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1 Introduction to the Guidelines

Chapter 1

Introduction to the Guidelines

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Purpose and Function of The Guidelines

The 2002 revision of the Connecticut Guidelines for Soil Erosion and Sediment Control (hereafter referred to as "the Guidelines") are intended to provide information to government agencies and the public on soil erosion and sediment control. The Guidelines are a useful reference for projects that require erosion and sediment control planning, design and implementation.

The Guidelines fulfill the requirements of Connecticut's Soil Erosion and Sediment Control Act (Public Act 83-388, codified in sections 22a-325 through 22a-329 of the Connecticut General Statutes) by providing guidance to municipal planning and zoning commissions. Contained within the Guidelines are methods and techniques for minimizing erosion and sedimentation based on the best currently available technology.

As a useful reference, the Guidelines may be designated as a primary guiding document, or as the foundation and minimum requirements for development of best management practices for construction activities for a number of programs beyond the original intent of the legislation that required the creation of this document. Such programs include water pollution control; coastal resource management; tidal wetlands; structures / dredging / fill in tidal, coastal and navigable waters; inland wetlands and watercourses; diversion of water; encroachments within stream channel encroachment lines; dam safety; and solid waste management (See Regulatory Index, Appendix F).

While erosion can be caused by wind, ice, gravitational creep and other geological processes, water accelerated erosion is unquestionably the most severe type of erosion in Connecticut. While the Guidelines make minor reference to controlling wind-generated erosion, the primary focus of the Guidelines is to prevent and control water-erosion and sedimentation.

Statement of The Problem

While all lands erode, not all land can be considered a source of sediment pollution. There has always been naturally occurring erosion. However, major problems can occur when large amounts of sediment enter our wetlands, watercourses and storm drain systems.

Erosion on agricultural land occurs mainly as sheet and rill erosion over a period usually measurable in years. Conversely, on developing land, erosion is frequently in the form of gully erosion on land disturbed for a year or less. Both conditions result in lower quality of soil and water resources. (see Chapter 2, Sediment Pollution and Damage). However, gully erosion, which is the result of concentrated flows of surface runoff, generates high sediment volumes requiring costly clean-up and the continual need for site stabilization during development. A construction site typically erodes at a rate of 50 tons/acre/year. This erosion rate is five times greater than cropland erosion and 250 times greater than woodland erosion. Each year more than one million acres of land in the United States are converted to urban use. These land use changes are the source of much of the sediment that pollutes our streams, rivers, lakes, ponds and reservoirs.

The Guidelines are intended to assist landowners, developers, commission members, engineers and architects to control sediment pollution caused by land disturbing activities.

History

Soil & Water Conservation Districts Established. In the late 1920s and early 1930s, large areas of the United States were devastated by erosion caused by unfavorable climatic conditions coupled with abuse and mismanagement of the country's crop lands. This resulted in the passage by Congress of the Soil Conservation Act in 1935. It was the first national recognition of the need for erosion and sediment control. The Act created the Soil Erosion Service, (also known as the Soil Conservation Service or SCS, now known as the Natural Resources Conservation Service or NRCS), an agency within the U.S. Department of Agriculture. However, it was not until two years later that President Roosevelt invited each state governor to enact legislation authorizing the establishment of soil conservation districts within the states. Once established, these districts were given technical assistance from the Secretary of Agriculture through the SCS.

Connecticut did not recognize the need for soil conservation districts until 1945. During the next several years, the soil conservation districts were established in Connecticut. In 1962, the word “water” was added to the title of the districts in recognition that erosion and sedimentation were adversely affecting water quality. In 1974, district boards were mandated by Public Act 74-325 to reorganize under the direction of the Commissioner of Environmental Protection. This Act further directed that a council be established to coordinate the activities of districts with the Department of Environmental Protection (DEP). Section 22a-315 of the Connecticut General Statutes states that the role of the districts is to “assist the Commissioner of Environmental Protection in identifying and remedying the problems of soil and water erosion.”

Federal Water Pollution Control Act and the 208 Program Causes Erosion and Sediment Control Regulation. In 1972, the Federal Water Pollution Control Act, PL 92-500 and Amendments were passed. Section 208 of PL 92-500 required that area-wide plans be prepared to control pollution from all sources including urban-industrial areas. The goal of PL 92-500 was to “restore and maintain the chemical, physical, and biological integrity of the nation’s waterways” by 1985. The Governor of Connecticut designated the entire state as the planning area and established the 208 Areawide Waste Treatment Management Planning Board to develop the State’s 208 program. The Connecticut Council on Soil and Water Conservation, with the assistance of the eight soil and water conservation districts, was contracted by the 208 Board to conduct an “Erosion and Sediment Source Inventory.” This inventory provided the information to assess and develop management plans to control non-point source pollution caused by sediment and associated pollutants.

The completion of this inventory was followed with efforts by the 208 Planning Board, with the cooperation of the districts and regional planning agencies, to encourage local planning and zoning commissions to require erosion and sediment control in their regulations. In 1977, the Connecticut General Statutes were amended to allow planning and zoning boards to include provisions on soil erosion and sediment control in their regulations.

Although more than 70 communities had adopted some form of erosion and sediment control requirements in their regulations, only half of these were considered to be effective in solving the erosion problems in developing areas.

In 1983 the Soil Erosion and Sediment Control Act was enacted by the Connecticut General Assembly and is now found in sections 22a-325 through 22a-329 of the Connecticut General Statutes. The Act established a public policy to “strengthen and extend its erosion and sediment control activities and programs and to establish and implement, through the Council on Soil and Water Conservation, Soil and Water Conservation Districts, the municipalities, and the Commissioner of Environmental Protection a statewide coordinated erosion and sediment control program which shall reduce the danger from stormwater runoff, minimize non-point sediment pollution from land being developed and conserve and protect the land, water, air and other environmental resources of the state." A copy of the Act is found in Appendix B of the Guidelines.

The Act required:

- *Municipal planning and zoning commissions to amend their regulations to make proper provisions for soil erosion and sediment control, mandating the submission and certification for adequacy of erosion and sediment control plans in applications before them where the disturbance of land is greater than one half acre,*

- *The Council on Soil & Water Conservation to develop guidelines to outline methods and techniques for minimizing erosion and sedimentation based on the best currently available technology, and*

- *Guidelines to contain model municipal regulations that may be used by the municipalities to comply with the Act.*

Guidelines Established and Revised. The first guidelines were published in January of 1985 and were the result of a task force that included many state and federal agencies, private corporations and individuals. They included excerpts from many sources, but relied heavily on documents from the SCS in Storrs, Connecticut and the Virginia Soil Erosion and Sediment Control Handbook published in 1980. In 1988 the guidelines were republished with several corrections.

Guidelines Cited in General Permit for Construction Activities. In 1992 the Federal Environmental Protection Agency (EPA) mandated that states, like Connecticut, who had been given the authority to administer provisions of the Federal Water Pollution Control Act (33 U.S.C. Section 466 et seq.) and issue National Pollution Discharge Elimination System (NPDES) permits, make provisions for the regulation of discharges of stormwater and dewatering waste waters from construction activities. As a result, the Connecticut Department of Environmental Protection issued a general permit for these activities on sites whose construction activities resulted in the disturbance of 5 acres or more of land. Among other things, the general permit requires the development of stormwater pollution control plans that include provisions for erosion and sediment controls during construction. Those plans are required to ensure and demonstrate compliance with the guidelines.

Unlike the Soil Erosion and Sediment Control Act, the general permit also affects state agencies. Agencies like the Connecticut Department of Transportation have, over time, established independent specifications for erosion and sediment control measures, which need consolidation with the guidelines or modification to demonstrate the compliance required by the general permit.

Major Changes

This 2002 revision of the Guidelines is intended to provide an easier to use format and to incorporate new technological advances. An attempt has been made to incorporate sediment control specifications developed by other state agencies. Finally, additions have been made to place greater emphasis on protecting nutrient sensitive Long Island Sound from sediment borne pollutants.

Format Changes: Erosion and sediment control measures have been regrouped according to their function and some selection charts have been revised or added to help the site planner develop an erosion and sediment control plan. Symbols for representing erosion and sediment control measures on plans have been offered in an attempt to be consistent with other states having similar guidelines. The format and style of individual measures in the Guidelines has also been standardized. A folded wall chart has been added to provide users with a single sheet reference to all of the erosion and sediment control measures found within the Guidelines.

Technical Changes: A number of new measures have been added, including:

- *Surface Roughening*
- *Temporary Erosion Control Blankets*
- *Permanent Turf Reinforcement Mats*
- *Stone Check Dam*
- *Temporary Sediment Trap*
- *Pumping Settling Basin*
- *Pump Intake and Outlet Controls*
- *Portable Sediment Tank*
- *Dewatering of Earth Materials*

Several measures have been reorganized to create new measures. For example, temporary mulch and permanent mulch were reorganized to create the new measures called:

- *Mulch for Seed*
- *Landscape Mulch*
- *Temporary Soil Protection*
- *Stone Slope Protection*

Similarly, the old diversion measure has been broken into four measures relating to diversion; grade stabilization structures have been broken into four related measures; and sediment barriers have been broken into four measures.

Measures that require design by an engineer contain sections entitled "Design Criteria" and "Installation Requirements". These are distinguished from non-engineered measures which have a "Specifications" section. Some measures need an engineer only when certain criteria are exceeded. These measures contain "Design Criteria" and "Specifications" sections but no "Installation Requirements." Erosion and sediment control (E&S) plans using measures that require engineered designs are

required to be signed and sealed by a professional engineer licensed to practice in Connecticut.

The former Chapter 9, Estimating Runoff, and Chapter 10, Estimating Rainfall-Erosion Soil Losses, have been eliminated. Engineers are directed to use standard engineering practices.

Appendixes have been added to provide miscellaneous reference materials, including the former model regulations required by the Erosion and Sediment Control Act.

A new chapter, Chapter 4, has been added, containing special guidance on the development of large construction sites, utilities, and road construction, which can involve massive earthmoving operations as well as special treatments where multiple E&S measures are used together to create an E&S system.

How To Use The Guidelines

The Guidelines are intended to serve as a technical guide for meeting the requirements of the Soil Erosion and Sediment Control Act and to assist in implementing the requirements of laws and statutes relating to water pollution control. The use of words such as “shall,”“will,” and “must” within design or implementation standards is meant to emphasize the direction which will ensure that the control measure or design procedure will serve its intended purpose.

The Guidelines provide technical details that are not site specific. Examples are provided which may not be applicable or sufficient to meet all engineering standards and building codes. Measures requiring an engineered design must be evaluated on a case by case basis by a professional engineer licensed to practice in Connecticut.

Innovative modifications to the control measures or design procedures contained in this guide are acceptable, and encouraged, especially if they improve upon sediment-loss mitigation. However, designers and plan reviewers must be sure that the modified procedure will be successful. Designers must present to plan reviewers sufficient technical data that show the proposed modification is at least as effective as the guideline measure meant to be replaced.

These Guidelines are not intended to provide guidance on the development of an integrated post- construction stormwater management plan. While some measures are identified as being permanent in nature, the long-term maintenance of these permanent measures should be addressed in a post-construction stormwater management plan.

Any recommendations for improving the Guidelines should be addressed to the Connecticut Council on Soil & Water Conservation or the Inland Water Resources Division of the Department of Environmental Protection, 79 Elm Street, Hartford, CT 06106. Any or all of the material contained in this manual may be reproduced, copied, or reprinted with the appropriate credit given.

This document contains, to the extent possible, measures that will prevent or correct sediment and erosion control problems. However, the use of the Guidelines does not relieve the user of the responsibility of complying with laws and regulations that cite the Guidelines.

2 The Erosion and Sedimentation Process

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Chapter 2 The Erosion and Sedimentation Process

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Definition

Soil erosion and sedimentation is a three-stage process: **detachment → transport → deposition**. Soil erosion involves the wearing away of the surface of the land by the action of wind, water, ice, and gravity. Once worn away, the detached soil particles are transported and ultimately deposited, resulting in sedimentation. Natural, or geologic erosion and sedimentation occur over long periods of geologic time resulting in the wearing away of mountains and the building up of floodplains, some coastal plains, deltas, etc., to create the topography we know today. Except for some cases of shoreline and stream channel erosion and sedimentation, natural erosion and sedimentation occur at a very slow rate.

Erosion and sedimentation become a problem when they are accelerated beyond natural rates. Accelerated erosion is primarily the result of the influence of human activities on the environment. Once exposed, unprotected soil is then subject to rapid erosion by the action of wind, water, ice or gravity.

As stated in Chapter 1, erosion can be caused by water, wind, ice and gravitational creep. The focus of these guidelines is directed at erosion caused by water.

Types of Erosion

Raindrop erosion or raindrop splash initiates the erosion process. Individual soil particles and small soil aggregates are detached and transported with splashing water droplets as the raindrop impacts the soil (see **Figure 2-1**). Although raindrop splash is incapable of moving sands or coarser materials very far, very fine particles can be suspended in water. They are then susceptible to and contribute to sheet erosion.

Figure 2-1 Rain Drop Splash

Sheet erosion is the removal of a thin, fairly uniform layer of soil from the land surface caused by shallow sheets of water running off the land. These very shallow moving sheets of water are seldom the detaching agents, but the flow transports soil particles which are detached by raindrop impact and splash. The shallow surface flow rarely moves as a uniform sheet for more than a few feet on land surfaces before concentrating in surface irregularities (see **Figure 2-3**).

Rill erosion develops as shallow surface flows begin to concentrate in the low spots and irregularities of the land surface. As the flow changes from the shallow sheets to deeper flows in these low areas, the velocity and turbulence increase. The energy of this concentrated flow is able to both detach and transport soil materials. This action begins to cause the creation of tiny channels called rills (see **Figure 2-3**). Rills are small but well-defined channels that are, at most, only a few inches (about 5 centimeters) deep.

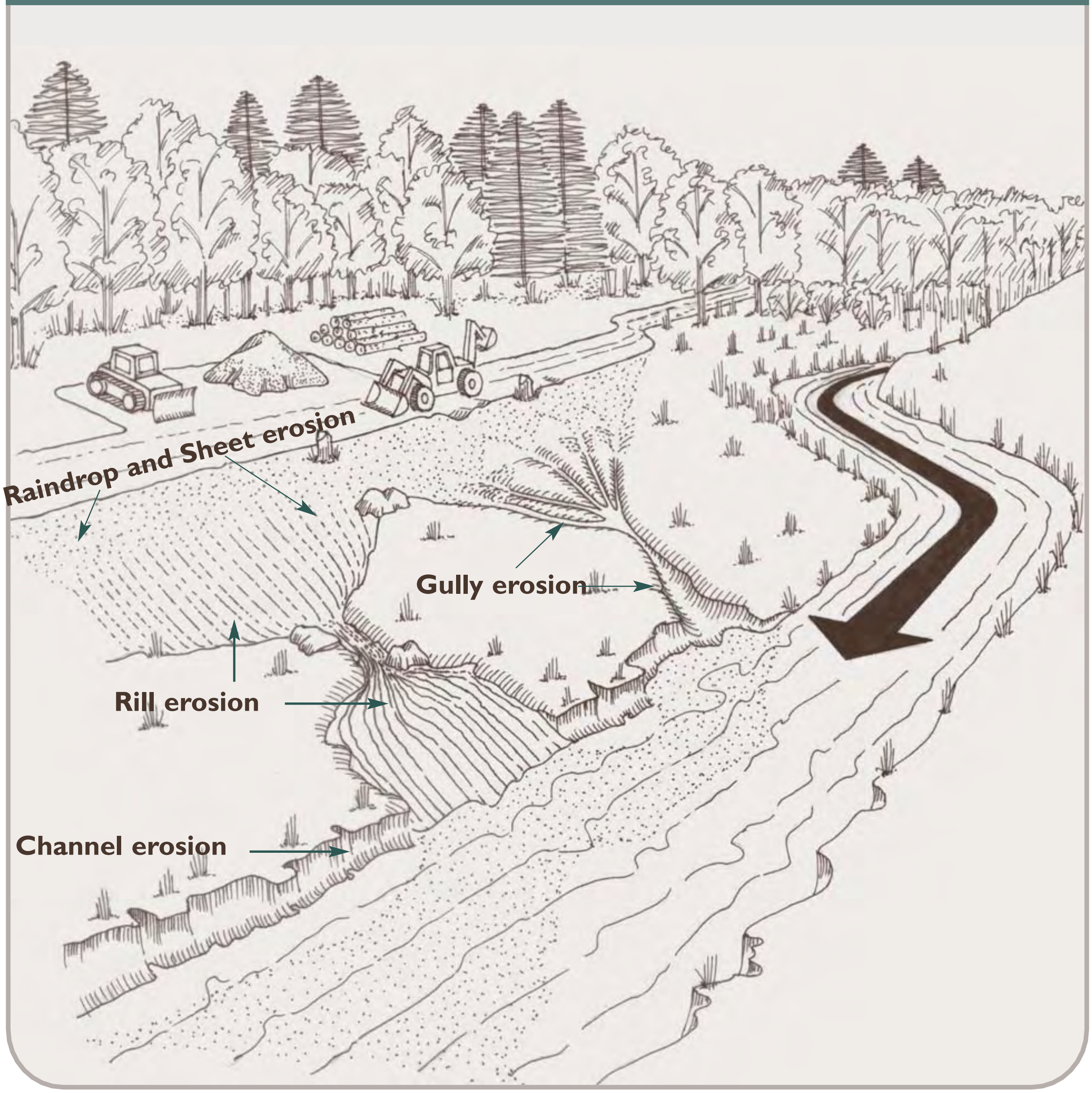
Gully erosion occurs as the flows in rills come together to form larger channels (see **Figure 2-2** and **Figure 2-3**). Size is the major difference between gully and rill erosion. Gullies are too large to be repaired with conventional tillage equipment and usually require heavy earthmoving equipment and special techniques for stabilization. Typically they reach depths in excess of 1 foot (.3 m) but on rare occasions reach depths as much as 75 to 100 feet (23-30.5 m) deep.

Channel erosion occurs as the volume and velocity of runoff concentrate in drainage channels and cause movement of the stream bed and bank materials.

Figure 2-2 Gully Erosion

Shoreline erosion occurs on tidal and inland waters as daily high tides, wave action and storm surges erode coastal and estuarine shorelines. Existing shoreline structures can then be heavily damaged by severe wave action, significant patterns of tidal exchange or flushing rates, fresh water input or existing basin characteristics and channel contours. Wave action caused by boat wakes can also cause shoreline erosion. Sediment displaced by land erosion can render shipping channels and harbors impassable and adversely impact coastal and estuarine habitats. Significant alteration of shoreline configurations, particularly within high velocity flood zones, can occur when the natural erosion patterns are altered. Tidal wetlands, beaches and dunes, rocky shore fronts, bluffs and escarpments can be greatly affected through changes in their natural characteristics or functions.

Figure 2-3 Types of Erosion



Factors Influencing Erosion

The erosion potential of any area is determined by four principal factors: soil characteristics, vegetative cover, topography, and climate. It is a reflection of all erosion factors combined. Although each of the erosion factors is discussed separately here, they are interrelated in determining erosion potential and no one factor determines erosion potential alone.

Erosion potential during dewatering activities is a function of the turbidity of the water being pumped and the discharge velocities of the pump.

Figure 2-4 below summarizes how erosion potential is influenced by these various factors. Understanding these four factors of soil erosion will aid the designer and planner in selecting the appropriate soil erosion control measure. Planning for soil conservation and water management requires knowledge of the relationship among these four factors that cause loss of soil and how these factors can be influenced to reduce such losses. In order to better understand the relationship of planned activities to soil erosion, a predictive soil erosion loss model, the Revised Universal Soil Loss Equation (RUSLE), was developed. See Appendix I for a discussion of RUSLE.

Figure 2-4 Factors Influencing Erosion Potential

Factor	Erosion Potential: Lower	Erosion Potential: Higher
Soil Characteristics		
soil texture	gravel, coarse sands	fine sands & silt
organic content	highly organic	no organic
soil structure	blocky	granular
soil permeability	sand/gravel	silt/clay
Vegetative Cover		
% cover	100%	0%
type of cover	treed with ground cover/mulch	no cover
Topography		
slope length	short	long
slope gradient	flat	steep
Climate		
rainfall intensity	low intensity	high intensity
rainfall frequency	infrequent	frequent
rainfall duration	short duration	long duration
wind	calm	gusty
temperature	frozen	thawed
Special Case - Dewatering		
dewatering discharge velocities	low velocity	high velocity

Soil Characteristics

Soil characteristics which influence erosion by rainfall and runoff are those properties which affect the infiltration capacity of a soil and those which affect the soil's resistance to detachment and transport by falling or flowing water. The following four characteristics are important in determining soil erodibility:

- *texture (particle size and gradation)*
- *organic matter content*
- *structure*
- *permeability*

Soils containing high percentages of fine sands and silt are normally the most erodible. Terrace escarpment soils in the Connecticut River valley are examples of soils that contain higher percentages of fine sands and silts and are very prone to erosion when disturbed. As the clay and organic matter content of soil increases, the erodibility decreases. Clays act as a binder to soil particles, thus reducing erodibility. However, while clays have a tendency to resist erosion, once eroded they are easily transported by water and the soil particles remain in suspension longer. In Connecticut, the existence of clay soils is very limited.

Gravelly soils are usually the least erodible. Soils high in organic matter have a more stable structure that improves their permeability. Such soils resist raindrop detachment and infiltrate more rainwater. Soils with high infiltration rates and permeabilities either prevent or delay and reduce the amount of runoff.

Vegetative Cover

Vegetative cover plays an important role in controlling erosion in the following five ways:

- *Protects the soil surface from the impact of falling rain*
- *Holds soil particles in place*
- *Enhances the soil's capacity to absorb water*
- *Slows the velocity of runoff*
- *Removes subsurface water between rain falls through the process of evapo-transporation*
- *Improves infiltration rates*

By limiting and/or staging the removal of existing vegetation, and by decreasing the area and duration of exposure, soil erosion and sedimentation can be significantly reduced. Give special consideration to the maintenance of existing vegetative cover on areas of high erosion potential such as erodible soils, steep slopes, ditches, and the banks of streams.

Topography

Topography describes the configuration of the land surface. The size, shape and slope characteristics of a watershed influence the amount and rate of runoff. As both slope length and gradient increase, the rate of runoff increases and the potential for erosion is magnified.

Climate

Climate is the sum total of all atmospheric influences, principally moisture (including rainfall), temperature, wind, pressure, and evaporation. It determines the frequency, intensity, and duration of rainfall which in turn determines the amounts of runoff produced in a given area. As both the volume and velocity of runoff increase, the capacity of runoff to detach and transport soil particles also increases. Where storms are frequent, intense, or of long duration, erosion risks are high. Seasonal and regional changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year.

Although wind can potentially remove more sediment than rainfall, in most cases in Connecticut it plays a relatively minor role in soil erosion. Its impact on the land is generally limited to large areas that are unprotected for long periods of time. However, there are areas of special concern. **This is particularly true of the sandy soils found in the Connecticut River Valley that can be very susceptible to wind erosion if left unprotected during hot, dry weather.** Wind can also agitate water bodies sufficiently to induce erosive wave action and/or cause the resuspension of deposited sediments.

One period of higher erosion potential exists during the spring thaw. It is a time when the coastal storm track increases rainfall potential. Additionally, because the ground is still partially frozen, the absorptive capacity is reduced. While frozen soils are relatively erosion resistant, they melt from the top down, creating a soft erodible surface over a hard impervious sub-surface. In Connecticut, thawing of the soils often occurs in conjunction with the early spring rains combined with snow melt. Additionally, soils with high moisture content are subject to frost heaving and can be very easily eroded upon thawing.

Types of Sediment and Sedimentation

From the time the soil particle is detached (either by rain drop splash or moving water), the velocity, turbulence and the size and types of material available are the primary factors determining the nature of the sediment load. The sediment being carried is either in the form of a **suspended load** or a **bed load** or both.

Suspended load is generally comprised of very fine material (clays and silts) and stays in suspension for long periods of time resulting in a condition called turbidity. The amount of these materials in suspension is dependent on the type of soil and the resistance to detachment by the erosive agent. Turbidity is measured with a nephelometer and recorded as nephelometric turbidity units. In Connecticut, any increase in turbidity from the norm is considered pollution.

Bed load is the sediment that moves on or near the stream bed. Typically this material moves at velocities less than the surrounding flow and can be measured in tons per unit of time. Bed loads are normally comprised of sands, pebbles and cobbles.

The amount of the total sediment load being carried as suspended load and/or bed load is related directly to the flow of the water. The movement of the sediment load tends to be in balance with flow conditions. This has an important bearing on channel stability. If the flow becomes loaded beyond its transporting capacity, deposition will occur. However, if the load is less than the transporting capacity, the flowing water attacks the channel in an effort to achieve a balance between load and capacity. Any change in sediment load or flow characteristics will have an effect on channel stability.

Deposition is the inverse of detachment. It occurs when the carrying capacity of the flow is reduced to a point below that needed to carry the sediment load. Deposition is a selective process. As flows slow down, the coarser fragments fall out of the water column first, followed by finer and finer particles, resulting in a noticeable gradation of particle sizes in the sediments.

Sediment deposits may occur in water bodies or on land. Deposits occur in water as a faster flowing stream flows into a slower one or into an area of slack water such as a pond or lake or ocean. A stream flowing from a steeper gradient to a lesser one will also lose velocity and carrying capacity and will form deposits. Additionally, deposition can take place on the inside bends of rivers and stream where flow velocities tend to be slower than on the outside of the bends. Deposits can also occur on land when the runoff loses velocity and hence the capacity to carry the same sediment load.

Sediment Pollution and Damage

Sediment pollution is soil out of place. It is the direct and indirect result of human activities that lead to severe soil loss. From the more than four billion tons of sediment delivered to our nation's water bodies, about one billion tons reach the ocean. Although about 10% of the sediment is estimated to be generated by highway construction and land development, these activities could represent over 50% of the sediment load carried by many streams draining small sub-watersheds that are undergoing development.

Sediment pollution causes physical, chemical and biological damage. The type of damage is related to the size of the sediment particle. **Figure 2-5** shows the relationship of particle size and character to damage or impact.

Figure 2-5 Particle Size vs Damage Impact

Damage Impact With Change in Particle Size

Boulders, Cobbles, Gravel | Very Coarse to Medium Sand | Fine Sand, Sites and Clay

Biological

- burying of benthic (a.k.a. bottom living) organisms
- habitat degradation by damaging rooted plants and possibly by changing substrate (e.g. cobble to sand)
- decrease in biological diversity

- loss of aquatic eggs, larva and fry
- clogging of fish gill increasing disease susceptibility
- damage to food chain
- decrease in biological diversity
- increase algal blooms in downstream impoundments
- reduced ability to grow plants on eroded land

Chemical

- water temperature increase from increase sunlight absorption caused by shallowing of water body

- nutrient transport (causing increased eutrophication of downstream water bodies and lost fertility from eroded land)
- water temperature increase from sunlight absorption cause by water opacity (a.k.a. cloudiness or turbidity)
- can result in lower dissolved oxygen levels

Physical

- reduced channel capacity, navigation obstruction requiring dredging, reduced flood storage increasing future damage from floods and increasing frequency of floods, increasing maintenance on culverts and storm drains, loss of reservoir storage capacity for drinking and industrial water supply
- loss of land

- turbidity adversely affecting use for surface water drinking supply and manufacturing, increasing filtration costs
- poor aesthetics

Erosion and Sediment Action Associated with Land Use Changes and Development

Land use changes and land development activities affect the natural or geologic erosion process by:

- *Removing the existing protective vegetative cover.*
- *Prolonging the exposure of unprotected disturbed areas.*
- *Exposing underlying soil or geologic formations less pervious and/or more erodible than original soil surface.*
- *Compacting soils with heavy equipment and increasing impervious surfaces, thereby reducing rainfall absorption and increasing runoff.*
- *Modifying drainage areas.*
- *Altering the topography in a manner that results in shortened times of concentration of surface runoff (e.g. altering steepness, distance and surface roughness, and installation of "improved" storm drainage facilities).*
- *Altering the groundwater regime (e.g. placing a detention basin at the top of a slope).*

Reshaping of land during construction or development alters the soil cover and the soil in many ways, often detrimentally affecting on-site drainage and stormwater runoff patterns. Many people may be adversely affected regardless of the size of the area being developed. Erosion and sediment from these areas often cause considerable economic damage to individuals and to society in general. Sediment deposition in waterways and reservoirs creates or aggravates flooding and surface water pollution problems. The result is damage to public and private property. Additionally, erosion and sedimentation may have adverse impacts on recreation, natural resources and wildlife due to the alteration and/or loss of aquatic habitat.

