

One disadvantage of streambank vegetation is that it lowers the carrying capacity of the channel and may promote flooding. Therefore, maintenance needs and the consequences of flooding should be considered. The erosion potential for the stream needs to be evaluated to determine the best solutions. The following items should be considered in the evaluation:

1. *The frequency of bankfull flow based on anticipated watershed development.*
2. *The channel slope and flow velocity, by design reaches.*
3. *The antecedent soil conditions.*
4. *Present and anticipated channel roughness ("n") values.*
5. *The location of channel bends along with bank conditions.*
6. *The location of unstable areas and trouble spots. Steep channel reaches, high erosive banks, and sharp bends may require structural stabilization measures such as riprap, while the remainder of the streambank may require only vegetation.*

Where streambank stabilization is required and velocities appear too high for the use of vegetation, one should consider structural measures or the use of permanent erosion control matting, as in **MULCHING** (in this chapter). **NOTE: Any applicable approvals or permits from other state or federal agencies must be obtained prior to working in such areas.**

Vegetation Zones along Watercourses

At the edges of all-natural watercourses, plant communities exist in a characteristic succession of vegetative zones, the boundaries of which depend on site conditions such as the steepness and shape of the bank and the seasonal and local variation in water depth and flow rate. Streambanks commonly exhibit the following zonation (see **Figure 4.6a**):

- **Zone 1: Aquatic Plant Zone** – This zone, which is normally permanently flooded, is inhabited by plants such as alligator weed, hydrilla, parrotfeather, and water lilies. These reduce the water's flow rate by friction. The plants' roots help bind the soil and protect the channel from erosion, because the water flow tends to flatten them against the banks.
- **Zone 2: Herbaceous Flooded Zone** – The lower part of this zone is normally flooded for only about half the year. In Florida, this zone is inhabited by rushes, sedges, pickerel weed, smartweeds, cattails, and other plants that bind the soil with their roots, rhizomes, and shoots and slow the water by friction.
- **Zone 3: Shrub Zone** – This zone is flooded only during periods of average high water. In Florida, it is inhabited by trees and shrubs with a high regenerative capacity, such as willow, red maple, button-bush, and sweet bay. These plants hold the soil with their root systems and slow the water by friction. They prevent the formation of strong eddies around large trees during flood flows. Woody zone vegetation is particularly beneficial along the impact bank of a stream meander, where maximum scouring tends to occur. The infringement of shrub vegetation into the channel reduces the channel width, increasing the probability of floods.
- **Zone 4: Tree Zone Infrequently Flooded** – This zone is flooded only during periods of very high water (i.e., the 2-year bankfull flow or greater flows). Typical trees in this zone in Florida are in the oak family. They hold soil in place with their root systems. However, the brief flooding of riverside woods and undeveloped areas does no significant damage, and the silt deposits in these wooded areas are less of a problem than failed banks.

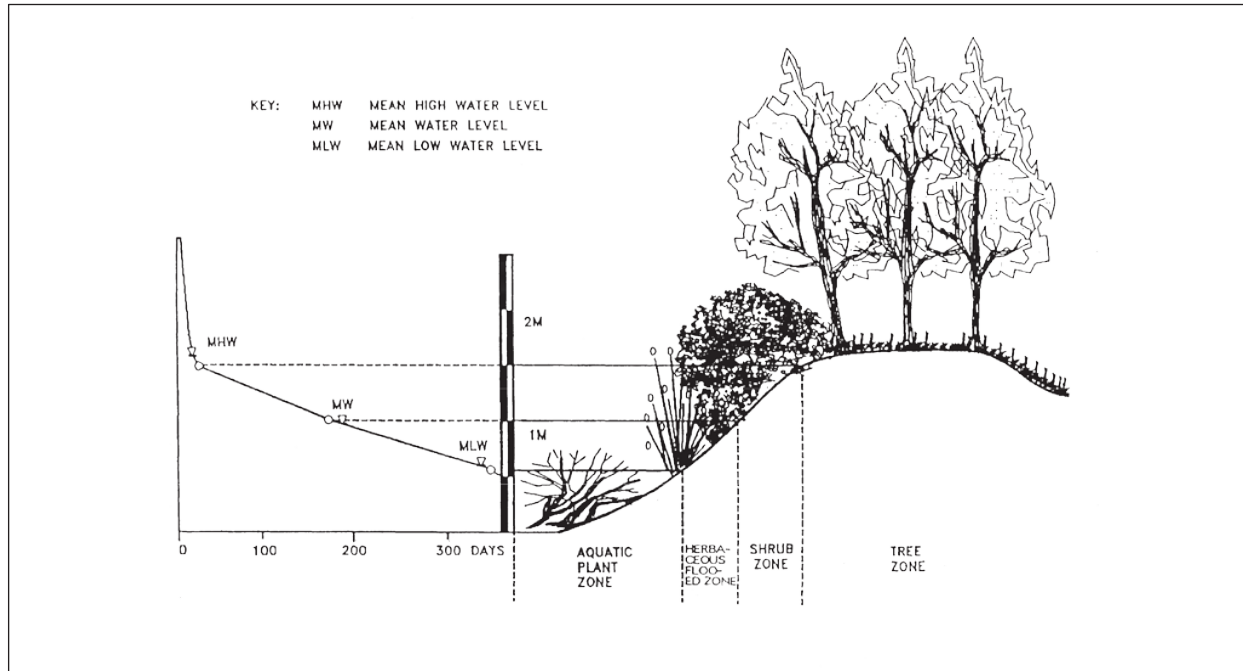


Figure 4.6a. Typical annual curve of water levels correlated with typical vegetative zones

Source: Seibert 1968

Design Criteria

Table 4.3 lists general guidelines for the maximum allowable velocities in streams to be protected by vegetation.

Table 4.3. Conditions where vegetative streambank stabilization is acceptable

Source: Virginia DSWC

Frequency of Bankfull Flow	Maximum Allowable Velocity for Highly Erodible Soil	Maximum Allowable Velocity for Erosion-Resistant Soil
> 4 times/year	4 feet/second	5 feet/second
1 to 4 times/year	5 feet/second	6 feet/second
< 1 time/year	6 feet/second	6 feet/second

The following criteria should be incorporated into the design:

1. Ensure that channel bottoms are stable before stabilizing channel banks.
2. Keep velocities at bankfull flow so that they are nonerosive for the site conditions—i.e., maintain the stream at capacity, but with the water flowing slowly enough that it does not erode the streambanks.

3. *Provide mechanical protection such as riprap on the outside of the channel bend if bankfull stream velocities approach the maximum allowable for site conditions.*

Be sure that the design meets the requirements of other state or federal agencies, in case other approvals or permits are necessary.

Planting Guidelines

Guidelines are presented only for Zones 2 and 3. Zone 1 is difficult to implant and establish naturally when herbaceous flooded zone vegetation is present. Currently, there are many federal, state, and private sector experts in this field who can provide assistance in successfully establishing plants in the aquatic zone.

Zone 4 is the least significant zone in terms of protecting banks from more frequent erosion-force flows, since this zone is seldom flooded. Also, shade from trees in this zone can prevent the adequate establishment of vegetation in other zones.