It is because of these adverse effects that steps must be taken to control the erosion and sedimentation that is associated with land use changes and development.

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3 Erosion and Sediment Control Plans

Erosion and Sediment Control Plans

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Erosion and Sediment Control Plans

This chapter is intended to be a guide for preparing a typical soil erosion and sediment control plan (hereafter referred to as an "E&S plan") for a construction activity where land disturbance exceeds one half acre. This chapter is divided into three parts:

Part I: General Guidelines

Presents the basic information with which all site planners and plan reviewers should be familiar. It describes criteria for E&S plan content and format, and ideas for improving planning effectiveness.

Part II: Planning Process

Describes a procedure for developing an E&S plan from the collection of data, through the analysis of the data to the final selection and design of each erosion and sediment control measure ("E&S measure").

Part III: Plan Requirements and Preparation

Presents details on the consolidation of planning information into a written document, the minimum information required and format. This procedure is written in general terms in order to be applicable to all types of construction projects.

Reviewing agencies and their staff, site planners, contractors, field inspectors and other individuals who are involved in or associated with construction activities are urged to become familiar with the contents of this chapter so that E&S plans will become more standardized, and thus more effective statewide.

Part I: General Guidelines

Definition of an E&S Plan

Connecticut General Statutes §22a-327(5)(“CGS”) defines a soil E&S plan as:

> *a scheme that minimizes soil erosion and sedimentation and includes, but is not limited to, a map and a narrative. The map shall show topography, cleared and graded areas, proposed area alterations and the location of and detailed information concerning erosion and sediment measures and facilities. The narrative shall describe the project, the schedule of major activities on the land, the application of conservation practices, design criteria, construction details and the maintenance program for any erosion and sediment control facilities that are installed*

The E&S plan consists of two components: a narrative which describes the project in general terms and a map which illustrates in detail what is contained in the plan and how it will be implemented. The information required by the statute for the map is contained collectively in the site drawing(s) and the erosion and sediment control drawing(s) referenced later in this chapter. The narrative may be contained on the site plan sheets, but typically it exists as a separate document due to its length, particularly in larger projects that have more than one construction phase. For sites where the E&S measures require engineering analysis and design, the hydrologic and hydraulic calculations and other support documentation are considered to be part of the E&S plan and are either attached to the narrative or placed on the drawings.

The E&S plan is an integral part of an overall site plan. It should be a separate plan when needed for clarity, but can also be on the site plan if the proposed E&S measures can be clearly shown and noted. The E&S plan itself shall contain notes to ensure that the controls are installed, inspected and maintained properly. This could be done in a separate specifications package supplemented by notes on the drawings.

Figure 3-1 E&S Plan Complexity

LESS

Single House
Low Soil Erodibility
Flat Terrain
No Wetlands or Watercourses Nearby
Low Density Population
Small Disturbed Area (5 Ac. or Less)

MORE

Subdivision with Roads
High Soil Erodibility
Steep Slopes
In or Near Wetlands or Watercourses
Dense Population
Large Disturbed Area >5 Ac.
Located within Public Water Supply Watershed

Plan Adequacy

CGS §22a-327(5) sets minimum requirements for E&S plans mandated under the Soil Erosion and Sediment Control Act (CGS §§22a-325 through 22a-329). This law specifically requires local planning and zoning commissions to consider erosion and sediment controls and provide for certification that an adequate E&S plan has been submitted. Many municipal planning and zoning commissions have cited these guidelines in their regulations and frequently require them as the standard to follow. Other requirements may be mandated by individual municipal planning and zoning commission regulations.

Additional regulatory agencies, such as a municipal inland wetland agency and the Connecticut DEP, may request the submission of an E&S plan for review and approval. These other areas of regulatory control can include inland wetlands and watercourses, water pollution control, diversion of water, encroachments riverward of stream channel encroachment lines, tidal wetlands and tidal, coastal and navigable waters.

Regardless of the regulating authority, E&S plans shall contain sufficient information to show that the potential problems of soil erosion and sedimentation have been addressed for a proposed project.

The length and complexity of the plan is directly related to the size of the project, the severity of site conditions, and the potential for off-site damage (see **Figure 3-1**).

E&S plans using measures that contain “DESIGN CRITERIA” shall be signed and sealed by a professional engineer licensed to practice in Connecticut.

Site planners and plan reviewers may use the checklists contained in Part III of this chapter as a guide to E&S plan content. Most projects are subject to a local regulatory review. The procedure outlined in this chapter is recommended for the development of all plans.

Minimum Standards and Specifications

Chapter 5 of these Guidelines contains the minimum standards and specifications for E&S measures. Whenever any of these measures are to be employed on a site, the specific measure should be clearly marked on the plan. By referencing the Guidelines properly, the planner can reduce the need for lengthy descriptions of the measures in the plan. The plan shall contain diagrams and notes related to the installation and maintenance of the measures.

Modifications to the standard measures given in these Guidelines or new and innovative E&S measures may also be employed. Such modifications or measures shall be thoroughly described in detail to the satisfaction of the reviewing agency. The modified or new measure shall be at least as effective as the Guideline measure being replaced.

Standard Measure Coding System

Site planners and engineers are encouraged to use the standard coding system for E&S measures contained in these Guidelines. Appendix L contains a large fold-out chart which lists each measure with its definition and code. It is expected that the use of this identification system will result in increased uniformity of plans as well as clarity and simplicity for plan reviewers' job.

Part II - Selection & Planning Process

Site Selection

Historically sites for development have been selected based upon the availability of property where zoning and wetland restrictions can be compatible with development needs. Existing infrastructure is also a major determining factor in the selection of potential sites for development. Irrespective of the ultimate use or location of the proposed development, erosion and sediment control needs to be an integral part of the site selection process.

Review of Available Information

In Connecticut, there are many sources of information[1] that already exist and are available to the site planner or engineer as aides in developing site plans.
They include:

1. USGS topographical maps available from the DEP store;
2. local governmental topographical maps (e.g. MDC topographic maps, town contour maps);
3. site drawings from previous development proposals;
4. USDA County Soil Surveys available from most county soil and water conservation districts;
5. aerial photography usually available from a variety of sources including the DEP store[2], ConnDOT, and USDA Farm Services Agency;
6. municipal inland wetlands map(s) available from town halls;
7. water quality classification maps available from the DEP store;
8. Connecticut Natural Resource Atlas Series; Community Water Systems in Connecticut, a 1984 Inventory available from the DEP store;
9. Gazetteer of Drainage Areas of Connecticut, 1997, Water Resources Bulletin # 45 available from the DEP store;
10. Protecting Connecticut's Water-Supply Watersheds, A Guide For Local Officials, January 1993;
11. Protecting Connecticut's Groundwater, A Guide For Local Officials, January 1997, DEP Publication # 26;
12. Federal Emergency Management Agency floodplain mapping and studies available for viewing at local planning and zoning offices and at DEP Inland Water Resources Division;
13. State established Stream Channel Encroachment Line maps available at DEP Inland Water Resources Division or for viewing in the map section of the local land records in the respective town clerk's office;
14. Natural Resource Inventory (NRI) data available from the local office of the USDA Natural Resources Conservation Service;
15. coastal resource maps on file in town planning and/or zoning offices (also available from the DEP store);
16. tidal wetland maps on file in individual town planning and/or zoning offices;
17. natural diversity database maps entitled Federally and State Listed Endangered, Threatened and Special Concern Species and Significant Habitats (available from the DEP store);
18. GIS Data Catalog, July 1996 available from the DEP store (some of the information listed is available from the Internet web site http://magic.lib.uconn.edu/);

[1] See Appendix E for agency contact information.

[2] See DEP Information Directory & List of Publications for information on ordering copies of aerial photography

19. Connecticut Aquifer Protection Areas Map, available from the DEP store (also available from town halls); and

20. Information Directory & List of Publications available from the DEP store listing all documents available from the DEP.

Site Investigations and Limitations

A review of existing information can assist the planner in determining initially if the site is compatible with the development needs, or if limitations exist that will impact site development. Features such as existing topography, wetlands, watercourses, expected surface and groundwater quality, habitats of endangered species, steep slopes and flood prone areas can be generally identified by reviewing existing information. Projects that propose filling flood prone areas or inland wetlands require permits or approvals from local agencies and may require state and/or federal permits. These permits are sometimes difficult to obtain, if at all, and may result in the need for costly mitigation procedures.

Potential structural measures, such as detention basins and sedimentation basins can be identified. For example, the development of a site located near the top of a watershed may result in decreased infiltration and increased runoff (e.g. wooded land to grass or vegetation to pavement). In this case detention or recharge facilities may be needed to reduce or eliminate the expected increases in runoff.

The presence of wetlands or flood prone areas can severely limit the siting of detention and sedimentation basins on the site, not to mention other structural features such as buildings and roads.

Soil limitations that interfere with the siting of structures and construction can be identified from the published soil surveys. Complex sites may require a more detailed soil survey by a soil scientist or geologist in order to identify problems not indicated by a general soil survey. Highly erodible soils coupled with the close proximity of a sensitive resource (e.g. public water supply reservoir, cold water fisheries, endangered species habitat) may require greater efforts and costs to control soil erosion and sedimentation.

The data collected during the preliminary site selection process will need to be supplemented and clarified with data collected in the field. This supplemental data collection includes mapping of wetlands by a soil scientist or, in the case of tidal wetlands, a wetlands ecologist. This detailed mapping will confirm soil types and wetland locations. Land surveys to locate property boundaries and to confirm topography and watercourse locations will be needed. Vegetation patterns and conditions both on site and on adjacent areas will need to be determined. Soil borings and/or test pits may be required to determine depth to bedrock, soil bearing strength, subsoil texture and ground water characteristics.

The combined data is used to develop the following maps:

Site Locus Map

A map that shows the site's relationship to roads and other environmental features such as major watercourses. The USGS Quadrangle Map or local street map may be used as the base map for identifying the location of the site.

Detailed Existing Conditions Map

A map or maps of the site where 1 inch represents no more than 100 feet containing detailed information on topography, drainage patterns, soils, existing vegetation, adjacent areas and coastal resources, where appropriate. A map scale of 1" = 40' is generally suitable but may vary depending on site complexity, size of site or requirements of the reviewing agency.

By analyzing the data collected during the review of the existing information and the detailed site investigations, site limitations are identified. The site planner should also be able to determine those areas that will need special consideration during the development of the site plan.

Topography: Show the existing contour elevations at intervals of from 1 to 5 feet depending upon the slope of the terrain. Existing topographic maps (e.g. USGS, local government, or topographic maps from previous proposals) can be a good starting point, however, the information should be verified by a field investigation. On larger tracts of land (generally greater than 25 acres in size) a photogrammetric contour map with 2-foot contour intervals is suggested, especially in areas proposed for intensive development where existing topography may cause serious site limitations.

The topography of any given site is the composite of the physical features that make up the site including slopes and drainage ways and their relationship to each other. Most slopes in their natural vegetated state have achieved a state of stability and are not subject to excessive erosion. When sites are developed and the natural vegetation is removed, the potential for erosion increases dramatically. The longer and steeper the slope, the greater the erosion potential. On sites where soil survey information is available, slope designations appear in the form of a letter within the symbol denoting the soil type. Slopes can also be described as a ratio of rise to run. (See **Land Grading** measure for description of slope ratios and potential limitations created by slope gradients).

Drainage Patterns: Show the location of all existing depressions, drainage swales, permanent and intermittent watercourses, FEMA floodways and 100-year flood boundaries, Stream Channel Encroachment Lines (if any), and buffers established by regulation. Since regulatory buffers vary from town to town, it is important that the site planner consult with the individual town wetland staff or commission early in the development of the site plan.

The site development should be compatible with natural drainage patterns to the fullest extent possible. These drainageways should be used to convey runoff through and off the site to avoid the expense and problems of constructing an artificial drainage system. Man-made ditches and watercourses are prone to erosion if they are not properly designed and constructed.

Increased runoff from the site should not erode or exceed the capacity of existing natural drainage systems both on and off site.

A preliminary analysis of the downstream channel should be used to indicate what effect changes in flow from the completed development site will have within those channels and on other downstream properties. The analysis should consider potential sites for stormwater detention at this time in recognition of applicable regulatory requirements.

However, on-site detention may not be desirable when the site is located in a subwatershed that is positioned in the lower portions of a substantially larger watershed. If detention is located in the lower reaches of a watershed, then there is a risk, depending on the size and release rate of the detention basin, that the peak flow released from the site will be detained long enough to combine with the peak flows from the upper reaches, thus increasing peak downstream flows.

A detailed engineering analysis is required in order to avoid improperly designed and located detention basins using the following steps:

1. Locate the area downstream that is to be targeted for protection from additional runoff. A target area might be a flood prone road crossing, eroding stream bank or reach of stream where homes are currently endangered.

2. Delineate the watershed to the targeted area.

3. Determine where the proposed detention basin will be located within the watershed.

4. Conduct a hydrograph analysis to determine the timing of peak discharges. Use the USDA-Natural Resource Conservation Service's Technical Releases 20 (TR 20) or 55 (TR 55) or other appropriate methods which produce hydrographs that can be used to evaluate existing and post-development conditions.

If the hydrograph analysis indicates that detention is detrimental to the target area, and increases in peak runoff from the development site are expected to adversely affect area between the site and the target area, then other methods to decrease peak flows from the site may be utilized. These include, but are not limited to, infiltration devices such as subsurface galleries, storm water leaching systems, dry catch basins, or retention basins. These are post-construction storm water management practices and are not within the intent of these guidelines. Standard engineering practices for the design criteria for these in-ground measures must be used.

In-ground infiltration devices are useful only as long as the seasonal high water table is at a sufficient depth to allow infiltration. Other methods include decreasing the area of impervious surfaces, using grassed or riprapped waterways instead of storm sewers, leaving wooded buffers, requiring larger lot sizes, or combining these techniques.

Soils: Determine the major soil type(s) on the site and **show** them on the detailed site drawing. General soils information can be obtained from the USDA county soil survey available at most county soil and water conservation district offices. The USDA county soil surveys contain tables that identify soil capabilities and suitabilities for certain management and conservation practices. These tables will help to assist in identifying soil limitations.

For large or complex sites, such as subdivisions with road construction, shopping centers, schools, apartment complexes, and projects with multiple phases, detailed soils investigations are recommended as they provide more comprehensive soils information than that provided in the county soils surveys. When the county soil survey information is determined to be insufficient for design, a detailed soil investigation is required. Detailed soil boundaries are marked in the field by a soil scientist, field located by a land surveyor, and plotted directly onto the map or an overlay at the same scale for ease of interpretation. Inland wetlands can be delineated from this detailed soils information.

Vegetation: Identify and show the existing vegetation types and patterns on the site. Features such as tree clusters, grassy areas, tidal and/or inland wetlands vegetation, and unique vegetation should be shown on the detailed map. In addition, existing exposed soil areas, such as borrow pits, should be indicated.

Coastal Resources and Other Sensitive Areas: If the project is within the coastal area management zone, **identify and show** all coastal resources on-site including tidal wetlands, beach soils, dunes, bluffs, escarpments, coastal flood hazard areas, coastal waters, estuarine embayments, intertidal flats, submerged aquatic vegetation and shellfish concentration areas. If applicable, **identify and show** the location of the high tide line and mean high water.

Other sensitive areas that are not necessarily identified as a coastal watercourse but which need to be identified and mapped include inland wetlands, watercourses in general and watercourses containing cold water fisheries, endangered species habitat identified by the natural diversity database (maintained by the DEP Natural Resources Center) and terrace escarpments located in the Connecticut River valley.

Additionally, **determine** if the site is located within a public water supply watershed area by referring to DEP's Connecticut Natural Resource Atlas Series: Community Water Systems in Connecticut, a 1984 Inventory or reviewing available GIS data. **Show** the watershed boundary on the site locus map. CGS §§ 8-3i and 22a-42f require the applicant to notify the affected water utility of any projects located within the public water supply watershed area.

Minimize direct impact to coastal resources and other sensitive areas.

When the project is located in a public drinking water supply watershed area review the DEP's publications Protecting Connecticut's Water-Supply Watersheds, A Guide For Local Officials, January 1993, and Protecting Connecticut's Groundwater, A Guide For Local Officials, January 1997, DEP Publication # 26. **Identify** measures needed to reduce potential impacts to the public water supply caused by the development activities. It is suggested that a copy of the plan be submitted to the water utility for their review and comments.

Adjacent Areas: Investigate areas adjacent to the site which will either impact or be impacted by the project. Features such as perennial and intermittent streams, roads, houses or other buildings, or wooded areas should be shown. Wetlands, watercourses and downstream culverts which will receive runoff from the site should be located and surveyed to determine their ability to retain or discharge projected runoff. **Identify** sensitive downstream areas, such as existing stream bank erosion, hydraulic constraints, public water supply reservoirs, Aquifer Protection Areas, and in-stream recreation areas. **Identify** approved and future development site(s) in the upper watershed area.

In addition to the hydraulic concerns raised in the Drainage Patterns subsection, **evaluate** the environmental conditions in areas down slope and up slope from the construction project. The potential for sediment deposition on down slope properties should be analyzed so that appropriate erosion and sediment controls can be planned. Down slope wetlands and watercourses (especially those containing drinking water reservoirs or cold water fisheries habitat) which will receive runoff from the site are concerns.

Drainage conditions up slope or off site from a proposed embankment cut need to be checked to insure that the cut does not eliminate a hydrologic and hydrogeologic feature. These features could be providing for flood storage and/or water quality renovation on or adjacent to the site. Additionally, drainage swales and depressions that traverse the cut area will require an engineered design to ensure channel stability both on and off site.

Principles of Site Planning for Erosion and Sediment Control

The primary function of erosion and sedimentation controls is to absorb erosional energies and reduce runoff velocities that force the detachment and transport of soil and/or encourage the deposition of eroded soil particles before they reach any sensitive area. Erosion and sedimentation control principles are all formulated on the premise that it is easier, cheaper and less environmentally damaging to reduce soil detachment in the first place than it is to control its transport and deposition or to remediate damage after it occurs. Specific control measures are discussed in detail in Chapter 5 of these Guidelines.

After reviewing the data and determining the site limitations, the planner can then develop a site plan. This plan is based upon basic erosion and sediment control principles. These principles are as follows:

Plan Development to Fit Environmental Conditions

Start by selecting a site that is suitable for a specific proposed activity. Sites with resource limitations should be developed in conformance with the capacity of the site to support such development, rather than by attempting to modify a site to conform to a proposed activity.

- ❍ *Utilize the existing topography.*
- ❍ *Align roads on the contour wherever possible and use them to divert surface water, thereby reducing slope lengths.*
- ❍ *Concentrate development on flattest area of the site to avoid excessive slope cuts or fills where possible.*
- ❍ *Avoid steep slopes and soils with severe limitations for the intended uses. If there are no feasible alternatives to avoiding steep slopes and/or erodible soils, sound engineering practices should be employed to overcome the site limitations. For example, long steep slopes need to be broken up by benching, terracing or diversions to avoid erosion problems. Seeps emanating from cut slopes will need provisions for internal drainage to prevent slope failure.*
- ❍ *Avoid flood prone areas, wetlands, beaches, dunes and other sensitive areas and when possible keep floodplains free of fill or obstructions.*
- ❍ *Keep stockpiles, borrow areas, access roads and other land-disturbing activities away from critical areas (such as steep slopes and highly erodible soils) that drain directly into wetlands and water bodies.*
- ❍ *Avoid siting buildings in drainage ways, over watercourses and over storm drainage systems.*
- ❍ *Utilize the natural drainage system whenever possible. If the natural drainage system of a site can be preserved instead of being replaced with piped storm sewers or concrete channels, the potential for downstream damages from increased runoff can be minimized, making compliance with storm water management criteria easier.*

Keep Land Disturbance to a Minimum

The more land that is kept in vegetative cover, the more surface water will infiltrate into the soil, thus minimizing stormwater runoff and potential erosion. Keeping land disturbance to a minimum not only involves minimizing the extent of exposure at any one time, but also the duration of exposure. Phasing, sequencing and construction scheduling are interrelated. **Phasing** divides a large project into distinct sections where construction work over a specific area occurs over distinct periods of time and each phase is not dependent upon a subsequent phase in order to be functional. A **sequence** is the order in which construction activities are to occur during any particular phase. A sequence should be developed on the premise of "first things first" and "last things last" with proper attention given to the inclusion of adequate erosion and sediment control measures. A **construction schedule** is a sequence with time lines applied to it and should address the potential overlap of actions in a sequence which may be in conflict with each other.

- *Cluster buildings to minimize the amount of disturbed area, concentrate utility lines and connections in one area, and provide for more open space. The cluster concept not only lessens the area subject to erosion, but reduces potential increases in runoff, and generally reduces development costs.*

- *Limit areas of clearing and grading by concentrating construction activities on the least critical or sensitive areas. Protect natural vegetation from construction equipment with fencing, tree armoring, and retaining walls or tree wells.*

- *Route traffic patterns within the site to avoid existing or newly planted vegetation.*

- *Phase developments so that areas which are actively being developed at any one time are minimized and only that area under construction is exposed. Clear only those areas essential for construction. Consider restricting the start of a later phase contingent upon the completion of a prior phase. At any given point of time, when the disturbed area exceeds 5 acres and drains to a common point of discharge the construction of a sedimentation basin is indicated. Restrictive phasing can sometimes keep the disturbed area below this 5 acre threshold.*

- *Sequence the construction of storm drainage and sewer systems so that they are operational as soon as possible during construction. Ensure all outlets are stable before outletting storm drainage flow into them. See Chapter 4 for examples of sequences for large construction sites.*

- *Schedule construction so that final grading and stabilization is completed as soon as possible. Include early stabilization or covering of stockpiled topsoil or other erosive materials when they will not be used within 30 consecutive days. Grading and stabilization of steep slopes and erodible soils with severe limitations should be sequenced early in the construction so that grading work proceeds from the highest to lowest elevation.*

- *Schedule construction where possible to avoid disturbing large or critical areas during frozen ground conditions (December to February) and spring thaw (February to early March).*

- *Use planning tools such as flow charts, Critical Path Method (CPM) or Gantt Charts (see Appendix G) to develop feasible sequences and schedules in the most environmentally sound and cost effective way. Additionally, they can be used by financial lenders to develop funding schedules.*

- *Schedule the implementation of erosion and sediment controls so that they are timed to match the erosion and sediment needs created by the sequencing in each phase.*

Slow the Flow

Detachment and transport of eroded soil must be kept to a minimum by absorbing and reducing the erosive energy of water. The erosive energy of water increases as the volume and velocity of runoff increases. The volume and velocity of runoff increases during development as a result of reduced infiltration rates caused by the removal of existing vegetation, removal of topsoil, compaction of soil and the construction of impervious surfaces.

- *Minimize impervious areas. Encourage infiltration where appropriate*[3]*. Keep paved areas such as parking lots and roads to a minimum. This complements cluster developments in eliminating the need for duplicating parking areas, access roads, and other impervious areas.*

- *Keep in mind that increases in runoff may require control measures or channel improvements.*

- *Use diversions, stone dikes, silt fences and similar measures to break flow lines and dissipate storm water energy.*

- *Consider collecting and detaining runoff when there is an increased potential for flooding and resultant damage to downstream facilities.*

- *Avoid diverting one drainage system into another without calculating the potential for downstream flooding or erosion.*

- *Perform runoff calculations to determine the effect of the development on the existing hydraulic system. Make changes where necessary to avoid downstream damage and to comply with runoff requirements of the municipal reviewing agency.*

- *Determine the potential need for detention basins. Attempt to locate detention basins outside of floodplains, wetlands and water courses, and adjacent to steep escarpments.*

[3] Slope stability and soil permeability must be considered when considering infiltration options.

Keep Clean Runoff Separated

Clean runoff should be kept separated from sediment laden water and should not be directed over disturbed areas without additional controls. Additionally, prevent the mixing of clean off-site generated runoff with sediment laden runoff generated on-site until after adequate filtration of on-site waters has occurred.

- *Segregate construction waters from clean water.*
- *Divert site runoff to keep it isolated from wetlands, watercourses and drainage ways that flow through or near the development until the sediment in that runoff is trapped or detained.*

Reduce on Site Potential Internally and Install Perimeter Controls

While it may seem less complicated to collect all waters to one point of discharge for treatment and just install a perimeter control, it can be more effective to apply internal controls to many small sub-drainage basins within the site. By reducing sediment loading from within the site, the chance of perimeter control failure and the potential off-site damage that it can cause is reduced. It is generally more expensive to correct off-site damage than it is to install proper internal controls.

- *Control erosion and sedimentation in the smallest drainage area possible. It is easier to control erosion than to contend with sediment after it has been carried downstream and deposited in unwanted areas.*
- *Direct runoff from small disturbed areas to adjoining undisturbed vegetated areas to reduce the potential for concentrated flows and increase settlement and filtering of sediments.*
- *Concentrated runoff from development should be safely conveyed to stable outlets using riprapped channels, waterways, diversions, storm drains or similar measures.*
- *Design conveyance systems to withstand the velocities of projected peak discharges.*
- *Determine the need for sediment basins. Sediment basins are required on larger developments where major grading is planned and where it is impossible or impractical to control erosion at the source.[4] Sediment basins are needed on large and small sites when sensitive areas such as wetlands, watercourses, and streets would be impacted by off-site sediment deposition. Do not locate sediment basins in wetlands or permanent or intermittent watercourses. Sediment basins should be located to intercept runoff prior to its entry into the wetland or watercourse.*
- *Grade and landscape around buildings and septic systems to divert water away from them.*

Implement a Thorough Maintenance and Follow up Program

Having a failing E&S measure that is not promptly repaired is like having no control at all. A site cannot be effectively controlled without thorough periodic checks of the erosion and sediment control measures and repairs of failures. These measures must be maintained just as construction equipment must be maintained and materials checked and inventoried. Monitoring and maintenance of erosion and sediment controls is essential to the success of an E&S plan.

Select Erosion and Sediment Control Measures

Erosion and sedimentation controls are used to dissipate erosive energies, requiring that their performance and structural limitations be considered. Increases in runoff occurring during development are caused by reduced infiltration resulting from the removal of vegetation, the removal of topsoil, compaction and the construction of impervious surfaces. These increases must be taken into account when providing for erosion control.

The selection of erosion and sediment control measures consists of the following four steps:

Step 1. Identify problem areas.
Step 2. Identify the control problems.
Step 3. Identify a strategy or strategies for each problem.
Step 4. Select appropriate measures from the control groups.

On Page 3-11 is a matrix to guide the selection of soil erosion and sediment control measures. Following the measure selection matrix in steps from left to right, the user can identify the potential problems and solutions for control of these problems. To use the measure selection matrix follow the four basic steps:

[4] For requirements, see the current General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities issued by the DEP

Step 1:
Identify Problem Areas - Areas where erosion will need to be controlled will usually fall into categories of disturbed areas, drainage ways and dewatering operations.

Step 2:
Identify Control Problems - Problems fall into the three broad categories of soil detachment, water and sediment transport and sediment deposition. Identify the type of erosion the problem area is expected to experience.

- *For areas having rain drop erosion, sheet erosion or rill erosion focus on controlling sediment detachment.*
- *For areas expected to experience gully erosion or concentrated flows focus on controlling water movement.*
- *For areas where soil detachment can not be prevented due to construction limitations focus on controlling sediment deposition.*

Step 3:
Identify Strategy - Select a strategy or strategies to control the problem, using the measure selection matrix as a guide.

There may be several strategies used individually or in combination to provide the solution. For example, if a cut slope is to be protected, the strategies may be to conserve existing site resources, protect the exposed surface, direct water from the slope, detain sediments at the toe of the slope, or any combination thereof. If no water except that which falls directly on the slope has the potential to cause erosion and if the slope is relatively short, protecting the soil surface may be all that is required to solve the problem.

Structures are generally more costly than vegetative controls. However, they are often necessary since not all disturbed areas can be protected with vegetation. Structural measures are often used as a second or third line of defense to capture suspended sediment before it leaves the site.

Step 4:
Select the Appropriate Measures from the Control Groups - Once strategies to solve the erosion and sediment problem are identified, the measure selection matrix leads to the group or groups of control measures that will accomplish each strategy. Control measures within each group have a similar function. Therefore, any measure within a group could address the problem in question.

The final step in erosion and sediment control planning is selecting the measure(s) within a group(s) that address the specific erosion and sediment problem. Select the measures which are most effective and feasible for the site.

Once the specific measures have been selected, the plan key symbols given in the measure selection matrix can be placed on the erosion and sediment control drawings to show where the measures will be applied or installed. Standardized design, plan, and construction specification sheets can then be completed for each control measure.

Part III E&S Plan Requirements

Plan Format

The E&S plan should be an integral part of the overall site plan. However, for the purposes of review, certification, bonding and enforcement, the E&S plan narrative and drawings should be developed so that they can be separated from the overall site plan (which include construction drawings), as needed, to facilitate their use. On non-complex projects, the E&S plan need not be separate if clarity of information is maintained.

To facilitate plan review, certification, implementation, and the construction inspection process:

1. Place the information needed for construction on the construction drawings or in the specifications package.
2. Make all construction drawings for a specific project the same size sheets.
3. Make the soil erosion and sediment control drawings a part of the overall construction drawings for the project.
4. For larger projects, show the installation requirements and specifications for measures to be used on a separate sheet from the plan view sheets. For small projects, if room allows for details to be clearly shown, placing details on the plan view sheet can be advantageous.
5. Place the phases of development, associated sequences of major operations, and maintenance program during construction either in the narrative portion of the plan or on the construction drawings. (See Appendix G on the use of Gantt diagram and critical path flow charts)
6. Attach all supporting information, such as design calculations, boring logs, test pit logs, percolation or permeability results to the narrative. Show the location of all borings, test pits, percolation tests and permeability holes on a separate drawing. For simple projects show them on the erosion and sediment control drawings.

Figure 3-2 Measure Selection Matrix

Identify Problem Areas	Identify Control Problems	Identify Strategy	Select Specific Measure		Plan Key
			Functional Group	Measure	
	Control Soil Detachment	Preserve and Conserve Existing Site Resources	Protect Vegetation	Tree Protection	TP
			Preserve and Conserve Soil	Topsoiling	TO
Disturbed Areas				Land Grading	LG
	Raindrop Splash			Surface Roughening	SR
Short or Shallow Slopes				Dust Control	DC
	Sheet & Rill Erosion	Protect Surface	Vegetative Soil Cover	Temporary Seeding	TS
				Permanent Seeding	PS
	Wind Erosion			Sodding	SO
				Landscape Planting	LP
Steep Slopes			Non-Living Soil Protection	Temporary Soil Protection	TSP
				Mulch for Seed	MS
				Landscape Mulch	LM
Long Slopes				Temporary Erosion Control Blanket	ECB
				Permanent Turf Reinforcement Mat	TRM
				Stone Slope Protection	SSP
		Protect Surface and/or Convey Runoff	Stabilization Structures	Retaining Walls	RW
Stockpile Areas				Riprap	RR
	Control Water Movement			Gabions	G
				Permanent Slope Drain	PSD
Borrow Areas				Channel Grade Stabilization Structure	CSS
	Gully Erosion			Temporary Lined Chute	TC
				Temporary Pipe Slope Drain	TSD
	Channel & Stream Erosion		Drainageways and Watercourses	Vegetated Waterway	VW
Drainage Ways		Convey Runoff		Temporary Lined Channel	TLC
				Permanent Lined Waterway	PW
				Temporary Stream Crossing	TSC
Wetlands and Watercourses		Direct Runoff	Diversions	Temporary Fill Berm	TFB
				Water Bar	WB
				Temporary Diversion	TD
				Permanent Diversion	PD
Waterbodies		Intercept Grnd. Water	Subsurface Drains	Subsurface Drain	SD
		Detain Runoff	Detention Structures	Detention Basin	DB
Areas of Flooding and Existing Erosion	Natural Resource Degradation	Diffuse Runoff	Energy Dissipators	Level Spreader	LS
				Outlet Protection	OP
				Stone Check Dam	SCD
	Control Sediment Deposition	Detain Sediments	Sediment Impoundments, Barriers, and Filters	Temporary Sediment Basin	SB
				Temporary Sediment Trap	TST
				Hay Bale Barrier	HB
Drainage Outlets	Protect Onsite and Offsite Areas			Geotextile Silt Fence	GSF
				Turbidity Curtain	TC
				Vegetative Filter	VF
Travel Areas		Control Mechanically Moved Waters and Soils	Tire Tracked Soils	Construction Entrance	CE
			Dewatering	Pump Intake and Outlet Protection	PuP
				Pumping Settling Basin	PSB
Dewatering				Portable Sediment Tank	PST
				Dewatering of Earth Materials	DWM

Monitoring and Maintenance

The E&S plan and any revisions, shall identify an agent or agents who have the responsibility and authority for the implementation, operation, monitoring and maintenance of E&S measures. Such agent(s) shall be familiar with each control measure used including its limitations, installation, inspection and maintenance. When control measures fail, or are found to be otherwise ineffective, such agent(s) shall coordinate plan revisions with a professional experienced in erosion and sediment control and any approving agency when that agency's approval is required. Such agent(s) shall have the additional responsibility for ensuring all erosion and sediment controls are properly installed and maintained the construction site before predicted major storms. A major storm is defined as a storm predicted by the National Office of Atmospheric Administration (NOAA) Weather Service with warnings of flooding, severe thunderstorms or similarly severe weather conditions or effects.

Each measure has inspection requirements included in the measure's section entitled "Maintenance". Many of the measures require inspections at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater; some others require daily inspection. Only the permanent measures have less frequent inspections. More frequent inspections than those identified in the measure may be necessary for sites that are heavily traveled and before major storms.

E&S Plan Checklists

These checklists are intended to be of assistance in preparing and approving E&S plans, and serve as a reminder of major items that typically need to be considered when developing the plan.

1. Narrative

1.1 Purpose and description of project.

1.2 Estimates of the total area of the project site and the total area of the site that is expected to be disturbed by construction activities.

1.3 Identification of site-specific erosion or sediment control concerns and issues.

1.4 The phases of development if more than one phase is planned

1.5 The planned start and completion dates for each phase of the project.[5]

1.6 Either provide or identify where in the E&S plan the following information is found:

- 1.6.1 the design criteria, construction details and maintenance program for the erosion and sediment control measures to be used,
- 1.6.2 the sequence of major operations within each phase, such as installation of erosion control measures, clearing, grubbing, excavation, grading, drainage and utility installation, temporary stabilization, road base, paving for roadways and parking areas, building construction, permanent stabilization, removal of temporary erosion control measures
- 1.6.3 The time (in days) required for the major operations identified in the sequence

1.7 Identify other possible local, state and federal permits required.

1.8 Identify the conservation practices to be used.

1.9 A listing of all other documents to be considered part of the E&S plan (e.g. reports of hydraulic and hydrologic computations, boring logs, test pit logs, soils reports, etc.)

2. Support Documents (as may be needed to support Engineering Designs)

2.1 Hydraulic Calculations

- 2.1.1 Size and locations of existing and planned channels or waterways with design calculations and construction details.
- 2.1.2 Existing peak flows with calculations
- 2.1.3 Planned peak flows with calculations
- 2.1.4 Changes in peak flows
- 2.1.5 Off-site effects of increased peak flows or volumes
- 2.1.6 Design calculations and construction details for engineered measures used to control off-site erosion caused by the project
- 2.1.7 Design calculations and construction details for engineered measures used to control erosion below culverts and storm sewer outlets
- 2.1.8 Design calculations and construction details for engineered measures used to control groundwater, i.e. seeps, high water table, etc.

2.2 Boring logs, test pit logs, soils reports, etc.

3. Site Drawing(s) Checklist

3.1 Jurisdictional Features Required on All Maps or Drawings

- 3.1.1 North arrow
- 3.1.2 Scale (including graphical scale)
- 3.1.3 A title block containing the name of the project, the author of the map or drawing, the owner of record for the project, date of drawing creation and any revision dates
- 3.1.4 Property lines
- 3.1.5 Legend identifying the symbols used
- 3.1.6 For plans containing E&S measures which require an engineered design, the signature and seal of a professional engineer licensed to practice in Connecticut

3.2 Site Locus Map

- 3.2.1 Scale (1:24,000 recommended)
- 3.2.2 Project location (show property boundaries and at least the area that is within 1000 feet of the property boundaries)
- 3.2.3 Roads, streets/buildings
- 3.2.4 Major drainage ways (at least named watercourses)
- 3.2.5 Identification of any public drinking water supply watershed area

3.3 Topography, Natural Features and Regulatory Boundaries

- 3.3.1 Existing contours (2 foot intervals)
- 3.3.2 Planned grades and elevations

[5] These are often subject to change depending on markets, financing, permit approvals and weather conditions. A change in a start date can cause a restriction or prohibition in the use of proposed measures, and thereby require revisions to the E&S plan.

- 3.3.3 Limits of cuts and/or fills
- 3.3.4 Soils, bedrock
- 3.3.5 Seeps, springs
- 3.3.6 Inland wetlands boundaries
- 3.3.7 FEMA identified floodplains, floodways and State established stream channel encroachment lines
- 3.3.8 Streams, lakes, ponds, drainage ways, dams
- 3.3.9 Existing vegetation
- 3.3.10 Tidal wetland boundaries and coastal resource limits (e.g. mean high water, shellfish beds, submerged aquatic vegettion, CAM boundary)
- 3.3.11 Public water supply watershed, well heads or aquifer boundaries (when available)

3.4 Drainage Patterns

- 3.4.1 Existing and planned drainage patterns (including offsite areas
- 3.4.2 Size of drainage areas
- 3.4.3 Size and location of culverts and storm sewers (existing and planned)
- 3.4.4 Size and location of existing and planned channels or waterways
- 3.4.5 Major land uses of surrounding areas

3.5 Road and Utility Systems

- 3.5.1 Planned and existing roads and buildings with their location and elevations
- 3.5.2 Access roads: temporary and permanent
- 3.5.3 Location of existing and planned septic systems
- 3.5.4 Location and size of existing and planned sanitary sewers
- 3.5.5 Location of other existing and planned utilities, telephone, electric, gas, drinking water wells, etc.

3.6 Clearing, Grading, Vegetation Stabilization

- 3.6.1 Areas to be cleared, and sequence of clearing
- 3.6.2 Disposal of cleared material (off-site and on-site)
- 3.6.3 Areas to be excavated or graded, and sequence of grading or excavation
- 3.6.4 Areas and acreage to be vegetatively stabilized (temporary and/or permanent)
- 3.6.5 Planned vegetation with details of plants, seed, mulch, fertilizer, planting dates, etc.

4. Erosion & Sediment Control Drawings

4.1 Location of E&S measure on site plan drawing with appropriate symbol

4.2 Construction drawings and specifications for measures

4.3 Maintenance requirements of measures during construction of project

4.4 Person responsible for maintenance during construction of project

4.5 Maintenance requirements of permanent measures after project completion

4.6 Organization or person responsible for maintenance of permanent measures having the authority to maintain and upgrade control measures as designed or as needed to control erosion and sedimentation

4.7 Handling of emergency situations (e.g. severe flooding, rains or other environmental problems).

4.8 If not provided in the narrative, the information listed in check list paragraph 1.6 (see Narrative heading)

TO MAIN TOC

4 Large Construction Site Sequences and Special Treatments

Large Construction Site Sequences and Special Treatments

TO MAIN TOC

Large Construction Site Sequences and Special Treatments Introduction

This chapter provides samples of sequences of activities for large construction sites and discussions on difficult soil erosion and sediment control problems which can require a combination of measures. The actual sequence used may be different than those listed below to fit a specific project or field conditions. This information supplements the guidance provided in Chapter 3 regarding the development of an erosion and sediment control plan.

Part I: Large Construction Site Sequences

Part I addresses sites where major construction activities (earthmoving, extensive drainage work or land grading) will involve heavy earthmoving equipment and when construction may last more than one construction season (typically March through December). Projects with a total land disturbance of 5 acres or greater are considered to be large construction sites. Smaller sites may also require sequencing, particularly if they involve large cuts or fills, sensitive sites, or complex construction activities. Typical construction sequences are provided for the following types of large construction projects:

New Roadway Construction
Large Building Sites and Parking Areas
Underground Utility Lines

Phasing is encouraged for large construction sites, with each phase containing its own construction sequence. To phase a project is to break the proposed work into distinct sets of activities wherein the work completed in an earlier phase is not dependent upon the completion of a later phase to make the earlier phase functional. In other words, if a later phase was not completed for any reason, the initial development phase could be considered complete by itself. A phased project does not mean that a given location cannot be involved in several phases of construction. A location on a site included in a phase may also be involved with a later phase of construction.

For example, a 100 unit condominium complex may be broken into several phases: the first phase involving the construction of a portion of the primary access road, a detention basin, two buildings containing 20 units and borrowing fill materials from the final phase building site; a second phase involving the extension of the primary access road, recreational facilities and six buildings containing 60 condominium units; and a final phase to complete the primary access road and two buildings containing the last 20 units.

Each phase of construction, regardless of the number of sequences it contains, requires a preconstruction meeting that should include the owner of record or authorized agent, the contractor, town engineer, wetlands agent, utility representatives, project engineer, and the agent or agents who have the responsibility and authority for the implementation, operation , monitoring and maintenance of the erosion and sediment controls. The purpose of the preconstruction meeting is to make all responsible parties of a project aware of the project's needs so that resources can be properly distributed and to identify limitations and restrictions. The preconstruction meeting may identify modifications needed to the construction sequence and the application of special treatments. Include in the preconstruction meeting agenda, at a minimum, a review of plans, permit conditions, the contractors' sequences and schedules for construction, site restrictions and other special needs.

The sequences provided in these Guidelines shall be adjusted to specific project needs, site conditions and regulatory requirements. These sequences assume work to be continuous and without delay. When work is suspended within the sequence, additional erosion and sediment controls may be required to secure the site. Erosion and sediment controls are installed and maintained as dictated by the construction schedule and as identified by the E&S plan. Inspection frequencies are site specific and are not included in the sequences given here. Additional erosion and sediment control may be required depending on site conditions.

New Roadway Construction

This sequence applies to a single phase of new roadway construction.

1. Flag the limits of construction, roadway base-line, right-of-way and tree protection zones.

2. Hold preconstruction meeting. (Remember to call before you dig 1-800-922-4455).

3. Hold tree cutting meeting.

4. Install the construction entrance.

5. Install perimeter erosion and sediment controls and tree protection devices in accordance with the E&S plan.

6. Cut trees within the defined clearing limits and remove cut wood. Chip brush and slash, stockpile chips for future use or remove off site.

7. Construct sediment basins.

8. Excavate all stumps located in the structural area and remove to a disposal site or stockpile area to be chipped. Stumps in non-structural areas may be ground in place or cut flush with the ground level and left in place in accordance with the plans. (Note: for DOT projects stumps in non-structural areas left in place are required to be in fill areas at least 5 feet deep.)

9. Strip all topsoil within the right-of-way and slope limits. Stockpile all topsoil in an approved area and secure with erosion and sediment controls. (See Chapter 4, Part II on Stockpile Management).

10. Cut or fill the proposed roadway to establish the sub-grade.

11. Install all sanitary sewers and drainage facilities starting at the outfall and proceeding upgrade. Install remaining utilities (water, gas, electric, cable, fiber optic, telephone). Ensure that the drainage outlet protection is in place prior to any flow being allowed to discharge.

12. Place, grade and compact the processed aggregate in the roadway base.

13. Topsoil and grade in all slope areas to within 2 feet of the proposed curbing.

14. Install first course of bituminous concrete.

15. Install curbing if required.

16. Apply stabilization measures to remaining disturbed areas in accordance with the erosion and sediment control plan (topsoil, seeding, sodding, mulching, etc.)

17. Inspect and clean drainage system, as needed.

18. Install the final course of bituminous concrete pavement.

19. After roadway shoulders are stabilized in accordance with the applicable E&S measure, remove temporary erosion and sediment controls (e.g. geotextile silt fences).

Limitations of Sequence:
This sequence is for new roadway construction on undisturbed land. Roadway reconstruction requires a more complex sequence that includes such items as maintenance and protection of traffic.

Large Building Sites and Parking Areas

This sequence applies to any building site or a single phase of a multi-phase project.

1. Flag the limits of construction necessary to facilitate the preconstruction meeting.

2. Hold preconstruction meeting. (Remember to call before you dig 1-800-922-4455).

3. Flag remainder of the limits of construction and tree protection zones.

4. Install the construction entrance.

5. Install perimeter erosion and sediment controls and tree protection devices in accordance with the E&S plan.

6. Cut trees within the defined clearing limits and remove cut wood. Chip brush and slash, stockpile chips for future use or remove off site.

7. Construct sediment basins.

8. Strip and stockpile all topsoil that is within the footprint of the construction site and reference stockpile management for erosion and sediment controls. (See Chapter 4, Part II on stockpile management). Either remove tree stumps to an approved disposal site or chip in place as indicated on the plans.

9. Make all cuts and fills required. Establish the subgrade for the topsoil areas, parking and roadway as required and bench the building to a subgrade. Allow a reasonable amount of area around the footprint of the building for the construction activities.

10. Begin construction of the building.

11. Prior to installing surface water controls such as temporary diversions and stone dikes, inspect existing conditions to ensure discharge locations are stable. If not stable, review discharge conditions with the design engineer and implement additional stabilization measures prior to installing water surface controls.

12. Install all sanitary sewers, drainage systems and utilities to within 5 feet of the building or as otherwise modified by the design engineer to adjust for unforseen site conditions.

13. Prepare sub-base, slopes, parking areas, shoulder areas, access roads and any other area of disturbance for final grading.

14. Install process aggregate in parking areas.

15. Place topsoil where required. Complete the perimeter landscape plantings.

16. Fine grade, rake, seed and mulch to within 2 feet of the curbing.

17. Upon substantial completion of the building, complete the balance of site work and stabilization of all other disturbed areas. Install first course of paving.

18. When all other work has been completed, repair and sweep all paved areas for the final course of paving. Inspect the drainage system and clean as needed.

19. Install final course of pavement.

20. After site is stabilized remove temporary erosion and sediment controls (e.g. geotextile silt fences).

Limitations of this sequence:
This sequence does not include the construction of an access road. (See New Roadway Construction Sequence). It is not for previously disturbed sites. For redevelopment of existing building site(s) expect the sequence to be more complex. Separate sequences are required when the construction of multiple buildings are planned to occur in phases.

Utility Projects

This sequence applies to the initial construction or reconstruction of utility projects in developed or undeveloped areas. These utilities may include, but are not limited to, sewer, water, subsurface drainage, gas, electric, telephone and cable.

1. Flag the limits of construction necessary to facilitate the preconstruction meeting.

2. Hold preconstruction meeting. (Remember to call before you dig 1-800-922-4455).

3. Flag the remainder of the limits of construction and tree protection zones in the field.

4. Secure the areas from vehicular traffic and pedestrian access. Provide for traffic and pedestrian control.

5. Install all erosion and sediment controls and tree protection devices in accordance with the E&S plan.

6. Saw cut pavement or concrete as shown on the plans.

7. Excavate trench, stockpile suitable materials. Use dewatering measures as needed. Remove unsuitable materials to a secured stockpile area. Whenever practicable, excavate no more than the linear feet of the construction project that can be completed and backfilled in the course of a normal workday.

8. Install utilities per the design plan.

9. Backfill the trench with materials that meet the specification standards and required compaction.

10. Restore paved areas and apply stabilization measures in accordance with the E&S plan (topsoil, seeding, sodding, mulching, etc.).

11. On a daily basis repeat Items 6 through 10.

12. After site is stabilized, remove temporary erosion and sediment controls (e.g. geotextile silt fences).

Limitations of Sequence:
Utility installation as it stands today is very complex, due to existing conditions. It is essential that the above outlined sequence be used to meet the site conditions as they exist. Dewatering and handling of surplus materials as well as blasting require sensitive sequencing and methods.

Part II: Special Treatments

Infrequent, but not uncommon conditions, that occur or can be expected to develop on a construction site generally require the integrated use of several measures. The special conditions reviewed here include:

Water Management Within Slopes
(Slope Stability & Infinite Slope Failure)
Stockpile Management
Stream Deflectors
Construction Access Road
Utility Stream Crossing
Soil Bioengineering for Stabilization

The limitation and restrictions for each E&S measure used in the following special treatments shall be taken into consideration to determine the overall effectiveness.

Water Management Within Slopes

This section is not intended to be a design text, but this section will prove useful to the designer and the regulator in defining the parameters to be looked at and investigated during the design phase of a slope. If the slope already exists then this section may be used to gain some insight into the long term stability of the slope.

There are three different types of slopes discussed in this section. They are the cut slope, the fill slope, and the existing slope. Most situations should be covered within the text on one of these slope types.

Cut Slopes or Cuts into Existing Slopes

Before the extent and depth of the cut are determined, the following information should be gathered. In some instances portions of the following information may not be required. In those cases, detailed descriptions of the reasons for not gathering the information should be given.

Look at the undisturbed slope, if one exists. Look for signs of sloughing, sliding, and seepage. This information may prove important in determining the reaction of the slope to the proposed changes. With an undisturbed slope, determine the degree of slope. It may also prove helpful to determine the type of vegetation growing on the existing slope.

Investigate the underlying material. This could be done by using existing soil surveys, existing borings or test pits in the area. If this information does not exist then information should be gathered by borings or test pits. Keep in mind that the extent of the information should not stop at the proposed toe of slope, but should extend below the proposed bottom of the excavation.

Evaluate the soil layers for engineering characteristics. This can be performed in the field but is more likely to be performed in a laboratory to determine soil properties such as composition, permeability, and friction angle. These properties should be evaluated for each different type of soil encountered in the borings.

In the design, minimize the amount of water that will be allowed to flow towards and onto the proposed slope. Several measures exist within these guidelines to help limit the amount of water received on the embankment, (e.g., **Temporary Pipe Slope Drain**, **Temporary Lined Chute**).

Slope of Placed Fill

As in the preceding section, the following information should be gathered before final design is achieved.

Determine the purpose of the fill. Will it need to support a building foundation? Will additional fill be added at some future time? It is important to recognize the limitations of the specific fill which is to be used. It is best to compact the fill in layers (known as lifts). The extent and precision of the compaction will depend on the future use of the fill. It is often critical to strip existing topsoil and organic material off the existing slope and foundation area before filling takes place.

The designed slope angle must be suitable for the material that will be utilized. In some designs the toe of the fill slopes can be protected with riprap to allow an increase in the slope of the fill. The riprap can also be used to protect the slope from the erosive effects of water flow.

In a best case scenario, the fill should be from one source and be of homogeneous material. If several types of material are to be used, then it is important to make logical decisions on the placement sequence. For instance, it is unwise to place several layers of sand against a natural slope, only to backfill down slope of the sand with a fine silt or clay without providing adequate drainage.

It will be important to notice field conditions in the area of the proposed fill. One of the things to look for is the proximity of the fill to any existing slopes. It is important to notice existing drainage patterns above your site. Filled slopes should not be subjected to concentrated overland flow.

Failure of an Existing Slope:

In many cases natural and manmade slopes show signs of failure. Among these signs are cracks in the downgradient slope, cracks in the ground surface at the top of the slope running parallel to the break in slope, bulges or piles on the slope and hollow areas on the slope. Sometimes slopes fail after or during a heavy rain, or fail during spring months when the groundwater table is high. It is important to look at the timing of the failure to see if that information offers any clues to the mode of failure. If the location is critical, these slopes will need to be repaired or stabilized.

Seepage and water are big factors in many slope failures. If seepage or overland flow is causing or worsening the slope condition, use engineered measures whose strategy is to convey runoff, direct runoff, and intercept groundwater (see Measure Selection Matrix, Chapter 3).

Precautions should be taken to prevent accumulated water from flowing on or down the slope.

Possible Repair Designs

The actual construction techniques used for the repair of some slope failures can be simple. These designs are all made up of a combination of systems found within these Guidelines. Some of the design components can be changed and modified to fit the situation or the preferences of the designer.

Figure 4-1, **Figure 4-2** and **Figure 4-3** illustrate three different designs for the repair of slope failures that integrate the use of several E&S measures to create a stable slope. **Figure 4-1** shows a drainage blanket covered with 4" to 6" of topsoil. **Figure 4-2** shows the use of gabions. When slope stabilization is associated with a waterway, this method can be modified to include the addition of topsoil above the expected water surface within the waterway as illustrated in **Figure 4-1**. Drains shown in **Figure 4-3** intercept subsurface water in a series of subsurface drains to create a stable slope.

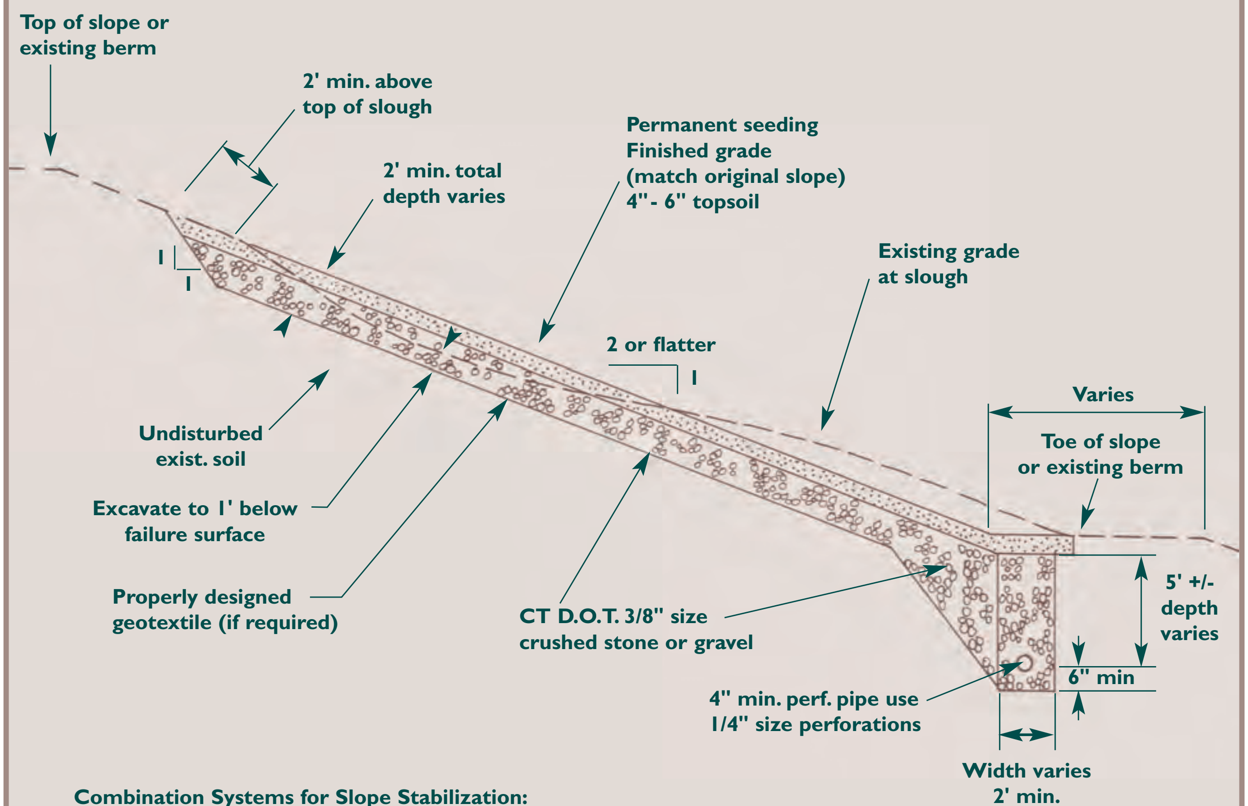
There are many parameters that need to be considered in the design of stable slopes. These Guidelines are not meant to be an all inclusive design manual, but are meant to assist engineers and regulators in asking appropriate questions of themselves and the designers during design review and construction of projects resulting in new slopes.