Establishing an Herbaceous Flooded Zone

There are various approaches to planting herbaceous vegetation. Note that many plant species are now considered invasive and not suitable for planting shorelines. Consult with your local water management district, the NRCS, Agricultural Extension Office under UF–IFAS for the county you will be working in, and local professional nursery on the selection of the appropriate noninvasive shoreline plants. Also review the plant listings of the Florida Exotic Pest Plant Council (FLEPPC).

The following guidelines should be used to establish an herbaceous flooded zone:

1. ***Planting in Clumps*** – *Most plants can be planted in clumps. Square clumps of entire plants are cut out of the ground and placed in pits prepared in advance on the chosen site. The clumps are planted at a depth where they will be submerged to a maximum of two-thirds their height.*
2. ***Planting Rhizomes and Shoots*** – *Less material is needed for the planting of rhizomes and shoots, which can be used to establish common reed and other plants as allowed by the water management district and county Agricultural Extension Office. Slips are taken from existing beds during the dormant season after the stems have been cut. Rhizomes and shoots are carefully removed from the earth without bruising the buds or the tips of the sprouts. They are placed in holes or narrow trenches along the line of the average summer water level, so that only the stem sprouts show above the soil.*
3. ***Planting Stem Slips*** – *It is possible to plant stem slips of common reed along slow-moving streams. Usually, 3 slips are set in a pit 12 to 20 inches (30 to 50 cm) deep. If the soil is packed or strong, the holes must be located*

approximately 1 foot (30 cm) apart.

4. **Using Reed Rolls** – *In many cases, the first 3 methods do not consolidate the banks sufficiently during the period immediately after planting. Combined structures have therefore been designed, in which the protection of the bank is initially ensured by structural materials. Along slow to fairly fast streams, the most effective method of establishing herbaceous vegetation is the use of reed rolls, also known as wattles (see **Figure 4.6b**).*
5. **Seeding** – *Wild millet can be sown 1/2 inch (13 mm) deep on very damp soil, provided the seeded surface is not covered by water for several months after sowing. Seed at a rate of 20 pounds per acre (22 kg/ha).*
6. **Using Vegetation with Stone Facing** – *Vegetation can be planted in conjunction with riprap or other stone facing by planting clumps, rhizomes, or shoots in the crevices and gaps along the line of the average summer water level.*

NOTE:

1. STRAW WATTLES ARE TUBES MADE FROM STRAW BOUND W/ PLASTIC NETTING. THEY ARE APPROX. 8" DIA. AND 20 - 30 FT. LONG.
2. STRAW WATTLES TRAP SEDIMENT AND REDUCE SHEET & RILL EROSION BY REDUCING SLOPE GRADIENT, INCREASING INFILTRATION RATES AND BY PRODUCING A FAVORABLE ENVIRONMENT FOR PLANT ESTABLISHMENT.
3. STRAW WATTLE INSTALLATION REQUIRES THE PLACEMENT AND SECURE STAKING OF THE WATTLE IN A TRENCH, 3" - 5" DEEP, DUG ON CONTOUR. RUNOFF MUST NOT BE ALLOWED TO RUN UNDER OR AROUND WATTLE.

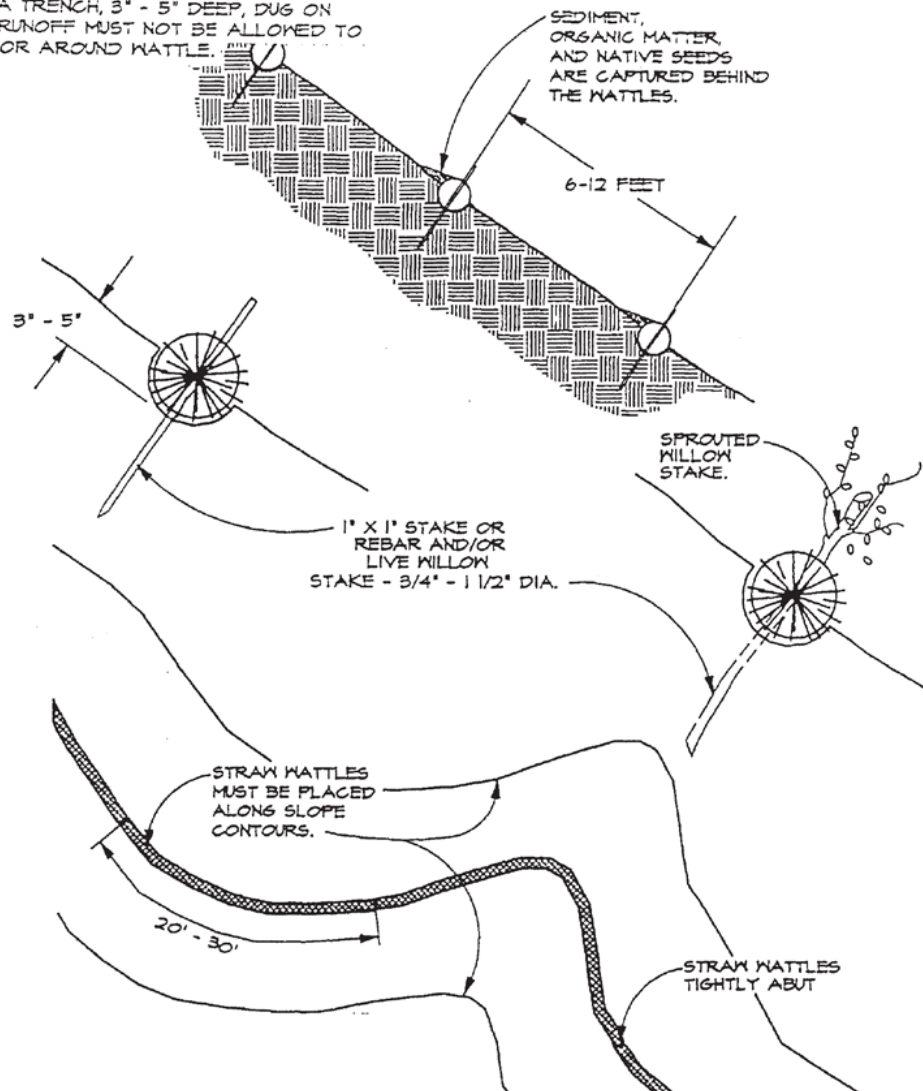


Figure 4.6b. Straw wattles

Source: Erosion Draw

Establishing Shrub Zone Vegetation

Stands of full-grown trees are of little use for protecting streambanks, apart from binding soil with their roots. Shrub wood provides much better protection, and in fact riverside stands of willow trees are often replaced naturally by colonies of shrublike willows.