Depending on site conditions, the designer may want to use the "Infinite Slope Analysis", "Bishop's Slip Circle", or "Sliding Wedge Analysis".

Measures used to address water management within slopes for initial slope design and for the repair of slope failures include **Land Grading**, **Subsurface Drain**, **Permanent Diversion** with **Subsurface Drain** and any of the slope stabilization measures in the Stabilization Structures Functional Group.

Figure 4-1 Slope Repair Example 1: Using Drainage Blanket Covered with Topsoil

Not to Scale



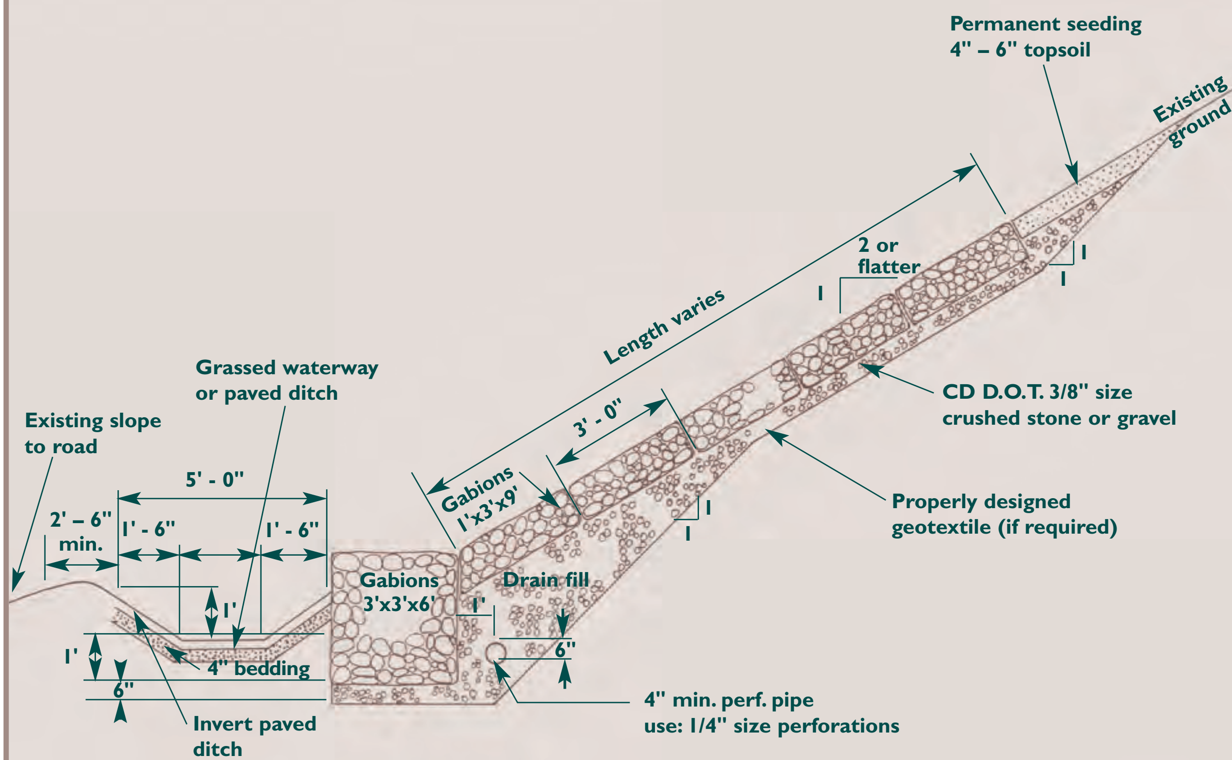
Combination Systems for Slope Stabilization:
E&S Measures Include:

PS Permanent Seeding
TO Topsoiling
SP Stone Slope Protection
SD Subsurface Drain

Source: USDA-NRCS

Figure 4-2 Slope Repair Example 2: Using A Gabion Blanket

Not to Scale

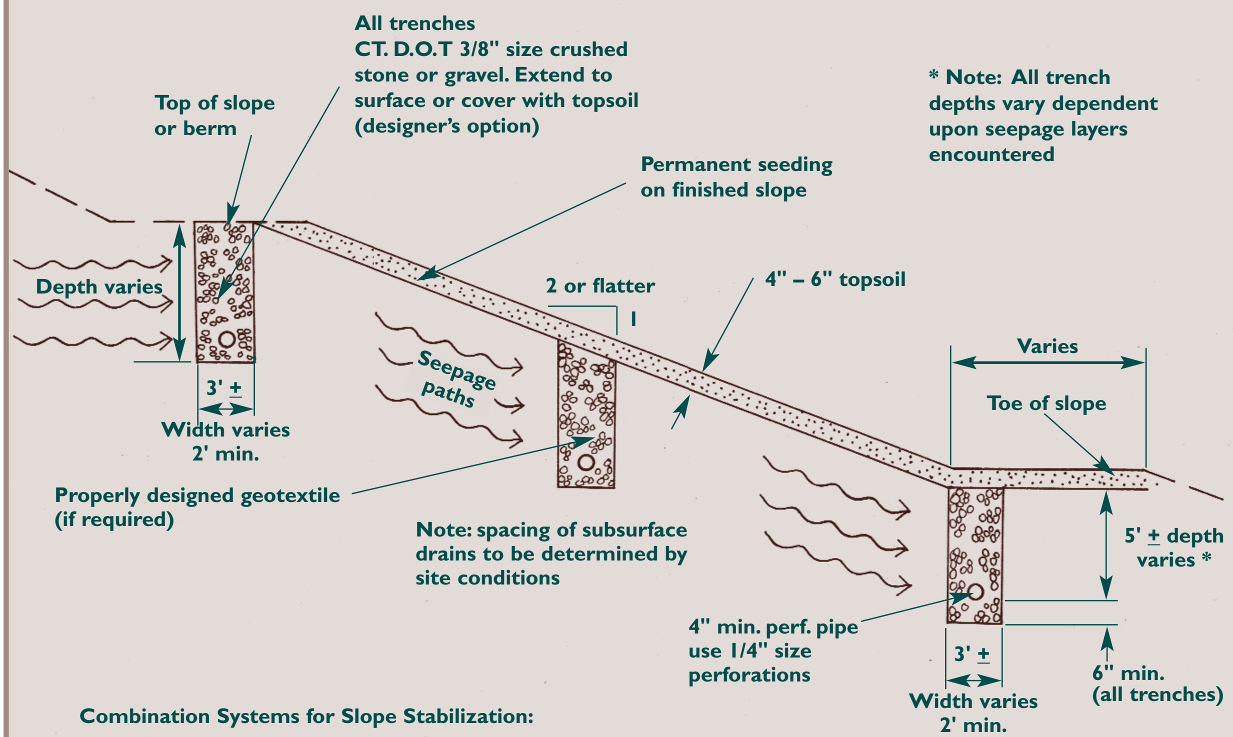


Combination Systems for Slope Stabilization:
E&S Measures Include:

PS Permanent Seeding
TO Topsoiling
SD Subsurface Drain
G Gabions
RR Riprap
LW Permanent Lined Waterway
GW Grassed Waterway

Source: USDA-NRCS

Figure 4-3 Slope Repair Example 3: Using Multiple Subsurface Drains



Combination Systems for Slope Stabilization:
E&S Measures Include:

PS Permanent Seeding
TO Topsoiling
SD Subsurface Drain

Source: USDA-NRCS

Stockpile Management

Stockpile management of topsoil and other types of erodible soils is necessary to prevent unnecessary damage resulting from erosion of stockpile material. Locate stockpiles so that natural drainage is not obstructed. Attempt to maximize the distance of stockpiles from wetlands, watercourses, drainage ways, and steep slopes. When the stockpile is downgradient from a long slope, divert runoff water away from or around the stockpile (see **Temporary Diversion** measure). Install a geotextile silt fence or hay bale barrier around the stockpile area approximately 10 feet from the proposed toe of the slope (see **Geotextile Silt Fence** and **Hay Bale Barrier** measures).

The side slopes of stockpiled material that is erodible should be no steeper than 2:1. Stockpiles that are not to be used within 30 days need to be seeded and mulched immediately after formation of the stockpile (see **Temporary Seeding**, **Permanent Seeding** and **Mulch for Seed** measures). The seed mix used depends upon the stockpiled material and the length of time it is to remain stockpiled. Information gathered from soil borings and soil delineation can be used to plan the type of seed and any soil amendments that are appropriate for the stockpile. After the stockpile has been removed, the site should be graded and permanently stabilized.

If a stockpile is located off-site, local zoning approval may be required. In addition to the above criteria, stockpiles that are located off-site require a construction entrance pad installed at that site (see **Construction Entrance** measure). Depending on the volume of traffic, the installation of "truck crossing" signs and sweeping of the roadway (see **Dust Control** measure) may also be necessary.

Stream Deflectors

Stream deflectors are structures placed within a stream channel that are used to divert flows away from a road, structure, utility or unstable streambank. They may also be designated for the establishment of meanders, the concentration of flows, or aquatic habitat improvement. Deflectors can be constructed of a variety of materials, including rock, riprap, timber, or other materials.

Because of the nature of these structures and the effect that they can have on stream flow, they should be designed by a licensed professional engineer, fluvial geomorphologist or other professional experienced in hydraulics and flow dynamics. An aquatic biologist should be consulted if the purpose is to improve aquatic habitat.

Important considerations in planning the use of stream deflectors are diversion direction, velocity, and effects on downstream conditions and structures. Extreme care must be taken to ensure that the redirected flow will not create a problem at another point in the stream. Questions to be answered in planning and design of stream deflectors include:

- ❍ *Will the deflected water negatively impact the opposite bank?*
- ❍ *Will the increased velocities and tractive stresses cause unacceptable bank and bed erosion?*
- ❍ *Are the construction materials suitable for the planned longevity?*
- ❍ *Are the deflectors located and spaced for optimum results?*
- ❍ *Are the deflectors properly sized as to height and lateral extent?*
- ❍ *Are the deflectors designed to withstand loading from snags, ice and debris? Deflectors designed with sufficiently low profiles should be overtopped during high flows and should not be susceptible to loading from ice, snags, debris, etc.*

Depending on the design and site conditions, any number of erosion and sediment control measures (that are related to slope stabilization structures, drainage ways, watercourses and sediment filters) may be used. See USDA publication Wildlife and Fisheries Habitat Improvement Handbook, December 1988, for additional advice on stream deflector design and construction.

Construction Access Road

Construction access roads are unpaved roadways consisting of a travel surface and associated side slopes. During wet weather such roadways can generate significant quantities of sediment if not constructed with adequate erosion and sediment control measures.

To control erosion and flow conditions utilize a number of E&S measures: **Construction Entrance** is used where the construction access road meets a paved access point; **Temporary Diversion** and **Temporary Lined Channel** are used to control concentrated flows where they enter and cross the construction access road; **Temporary Stream Crossing** is used to carry concentrated flows across the construction access road; **Outlet Protection**, **Level Spreader** or **Stone Check Dam** may be used to de-energize concentrated flows from diversions and in temporary channels; **Water Bar** is used to maintain natural drainage patterns and break flow lines within the construction access road; **Geotextile Silt Fencing** and **Hay Bale Barriers** are used to provide protection at the toe of fill slopes and the discharges from water bars; **Temporary Soil Protection** or **Temporary Seeding/Permanent Seeding** with **Mulch for Seed** are used to protect disturbed side slopes; and **Dust Control** is used when construction access road conditions create airborne dust.

Temporary construction access roads should be carefully planned, choosing materials and erosion control measures to maintain the usefulness of the construction access road during wet weather while minimizing the potential for erosion. Consider the volume and type of construction traffic as well as the extent of natural ground that must be altered to accommodate the traffic. If no grading is required and the construction traffic is very intermittent (such as access roads used to maintain utility lines) the measures used may be limited to water bars, some top dressing with gravel or stone in areas where the vegetation over soft soil is destroyed by the traffic. After access is no longer needed seeding and mulching of the disturbed area is required.

For construction access roads that require grading and filling or are to be heavily used, the creation of a stable, tractable, bearing surface resistant to erosion should be planned. If the existing soil and subsoil are not well drained, plan on importing an aggregate road base such as that meeting the requirements of aggregate found in the DOT Standard Specifications. When the construction access road follows the same route as the permanent design road, constructing the grades and subgrade for the permanent roadway early in the construction sequence is recommended.

Where possible, these construction access roads should conform to the contours of the land, avoiding grades steeper than 10% and creating side slopes no steeper than 2:1. If the side slopes are steeper than 2:1, then use engineered slope stabilization methods (see Stabilization Structures Functional Group).

Construction access roads that are constructed in or across wetlands require additional considerations[1]:

- *Avoid putting the construction access road in a wetland whenever possible. Explore all feasible and prudent alternatives before determining that a wetland crossing is absolutely necessary. When avoidance is not possible, consider crossings that will cause the least impact. This may involve locating the construction access road so that it crosses the wetland at its narrowest width or uses areas previously disturbed for access or other purposes. Also, consider the road's impact to adjacent uplands.*

- *Minimize the width of the construction access road through the wetlands (generally no wider than 14 feet). It is preferable to have a passing point created before and after the wetland crossing, but internal passing points may be needed if the crossing is long and sight line restrictions exist.*

- *Consider the soil conditions. Expect deep organic wetland soils to require geotextiles, wooden mats or other materials during use to keep construction access road materials separated from wetland soils. In shallow organic wetland soils brush matting, wood slabs and crushed stone may be sufficient to support a stable travel surface.*

- *Prevent obstructions to surface and subsurface flow across and through the construction access road. Provide adequate drainage. This may require the use of crushed stone or multiple cross culverts, particularly if the wetland does not contain a well defined watercourse channel or the crossing is long. If the wetland soils are susceptible to seasonal high water tables or flooding, then give additional consideration for maintaining flows across or over the construction access road without causing erosion or siltation during such times.*

- *Plan in advance how the construction access road will be removed and the wetland restored. A road stabilization geotextile can assist in keeping imported soils segregated from the wetland soils and make wetland restoration easier.*

Inspection of the construction access road and the associated erosion and sediment control should occur at the end of each day the road is used and repairs to controls made immediately. If the road is not used for more than a week, then inspect the erosion and sediment controls at a frequency as required by the E&S measure used. Repairs may include regrading or top dressing the traveled surface with additional aggregate to eliminate ruts, as well as those repairs required by each E&S measure used.

Utility Watercourse Crossing

Utility line construction, by virtue of its contiguous, linear nature, necessarily crosses and impacts wetlands, streams and intermittent watercourses. Although the time of in-stream construction for this special treatment is intended for less than one month, there is a potential during that time for excessive sediment loss into a watercourse by both the disturbance of the approach areas and by the work within the stream bed and banks. Therefore, methods that allow for "working-in-the-dry" are recommended and described below.

Three "working-in-the-dry" methods employed for watercourse crossings are (1) pipe flume crossing, (2) diversion channel crossing, and (3) sequential cofferdam crossing. The utility watercourse crossing method used depends upon the stream flow characteristics and the anticipated length of time for the construction to occur. Regardless of the method used, a professional engineer licensed to practice in Connecticut is required to design any diversion channels and linings, temporary culverts, cofferdams or other structures used.

Pipe Flume Crossing - Used when in-stream construction will last less than 72 hours and the contributing drainage area is less than 100 acres. It consists of a pipe and cofferdams of sandbags or gravel at each end of the pipe placed within the channel. The pipe is sized to handle the anticipated flow during the construction period. Check weather forecasts to avoid construction during anticipated storms. Upon completion of the utility installation, the watercourse channel between the cofferdams is re-established with stream bedding material that is equivalent to the pre-construction bedding material. The cofferdams and pipe are then removed and channel banks stabilized. (See **Figure 4-4**.)

[1] See Appendix F, Regulatory Matrix, for possible regulatory requirements

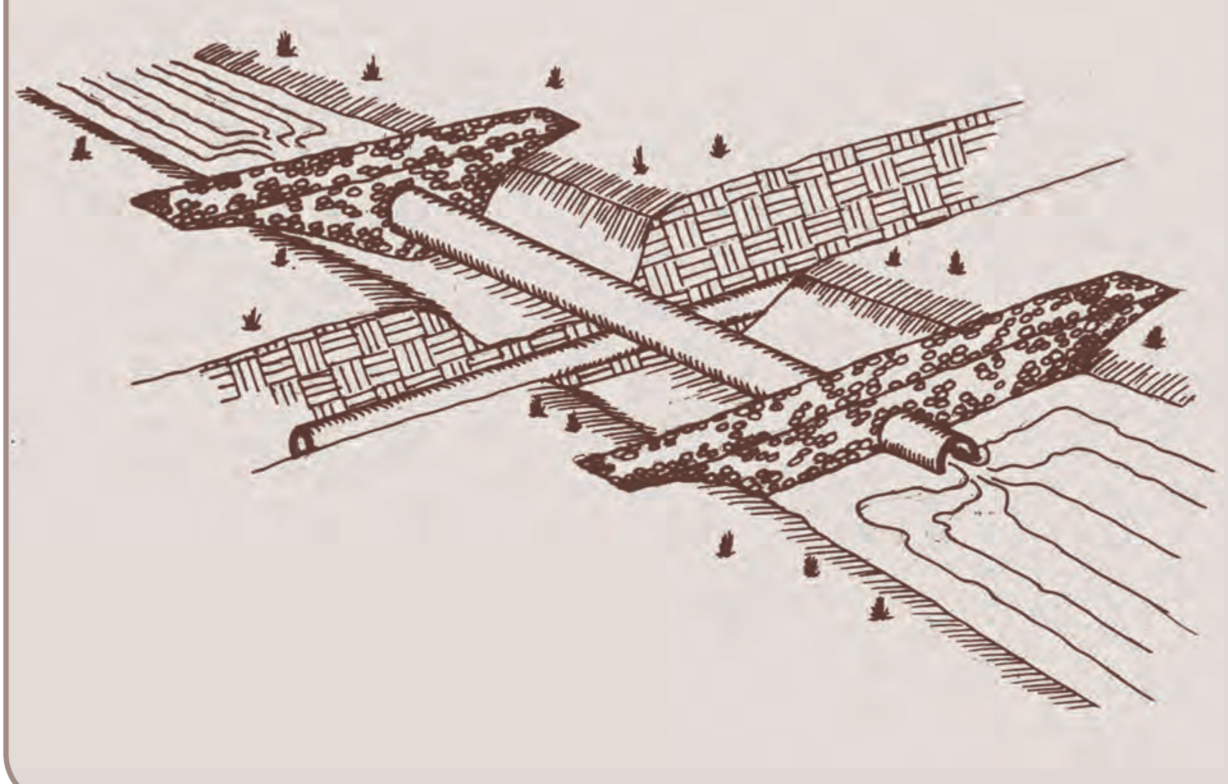
Diversion Channel Crossing - Used when in-stream construction will last longer than 72 hours. It consists of the construction of a temporary diversion channel (stabilized as needed with a channel lining to prevent erosion) with associated cofferdams and riprap to divert water flows around the stream bed to be crossed and a temporary stream crossing for construction access (see **Temporary Channel Lining**, **Permanent Channel Lining**, and **Temporary Stream Crossing** measures). The diversion channel is designed to safely pass flows in accordance with the DOT Drainage Manual section on "Temporary Hydraulic Facilities."

As with the pipe flume crossing, water that is trapped between the cofferdams is removed using the measures given in the Dewatering Functional Group. Upon completion of the utility installation, the watercourse channel between the cofferdams is re-established with stream bedding material that is equivalent to the pre-construction bedding material. Channel banks stabilized, the cofferdams are removed, new cofferdams are constructed at the inlet and outlet to the diversion channel, and the diversion channel backfilled and stabilized. Once started, stream relocation occurs without interruption until natural channel flows are re-established and the bank stabilization measure applied. See **Figure 4-5** for the recommended construction sequence and **Figure 4-6** for an illustration of a diversion channel crossing in progress.

Sequential Cofferdams - Used only during low flows (typically between the months of June and October) when a diversion channel crossing is not practical and the stream is wide enough (at least 10 feet) to make cofferdam installation practical. It consists of isolating more than half the watercourse channel from flow using sandbags or similar non-erosive material capable of obstructing water flow, constructing half the utility in the isolation area, removing the cofferdam and reconstructing so that the remaining half of the utility can be constructed in the dry. To reduce the potential for flood damage to neighboring properties the height of the cofferdam should not exceed that which is needed to keep low flows out of the construction area and should allow for overtopping during storm events. (See **Figure 4-7**.)

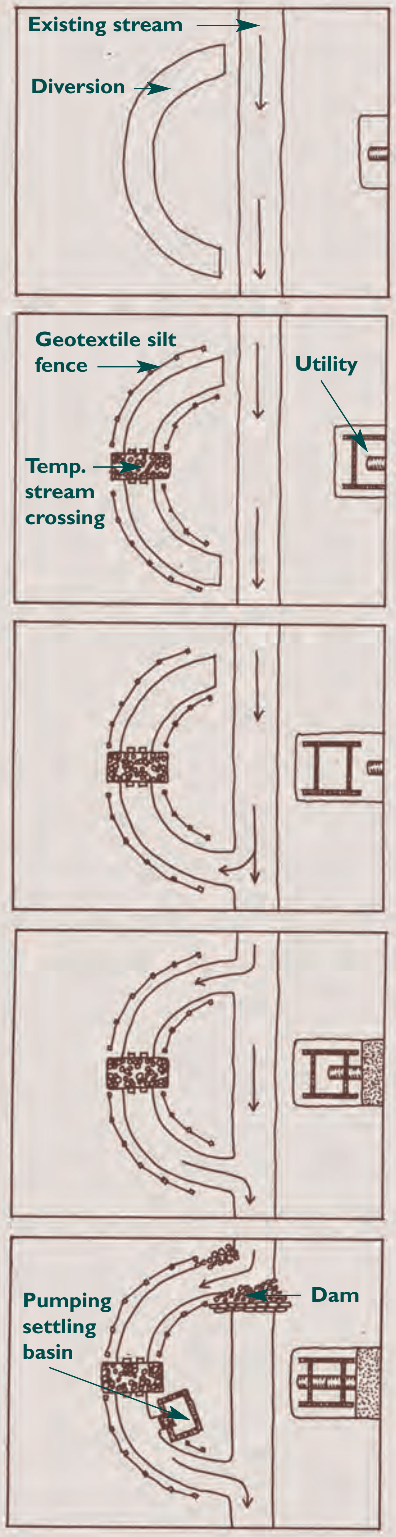
Regardless of the method used, water that is trapped between or within cofferdams should be removed using the measures given in the Dewatering Functional Group.

Figure 4-4 Pipe Flume Crossing Illustration



Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

Figure 4-5A Diversion Channel Crossing Sequence



1. Excavate diversion channel with ends blocked. Install temporary channel lining.

2. Install temporary stream crossing and perimeter E&S controls for diversion channel.

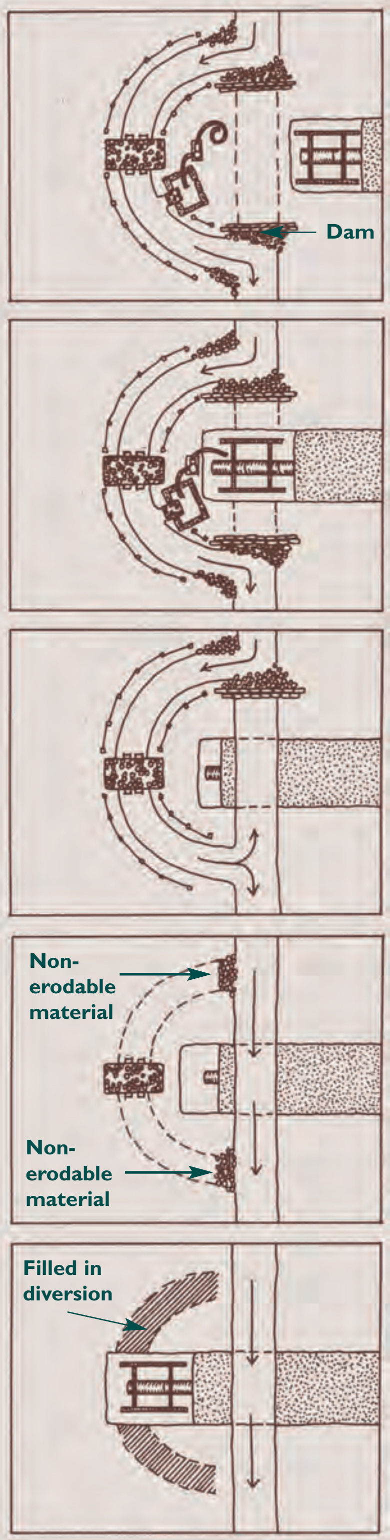
3. Open downstream end of diversion, allowing water pressure to equalize in diversion.

4. Open upstream end of diversion. Some sedimentation will occur.

5. Construct non-erodable dam in the upstream end of the existing stream channel. Construct pumping settling basin.

Source: Adapted from "Damming by the Numbers" Erosion Control. July/August, 1995.

Figure 4-5B Diversion Channel Crossing Sequence



6. **Construct non-erodable dam in the downstream end of the existing stream channel. Dewater blocked stream channel.**

7. **Construct utility across blocked streambed, dewatering as necessary.**

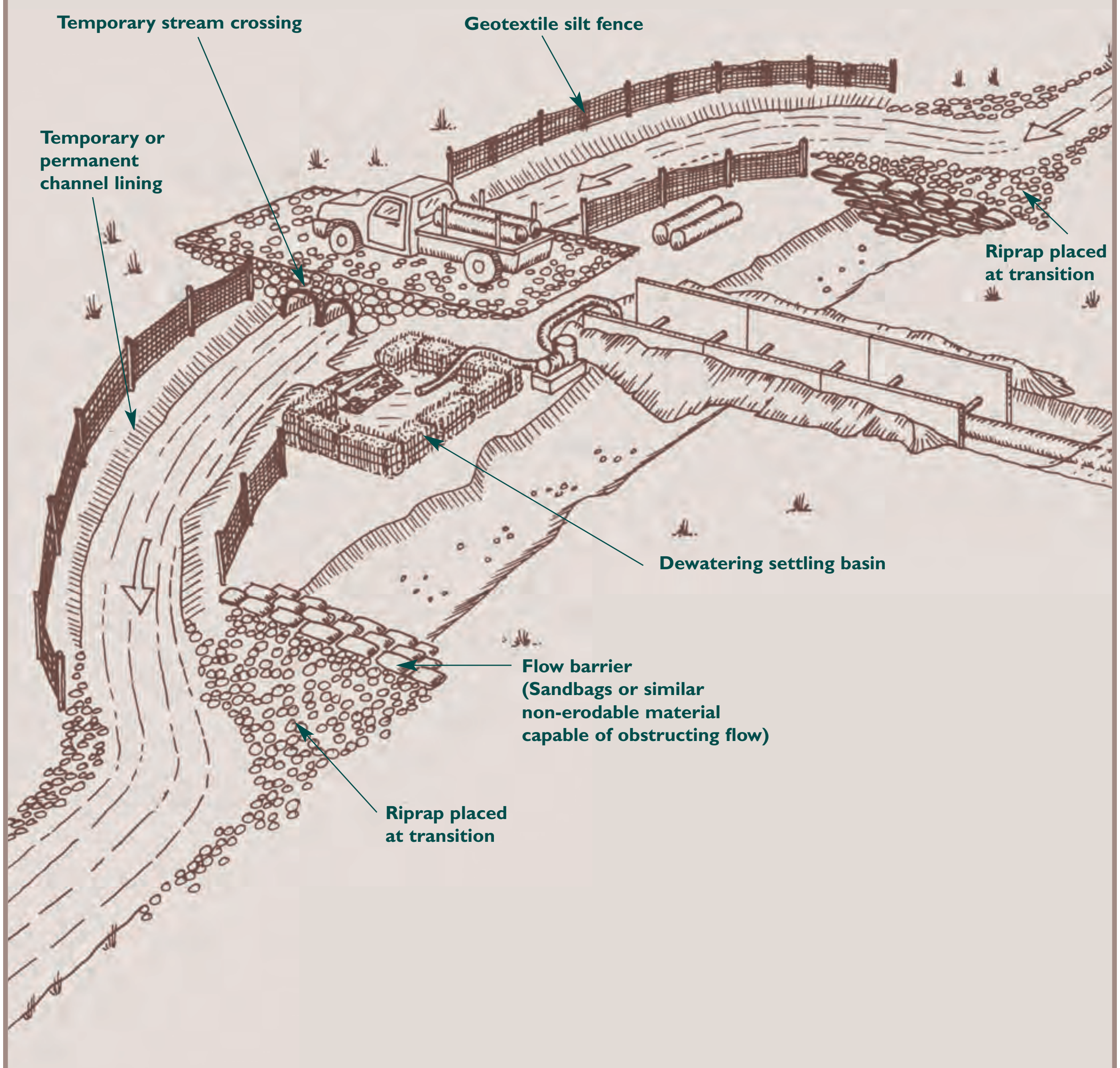
8. **After re-establishing stream channel, remove dam from downstream end of existing channel.**

9. **Remove dam from upstream end of existing channel. Fill in downstream and upstream end of diversion with non-erodable material.**

10. **Remove temporary stream crossing from diversion channel. Fill diversion channel, continue utility construction and stabilize disturbed soils.**

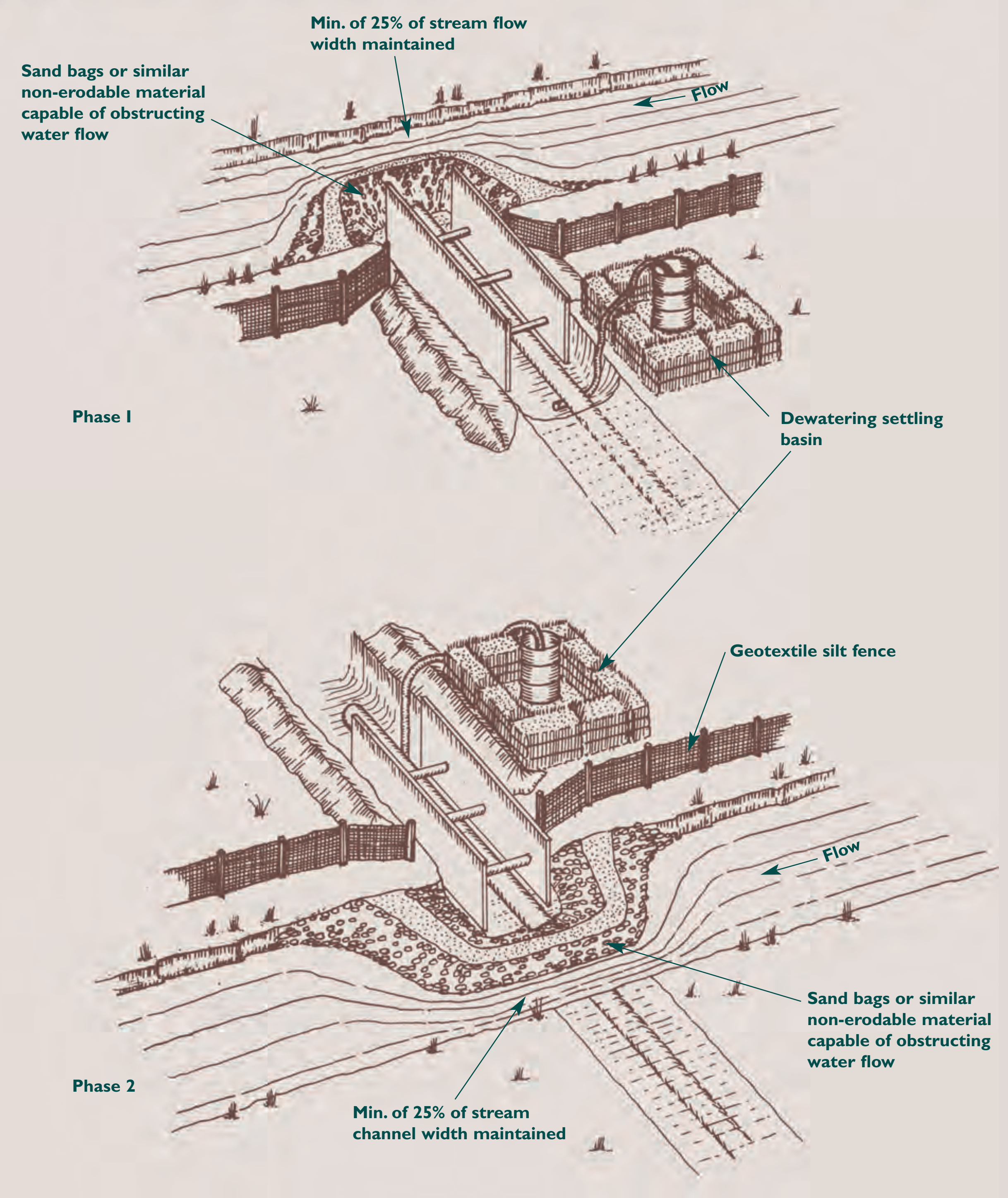
Source: Adapted from "Damming by the Numbers" Erosion Control. July/August, 1995.

Figure 4-6 Diversion Channel Crossing Illustration



Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

Figure 4-7 Sequential Cofferdam Crossing Detail



Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

Soil Bioengineering for Stabilization

Soil bioengineering is a system of using living plant materials, soil and other components in combination for soil protection and reinforcement. The main construction materials are live cuttings from suitable plant species, installed in specific configurations that provide immediate soil protection and reinforcement.

Under certain conditions, soil bioengineering installations work well in conjunction with structural components to create a more permanent erosion control system with enhanced aesthetics and other environmental benefits. These benefits include the establishment of diverse and productive riparian habitats, shade and the addition of organic matter to the watercourse, cover for fish, and water quality improvement.

Soil bioengineering techniques are applicable to upland slopes, stream banks, and some shorelines, but are of a more limited value in application on oceanfronts, or on the shorelines of large lakes or large rivers. Soil bioengineering techniques may not effectively mitigate severe scour, severe roadway erosion, or deep seated slope instabilities. In these situations, soil bioengineering can be used in combination with other engineering techniques.

A multi-disciplinary approach is necessary for the design of functional soil bioengineering systems, combining the expertise of hydraulics engineers, geotechnical engineers, engineering geologists, landscape architects, horticulturists, biologists, water quality specialists, environmental planners, and others.

Each situation where soil bioengineering techniques may be useful requires an engineering and a multi-disciplinary approach to be most effective. As the methodology of soil bioengineering is rapidly evolving and improving, it will not be discussed in these Guidelines.

More information on bioengineering techniques is contained in the USDA Natural Resources Conservation Service National Engineering Handbook – Part 653 entitled "Stream Corridor Restoration: Principles, Processes and Practices," and Part 650 entitled "Engineering Field Manual."

5 The Functional Groups and Measures

TO MAIN TOC

Protect Vegetation
Subsurface Drains
Preserve and Conserve Soils
Detention Structures
Vegetative Soil Cover
Energy Dissipators
Short-Term Non-Living Soil Protection
Sediment Impoundments, Barriers and Filters
Stabilization Structures
Tire Tracked Soils
Drainageways and Watercourses
Dewatering
Diversions

The Functional Groups and Measures

TO MAIN TOC

TO MAIN TOC

5-1 Protect Vegetation

TO MAIN TOC

Protect Vegetation Planning Considerations

The measure included in this group is **Tree Protection**.

The **Tree Protection** measure is used on sites where woody vegetation is intended to be kept as a site amenity. Established trees and shrubs are already adapted to their growing environment and have a root system that assists in keeping soils stable. By controlling construction equipment access and protecting as much of the root zone as possible existing vegetation can sometimes be retained. It can be less expensive to protect and maintain existing vegetation than to import new vegetation which must recover from the transplanting process.

I-Protect Vegetation

Tree Protection (TP)

Definition
The protection of desirable trees from mechanical and other injury during construction.

Purpose
To ensure the survival of desirable existing trees for their effectiveness in soil erosion and sediment control during construction and after the adjacent land is developed, and because they provide significant other environmental benefits.

Applicability
Where individual trees and forested areas are subject to land disturbing activities and where the protection and preservation of trees will aid in erosion and sediment control or provide other environmental benefits.

Planning Considerations
It is best to consult an arborist licensed to practice in Connecticut when considering tree protection options. The following information is given to provide an understanding of the factors that go into planning for tree protection.

Importance of Tree Protection

Trees can:

- *stabilize the soil and prevent erosion,*
- *decrease storm water runoff through canopy interception and root zone absorption,*
- *moderate temperature changes and provide shade,*
- *moderate the effects of sun and wind,*
- *provide visual buffers,*
- *filter pollutants from the air and produce oxygen,*
- *provide habitat for wildlife, and*
- *preserve and increase property values by increasing aesthetic values.*

Considerations for Tree Protection and Preservation
The protection and preservation of existing trees is important. It takes 20 to 30 years for newly planted trees to provide the benefits of mature trees. Several factors weigh on the decision to retain specific trees or groups of trees.

Location: Compatibility with the Developed Site - Trees must be appropriate for the intended use of the developed site. Review the location of proposed overhead and underground utilities, paved surfaces (like driveways, walkways and patios), walls, water lines, septic tanks, underground drainage and buildings. Determine if the trees to remain might interfere with these features when they grow to mature height, crown and root spread. Select trees whose natural growth habit will remain contained within the design space.

Condition: Trees should be healthy, preferably of good visual form, and reasonably free of large rotted or broken limbs or trunk sections that could threaten the structural integrity of the tree.

Check for evidence of diseases and pests that may seriously affect the health or survivability of the tree. Trees that leaf out abnormally late in the spring or that drop their leaves abnormally early in the fall are showing signs of stress and may have root problems which can have a significant impact on the tree's ability to withstand high winds, ice, and snow , especially if left in an exposed location. Consult a licensed arborist if there is any doubt as to the structural integrity of the tree.

Longevity: Long-lived, slow growing tree species, such as oak, hickory, beech, and some maples, should be given greater consideration for protection, particularly the larger specimens of these species. Beech trees do poorly in construction sites and may be difficult to save if their root systems are disturbed. Fast growing, brittle trees, such as birch, cherry, and poplar, are of limited long term value. Naturally seeded young trees of appropriate species should be given preference especially when older trees on the site are of declining health. These vigorous young trees will typically grow faster than the equivalent nursery grown tree planted after development. Retaining groups of these trees provides the additional benefit of avoided land disturbance, and making it less subject to erosion.

When an individual tree is to be retained it is described by its size (normally the trunk diameter in inches at 4.5 feet above ground level, known as diameter at breast height or DBH), and by its species. Groups of trees or forested areas to be retained are described by their average tree size, including average height, species distribution and density.

Aesthetic values: Trees that are well positioned in the landscape, well formed, unusually large, rare, uncommon, or unusually shaped can enhance the aesthetics of any site, and are good candidates for protection and preservation.

Sanitation: Elm, black locust and some of the willows are noted for being "dirty." They drop twigs, bark, seeds, fruit, and plant exudates. Trees which seed prolifically or sucker profusely are generally less desirable for retention.

Comfort: Trees relieve the heat of summer and buffer strong winds throughout the year. Deciduous trees drop their leaves in winter, allowing the sun to warm buildings and soil. Evergreens are more effective wind buffers.

Wildlife: Where appropriate, consideration should be given to retaining trees that provide food, cover, and nesting sites for wildlife

Stresses of Construction

Construction activities expose trees to a variety of stresses or conditions which may injure or cause a tree to decline in health and die within two to five years:

Above Ground Impacts: Construction related conditions exerted on the tree above the ground can cause significant damage:

- *Excessive thinning or the removal of most trees from a group may leave remaining trees subject to wind throw. It is best to retain groups of trees rather than individuals.*

- *Improper pruning of trees can create future hazards by promoting disease and decay, and by altering the structure of the tree. Improper pruning can easily destroy the tree's aesthetic value, or kill it.*

- *Equipment damage to tree trunks and lower branches increases the likelihood that wood boring insects will attack and damage or kill the tree, and allows a path of entry for disease and decay organisms.*

Below Ground Impacts: In natural growing conditions, tree roots extend out from the trunk a distance of from one to two times the height of the tree. Commonly the root zone extends well beyond the average extent of the branches of the tree. About 90% of the working roots, those that take in essential water, air and nutrients, are usually located within the top 12 inches of soil. Construction related activities within a tree's root zone can cause significant damage.

- *Raising the grade as little as six inches in the root zone area can retard the normal exchange of gases in the soil and small roots may suffocate. Raising the grade may also elevate the water table and drown the roots.*

- *Lowering the grade by 6 to 8 inches can remove most of the topsoil, destroy feeder roots and expose the upper root system to drying and freezing. Lowering the grade may also lower the water table, inducing drought. At a minimum, grading should not take place within the Critical Root Zone (see below) of any tree to be retained.*

- *Excavations may cut a large portion of the root system, depriving the tree of water and nutrients and increasing the chance of disease and wind throw.*

- *Compaction of the soil by even limited operation of construction vehicles or equipment within the root zone of a tree will compact the soil severely, crushing the soil structure. This in turn inhibits the flow of air and water within and through the soil, altering the soil environment to the detriment of the tree.*

- *Breakage of roots can be caused by the operation of heavy equipment within the root zone of a tree.*

- *Construction chemicals or refuse disposed of in the soil can change soil chemistry or be toxic to trees.*

Tree Protection Zone and Critical Root Zone

The Tree Protection Zone (TPZ) is defined as a circular area surrounding a tree or group of trees with a diameter twenty times the DBH (diameter of the trunk of the tree measured at 4.5 feet above the ground). (See **Figure TP-1** for example calculating TPZ). Where groups of trees or forested areas require delineation of the TPZ, trees within 20 feet of the edge of the group or forest that have a larger DBH than the outermost trees should be noted to properly establish the TPZ. The TPZ encompasses and creates a buffer to the critical root zone. (See **Figure TP-2**).

The Critical Root Zone (CRZ) is defined as a cylindrical area, with a diameter ten times the DBH, including the soil within this area to a depth of two to three feet. (See **Figure TP-1** for example calculating CRZ). Where tree roots are severely crowded by sidewalks, paved surfaces, or buildings, and restricted by linear strips between sidewalks and roads, the CRZ should be extended to encompass the Tree Protection Zone (see below) where there are roots present. All TPZs should be delineated on the grading drawings.

When a significant portion of the TPZ or any portion of the CRZ must be impacted, obtain guidance from an arborist licensed to practice in Connecticut. Disturbance within the CRZ can seriously threaten tree survival. The arborist should provide specific guidance on whether to keep or remove the tree, including measures to maintain tree health and safety. These measures may include clean cutting of roots exposed by excavation, maintaining grades and mulch (See **Landscape Mulch** measure), ensuring proper aeration and drainage, construction of tree wells and tree walls (see **Figure TP-3** and **Figure TP-4**), pruning (see **Figure TP-5**), mechanical protection of the tree trunk (see **Figure TP-7**) and the possibility of tunneling under the CRZ[1] (see **Figure TP-6**).

When grades must be changed or trenching is to occur either within the tree protection zone or the critical root zone, the undisturbed portion of the critical root zone must be protected by a fence.

Figure TP-1 Example of Calculating the Extent of the TPZ and CRZ

Given: trunk DBH = 15 inches or 1.25 feet

***TPZ diameter(ft) = trunk DBH(ft)* X 20 = 1.25 X 20 = 25 feet**

***CRZ diameter(ft) = trunk DBH(ft)* X 10 = 1.25 X 10 = 12.5 feet**

Tree Protection Plans

When the decision has been made to require tree protection, then the location and size of the individual trees or groups of trees to be retained should be identified on the E&S plan. Each individual tree to be retained should be described by its size (DBH) and by its species. Groups of trees or forested areas to be retained should be described by their average tree size, height and species.

Specifications

Pre-Construction Meeting

At a preconstruction meeting, review with the E&S agent, contractor and on-site construction supervisor or foreman the clearing limits, the trees to be protected, the location of tree protection zone(s), marking requirements for the protected trees and zones, allowed pre-construction trimming, equipment and chemical storage and disposal, and special construction methods to be used when grading is to occur within any tree protection zone.

[1] Tunneling is more expensive initially, but usually causes less soil disturbance and physiological impact on the tree's root system. The extra cost may offset the potential cost of tree hazard abatement pruning, tree removal, and replacement.

Pre-Clearing Tree Marking

Prior to the start of clearing activities, visibly mark or tag trees to differentiate the trees to be retained from those to be cut. Trees to be retained within the limits of clearing are typically marked with surveyor's ribbon applied in a band circling the tree at a height visible to equipment operators. Trees to be removed are typically spray painted with an "X" at a height visible to the equipment operator.

Pre-Clearing Tree Protection Zone Marking

Mark the tree protection zones and restrict access by equipment. Use devices which will effectively protect the roots, trunk and tops of trees retained within the protection zone.

Fencing: Fencing is required to identify the protection zones of trees to be retained within 40 feet of a proposed building or excavation. Fencing shall be highly visible, of sturdy construction and at least 3 feet high. Fences may be snow fence, chain link, board fence, geotextile silt fence, plastic fence or similar materials (see **Figure TP-7**). Consider fencing as permanent during the construction period and do not move or remove without the permission of the E&S agent. Where there is work within the tree protection zone, fencing is required to protect the CRZ.

Trunk Armoring: Trunk armoring is a method of last resort to prevent damage to trees in situations where there are sidewalks, paved surfaces, or buildings that prevent adequate fencing of the TPZ. This would include cases like urban "tree lawns," where trees grow between road curbs and sidewalks where even the CRZ cannot practically be fenced in. (see **Figure TP-7**)

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, in order for this alternative to be used, the trunks of the trees in the buffer must be no more than six feet apart to prevent passage of equipment and material through the buffer. Reexamine these additional trees prior to the completion of construction and either give sufficient treatment as may be necessary to ensure their survival, or remove them.

Preconstruction Pruning[2]

Before beginning construction, examine the trees selected for retention with an arborist to determine if there is a need for pruning or temporarily tying back selected branches. This is to prevent unnecessary damage and breakage if equipment inadvertently strikes the branches. Typically, branches lower than 16 feet over travel ways will require tree pruning to facilitate the passage of vehicles.

Equipment Operation and Storage

Prohibit and prevent heavy equipment travel, storage or stockpiles of any construction materials, including topsoil, within the tree protection zone of any tree to be retained.

Storage and Disposal of Hazardous or Toxic Materials

Properly store and contain all materials toxic to plants no closer than 25 feet from the tree protection zone of any trees to be retained. Do not dispose of hazardous or toxic materials such as paint, acid, nails, gypsum board, wire, chemicals, fuels, and lubricants in such a way as to contaminate soils or injure vegetation.

Maintenance

Inspect tree protection zones weekly during site construction for damage to the tree crown, trunk, root system and soil compaction. When trees have been damaged or when tree protection zones are violated during construction, immediately consult an arborist licensed to practice in Connecticut to determine how damage should be addressed.

At the end of construction, once construction equipment is no longer expected to be used in the area, remove fences and barriers used for tree protection. The cleanup 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.

[2] CGS §23-61b. of the Connecticut General Statutes requires licensing for arboriculture: "No person shall advertise, solicit or contract to do arboriculture within this state at any time without a license issued in accordance with the provisions of this section". "Arboriculture" means any work done for hire to improve the condition of fruit, shade or ornamental trees by feeding or fertilizing, or by pruning, trimming, bracing, treating cavities or other methods of improving tree conditions, or protecting trees from damage from insects or diseases or curing these conditions by spraying or any other method; "Arborist" means one who is qualified to perform arboriculture and is licensed by the State Tree Protection Examining Board as provided in CGS §23-61b.

In addition, any activity involving the cutting, removal, harvesting or trimming of trees within the limit of public roads or grounds in the State of Connecticut is subject to CGS §23-65(f). Many towns also have local ordinances which place certain restrictions on tree cutting or pruning

Figure TP-2 Diagram of Zones Relating To Tree Protection

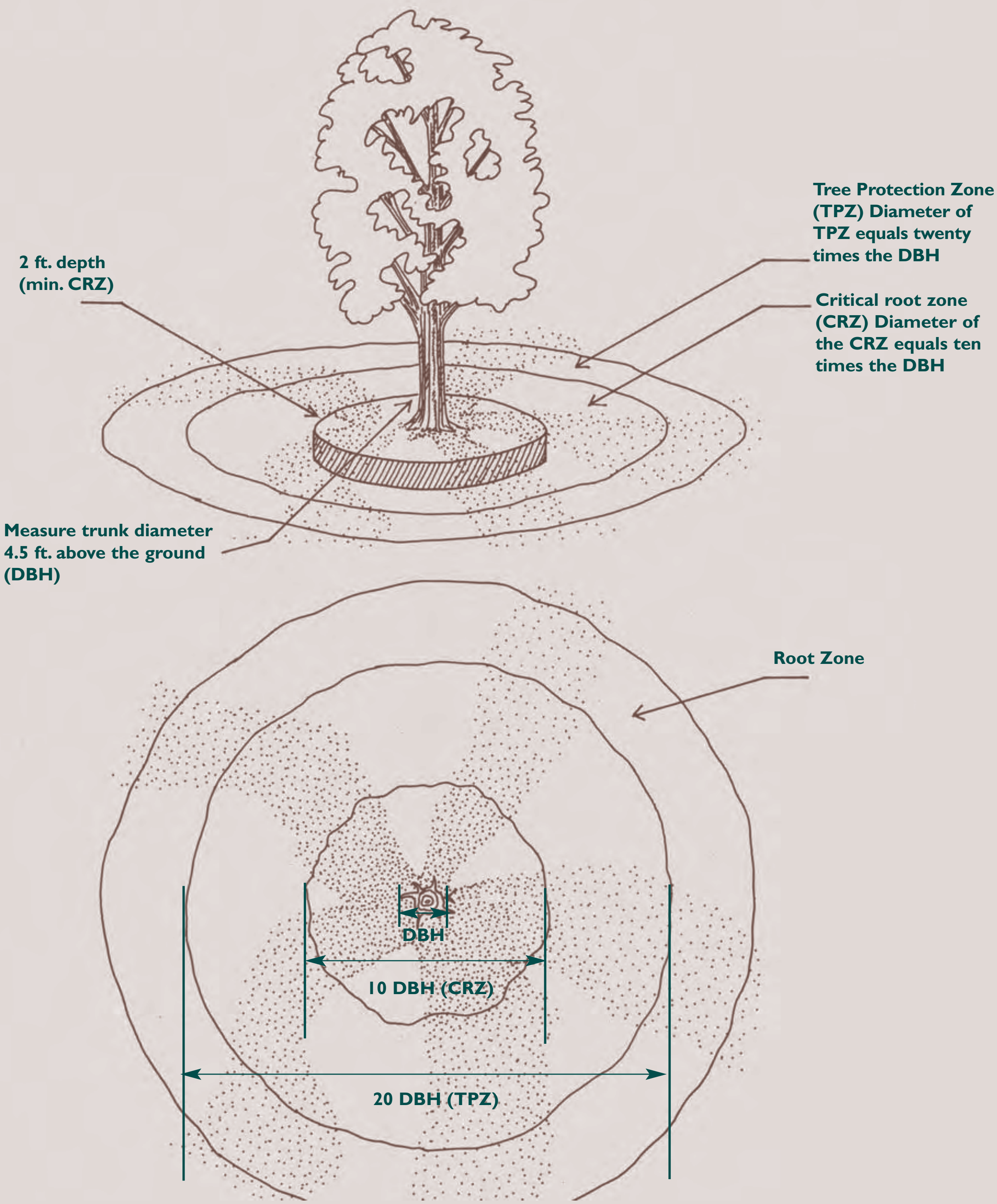
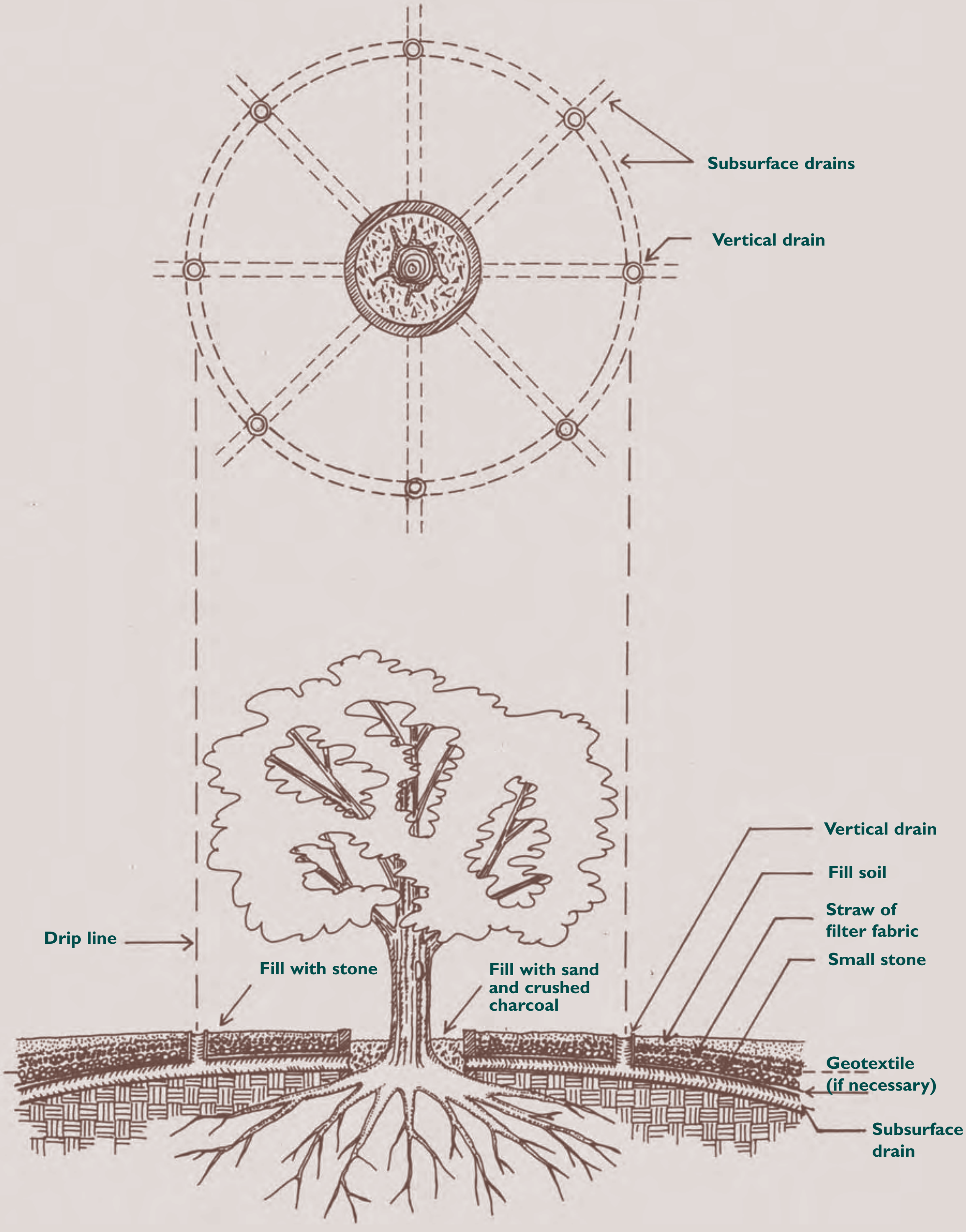
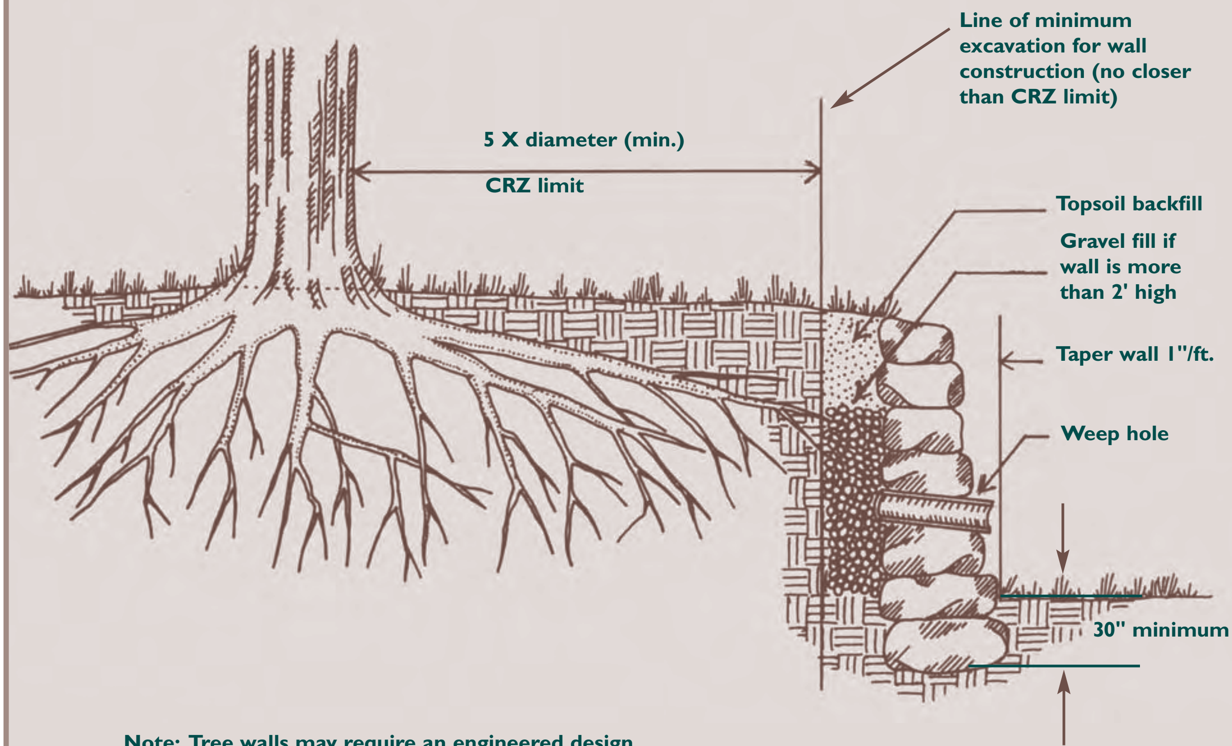