Plants should be used that can easily adapt to the stream and site conditions. The following procedures should be used to establish shrub zone vegetation:

1. ***Seeding and Sodding*** – Frequently, if the stream is small and a good seedbed can be prepared, grasses can be used alone to stabilize streambanks. To seed the shrub zone, first grade eroded or steep streambanks to a maximum slope of 2:1 (3:1 preferred). Existing trees greater than 4 inches (10 cm) in diameter should be retained whenever possible. Topsoil should be conserved for reuse. Seeding mixtures should be selected and operations performed according to **PERMANENT SEEDING** (in this chapter). Some type of erosion control blanket, such as jute netting, excelsior blankets, or an equivalent structure should be installed according to **MULCHING** (in this chapter). Sod can also be placed in areas where grass is suitable. Sod should be selected and installed according to **SODDING** (in this chapter). Turf should only be used where the grass provides adequate protection, necessary maintenance can be provided, and the establishment of another streambank vegetation is impractical or impossible.
2. ***Planting Cuttings and Seedlings*** – Select only those plant species acceptable to the water management district and county Extension Service Office, or other county offices that may specifically work with exotic plant species. The plants can be put into the soil as cuttings, slips, or stems. Again, the first step in the planting process is to grade eroded or steep slopes to a maximum slope or 2:1 (3:1 preferred), making sure to remove overhanging bank edges.

Willows can be planted as 1-year-old, nursery-grown, rooted cuttings or as fresh hardwood cuttings gathered from local motherstock plantings. Swamp dogwood and alders should be nursery-grown seedlings 1 or 2 years old. Always verify that a plant species is acceptable for shoreline restoration.

Chapter 5: BMPs for Dewatering

- 5.1 Introduction
- 5.2 Limitations
- 5.3 Implementation
- 5.4 Inspection and Maintenance
- 5.5 Control Technologies
 - 5.5.1 Sediment Traps and Sediment Basins
 - 5.5.2 Weir Tanks and Dewatering Tanks
 - 5.5.3 Filters
 - 5.5.4 Chemical Treatment

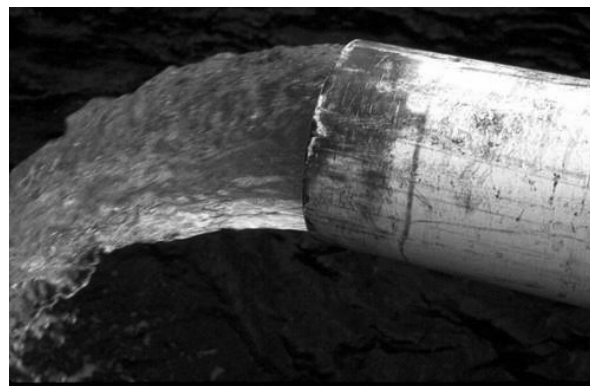
5.1 Introduction

A number of technologies are available to engineers, hydrologists, and construction personnel for removing suspended sediment and reducing the associated turbidity in waters produced as a part of dewatering operations at construction sites in Florida. Dewatering operations are practices that manage the discharge of pollutants when waters other than stormwater (nonstormwater) and accumulated precipitation must be removed from a work location so that construction may be carried out. Nonstormwater includes, but is not limited to, groundwater, water from cofferdams, water diversions, and water used during construction activities that must be removed from a work area.

Dewatering operations provide unique challenges at construction sites. This is primarily because of the possibility of adverse impacts to receiving waterbodies and often because of the limited land area available for implementing control practices. The waters associated with dewatering operations are also highly variable in their quality and are associated with highly varying geological materials and other environmental influences.

In addition, construction sites in Florida are often subject to high water table conditions, and various dewatering activities and associated practices must be used to locally lower groundwater levels, in order to facilitate excavation and construction activities and manage stormwater and other waters onsite.

A variety of methods can be used to treat water during dewatering operations. The methods described in this chapter are used to manage discharges of nonstormwater from



construction sites. They are also appropriate for managing the removal of accumulated precipitation (stormwater) from depressed areas at a construction site.

This chapter discusses four principal types of control technologies for dewatering: sediment traps and sediment basins, weir tanks and dewatering tanks, filters, and chemical treatment (see **Table 5.1** for a comparison of the different technologies).¹² These technologies and approaches provide options to remove sediment. The size of the particles in the sediment and the receiving water's limitations for sediment are key considerations for selecting sediment treatment option(s); in some cases, the use of multiple devices in a "treatment train" may be appropriate.

The information provided for each group of technologies used in dewatering operations generally includes the following:

- *Description of the technology.*
- *General application of the technology.*
- *Limitations of the technology.*
- *Considerations for implementing the technology.*
- *Inspection and maintenance needs.*
- *Design considerations for the technology.*

Table 5.1. Comparison of dewatering technologies

Treatment Technology Group	Treatment Technology	Pollutant Treated	Design Flow (gallons per minute [gpm])	Footprint (square feet)
Sediment Traps and Sediment Basins	Sediment Traps	Sediment	25 to 500	Varies
Sediment Traps and Sediment Basins	Sediment Basins	Sediment	25 to 500	Varies
Weir Tanks and Dewatering Tanks	Weir Tanks	Sediment, Metals, Oil, and Grease	60 to 100	1,800
Weir Tanks and Dewatering Tanks	Dewatering Tanks	Sediment, Metals, Oil, and Grease	Varies	1,200 to 1,500
Filters	Gravity Bag Filter	Sediment and Metals	300 to 800	100 to 400
Filters	Sand Media Filter	Sediment, Metals, Biochemical Oxygen Demand (BOD)	80 to 1,000	17 to 450
Filters	Pressurized Bag and Cartridge Filter	Sediment, Metals, BOD, and Hydrocarbons	50 to 1,000	200 to 320
Chemical Treatment	Continuous Chemical Treatment	Sediment	Varies	Varies
Chemical Treatment	Batch Chemical Treatment	Sediment	Varies	Varies

¹² Additional design specifications and implementation guidance for many of the technologies discussed in this chapter are provided in other chapters (see the Contents). **Source:** Caltrans 2006.