Figure TP-3 Example of Tree Well



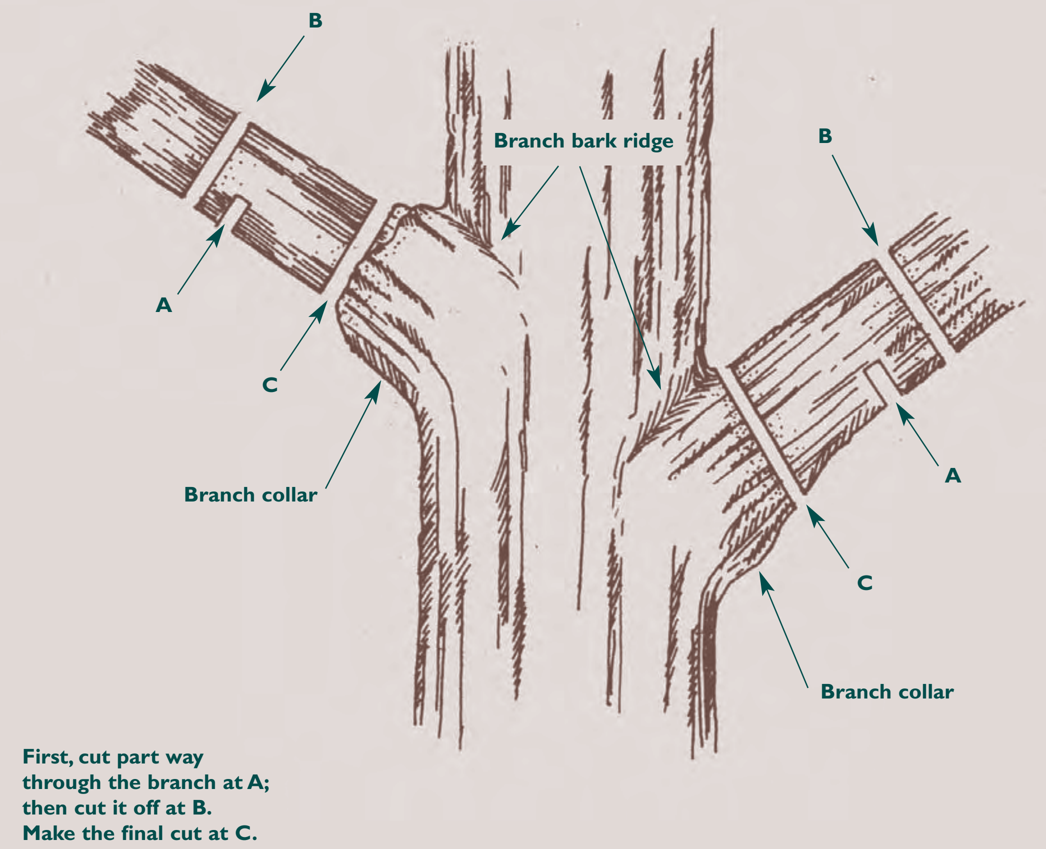
Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

Figure TP-4 Example of Tree Well



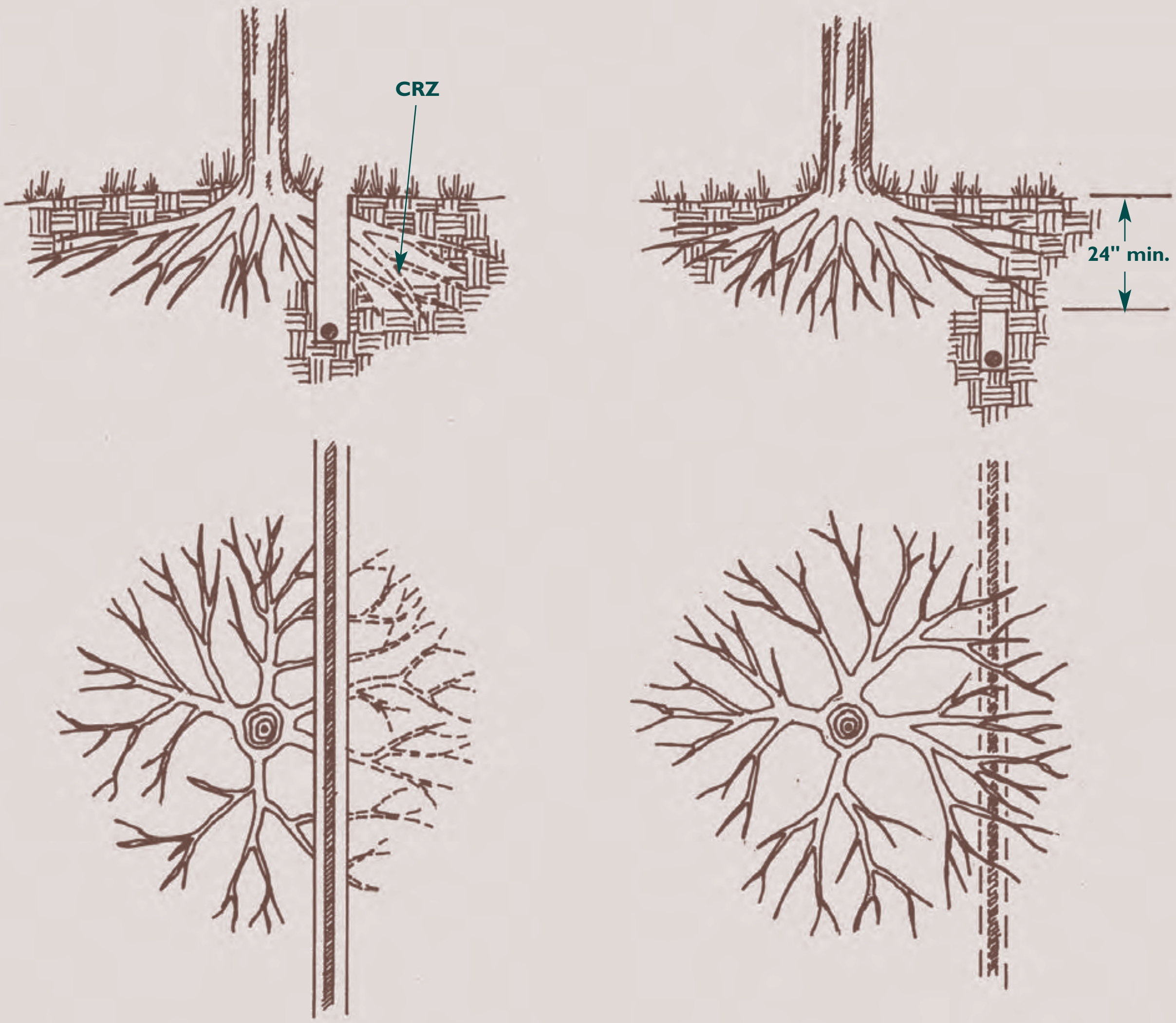
Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

Figure TP-5 Pruning Details



Source: Protecting Trees from Construction Damage - A Homeowner's Guide, University of Minnesota Extension Service. 1993.

Figure TP-6 Trenching vs. Tunneling



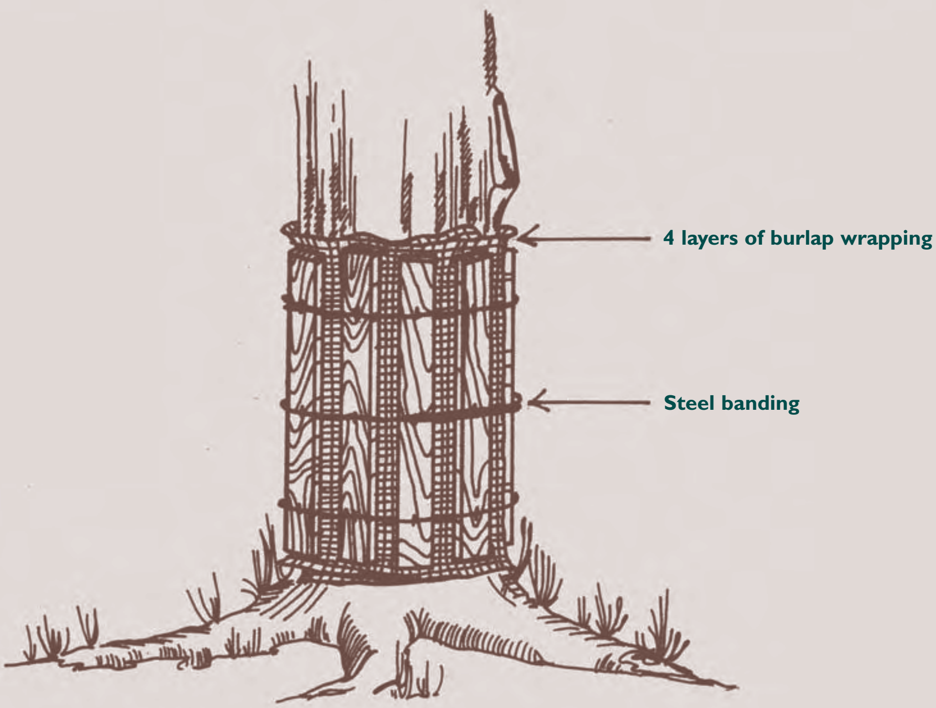
Destruction of feeder roots within the CRZ will probably kill the tree.

Tunneling under the CRZ will preserve important feeder roots.

Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

Figure TP-7 Mechanical Tree Protection

Correct methods of fencing tree protection zones



Correct trunk armoring

Note: Use for protecting street tress adjacent to construction area where paved surfaces make it impractical to establish tree protection zone.

Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

Protect Vegetation
Tree Protection (TP)

TO MAIN TOC

Planning Considerations

The measures in this group include: **Topsoiling, Land Grading, Surface Roughening,** and **Dust Control**. All four measures involve manipulating or amending the soil surface in a fashion that will preserve and conserve the soils on site. These measures can be accomplished on an individual basis, in conjunction with each other, or in conjunction with other types of structural or nonstructural measures.

Topsoiling includes the stripping and (re)application of topsoil to improve soil fertility and enhance vegetative growth.

Land Grading places restrictions on slope lengths and grades for cuts and fills to reduce erosion for the establishment of a stable slope.

Surface Roughening is the creation of a rough surface on a slope and is applied after land grading has occurred. It is usually done in preparation for seeding and/or mulching.

Dust Control is applicable at all stages of site development and involves anchoring fine particles of soil by applying various materials.

Topsoiling (TO)

Definition

The application of topsoil to promote the growth of vegetation following the establishment of final grades.

Purpose

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

Applicability

- Where the texture, pH, or nutrient balance of the available soil (sands, gravels or other unconsolidated materials) cannot be modified by reasonable means to provide an adequate growth medium.
- Where the existing soil material is too shallow to provide an adequate root zone and to supply necessary moisture and nutrients for plant growth.
- Where high quality turf is desirable to prevent erosion and withstand intensive use and/or meet aesthetic requirements.
- Where landscape plantings are planned.
- Where extensive filling and cutting of slopes has occurred.
- Only on slopes no steeper than 2:1.

Planning Considerations

Topsoil is the surface layer of a soil profile (known as the A horizon of a soil), generally characterized as being darker than the subsoil due to the presence of organic matter. This layer is the major zone of root development, containing most of the nutrients available to plants, and supplying a large amount of the water used by plants, and is the zone where the respiration of plant roots occurs.

Consider the following:

❍ *Need – Vegetative growth is more rapid on sites with at least 4 inches of topsoil. Also, the health and quality of vegetation is better when topsoil is present. Topsoiling is strongly recommended where landscape plantings or high-maintenance turf will be grown. Topsoiling is required when establishing vegetation on shallow soils, and soils with a pH of 4 or below (acidic).*

❍ *Availability - Determine if sufficient volume of topsoil exists on the site. If not, it will be necessary to identify additional sources of topsoil.*

❍ *Costs - Compare the cost of topsoiling to the cost of preparing a seedbed in subsoil (See* ***Permanent Seeding****,* ***Sodding*** *and* ***Landscape Planting*** *measures). Limed and fertilized subsoils with proper seedbed preparation may provide an adequate growth medium if moisture is not limiting. Stripping, stockpiling, and reapplying topsoil, or importing topsoil can be expensive. Additionally, imported topsoils may contain weed seeds or invasive plants that are objectionable to the establishment of the permanent vegetation and may require additional treatments.*

❍ *Scheduling - The application of topsoil must be scheduled so as not to delay seeding or sodding operations. This delay increases the exposure time of critical areas, thereby increasing maintenance cost of existing controls.*

❍ *Stockpiles Management - Topsoil stockpiles need to be located away from construction activities. If topsoil is to be* *stockpiled longer than 30 days, it must be protected with a temporary seeding, matting or other acceptable means of preventing erosion. (See Stockpile Management, Chapter 4, Special Treatments).*

- *Application Limitations - Care must be taken when applying topsoil to subsoil if the two soils have contrasting textures or strongly contrasting density (i.e. hardpan). Topsoil applied to a compacted subsoil can result in water flows between the two soil layers, causing the topsoil to slough. Where hardpan exists, it must be loosened with appropriate equipment such as a disk or harrow prior to spreading topsoil to ensure adequate bonding. Additionally, for slopes 2:1 through 5:1 slope tracking is required prior to the placement of topsoil to improve bonding (see* **Surface Roughening** *measure).*

Specifications

Materials

Topsoil shall inclusively mean a soil:

- *meeting one of the following soil textural classes established by the United States Department of Agriculture Classification System based upon the proportion of sand, silt, and clay size particles after passing a 2 millimeter (mm) sieve and subjected to a particle size analysis:*
  - loamy sand, including coarse, loamy fine, and loamy very fine sand,
  - sandy loam, including coarse, fine and very fine sandy loam,
  - loam, or
  - silt loam with not more than 60% silt;
- *containing not less than 6% and not more than 20% organic matter as determined by loss-on-ignition of oven dried samples dried at 105 degrees centigrade;*
- *possessing a pH range of 6.0-7.5, except if the vegetative practice being used specifically requires a lower pH, then pH may be adjusted accordingly;*
- *having soluble salts not exceeding 500 ppm; and*
- *that is loose and friable and free from refuse, stumps, roots, brush, weeds, frozen particles, rocks, and stones over 1.25 inches in diameter, and any material that will prevent the formation of a suitable seedbed or prevent seed germination and plant growth.*

Topsoil may be of natural origin or manufactured by blending composted organic materials with organic deficient soils, mineral soils, sand and lime such that the resulting soil meets the material specifications listed above.

All topsoil shall be analyzed by a recognized soil testing laboratory for organic content, pH and soluble salts requirements given above.

Calculating Topsoil Needs

Topsoiling needs can be calculated by using the values given in **Figure TO-1**. Calculate topsoil needs in advance of stripping to determine if there is sufficient topsoil of good quality to justify stripping.

Stripping

Stripping shall be confined to the immediate construction area. A 4- to 6-inch stripping depth is common, but depth may vary depending on the particular soil. Place all perimeter dikes, basins, and other sediment controls prior to stripping.

Figure TO–1 Topsoil Required for Application of Various Depths

Depth in Inches	Cu. Yds / 1,000 ft^2	Cu. Yds/ Acre
4	12.4	537
5	15.5	672
6	18.6	806

Stockpiling

Stockpile topsoil that is stripped from the site in such a manner that natural site drainage is not obstructed and no off-site sediment damage results. In all cases, locate stockpiles to maximize distance from wetlands and/or watercourses.

The side slopes of all stockpiles shall not exceed 2:1.

Install a sediment barrier down slope to trap sediments eroding from the stockpile. Stabilize the stockpiled material if it is to remain for a period of 30 day or longer (see **Temporary Soil Protection**, **Temporary Seeding**, **Permanent Seeding**, and **Mulch for Seed** measures for application timing requirements).

Application of Topsoil

Site Preparation: Install and/or repair erosion and sediment control measures such as diversions, grade stabilization structures, waterways, silt fence and sediment basins before topsoiling. Maintain these measures during topsoiling.

Bonding: After bringing the subsoil to grade (and immediately prior to spreading the topsoil), the subgrade shall be loosened by discing, scarifying or tracking to a depth of a least 4 inches to ensure bonding of the topsoil and subsoil. For a tracking description, see **Surface Roughening** measure.

Applying Topsoil: Distribute the topsoil uniformly to a minimum depth of 4 inches. Maintain approved grades when spreading topsoil. Correct any irregularities in the surface resulting from topsoiling or other operations in order to prevent the formation of depressions or water pockets.

Note: *Do not place topsoil if the subgrade or the topsoil is frozen or excessively wet.*

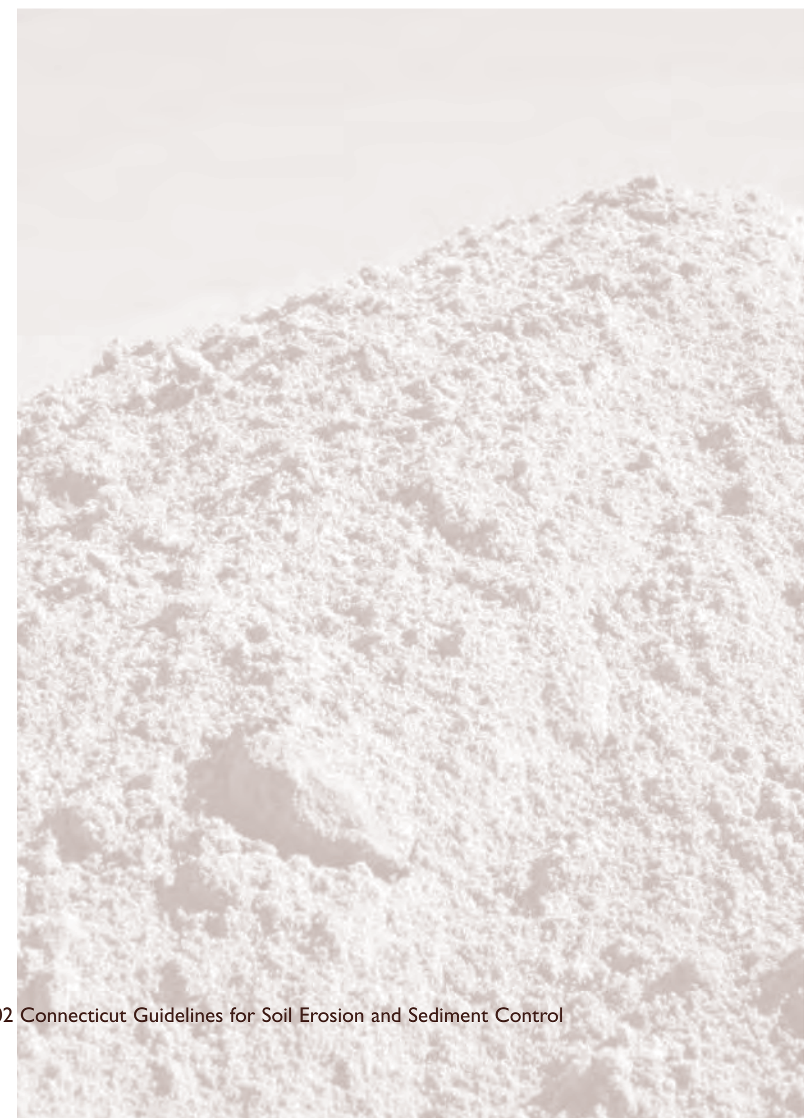
Ensure good contact with the underlying soil and obtain a uniform firm seedbed for the establishment of vegetation. Avoid excessive compaction as it increases runoff velocity and volume, and inhibits seed germination.

Liming: Where the pH of the subsoil is 6.0 or less, ground agricultural limestone shall be spread in accordance with the soil test to attain a pH of 6.0 to 6.5 or to attain a pH as required by the vegetative establishment practice being used.

Stabilizing Applied Topsoil: Immediately following topsoil applications, protect the topsoil from erosion by either sodding, seeding and/or mulching (see measures in the Short Term Non- Living Soil Protection Group and the Vegetative Soil Cover Group).

Maintenance

Inspect and maintain in accordance with the surface protection measure(s) used.



Land Grading (LG)

Definition
Reshaping of the ground surface by excavation or filling or both, to obtain planned grades.

Purpose
- To control surface runoff and reduce erosion potential.
- To prepare for the establishment of a vegetative cover on those areas where the existing land surface is to be reshaped by grading.

Applicability
- Where grading to planned elevations is practical for the purposes set forth above.
- On slopes no steeper than 2:1. For slopes steeper than 2:1, see the slope stabilization measures in the Stabilization Structures Functional Group.
- Does not apply to bedrock cuts or faces.

Planning Considerations
Utilize the existing topography and natural features as much as possible when developing a grading plan. This minimizes the degree of land disturbance and avoids extreme grade modifications within a site development.

The two primary factors that determine the potential for excessive erosion on any site are length of slope and steepness. Long slopes without provisions for surface water diversions are much more susceptible to erosion than shorter slopes. As slopes become steeper, the potential for erosion also increases.

Obtain sufficient topographic, soils, hydrologic and geologic information to determine what limitations, if any, are to be considered in a development plan and grading operation. Final slope stability, the impact of the grading operations on adjacent properties and drainage patterns, and the effect of land disturbance on existing vegetation, ground and surface water resources are examples of concerns that must be addressed during planning for land grading.

In situations where geologic and hydrologic conditions clearly indicate a potential stability problem, structural measures shall be considered. Consider the presence of bedrock. Seepage combined with steep slopes and the close proximity of bedrock very often result in an unstable condition. Surface and subsurface drains may be needed to remove excess water.

For fill slopes that will take more than 1 day to construct, consider requiring the use of a **Temporary Fill Berm** and associated **Temporary Pipe Slope Drain**, as may be needed. At the end of the work day divert erosive stormwater runoff away from the unstable slope to a stable discharge point.

Design Criteria

Slope Defined
Slope is the relationship of horizontal distance to vertical distance and is referenced as either horizontal to vertical, a ratio of horizontal:vertical or a percentage of the vertical divided by the horizontal. **Figure LG-1** identifies the methods by which slope is determined.

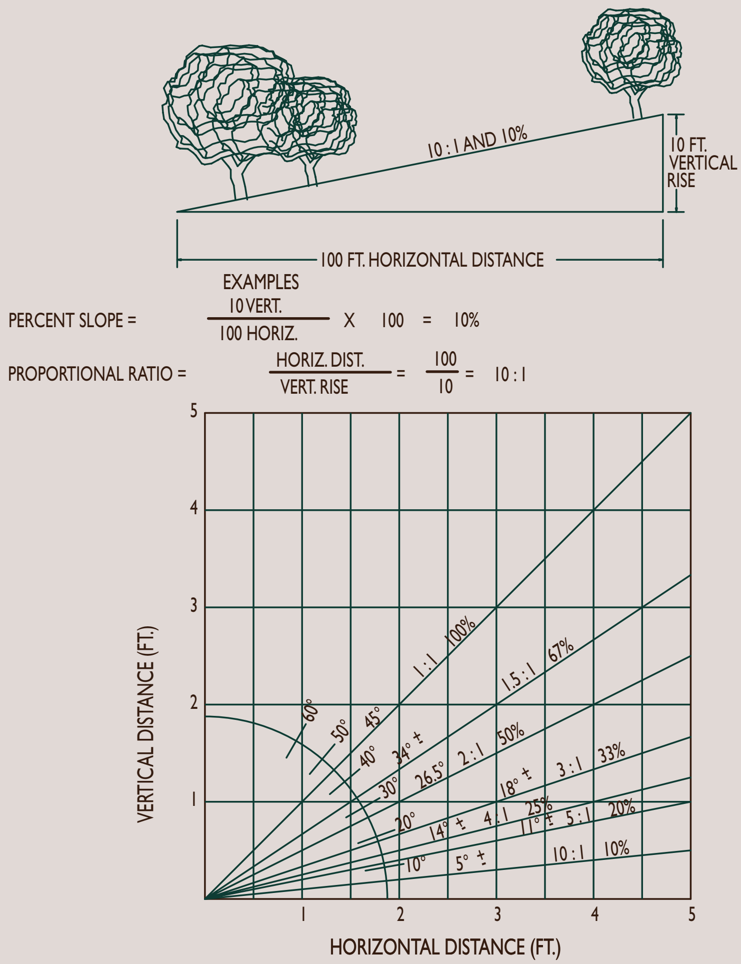
Slope Gradient Limitations
Vegetated Mowed Slopes: Where a slope is to be vegetated and mowed, the slope shall not be steeper than 3:1; flatter slopes are preferred because of safety factors related to the operation of equipment.

Vegetated Unmowed Slopes: Where a slope is to be vegetated but not mowed, the slope shall not be steeper than 2:1.

Structurally Stabilized Slopes: For slopes steeper than 2:1, or when slopes are steeper than 3:1 and the change in elevation exceeds 15 feet without a cross slope bench, engineered structural design features shall be incorporated. Applicable engineered measures may include those found in the Stabilization Structures Functional Group (see **Figure 3-2**, Selection Matrix) or other structural measures designed by the engineer.

Exceptions: Slope limitations may be increased providing detailed soil mechanics analysis calculations are performed which confirm an acceptable safety factor for the finished slope.

Figure LG-1 Determining Slope



Source: USDA-NRCS

Figure LG-2 Example of Formula for Top Slope Diversions

Example:	**Determine the maximum allowable overland flow distance, A, for a 3:1 side slope with a vertical interval of 7 feet.**
Given:	**X = 3 Y = 7**
Solution:	**A = X(15-Y)** **A = 3(15-7)** **A = 24'**
Summary:	**A = 24'** **B = 15(X) Since X=3 then 15'(3') = 45'**
Therefore:	**If the overload flow distance is <24, then A+XY<B and no diversion or cross slope bench is required.**

Slope Length Limitations and Reverse Slope Benches

Reverse slope benches are required whenever the vertical height of any **slope steeper than 3:1 exceeds 15 feet** (see **Figure LG-3**), except when engineered slope stabilization structures measures are included in the slope and/or a detailed soil mechanics analysis calculation has confirmed an acceptable factor of safety exists for the finished slope. Using the following design criteria provide:

- *spacing between benches into nearly equal segments and convey the surface and subsurface water to a stable outlet while still considering soils, seeps, rock outcrops, and other site conditions;*
- *bench width(s) of at least 6 feet (or sufficient to accommodate construction and long term maintenance equipment);*
- *reverse slope(s) of 5:1 or flatter between the outer edge of the bench and the toe of the upper slope;*
- *a minimum bench depth of 1 foot;*
- *bench gradient(s) to a stable outlet of at least 1% but not greater than 2%; and*
- *no total flow length(s) within the bench exceeding 800 feet unless accompanied by appropriate design and computations to demonstrate adequate capacity and stability.*

Controlling Water Movement

Make provisions to safely conduct surface runoff to storm drains, protected outlets or to stable watercourses to ensure that runoff will not damage slopes or other graded areas. See measures in the Stabilization Structures Group, **Vegetated Waterway, Permanent Diversion, Outlet Protection** and related measures. For slope designs that include engineered slope stabilization measures and where the change in elevation exceeds 15 feet without the inclusion of a reverse slope bench, perform an engineering analysis to determine the measures required to insure runoff will not damage the slope or other graded areas. For all other slopes perform the following analysis.

Surface Water: Maximum allowable overland flow distance in feet to the top of the designed slope with no diversion of surface water is determined by use of the formula:

$$A = X\,(15 - Y)$$

A = Maximum overland flow distance in feet above the crest of the designed slope

B = Maximum horizontal distance in feet shall not exceed 15*X*.

X = Side slope; horizontal distance in feet to one-foot vertical (e.g., = 2 for designed slope 2:1)

Y = Height of designed slope in feet measured vertically from toe elevation of the designed slope to top of cut or fill for the designed slope.

Either divert surface water from the face of all cut and fill slopes by the use of diversions, ditches and drainageways or otherwise convey it down the slope by the use of other appropriate measures. Surface water may be allowed to flow down cut and fill slopes when all of the following conditions exist:

- *the length of overland flow (in feet) to the crest of the designed slope does not exceed the distance "A";*
- *the face of the slope is already stable or the face of the slope is protected from surface runoff until it is stabilized (stability can be predicted by applying the Revised Universal Soil Loss Equation. See Appendix I);*
- *the face of the slope is not subjected to any concentrated flows of surface water from natural drainage ways and structures such as graded drainageways and downspouts; and*
- *the maximum total horizontal overland flow (A) plus slope distance (B) does not exceed 15 times the side slope (X) of the cut or fill slopes.*

Figure LG-2 contains an example that uses the formula referenced above.

Subsurface Water: Subsurface drainage shall be provided where necessary to intercept groundwater seepage that would otherwise adversely affect slope stability or create excessively wet site conditions that would hinder or prohibit desired vegetative growth. (See **Subsurface Drain** measure).

Land Grading (LG)

Other Design Limitations

Slopes shall not be created close to property lines so as to endanger adjoining properties without adequately protecting such properties against erosion, sedimentation, slippage, settlement, subsidence or other related damage.

Soil material used for earth fill shall be obtained from an approved borrow pit or other designated area. The fill material shall be free of brush, rubbish, large rocks, logs, stumps, building debris, and other objectionable material that would interfere with, or prevent construction of, satisfactory fills. It should be free of stones over 2 inches in diameter where compacted by hand or mech anical tampers or over 6 inches in diameter where compacted by rollers or other equipment. Frozen material shall not be placed in the fill nor shall the fill material be placed on a frozen foundation.

Stockpiles, borrow areas and spoil areas shall be located away from steep slopes and surface waters and shall be shown on the plans. Soil stockpiles shall be subject to the provisions of this measure.

All disturbed areas shall be stabilized in accordance with the E&S measures contained in these Guidelines.

Installation Requirements

1 Protect all graded or disturbed areas including slopes during clearing and construction in accordance with the approved erosion and sediment control plan until they are permanently stabilized.

2. Construct and maintain all erosion and sediment controls in accordance with the approved erosion and sediment control plan.

3. Clear and grub area to be graded. In filled areas where fill exceeds 5 feet in depth, grubbing may not be required.

4. Strip and stockpile topsoil required for the establishment of vegetation in amounts necessary to complete finished grading of all exposed areas. (See Chapter 4, Special Treatments, Stockpile Management)

5. Use only fill materials that are free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills. Frozen material or soft, saturated or highly compressible materials shall not be incorporated into fills. Rock fill and other clean fill[1] may be used providing it does not interfere with the construction of structures.

6. Place and compact all fill in layers not exceeding 1 foot in thickness. No embankment layer shall be deposited on surfaces of snow or ice nor shall it be placed on frozen or unstable surfaces. Where embankments are to be constructed on slopes steeper than 3:1, deeply scarify the existing slope or cut into steps before filling is begun. If fill placement is not completed within 1 day, then install temporary erosion and sediment controls, such as Temporary Fill Berm, as necessary to redirect runoff water away from the unstable slope until fill placement resumes.

7. Compact all fills as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill that is intended to support buildings, structures, conduits and other facilities shall be compacted in accordance with the design specifications.

8. Prior to final seeding, roughen slopes 2:1 through 5:1 to reduce runoff velocities unless the engineer directs otherwise. (See Surface Roughening measure)

9. If areas are to be topsoiled, refer to the **Topsoiling** measure.

10 During all phases of construction keep reverse slope benches free of sediment.

11. The treatment of seeps or springs encountered during construction shall be reviewed and addressed by the engineer in accordance with generally accepted engineering standards.

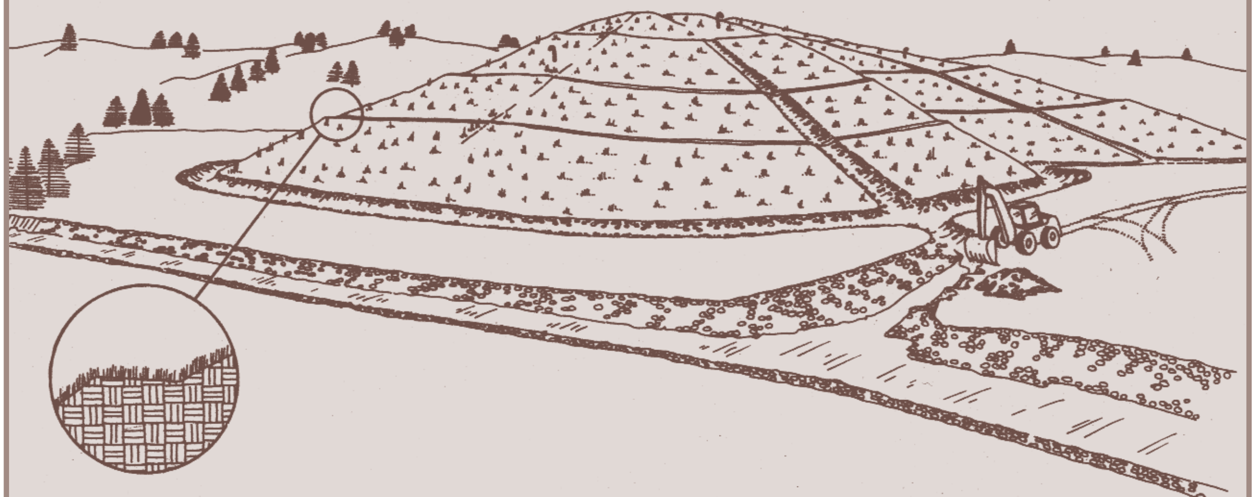
12. Apply permanent soil stabilization measures to all graded areas within 7 days of establishing final grade. (See measures in the Vegetative Soil Cover Functional Group.) If final grading is to be delayed for more than 30 days after land disturbance activities cease, temporary soil stabilization measures shall be applied in accordance with the **Temporary Seeding** measure and associated measures in the Short Term Non-Living Soil Protection Functional Group.

Maintenance

Inspect and maintain all erosion and sediment measures implemented during land grading operations according to their respective requirements.

[1] Clean fill is defined by CGS § 22a-209-1.

Figure LG-3 Illustration of Reverse Slope Bench



Cross slope bench with reverse slope of 5:1 or flatter, at least 1 foot deep.

2-Preserve and Conserve Soils

Surface Roughening (SR)

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

Purpose
- To promote the establishment of vegetative cover with seed.
- To reduce storm water runoff velocity and increase infiltration.
- To reduce sheet erosion and provide for sediment trapping.

Applicability
- On disturbed slopes whose gradients are between 2:1 and 4:1, inclusive.
- Not for slopes that are to be finished with a stable rock face, stone slope protection, or sod.

Planning Considerations
It is difficult to establish vegetation on smooth, hard surfaces. Roughened slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, however this encourages water infiltration, speeds the establishment of vegetation, and decreases runoff velocity.

Roughened loose soil surfaces give lime, fertilizer and seed protection from the erosive effects of rainfall and wind. Depressions in the surface provide microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this microclimate aids seed germination.

Different methods can be used for achieving a roughened soil surface on a slope. The selection of an appropriate method depends upon the type of slope. Roughening methods include grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether it is a cut or fill slope.

It is important to avoid excessive compaction of the soil surface when roughening the surface. Tracking with bulldozer treads is preferable to not roughening at all, but is not as effective as other forms of roughening, as the soil surface is severely compacted and runoff may be increased.

Specifications

For Areas Which Will Not Be Mowed
Cut Slope Applications: Cut slopes between 2:1 and 4:1, inclusive, to shall be tracked or grooved (see **Figure SR-1**). Grooving or tracking consists of using machinery to create a series of ridges and depressions which run perpendicular to the direction of the slope (on the contour). Grooves may be made with any appropriate implement which can be safely operated on the slope and which will not cause undue compaction. Suggested implements include discs, tillers, springtooth harrows, dozer track cleats or the teeth on a front-end loader bucket. Such grooves shall not be less than 3 inches deep nor further than 15 inches apart.

Fill Slope Applications: Fill slopes between 2:1 to 4:1, inclusive, shall be grooved or allowed to remain rough as they are constructed. As lifts of the fill are constructed, soil and rock materials may be allowed to fall naturally onto the slope surface after filling is completed if the surface is not sufficiently roughened. After filling is completed, if the surface is not sufficiently roughened groove or track surface the same as for cut slopes. Slopes shall not be bladed or scraped to produce a smooth, hard surface, except where slopes are meant to be used as a travelway for vehicles and additional erosion and sediment controls are installed.

Areas Which Will Be Mowed

Mowed slopes should not be steeper than 3:1. Excessive roughness is undesirable where mowing is planned. Surface roughening is not recommended for areas to be sodded (See Sodding measure). Areas to be seeded and mowed may be roughened with shallow depressions such as those that remain after harrowing, raking, or using a cultipacker-seeder. Depressions formed by such equipment should be at least 1 inch deep and not further than 12 inches apart. The final pass of any equipment shall be on the contour (perpendicular to the direction of the slope).

Roughening With Tracked Machinery

(see **Figure SR-1**)

Roughening with tracked machinery on soils with a high clay content is not recommended unless no alternatives are available. Undue compaction of surface soil results from this practice. Sandy soils do not compact severely, and may be tracked. In sandy soils tracking may not be as effective as the other roughening methods described.

When tracking is the chosen surface roughening technique, it shall be done by operating tracked machinery up and down the slope to leave horizontal depressions in the soil. As few passes as possible of the machinery should be made to minimize compaction.

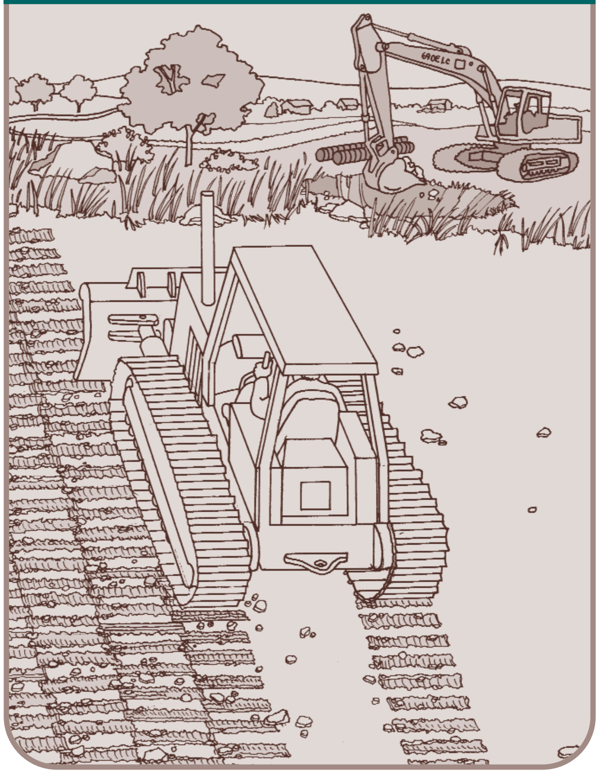
Stabilizing with Seed and/or Mulch

Immediately following surface roughening, protect the soil from erosion by seeding and/or mulching (See measures in the Short Term Non-Living Soil Protection Functional Group and the Vegetative Soil Cover Functional Group).

Maintenance

Inspect and maintain in accordance with the surface protection measure(s) used.

Figure SR-1 Tracking Slopes



Dust Control (DC)

Definition

The control of dust on construction sites, construction roads and other areas where dust is generated.

Purpose

To prevent the movement of dust from exposed soil surfaces, which may cause both off-site and on-site damage, be a health hazard to humans, wildlife and plant life, or create a safety hazard by reducing traffic visibility.

Applicability

- On unstable soils subject to construction traffic.
- Where unstable soils are located on hill tops or long reaches of open ground and can be exposed to high winds.

Planning Considerations

When construction activities expose soils, fugitive dust is emitted both during these activities (i.e., excavation, demolition, vehicle traffic, rock drilling and other human activities) and as a result of wind erosion of the exposed earth surfaces. Large quantities of dust can be generated during "heavy" construction activities, such as road and street construction, subdivision, commercial or industrial development.

In planning for dust controls:

❍ *Limit the amount of exposed soil by phasing construction to reduce the area of land disturbed at any one time and by using, as soon as possible, stabilization measures such as anchored* ***Temporary Soil Protection****,* ***Temporary Seeding*** *or* ***Permanent Seeding*** *with anchored* ***Mulch for Seed****,* ***Landscape Planting****s with* ***Landscape Mulch****,* ***Sodding*** *or* ***Stone Slope Protection****.*

❍ *Maintain as much natural vegetation as is practicable. Undisturbed vegetative buffers (minimum of 50-foot width) left between graded areas and area to be protected can be very effective.*

❍ *Identify and address sources of dust generated by construction activities. Limit construction traffic to predetermined routes. Paved surfaces require mechanical sweepers to remove soil that has been deposited or tracked onto the pavement. On unpaved travelways and temporary haul roads, use road construction stabilization measures and/or water as needed to keep surface damp. Stationary sources of dust, such as rock crushers, use fine water sprays to control dust. If water is expected to be needed for dust control, identify the source of water in advance. Pumping from streams, pond and similar waterbodies may require approval from the municipal inland wetland agency.*

❍ *Identify and address sources of wind generated dust. Provide special consideration to hill tops and long reaches of open ground where slopes may be exposed to high winds. Consider breaking up long reaches with temporary windbreaks constructed from brush piles, geotextile silt fences or hay bales. Plan on stabilizing slopes early. Mulch for seed will require anchoring when used.*

❍ *Consider water quality when selecting the method and/or materials used for dust control. When considering the use of calcium chloride, be aware of the following: the receiving soil's permeability so as to prevent groundwater contamination; the timing of the application to rainfall to prevent washing of salts into sensitive areas such as wetlands and watercourses; and proximity to sensitive areas such as watercourses, ponds, established or soon to be established area of plantings, where salts could impair or destroy plant and animal life. Additionally, some materials used for dust control may be rendered ineffective by degraded water quality if it is used for mixing.*

Consider using dust control measures only after it is determined that other measures for soil stabilization cannot be practically applied.

Specifications

Mechanical Sweeping

Use mechanical sweeping on paved areas where dust and fine materials accumulate as a result of truck traffic, pavement saw cutting spillage, and wind or water deposition from adjacent disturbed areas. Sweep daily in heavily trafficked areas.

Water

Periodically moisten exposed soil surfaces on unpaved travelways to keep the travelway damp.

Non-Asphaltic Soil Tackifier

Non-asphaltic soil tackifier consists of an emulsified liquid soil stabilizer of organic, inorganic or mineral origin, including, but not limited to the following: modified resins, calcium chloride, complex surfactant, copolymers or high grade latex acrylics. The solutions shall be non-asphaltic, nontoxic to human, animal and plant life, noncorrosive and nonflammable. Materials used shall meet local, state and federal guidelines for intended use. All materials are to be applied according to the manufacturer's recommendations and all safety guidelines shall be followed in storing, handling and applying materials.

Maintenance

Repeat application of dust control measures when fugitive dust becomes evident.

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Planning Considerations

The measures included in the vegetative soil cover group include **Temporary Seeding, Permanent Seeding, Sodding** and **Landscape Planting.** These measures serve the common function of stabilizing the soil through the establishment of a vegetative cover.

The **Temporary Seeding** measure is applicable to those areas where the phasing and sequencing of a project require an initial disturbance followed by an extended period of inactivity that is greater than 30 days but less than 1 year. It is important to note that temporary seedings will not provide the same level of protection that permanent vegetation will provide. Temporary seeding mixtures do not develop a "turf" or "sod." Temporary seedings do not generally receive the same level of maintenance as permanent seedings. This measure is used with the **Mulch for Seed** measure.

The **Permanent Seeding** measure is applicable to those areas that have been disturbed and will remain so for 1 year or more. It is also applicable to those areas that have been brought to a final grade and ready for final vegetation establishment. This measure is used with the **Mulch for Seed**, **Topsoiling, Temporary Erosion Control Blanket** and **Permanent Turf Reinforcement Mat** measures.

The **Sodding** measure is recommended for lands needing rapid establishment and highly effective grass cover. It provides almost instantaneous soil protection with high aesthetic value and is very useful in critical watersheds, particularly at times outside of the recommended seeding dates. This measure may be used following the **Topsoiling** and **Permanent Turf Reinforcement Mat** measures.

The **Landscape Planting** measure is most commonly used where aesthetics, wildlife habitat and noise control are needed. It is frequently used in conjunction with the **Landscape Mulch** measure.

The early establishment of either temporary or permanent vegetative cover can reduce and even prevent costly maintenance operations for other erosion control systems. For example, the frequency of cleaning out sediment basins will be reduced if the drainage area of the basin is seeded where grading and construction are not taking place. The establishment of grass cover is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

Definition

Establishment of temporary stand of grass and/or legumes by seeding and mulching soils that will be exposed for a period greater than 1 month but less than 12 months.

Purpose

To temporarily stabilize the soil and reduce damage from wind and/or water erosion and sedimentation until permanent stabilization is accomplished.

Applicability

- Within the first 7 days of suspending work on a grading operation that exposes erodible soils where such suspension is expected to last for 1 to 12 months. Such areas include soil stockpiles, borrow pits, road banks and other disturbed or unstable areas.
- Not for use on areas that are to be left dormant for more than 1 year. Use permanent vegetative measures in those situations.

Specifications

Seed Selection

Select grass species appropriate for the season and site conditions from **Figure TS-2**.

Timing Considerations

Seed with a temporary seed mixture within 7 days after the suspension of grading work in disturbed areas where the suspension of work is expected to be more than 30 days but less than 1 year. Seeding outside the optimum seeding dates given in **Figure TS-2** may result in either inadequate germination or low plant survival rates, reducing erosion control effectiveness.

Site Preparation

Install needed erosion control measures such as diversions, grade stabilization structures, sediment basins and grassed waterways in accordance with the approved plan.

Grade according to plans and allow for the use of appropriate equipment for seedbed preparation, seeding, mulch application, and mulch anchoring. All grading should be done in accordance with the **Land Grading** measure.

Seedbed Preparation

Loosen the soil to a depth of 3-4 inches with a slightly roughened surface. If the area has been recently loosened or disturbed, no further roughening is required. Soil preparation can be accomplished by tracking with a bulldozer, discing, harrowing, raking or dragging with a section of chain link fence. Avoid excessive compaction of the surface by equipment traveling back and forth over the surface. If the slope is tracked, the cleat marks shall be perpendicular to the anticipated direction of the flow of surface water (see **Surface Roughening** measure).

Apply ground limestone and fertilizer according to soil test recommendations (such as those offered by the University of Connecticut Soil Testing Laboratory or other reliable source). Soil sample mailers are available from the local Cooperative Extension System office. Appendix E contains a listing of the Cooperative Extension System offices.

If soil testing is not feasible on small or variable sites, or where timing is critical, fertilizer may be applied at the rate of 300 pounds per acre or 7.5 pounds per 1,000 square feet of 10-10-10 or equivalent. Additionally, lime may be applied using rates given in **Figure TS-1**.

Figure TS-1 Soil Texture vs. Liming Rates

Soil Texture	Tons / Acre of Lime	Lbs / 1000 ft^2 of Lime
Clay, clay loam and high organic soil	3	135
Sandy loam, loam, silt loam	2	90
Loamy sand, sand	1	45

Seeding

Apply seed uniformly by hand, cyclone seeder, drill, cultipacker type seeder or hydroseeder at a minimum rate for the selected seed identified in **Figure TS-2**. Increase seeding rates by 10% when hydroseeding.

Mulching

Temporary seedings made during optimum seeding dates shall be mulched according to the **Mulch for Seed** measure. Note when seeding outside of the optimum seeding dates, increase the application of mulch to provide 95%-100% coverage.

Maintenance

Inspect seeded area at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater for seed and mulch movement and rill erosion.

Where seed has moved or where soil erosion has occurred, determine the cause of the failure. Bird feeding may be a problem if mulch was applied too thinly to protect seed. Re-seed and re- mulch. If movement was the result of wind, then repair erosion damage (if any), reapply seed and mulch and apply mulch anchoring. If failure was caused by concentrated runoff, install additional measures to control water and sediment movement, repair erosion damage, re-seed and re-apply mulch with anchoring or use **Temporary Erosion Control Blanket** measure.

Continue inspections until the grasses are firmly established. Grasses shall not be considered established until a ground cover is achieved which is mature enough to control soil erosion and to survive severe weather conditions (approximately 80% vegetative surface cover).

Figure TS-2 Temporary Seeding Rates and Dates

Species[4]	Seeding Rates (pounds) /Acre	Seeding Rates (pounds) /1000 sq. ft.	Optimum Seed Depth[2] (inches)	Optimum Seeding Dates[1]	Plant Characteristics
Annual ryegrass Lolium multiflorum	40	1.0	0.5	3/1–6/15; 8/1–10/15	May be added in mixes. Will mow out of most stands
Perennial ryegrass Lolium perenne	40	1.0	0.5	3/15–7/1; 8/1–10/15	Use for winter cover. Tolerates cold and low moisture.
Winter Rye Secale cereale	120	3.0	1.0	4/15–7/1; 8/15–10/15	Quick germination and heavy spring growth. Dies back in June with little regrowth.
Oats Avena sativa	86	2.0	1.0	3/1–6/15; 8/1–9/15	In northern CT. will winter kill with the first killing frost and may through-out the state in severe winters.
Winter Wheat Triticum aestivum	120	3.0	1.0	4/15–7/1; 8/15–10/15	Quick germination with moderate growth. Dies back in June with no regrowth.
Millet Echinochloa crusgalli	20	0.5	1.0	5/15–7/15	Warm season small grain. Dies with frost in September.
Sudangrass Sorghum sudanense	30	0.7	1.0	5/15–8/1	Tolerates warm temperatures and droughty conditions.
Buckwheat Fagopyrum esculentum	15	0.4	1.0	4/1–9/15	Hardy plant that will reseed itself and is good as a green manure crop.
Weeping lovegrass Eragostis curbula	5	0.2	0.25	6/1–7/1	Warm-season perennial. May bunch. Tolerates hot, dry slopes, acid infertile soils. Excellent nurse crop. Usually winter kills.
DOT All Purpose Mix[3]	150	3.4	0.5	3/15–6/15; 8/15–10/15	Suitable for all conditions.

[1] May be planted throughout summer if soil moisture is adequate or can be irrigated. Fall seeding may be extended 15 days in the coastal towns.

[2] Seed at twice the indicated depth for sandy soils.

[3] See Permanent Seeding **Figure PS-3** for seeding mixture requirements.

[4] Listed species may be used in combinations to obtain a broader time spectrum. If used in combinations, reduce each species planting rate by 20% of that listed.

Source: USDA–NRCS

Definition

Establishment of permanent stand of grass and/or legumes by seeding and mulching exposed soils with a seed mixture appropriate for long term stabilization.

Purpose

To permanently stabilize the soil with a vegetative cover that will prevent damage from wind and/or water erosion and sedimentation.

Applicability

- On disturbed or erodible soils have been brought to final grade or where the suspension of work is expected to exceed 1 year, and
- Where slopes gradients are no steeper than 2:1. For slopes steeper than 2:1, use slope stabilization measures from the Stabilization Structures Functional Group.

Planning Considerations

There are several factors that should be considered when evaluating a site for the establishment of permanent vegetation.

Time Of Year

Seeding dates in Connecticut are normally April 1 through June 15 and August 15 through October 1. Spring seedings give the best results and spring seedings of all mixes with legumes is recommended. There are two exceptions to the above dates. The first exception is when seedings will be made in the areas of Connecticut known as the Coastal Slope and the Connecticut River Valley. The Coastal Slope includes the coastal towns of New London, Middlesex, New Haven, and Fairfield counties. In these areas, with the exception of crown vetch[1], the final fall seeding dates can be extended an additional 15 days. The second exception is frost crack or dormant seeding. In this type of seeding, the seed is applied during the time of year when no germination can be expected, normally November through February. Germination will take place when weather conditions improve. In this type of seeding, mulching is extremely important to protect the seed from wind and surface erosion and to provide erosion protection until the seeding becomes established.