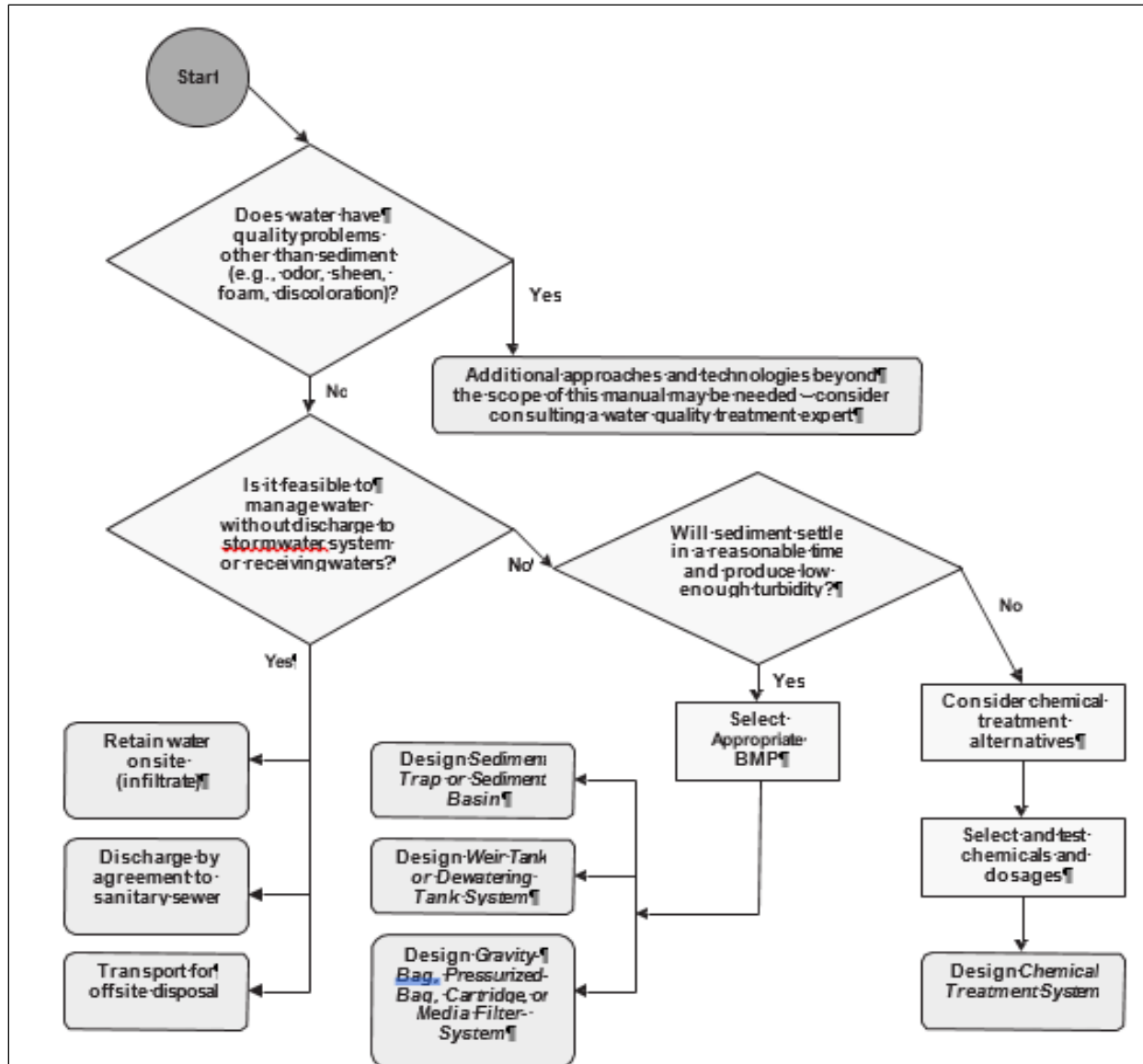


Figure 5.1. Dewatering operations flow chart

5.2 Limitations

The following general limitations apply to dewatering operations:

- *Site conditions dictate the design and use of dewatering operations.*
- *The controls discussed in this chapter address sediment only.*
- *The controls described in this chapter allow only minimal settling time for sediment particles. Use these controls only when site conditions restrict the use of the other control methods.*
- *Dewatering operations require, and must comply with, applicable local and DEP and water management district regulatory requirements. It is recommended that you contact your local regulatory agencies prior to the start of dewatering activities on your site.*
- *For discharges of produced groundwater from a noncontaminated site activity, a DEP Generic Permit for the Discharge of Produced Groundwater from any Noncontaminated Activity (Generic Permit) is required. Coverage may be obtained through the CGP or separately through a separate permit under Paragraph 62-621.300(2), F.A.C. (additional information is available [online](#)).¹³*
- *For contaminated sites, no Generic Permit is available, and DEP should be contacted for applicable requirements (a listing of rules by number is available online).¹⁴ For water management district regulatory requirements, contact the district with jurisdiction where the construction site is located.*
- *Avoid dewatering discharges, if possible, by using the water for dust control, infiltration, etc.*
- *The design of dewatering operations requires significant professional judgment and experience because of the many influencing environmental variables to consider, including pumping rate, depth and area of dewatering, depth to groundwater table, soil hydraulic conductivity, and soil particle sizes.*

5.3 Implementation

The following issues are important in the implementation of dewatering activities:

- *Dewatering nonstormwater cannot be discharged without prior notice to and approval from DEP and the local water management district. This includes stormwater that is comingled with groundwater or other nonstormwater sources.*

¹³ [http://www.dep.state.fl.us/legal/rules/shared/62-621\(2\).doc](http://www.dep.state.fl.us/legal/rules/shared/62-621(2).doc).

¹⁴ <http://www.dep.state.fl.us/legal/rules/rulelistnum.htm>.

Once the discharge is allowed, appropriate BMPs must be implemented to ensure that the discharge complies with all permitting and other regulatory requirements.

- *Sites within 500 feet of known groundwater contamination are not eligible for discharge offsite under the Non-Contaminated Groundwater Dewatering Permit. Reference Part 3 of the CGP (Paragraph 62-621.300[4][a]) and Notice of Intent (Paragraph 62-621.300[2][b], F.A.C.).*
- *DEP may require a separate NPDES permit prior to the dewatering discharge of nonstormwater. These permits have specific testing, monitoring, and discharge requirements and can take a significant amount of time to obtain.*
- *The flow chart in **Figure 5.1** should be used to guide dewatering operations.*
- *Dewatering discharges cannot exceed 29 nephelometric turbidity units (NTU) over background conditions, unless discharging to an Outstanding Florida Water (OFW), in which case discharges must be equal to or less than background conditions (0 NTU over b).*
- *Dewatering discharges must not introduce contamination to surface waters, wetlands, or a municipal separate storm sewer system (MS4). Contamination must be checked for prior to the start of dewatering activities. This may include analytical sampling to determine a site's status. (For additional information, contact your local DEP Compliance Representative.)*
- *Dewatering discharges must not cause erosion at the discharge point.*

5.4 Inspection and Maintenance

A number of essential inspection and maintenance activities should be carried out as part of dewatering operations. These include the following:

- *Prepare a dewatering plan per the requirements of the CGP and incorporate the pumps and discharge locations into the SWPPP and BMP map.*
- *Flow rates for the pumps installed on your site are to be tracked and noted per the requirements in Paragraph 62-621.300(2)(a), F.A.C., at a minimum weekly.*
- *Inspect and verify that BMPs are in place before beginning dewatering activities and that they are adequate for your project.*
- *While activities associated with the BMP are under way, inspect at a minimum daily and field check your turbidity with a calibrated field turbidity meter. Record your field readings in a log for review by agency inspectors.*

- *Inspect BMPs subject to nonstormwater discharges until dewatering operations are completed.*
- *Maintain your BMPs in proper operating condition per the specific maintenance requirements for your selected BMPs.*
- *Uncontaminated sediment removed during the maintenance of a dewatering device may be either spread onsite and stabilized or disposed of at a disposal site as approved by the owner.*
- *Sediment that is comingled with other pollutants must be disposed of in accordance with all applicable laws and regulations and as approved by the owner.*

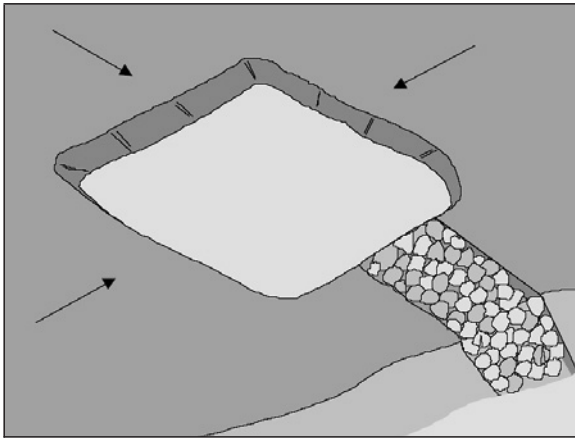
5.5 Control Technologies

As discussed previously in this chapter, the selection of BMPs to manage your dewatering discharges should be based on the following:

- *Rate and duration of activities.*
- *Space available onsite for treatment.*
- *Soil type.*
- *Discharge location (OFW, MS4, impaired waters, etc.).*
- *Presence of contamination.*

5.5.1 Sediment Traps and Sediment Basins

Sediment Trap



Sediment trap



Sediment trap

(Source: <http://www.mnerosion.org>)

— ***A sediment trap is a temporary basin formed by the excavation and/or construction of an earthen embankment or low drainage area to detain sediment-laden runoff and allow sediment to settle out before discharging. Sediment traps are generally smaller than sediment basins.*** —

Purpose

- *Effective for the removal of large and medium-size particles (sand and gravel) and some metals that settle out with the sediment.*

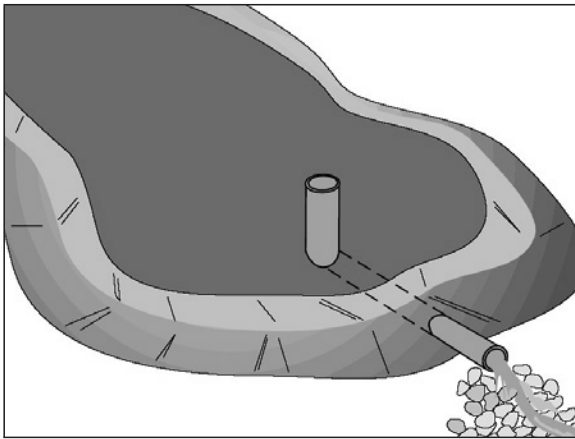
Applications

- *The inflow pipe should be located as far away from the outfall as possible to increase the residence time in the trap and allow more time for sediments to settle out.*
- *Use rock or vegetation to protect the trap outlets against erosion.*

Maintenance

- *Daily inspections of sediment trap embankments and the discharge point should be performed to prevent washout, scouring, and embankment blowouts.*
- *Sediment must be removed when the storage volume is reduced by one-half.*

Sediment Basin



Sediment basin



Sediment basin

(Source: <http://www.dot.ca.gov>)

— A sediment basin is a temporary basin with a controlled-release structure that is formed by the excavation or construction of an embankment to detain sediment-laden runoff and allow sediment to settle out before discharging. Sediment basins are generally larger than sediment traps. —

Purpose

- Effective for the settling of sediments such as sand, silt, and some metals that settle out with the sediment.

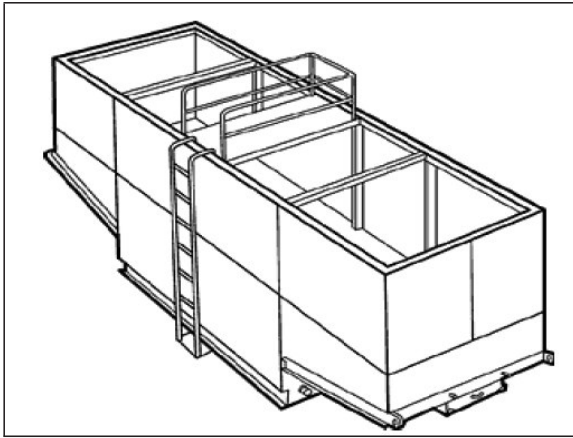
Applications

- Excavation and construction of related facilities is required.
- Temporary sediment basins must be fenced if safety is a concern.
- Outlet protection is required to prevent erosion at the outfall location.
- If offsite discharge is proposed, the turbidity sampling location should be at the discharge point of the basin.

Maintenance

- Daily inspections of sediment basin embankments and the discharge point should be performed to prevent washout, scouring, and embankment blowouts.
- Sediment must be removed when the storage volume is reduced by one-half.

5.5.2 Weir Tanks and Dewatering Tanks



Weir tank (Baker Tank) (Source: <http://www.dot.ca.gov>)



Dewatering tank (Source: <http://www.dot.ca.gov>)

Weir Tank

— A weir tank separates water and waste. The configuration of the weirs (over and under weirs) maximizes the residence time in the tank and determines the type of waste to be removed from the water, such as oil, grease, and sediments. —

Purpose

- The tank removes trash, some settleable solids (gravel, sand, and silt), some visible oil and grease, and some metals (removed with sediment). To achieve high levels of flow, multiple tanks can be used in parallel. If additional treatment is desired, the tanks can be placed in a series or used as pretreatment for other methods.

Applications

- The tank is delivered to the site by the vendor, who can provide assistance with set-up and operation.
- The tank size depends on flow volume, constituents of concern, and required residence time. Vendors should be consulted to appropriately size the tank.

Maintenance

- Periodic cleaning is required based on visual inspection or reduced flow.
- Oil and grease disposal must be carried out by a licensed waste disposal company.

Dewatering Tank

— A dewatering tank removes debris and sediment. Flow enters the tank through the top, passes through a fabric filter, and is discharged through the bottom of the tank. The filter separates the solids from the liquids. —

Purpose

- *The tank removes trash, gravel, sand, silt, some visible oil and grease, and some metals (removed with sediment). To achieve high levels of flow, multiple tanks can be used in parallel. If additional treatment is desired, the tanks can be placed in a series or used as pretreatment for other methods.*

Applications

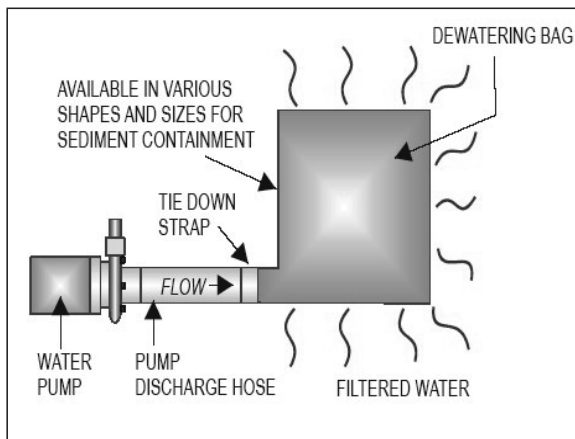
- *The tank is delivered to the site by the vendor, who can provide assistance with set-up and operation.*
- *The tank size depends on flow volume, constituents of concern, and required residence time. Vendors should be consulted to appropriately size the tank.*

Maintenance

- *Periodic cleaning is required based on visual inspection or reduced flow.*
- *Oil and grease disposal must be carried out by a licensed waste disposal company.*

5.5.3 Filters

Gravity Bag Filter



Gravity bag filter



Gravity bag filter

(Source: <http://www.spillcontainment.com>)

— A gravity bag filter, also referred to as a dewatering bag, is a square or rectangular bag made of a nonwoven geotextile fabric that collects sand, silt, and fines. —

Purpose

- Effective for the removal of sediments (gravel, sand, and silt). Some metals are also removed with the sediment.

Applications

- Water is pumped into one side of the bag and seeps through the bottom and sides of the bag.
- A secondary barrier, such as a rock filter bed or geobarrier, is placed beneath and beyond the edges of the bag to capture sediments that escape the bag.

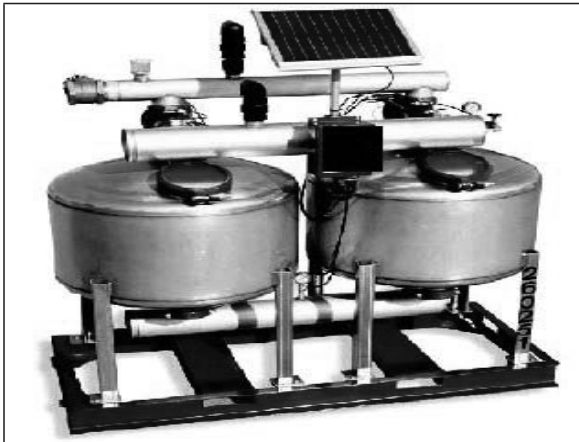
Uses

- Based on the velocity of water passing through the bag, the seams of the bag may fail.

Maintenance

- The flow conditions, bag condition, bag capacity, and secondary barrier must be inspected.
- The bag should be replaced when it no longer filters sediment or passes water at a reasonable rate.
- The bag is disposed of offsite.

Sand Media Filter



Sand media particulate filter
(Source: <http://www.dot.ca.gov>)



Sand media particulate filter
(Source: <http://www.spillcontainment.com>)

— Water is treated by passing it through canisters filled with sand media. Generally, sand filters provide a final level of treatment. They are often used as a secondary or higher level of treatment after significant amounts of sediment and other pollutants have been removed using other methods. —

Purpose

- *Effective for the removal of trash, gravel, sand, silt, and some metals, as well as the reduction of BOD and turbidity.*
- *Sand filters can be used for stand-alone treatment or in conjunction with bag and cartridge filtration if further treatment is required.*
- *Sand filters can also be used to provide additional treatment of water by settling or basic filtration.*

Applications

- *The filters require delivery to the site and initial set-up. The vendor can provide assistance with installation and operation.*

Maintenance

- *The filters require regular service in order to monitor and maintain the level of the sand media. If subjected to high loading rates, filters can plug quickly.*
- *Vendors generally provide data on maximum head loss through the filter. The filter should be monitored daily while in use and cleaned when head loss reaches target levels.*

- *If cleaned by backwashing, the backwash water may need to be hauled away for disposal or returned to the upper end of the treatment train for another pass through the series of dewatering BMPs.*

Pressurized Bag and Cartridge Filters



Pressurized bag filter
(Source: <http://www.dot.ca.gov>)



Cartridge filter
(Source: <http://www.dot.ca.gov>)

— A **pressurized bag filter** is a unit composed of single-filter bags made from polyester felt material. The water filters through the unit and is discharged through a header.

Vendors provide bag filters in a variety of configurations. Some units include a combination of bag filters and cartridge filters for enhanced contaminant removal. —

— Cartridge filters provide a high degree of pollutant removal when a number of individual cartridges are used as part of a larger filtering unit. They are often used as a secondary or higher (polishing) level of treatment after significant amounts of sediment and other pollutants are removed. Units come with various cartridge configurations (for use in a series with bag filters) or with a larger single-cartridge filtration unit (with multiple filters within). —

Purpose

- Effective for the removal of sediment (sand, silt, and some clays) and some metals, as well as the reduction of BOD, turbidity, and hydrocarbons. Oil-absorbent bags are available for hydrocarbon removal.
- Filters can be used to provide secondary treatment for water treated through settling or basic filtration.
- Hydrocarbons can often be removed with special resin cartridges.

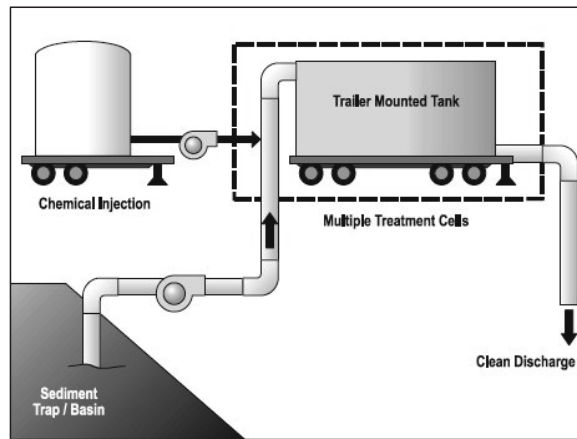
Applications

- The filters require delivery to the site and initial set-up. The vendor can provide assistance with installation and operation.

Maintenance

- The filter bags must be replaced when the pressure differential equals or exceeds the manufacturer's recommendation.
- The cartridges must be replaced when the pressure differential equals or exceeds the manufacturer's recommendation.

5.5.4 Chemical Treatment



— *Chemical treatment includes the application of carefully selected chemicals such as polymers (e.g., polyacrylamide [PAM]), alum, and other flocculants to waters to aid in the reduction of turbidity by more efficiently removing fine suspended sediment.* —

Purpose

- *Appropriate chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants and should be considered where turbid discharges to sensitive waters cannot be avoided using other available BMPs.*

Uses

- *DEP must preapprove the use of chemical treatment. Anionic PAM has been approved by DEP and the U.S. Environmental Protection Agency (EPA).*
- *Cationic charged polymers should not be used. Only anionic polymers are approved for use by DEP and EPA. Special permission is required from the DEP District Office for cationic polymers.*
- *Sediment basins or trailer-mounted units can be designed for chemical application.*
- *Treatment systems can be designed as flow-through continuous or batch-treatment systems.*
- *Chemical treatment systems may require a large area.*
- *Discharge rates may be limited, depending on the receiving waterbody.*
- *The design needs to consider operation and maintenance requirements.*
- *Treatment systems require monitoring for nonvisible pollutants.*

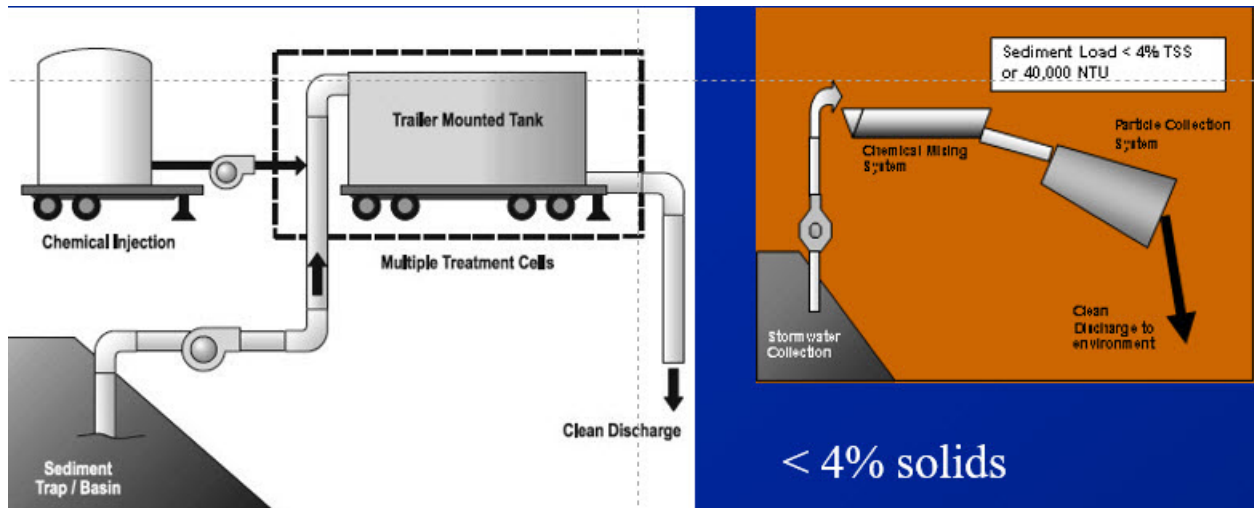
Applications

- *Turbidity is difficult to control if fine particles are suspended in dewatering discharges from a construction site. Sedimentation ponds are effective at removing larger particulate matter by gravity settling but are ineffective at removing smaller particulates such as clay and fine silt. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 millimeters [mm]). Chemical treatment may be used to reduce the turbidity of waters to be discharged. Turbidities need to be reduced to levels less than 29 NTU above background. **Note:** In Florida OFWs, the turbidity should not exceed the background measurement of the OFW.*
- *Chemically treated waters to be discharged from construction sites must be nontoxic to aquatic organisms. The protocol described below should be used to evaluate chemicals proposed for use in treatment at construction sites. The authorization to use a chemical in the field based on this protocol does not relieve the applicant from the responsibility for meeting all discharge and receiving water criteria applicable to a site. The protocol is as follows:*
 - *Treatment chemicals must be approved by DEP and EPA for potable water use. Only anionic PAMs do not require preapproval from the DEP District Office.*
 - *Prior to authorization for field use, laboratory batch tests should be conducted to demonstrate that the turbidity reduction necessary to meet the receiving water criteria could be achieved. Test conditions, including but not limited to, raw water quality and laboratory test procedures, should be indicative of field conditions. Although these small-scale tests cannot be expected to reproduce performance under field conditions, they are indicative of treatment capability. Testing should use water from the construction site where the treatment chemical is proposed for use.*
 - *Prior to authorization for field use, the chemical treatment should be tested for aquatic toxicity using a "worst-case scenario" of whole-product release. Whole effluent toxicity (WET) testing and limits (ASTM International WET test procedures) should be used.*
 - *The proposed maximum dosage should be at least a factor of five lower than the no observed effects concentration (NOEC).*
 - *The approval of a proposed treatment chemical should be conditional, subject to the full-scale bioassay monitoring of treated waters at the construction site where the proposed treatment chemical is to be used.*
 - *Treatment chemicals that have already passed the above testing protocol do not need to be re-evaluated. Contact DEP for a list of treatment chemicals that may be approved for use.*

Design Criteria

- *The design and operation of a chemical treatment system should take into consideration the factors that determine optimum, cost-effective performance. It may not be possible to fully incorporate all of the classic concepts into the design because of practical limitations at construction sites. Nonetheless, it is important to recognize the following:*
 - The **right** chemical must be used at the **right** dosage. A dosage that is either too low or too high is not likely to produce the lowest turbidity. There is usually an optimum dosage rate.
 - The coagulant must be mixed rapidly into the water to ensure proper dispersion.
 - Sufficient flocculation might occur in the pipe leading from the point of chemical to the settling or sediment basin.
 - Chemical treatment systems require the mixing of the chemical and turbid water for flocculation to occur. The size and volume of the treatment system may be restricted to provide adequate mixing.
 - In designing the withdrawal system, care must be taken to minimize outflow velocities and to prevent floc discharge. If possible, the discharge should be directed through a physical filter such as a vegetated swale to catch any unintended floc discharge.
 - A pH-adjusting chemical should be added into the sediment basin, if needed, to control pH.

CTS-1 Continuous Treatment



Purposes

- Chemical treatment systems can be designed as flow-through continuous treatment systems.
- These systems consist of a collection system, a chemical mixing system (where the chemical is mixed with the turbid water), a sediment collection device, and interconnecting conveyances.
- They may include a pump or pumps, to help convey turbid water through the treatment system; however, these are not always required.
- Primary sediment basins or grit pits may be required if the water to be treated has a high percentage of suspended solids, to prevent sediment from burying the treatment system and reducing its efficiency.

Applications

- The size of the continuous treatment system has to allow for continuous mixing for the length of time required to complete the continuous treatment system reaction at the flow rate expected through the system.
- The combination of any holding areas and treatment system capacity should be large enough to treat the volume of water anticipated.
- The total suspended solids (TSS) of the water running through the treatment system is not to exceed 4 % suspended solids or a turbidity reading greater than 40,000 NTU.
- Primary settling should be encouraged in a sediment basin or sediment trap if the

suspended solids load is above this level.

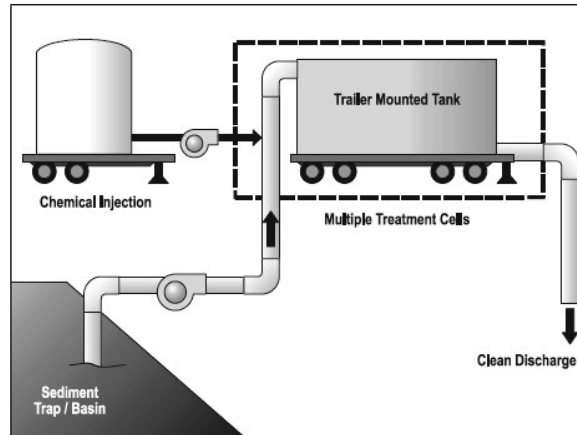
- *On sites where the suspended solids load going to the treatment system is below this level, sediment basins or sediment traps are not required for normal flow conditions, but some sort of particle collection device should be installed to prevent sediment deposition in the treatment system because of heavy rain events.*
- *The following discharge flow rate limits apply, absent any local requirements:*
 - *If the discharge is direct or indirect to a stream, the discharge flow rate should not exceed 50 % of the peak flow rate for all events between the 2-year and the 10-year, 24-hour event.*
 - *If the discharge occurring during a storm event is equal to or greater than the 10-year storm, the allowable discharge rate is the peak flow rate of the 10-year, 24-hour event.*
 - *Discharge to a stream should not increase the stream flow rate by more than 10 %.*
 - *If the discharge is directly to a lake or major receiving water, there is no discharge flow limit.*
 - *If the discharge is to a municipal storm drainage system, the allowable discharge rate may be limited by the capacity of the public system. It may be necessary to clean the municipal storm drainage system prior to the start of the discharge to prevent scouring solids from the drainage system.*

Maintenance

- *Inspect the flow-through treatment system at least daily and after rain events of 1/2 inch or greater, taking care to ensure the chemical treatment products are in place, are moist, and have not been buried by sediment.*
- *Inspect, repair, and clean out the sediment collection devices as needed to keep the system working at peak efficiency.*
- *Compliance monitoring:*
 - *pH and turbidity of the treated water.*
 - *pH and turbidity of the receiving water.*
- *Discharge compliance:*
 - *Treated stormwater must be sampled and tested for compliance with pH and turbidity limits at least weekly and during rain events of 1/2 inch or greater.*
 - *These limits may be established by water quality standards or a site-specific discharge permit.*
 - *Sampling and testing for other pollutants may also be necessary at some sites.*

- Turbidity must be within 29 NTU of background turbidity. Background is measured in the receiving water, upstream from the treatment process discharge point.
- pH must be within the range of 6.5 to 8.5 standard units (SU) and not cause a change in the pH of the receiving water of more than 0.2 SU.
- It is often possible to discharge treated water that has a lower turbidity than the receiving water and that matches the pH.
- Treated water samples and measurements should be taken from the point of discharge.
- Compliance with water quality standards is determined in the receiving water.
- *Sediment removal and disposal:*
 - Flocculated sediment should be removed from the sediment collection devices as necessary. Treated sediment can be disposed of in a landfill or can be used as a topsoil amendment elsewhere on the site to help prevent erosion and enhance vegetation establishment.
 - Flocculated sediment should never be used as structural fill material.

CTS-2 Batch Treatment



Purposes

- *Chemical treatment systems can be designed as batch treatment systems using either ponds or portable, trailer-mounted tanks.*
- *This chemical treatment system consists of a collection system, a sediment basin or sediment trap, pumps, a chemical feed system, treatment cells, and interconnected piping.*

Applications

- *The treatment system should use a minimum of two lined treatment cells. Multiple treatment cells allow for the clarification of treated water while other cells are being filled or emptied.*
- *Treatment cells may consist of basins, traps, or tanks. Portable tanks may also be suitable for some sites.*
- *The following equipment and supplies should be located in an operation shed:*
 - The chemical injector.
 - Secondary containment for substances such as acids, caustics, buffering compounds, diesel fuel, and treatment chemicals, in case a spill occurs.
 - Emergency shower and eyewash.
 - Monitoring equipment, consisting of a pH meter and a turbidimeter.
- *Sizing criteria:*
 - The combination of the sediment basin or other holding area and treatment capacity should be large enough to treat the volume of water anticipated.
 - Bypass should be provided around the chemical treatment system to accommodate

extreme storm events.

- Primary settling should be encouraged in the sediment basin/storage pond. A forebay with access for maintenance may be beneficial.
- There are two opposing considerations in sizing the treatment cells. A larger cell can treat a larger volume of water each time a batch is processed. However, the larger the cell, the longer the time required to empty it. A larger cell may also be less effective at flocculation and may therefore require a longer settling time.
- The simplest approach to sizing the treatment cell is to multiply the allowable discharge flow rate by the desired drawdown time. A 4-hour drawdown time allows 1 batch per cell per 8-hour work period, given 1 hour of flocculation followed by 2 hours of settling.
- The permissible discharge rate governed by the potential downstream effect can be used to calculate the recommended size of the treatment cells.
- *The following discharge flow rate limits apply, absent any local requirements:*
 - If the discharge is direct or indirect to a stream, the discharge flow rate should not exceed 50 % of the peak flow rate for all events between the 2-year and the 10-year, 24-hour event.
 - If discharge is occurring during a storm event equal to or greater than the 10-year storm, the allowable discharge rate is the peak flow rate of the 10-year, 24-hour event.
 - Discharge to a stream should not increase the stream flow rate by more than 10 %.
 - If the discharge is directly to a lake or major receiving water, there is no discharge flow limit.
 - If the discharge is to a municipal storm drainage system, the allowable discharge rate may be limited by the capacity of the public system. It may be necessary to clean the municipal storm drainage system prior to the start of the discharge to prevent scouring solids from the drainage system.

Maintenance

- *Chemical treatment systems must be operated and maintained by individuals with expertise in their use.*
- *These systems should be monitored continuously while in use.*
- *Test results should be recorded on a daily log kept onsite.*
- *Operational monitoring:*
 - pH, conductivity (as a surrogate for alkalinity), turbidity, and temperature of the untreated water.
 - Total volume treated and discharged.

- o Discharge time and flow rate.
- o Type and amount of chemical used for pH adjustment.
- o Amount of polymer, alum, or other flocculent used for treatment.
- o Settling time.
- *Compliance monitoring:*
 - o pH and turbidity of the treated water.
 - o pH and turbidity of the receiving water.
- *Biomonitoring:*
 - o Treated water should be tested for acute (lethal) toxicity. Bioassays should be conducted by a laboratory approved by the state. The performance standard for acute toxicity is no statistically significant difference in survival between the control and 100 % chemically treated stormwater.
 - o Acute toxicity tests should be conducted with the following species and protocols (or others approved by the state):

Fathead minnow, *Pimephales promelas* (96-hour static-renewal test, method: EPA/600/4-90/027F). Rainbow trout, *Oncorhynchus mykiss* (96-hour static-renewal test, method: EPA/600/4-90/027F), may be used as a substitute for fathead minnow.

Daphnid, *Ceriodaphnia dubia*, *Daphnia pulex*, or *Daphnia magna* (48-hour static test, method: EPA/600/4-90/027F).
 - o All toxicity tests should meet quality assurance criteria and test conditions in the most recent versions of the EPA test method. Bioassays should be performed on the first 5 batches and on every 10th batch thereafter, or as otherwise approved by the state. Failure to meet the performance standard should be immediately reported to the state.
- *Discharge compliance:*
 - o **Prior to discharge, each batch of treated stormwater must be sampled and tested for compliance with pH and turbidity limits.** These limits may be established by water quality standards or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. Turbidity must be within 29 NTU of background turbidity. Background is measured in the receiving water, upstream from the treatment process discharge point. pH must be within the range of 6.5 to 8.5 SU and must not cause a change in the pH of the receiving water of more than 0.2 SU. It is often possible to discharge treated water that has a lower turbidity than the receiving water and that matches the pH. Treated water samples and measurements should be taken from the discharge pipe or another location representative of the nature of the treated water discharge. Samples used for determining compliance with water quality standards in the receiving water should not be taken from the treatment pond to decanting.

Compliance with water quality standards is determined in the receiving water.

- *Operator training:*
 - Each contractor who intends to use chemical treatment should be trained by an experienced contractor on an active site for at least 40 hours.
- *Sediment removal and disposal:*
 - Sediment should be removed from the storage or treatment cells as necessary. Sediment remaining in the cells between batches may enhance the settling process and reduce the required chemical dosage.