Topsoiling Needs

The need to topsoil is determined by a combination of existing soil fertility and intended use. The poorer the site is in terms of natural fertility and soil texture, the greater the need for topsoil. This is especially true on sites where a high quality vegetative cover is needed either for erosion control or aesthetics.

Soil Texture

Soil texture (ratio of gravel, sand, silt, clay and organic matter) can affect the choice of a seed mixture for vegetating disturbed areas. For example, sites which have soils with a large percentage of sands and gravels will tend to be droughty and therefore require a drought tolerant mixture. Conversely, sites that exhibit somewhat poorly or poorly drained characteristics will require a mixture that will tolerate wet conditions. Soil texture of the site may warrant consideration for the use of topsoil (see **Topsoiling** measure) or sodding (see **Sodding** measure).

Intended Use

Referring to **Figure PS-2**, consider the ultimate use and maintenance requirements of the area when choosing a seed mixture to be used. There are two levels of maintenance: areas that will be mowed and areas that will not.

Areas that will be mowed can have different levels of maintenance and mowing. Golf courses and recreation areas will require more intensive management than roadside banks and medians.

Areas such as spoil banks, gravel pits and steep roadbanks once seeded and established will require no further mowing and little, if any, maintenance.

Topography or Finished Grade

Do not use permanent seeding on slopes steeper than 2:1. Under saturated conditions slopes could develop deep or shallow surface failures. In cases such as this, maintenance can be a constant problem and there can be danger to structures. A thorough site investigation is needed to determine if alternatives such as benching or

[1] When crown vetch is seeded in late summer, at least 35% of the seed should be hard seed (unscarified).

other structural methods are needed to ensure soil stability before seeding is done.

Cool Season versus Warm Season Grasses

Cool season grasses are those species that normally begin growth very early in the spring (late March to early April) and will continue to grow until warm weather sets in mid-June. At the onset of hot weather, cool season grasses will enter a stage of dormancy and exhibit little growth. They will maintain that dormant state until the cooler weather of the fall (end of August) and will then begin to grow again until late fall (end of October). Warm season grasses on the other hand, do not begin vigorous growth until warm weather (late May) and will continue growth until cool weather in the late fall (mid-September). Cool season grasses generally are the sod formers, such as bluegrass, while the warm season grasses, such as the perennial ryes, do not form sod.

Presence of Mulch

Sometimes seeding will occur after a previous application of mulch. If wood chips, bark or similar materials were used on the seeding area, plan on either removing the mulch or incorporating it into the soil and applying more nitrogen (see **Seed Bed Preparation**). Previously applied hay and straw mulch can be incorporated into the soil without adding supplemental nitrogen.

Specifications

Seed Selection and Quantity

Select a seed mixture appropriate to the intended use and soil conditions from **Figure PS-2** and **Figure PS-3** or use mixture recommended by the NRCS. For seed mixtures containing legumes, select the type and amount of inoculant that is specific for the legume to be used.

When buying seed make sure the quality of the seed is given for pure live seed and germination rate. Ask the supplier for an affidavit of purity and germination rate if there is any question. Expect a purity between of 95% and 98% and a germination rate between 70% and 90%. Some seeding mixtures call for pure live seed. An example of calculating pure live seed is given in **Figure PS-3**.

Increase seeding rates 10% when using frost crack seeding[2] or hydroseeding.

Timing

Seed with a permanent seed mixture within 7 days after establishing final grades or when grading work within a disturbed area is to be suspended for a period of more than 1 year. Seeding is recommended from April 1 through June 15 and August 15 through October 1, with the following exceptions:

- *for the coastal towns and in the Connecticut River Valley final fall seeding dates can be extended an additional 15 days, and*
- *dormant or frost crack seeding is done after the ground is frozen.*

Site Preparation

Grade in accordance with the **Land Grading** measure.

Install all necessary surface water controls.

For areas to be mowed remove all surface stones 2 inches or larger. Remove all other debris such as wire, cable, tree roots, pieces of concrete, clods, lumps or other unsuitable material.

Note: *On areas where wood chips and/or bark mulch was previously applied, either remove the mulch or incorporate it into the soil with a nitrogen fertilizer added. Nitrogen application rate is determined by soil test at time of seeding; anticipate 12 lbs nitrogen per ton of wood chips and/or bark mulch.*

Seedbed Preparation

Apply topsoil, if necessary, in accordance with the **Topsoiling** measure.

Apply fertilizer and ground limestone according to soil tests conducted by the University of Connecticut Soil Testing Laboratory or other reliable source. A pH range of 6.2 to 7.0 is optimal for plant growth of most grass species.

Where soil testing is not feasible on small or variable sites, or where timing is critical, fertilizer may be applied at the rate of 300 pounds per acre or 7.5 pounds per 1,000 square feet using 10-10-10 or equivalent and limestone at 4 tons per acre or 200 pounds per 1,000 square feet. Additionally, lime may be applied using rates given in **Figure PS-1**. A pH of 6.2 to 7.0 is optimal.

For areas that were previously mulched with wood chips or bark and the wood chips or bark are to be incorporated into the soil, apply additional nitrogen at a rate that is determined by soil tests at time of seeding.

Figure PS-1 Soil Texture vs. Liming Rates

Soil Texture	Tons / Acre of Lime	Lbs / 1000 ft² of Lime
Clay, clay loam and high organic soil	3	135
Sandy loam, loam, silt loam	2	90
Loamy sand, sand	1	45

[2] Frost crack or dormant seeding is a method used to establish a seeding during the off season and should be used only in extreme cases as there is a smaller chance of success. It can be an effective way to plant grass seed during late winter or early spring. This method is most effective on frozen ground where a seedbed has been prepared, or on areas that have been disturbed and where topsoil exists but vegetation has not been established. Frost crack or dormant seeding can also be used to re-seed or over-seed an area previously seeded, but where the survival was poor. The existing plants will remain undamaged, while the frost works the seed into the soil in bare areas. In all cases, seedings of this type need to be mulched to protect the seed from wind and water until satisfactory growing conditions occur (See Mulch for Seed measure). This method works particularly well with legumes, such as crown vetch and flat pea, which have a hard seed coat and the freezing action breaks down the seed coat to allow for germination.

Work lime and fertilizer into the soil to a depth of 3 to 4 inches with a disc or other suitable equipment.

Continue tillage until a reasonably uniform, fine seedbed is prepared. For areas to be mowed the final soil loosening and surface roughening operation is by hand, harrow or disk. If done by harrow or disc, it is generally done on the contour. Areas not to be mowed can be tracked with cleated earthmoving equipment perpendicular to the slope (see **Surface Roughening** measure). However, for areas where **Temporary Erosion Control Blankets** are to be used instead of **Mulch for Seed** prepare the seed bed in accordance with blanket manufacturer's recommendations.

Inspect seedbed just before seeding. If the soil is compacted, crusted or hardened, scarify the area prior to seeding.

Seed Application

Apply selected seed at rates provided in **Figure PS-3** uniformly by hand, cyclone seeder, drill, cultipacker type seeder or hydroseeder (slurry including seed, fertilizer.). Normal seeding depth is from 0.25 to 0.5 inch. Increase seeding rates by 10% when hydroseeding or frost crack seeding.

Seed warm season grasses during the spring period only.

Apply mulch according to the **Mulch for Seed** measure.

Irrigation for Summer Seeding

When seeding outside of the recommended seeding dates in the summer months, watering may be essential to the establish a new seeding. Irrigation is a specialized practice and care needs to be taken not to exceed the infiltration rate of the soil. Each application must be uniformly applied with 1 to 2 inches of water applied per application, soaking the ground to a depth of 4 inches.

Maintenance

Initial Establishment

Inspect seeded area at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater during the first growing season.

Where seed has been moved or where soil erosion has occurred determine the cause of the failure. Bird damage may be a problem if mulch was applied too thinly to protect seed. Re-seed and re-mulch. If movement was the result of wind, repair erosion damage (if any), re-apply seed and mulch, and apply mulch anchoring. If failure was caused by concentrated water, (1) install additional measures to control water and sediment movement, (2) repair erosion damage, (3) re-seed and (4) re-apply mulch with anchoring or use **Temporary Erosion Control Blanket** measure and/or **Permanent Turf Reinforcement Mat** measure).

If there is no erosion, but seed survival is less than 100 plants per square foot after 4 weeks of growth, re-seed as planting season allows.

Continue inspections until at least 100 plants per square foot have grown at least 6 inches tall or until the first mowing.

First Mowing

Allow the majority of plants to achieve a height of least 6 inches before mowing it the first time. Do not mow while the surface is wet. Mowing while the surface is still wet may pull many seedlings from the soil and often leaves a series of unnecessary ruts. The first mowing should remove approximately one third of the growth, depending upon the type of grass and where it is being used. Do not mow grass below 3 inches.

If the seeding was mulched, do not attempt to rake out the mulching material. Normal mowing will gradually remove all unwanted debris.

Long Term Maintenance

Mow and fertilize at a rate that sustains the area in a condition that supports the intended use. If appropriate the height of cut may be adjusted downward, by degrees, as new plants become established. Carry out any fertilization program in accordance with approved soil tests that determine the proper amount of lime and fertilizer needed to maintain a vigorous sod yet prevent excessive leaching of nutrients to the groundwater or runoff to surface waters.

Although weeds may appear to be a problem, they shade the new seedlings and help conserve surface moisture. Do not apply weed control until the new seeding has been mowed at least four times.

Figure PS-2 Selecting Seed Mix to Match Need

Area To Be Seeded	Mixture Number[1]	
	Mowing Desired	Mowing Not Required
BORROW AREAS, ROADSIDES, DIKES, LEVEES, POND BANKS AND OTHER SLOPES AND BANKS		
A) Well or excessively drained soil[2]	1,2,3,4,5 or 8	5, 6, 7, 8, 9, 10, 11, 12, 16, ***22***
B) Somewhat poorly drained soils[2]	2	5, 6
C) Variable drainage soils[2]	2	5, 6, 11
DRAINAGE DITCH AND CHANNEL BANKS		
A) Well or excessively drained soils[2]	1, 2, 3, or 4	9, 10, 11, 12
B) Somewhat poorly drained soils[2]	2	
C) Variable drainage soils[2]	2	
DIVERSIONS		
A) Well or excessively drained soils[2]	2, 3 or 4	9, 10, 11
B) Somewhat poorly drained soils[2]	2	
C) Variable drainage soils[2]	2	
EFFLUENT DISPOSAL		5 or 6
GRAVEL PITS[3]		26, 27, 28
GULLIED AND ERODED AREAS		3, 4, 5, 8, 10, 11, 12
MINESPOIL & WASTE, AND OTHER SPOIL BANKS (If toxic substances & physical properties not limiting)[3]		15, 16, 17, 18, 26, 27, 28
SHORELINES (Fluctuating water levels)		5 or 6
SKI SLOPES		4, 10
SOD WATERWAYS AND SPILLWAYS	1, 2, 3, 4, 6, 7, or 8	1, 2, 3, 4, 6, 7, or 8
SUNNY RECREATION AREAS (Picnic areas and playgrounds or driving and archery ranges, nature trails)	1, 2 or ***23***	
CAMPING AND PARKING, NATURE TRAILS (Shaded)	19, ***21*** or ***23***	
SAND DUNES (Blowing sand)	25	
WOODLAND ACCESS ROADS, SKID TRAILS AND LOG YARDING AREAS		9, 10, 16, ***22***, 26
LAWNS AND HIGH MAINTENANCE AREAS	1, 19, ***21*** or ***29***	

[1] The numbers following in these columns refer to seed mixtures in **Figure PS-3**. Mixes for shady areas are in ***bold-italics*** print (including mixes 20 through 24).

[2] See county soil survey for drainage class. Soil surveys are available from the County Soil and Water Conservation District Office.

[3] Use mix 26 when soil passing a 200 mesh sieve is less than 15% of total weight. Use mix 26 & 27 when soil passing a 200 mesh sieve is between 15 and 20% of total weight. Use mix 26, 27 & 28 when soil passing a 200 mesh sieve is above 20% of total weight.

Source: USDA-NRCS

Figure PS-3 Seed Mixtures for Permanent Seeding

No.	Seed Mixture (Variety) [4]	Lbs/Acre	Lbs/1,000 Sq. Ft.
1[5]	Kentucky Bluegrass Creeping Red Fescue (Pennlawn, Wintergreen) Perennial Ryegrass (Norlea, Manhatten)	20 20 5 Total 45	.45 .45 .10 1.00
2[5]	Creeping Red Fescue (Pennlawn, Wintergreen) Redtop (Streeker, Common) Tall Fescue (Kentucky 31) or Smooth Bromegrass (Saratoga, Lincoln)	20 2 20 Total 42	.45 .05 .45 .95
3[5]	Creeping Red Fescue (Pennlawn, Wintergreen) Bird's-foot Trefoil (Empire, Viking) with inoculant[1] Tall Fescue (Kentucky 31) or Smooth Bromegrass (Saratoga, Lincoln)	20 8 20 Total 48	.45 .20 .45 1.10
4[5]	Creeping Red Fescue (Pennlawn, Wintergreen) or Tall Fescue (Kentucky 31) Redtop (Streeker, Common) Bird's-foot Trefoil (Empire, Viking) with inoculant[1]	20 2 8 Total 30	.45 .05 .20 .70
5[5]	White Clover Perennial Rye Grass	10 2 Total 12	.25 .05 .30
6[5]	Creeping Red Fescue Redtop (Streeker, Common) Perennial Rye Grass	20 2 20 Total 42	.50 .05 .50 1.05
7[5]	Smooth Bromegrass (Saratoga, Lincoln) Perennial Ryegrass (Norlea, Manhatten) Bird's-foot Trefoil (Empire, Viking) with inoculant[1]	15 5 10 Total 30	.35 .10 .25 .79
8[6]	Switchgrass (Blackwell, Shelter, Cave-in-rock) Weeping lovegrass Little Bluestem (Blaze, Aldous, Camper)	10[1] 3 10[1] Total 23	.25 .07 .25 .57
9[5]	Creeping Red Fescue (Pennlawn, Wintergreen) Crown Vetch (Chemung, Penngift) with inoculant[1] (or Flatpea (Lathco) with inoculant[1]) Tall Fescue (Kentucky 31) or Smooth Bromegrass (Saratoga, Lincoln) Redtop (Streeker, Common)	10 15 (30) 15 2 Total 42 (or 57)	.25 .35 (.75) .35 .05 1.00 (or 1.40)
10[5]	Creeping Red Fescue (Pennlawn, Wintergreen) Redtop (Streeker, Common) Crown Vetch (Chemung, Penngift) with inoculant[1] (or Flatpea (Lathco) with inoculant[1])	20 2 15 (30) Total 37 (or 52)	.45 .05 .35 (.75) .85 (or 1.25)
11[5]	Bird's-foot Trefoil (Empire, Viking) with inoculant[1] Crown Vetch (Chemung, Penngift) with inoculant[1] Creeping Red Fescue (Pennlawn, Wintergreen) or Tall Fescue (Kentucky 31) or Smooth Bromegrass (Saratoga, Lincoln)	8 15 20 Total 43	.20 .35 .45 1.00

continued

Figure PS-3 Seed Mixtures for Permanent Seeding (con't)

No.	Seed Mixture (Variety) [4]	Lbs/1,000 Lbs/Acre	No. Sq. Ft.
12[6]	Switchgrass (Blackwell, Shelter, Cave-in-rock) Perennial Ryegrass (Norlea, Manhatten) Crown Vetch (Chemung, Penngift) with inoculant[1]	101 5 15 Total 45	.25 .10 .35 1.05
13[6]	Crown Vetch (Chemung, Penngift) with inoculant[1] (or (Flatpea (Lathco) with inoculant[1]) Switchgrass (Blackwell, Shelter, Cave-in-rock) Perennial Ryegrass (Norlea, Manhatten)	10 (30) 5[1] 5 Total 20 (or 40)	.25 (.75) .10 .10 .45 (or .95)
14[5]	Crown Vetch (Chemung, Penngift) with inoculant[1] (or (Flatpea (Lathco) with inoculant[1]) Perennial Ryegrass (Norlea, Manhatten)	15 (30) 10 Total 25 (or 40)	.35 (.75) .25 .60 (or 1.00)
15[6]	Switchgrass (Blackwell, Shelter, Cave-in-rock) Big Bluestem (Niagra, Kaw) or Little Bluestem (Blaze, Aldous, Camper) Perennial Ryegrass (Norlea, Manhatten) Bird's-foot Trefoil (Empire, Viking) with inoculant[1]	5[1] 5[1] 5 5 Total 20	.10 .10 .10 .10 .40
16[5]	Tall Fescue (Kentucky 31) Flatpea (Lathco) with inoculant[1]	20 30 Total 50	.45 .75 1.20
17[6]	Deer Tongue (Tioga) with inoculant[1] Bird's-foot Trefoil (Empire, Viking) with inoculant[1] Perennial Ryegrass (Norlea, Manhatten)	10[1] 8 3 Total 21	.25 .20 .07 .52
18[6]	Deer Tongue (Tioga) with inoculant[1] Crown Vetch (Chemung, Penngift) with inoculant[1] Perennial Ryegrass (Norlea, Manhatten)	10[1] 15 3 Total 28	.25 .35 .07 .67
19[3]	Chewings Fescue Hard Fescue Colonial Bentgrass Bird's-foot Trefoil (Empire, Viking) with inoculant[1] Perennial Ryegrass	35 30 5 10 20 Total 100	.80 .70 .10 .20 .50 2.30
20[5]	Deleted due to invasive species		
21[5]	Creeping Red Fescue (Pennlawn, Wintergreen)	Total 60	1.35
22[5]	Creeping Red Fescue (Pennlawn, Wintergreen) Tall Fescue (Kentucky 31)	40 20 Total 60	.90 .45 1.35
23[5]	Creeping Red Fescue (Pennlawn, Wintergreen) Flatpea (Lathco) with inoculant[1]	15 30 Total 45	.35 .75 3.60
24[5]	Tall Fescue (Kentucky 31)	Total 150	3.60

Figure PS-3 Seed Mixtures for Permanent Seeding (con't)			
No.	**Seed Mixture (Variety)[4]**	**Lbs/Acre**	**Lbs/1,000 Sq. Ft.**
25[5]	American Beachgrass (Cape)	58,500 culms/acre	1,345 culms/ 100 sq. ft.
26[6]	Switchgrass (Blackwell, Shelter, Cave-in-rock) Big Bluestem (Niagra, Kaw) Little Bluestem (Blaze, Aldous, Camper) Sand Lovegrass (NE-27, Bend) Bird's-foot Trefoil (Empire Viking)	4.0 4.0 2.0 1.5 2.0 Total 13.5	.10 .10 .05 .03 .05 .33
27[5]	Flatpea (Lathco) Perennial Pea (Lancer) Crown Vetch (Chemung, Penngift) Tall Fescue (Kentucky 31)	10 2 10 2 Total 24	.20 .05 .20 .20 .65
28[5]	Orchardgrass (Pennlate, Kay, Potomac) Tall Fescue (Kentucky 31) Redtop (Streeker, Common) Birds-foot Trefoil (Empire Viking)	5 10 2 5 Total 22	.10 .20 .05 .10 .45
29	Turf Type Tall Fescue (Bonanza, Mustang, Rebel II, Spartan, Jaguar) or Perennial Rye ("Future 2000" mix; Fiesta II, Blazer II, and Dasher II)	175 to 250	6 to 8

[1] Use proper inoculant for legume seeds, use four times recommended rate when hydroseeding.

[2] Use Pure Live Seed (PLS) = $\frac{\%\ \text{Germination X}\ \%\ \text{Purity}}{100}$

EXAMPLE: Common Bermuda seed with 70% germination and 80% purity=

$\frac{70 \times 80}{100}$ or $\frac{56}{100}$ or 56%

$\frac{10\ \text{lbs PLS/acre}}{56\%}$ = 17.9 lbs/acre of bagged seed

[3] DOT All purpose mix

[4] Wild flower mix containing New England Aster, Baby's Breath, Black Eye Susan, Catchfly, Dwarf Columbine, Purple Coneflower, Lance-leaved Coreopsis, Cornflower, Ox-eye Daisy, Scarlet Flax, Foxglove, Gayfeather, Rocky Larkspur, Spanish Larkspur, Corn Poppy, Spurred Snapdragon, Wallflower and/or Yarrow may be added to any seed mix given. Most seed suppliers carry a wild flower mixture that is suitable for the Northeast and contains a variety of both annual and perennial flowers. Seeding rates for the specific mixtures should be followed.

[5] Considered to be a cool season mix.

[6] Considered to be a warm season mix.

Definition

Stabilizing fine-graded disturbed areas with the use of cut pieces of turf.

Purpose

- To permanently stabilize the soil.
- To immediately reduce erosion and the production of dust.
- To filter runoff water, reduce pollution.
- To improve site aesthetics.

Applicability

- On slopes 2:1 or flatter, except on very short slopes where the slope length is no longer than the width of the cut sod.
- In channels where the design velocity does not exceed 5 feet per second (fps) with a duration of 1 hour or less when the velocity is at or near 5 fps. For design velocities that exceed 5 fps, refer to the **Riprap** and **Permanent Turf Reinforcement Mat** measures.
- On sediment producing areas such as drainageways carrying intermittent flows, around drop inlets, in grassed drainageways, cut and fill slopes and other areas where conventional methods of turf establishment may be difficult or risky.
- In watersheds where maintenance of high water quality is particularly important.
- Where establishing turf grass and lawn is needed in the shortest time possible.

Planning Considerations

While the initial cost of sod is much higher than seed and mulch/erosion control blankets, sodding has some distinct advantages. Properly installed, sodding provides the following benefits which may justify the initial added expense:

- *Provides initial higher level of erosion control than seeding and mulching, capable of withstanding heavier rainfalls and velocities without failure and subsequent need for repair;*
- *Is an immediate soil cover and erosion protection where concentrated surface runoff would prevent the establishment of sod by normal seeding procedures;*
- *Establishes of a grass cover outside of the non-seeding dates.*
- *Offers immediate filtration of storm water runoff;*
- *Allows use of site in a much shorter length of time;*
- *Provides a quality controlled product, free from weeds, with predictable results; and*
- *Is aesthetically impressive.*

These reasons are particularly true where quick establishment and protection is important, such as sites in public water supply watersheds or near watercourses, where maintenance of high water quality may be particularly important to fisheries or human consumption.

Additionally, in drainageways and intermittent waterways where concentrated flow will occur, properly installed sod is preferable to seed because there is no time lapse between installation and the time when the channel is protected. Sodding can reduce maintenance to other sediment controls by keeping them free from the silts, sediments and other debris that can result from conventional methods of turf establishment. However, sod is limited in its ability to withstand high velocity and/or long duration flows.

Note: *The application of sod within a drainage way should be based on a determination that vegetation will satisfactorily resist channel velocities. Channel velocities for the design storm should not exceed 5 fps with a duration of less than 1 hour at or near 5 fps.*

As with any other seeding or planting of vegetation, a decision on top soiling must be made. Generally speaking, the poorer the site in terms of natural fertility and soil texture, and where a high quality vegetative cover is needed either for erosion control or aesthetics, the greater the need for topsoil.

Specifications

Materials

Sod consists of:

- *stoloniferous or rhizomatous grasses that form a dense mat of plants, being cut at a uniform soil thickness of 0.75 inch ±0.25 inch) at the time of cutting, excluding the shoot growth and thatch, and*

- *standard size sections of sod 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.*

For sodded waterways, the sod type shall consist of plant materials able to withstand the design velocity (see **Vegetated Waterway** measure).

Timing Limitations

Sod may be placed anytime during the year for slope stabilization but shall not be installed on frozen ground, nor for waterway applications during the months of December, January or February.

Sod shall be harvested, delivered, and installed within 36 hours. Plan site preparation (see below) and delivery of sod accordingly. Have sod delivered to the site as soon as practical after harvesting. During hot weather, delivery should be made within 6 hours and may be extended to 48 hours during cool seasons. It is generally unwise to move sod during July and August. If moved during this period, sod may need to be cut thicker and will require frequent irrigation.

Selection of Sod

Select sod grown from seed of adapted varieties or types and under cultural practices conducive to quality sod that will be free of any serious thatch, weed, insect, disease, and other pest problems.

Select species and varieties best suited for the sites to be stabilized. Use mixtures tested and approved by state experiment stations.

Select sod at least 15 months old but no older than three years. Cultivated turf grass is usually considered ready for harvest when a cut portion of sod 3 feet long by 1 to 1.5 feet wide will support its own weight when suspended vertically from the upper 10% of the section. The most common age of sod when cut is 15 to 24 months.

Select sod cuts of width and length suited to the equipment and job. Generally, sod cuts are from 12 to 24 inches wide with 18 inches being the most common width in New England. Lengths of cuts vary from 4 to 8 feet. Sod may also be available in rolls 16-48" wide with lengths as much as 100 feet in length. In New England, this “big roll” system commonly cuts sod in 200 sq. ft. or 250 sq. ft. rolls made up of 3 units, each 16 inches wide (4 ft. total) and 50 ft. or 62.3 ft long. Mechanical equipment is required for installation. Sod may be cut and rolled or folded in the middle and stacked on pallets.

Folded sod is cut shorter than rolled sod, about 3 to 4 feet in length. About 80% of all rhizomes are in the top fl inch of soil. The thinner the sod is cut the more quickly it will knit to the soil. However, the thinner the sod, the greater the need for irrigation as the thin sod will be more susceptible to drying out.

Site Preparation

Prior to soil preparation, bring to grade areas to be sodded in accordance with the approved plan.

Install and/or repair other sediment control measures needed to control water movement into the area to be sodded.

Clean soil surface of trash, debris, large roots, branches, stones and clods in excess of 1 inch in length or diameter. Do not apply sod to gravel or non-soil surfaces.

Place topsoil as needed, meeting the requirements of Topsoiling measure.

Perform soil tests to determine the exact requirements for lime and fertilizer. The soil tests may be conducted by the agronomy laboratory at the University of Connecticut Soil Testing Laboratory or a reputable commercial laboratory. Information on soil tests and procedures are available from county Cooperative Extension System, commercial nurserymen, lawn care professionals or other reliable source.

When required, spread these amendments evenly over the area to be sodded, and incorporate into the top 3 to 6 inches of the soil (if possible) by discing, harrowing or other acceptable means.

Fill or level any irregularities in the soil surface resulting from top soiling or other operations in order to prevent the formation of depressions or water pockets.

Note: *If the soil is hot or dry, lightly irrigate the soil immediately prior to laying the sod to cool the soil and reduce root burning and die back.*

Sod Installation (see **Figure SO-1**)

Install the first row of sod in a straight line with subsequent rows placed parallel to and butting tightly against each other. Stagger lateral joints to promote more uniform growth and strength. Take care to ensure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids which would cause drying of the roots.

On slopes 3:1 or steeper or wherever erosion may be a problem, lay sod with staggered joints perpendicular to the direction of flow (i.e. on the contour) and secure by pegging or other approved methods. If the site of sodding is to be mowed, the use of wood pegs or biodegradable staples is recommend over metal staples for anchoring to reduce problems caused by mowing equipment hitting metal staples should they get lifted over time from the sod surface. Also, for these areas, sod cut into long strips and rolled for transport is desired because it minimizes the number of sections.

As sodding is completed, roll and tamp the sod to ensure contact with the soil.

After rolling, irrigate the sod to a depth sufficient to thoroughly wet the underside of the sod pad and the 4 inches of soil below the sod.

Sodded Waterway Installations

Follow site preparation requirements listed above.

Use a sod capable of withstanding the design velocity. Lay sod strips perpendicular to the direction of channel flow, taking care to butt the ends of strips tightly.

As sodding of clearly defined areas is completed; roll or tamp the sod to ensure contact with the soil.

Peg or staple to resist washout during the establishment period. Fasten every 3 inches on the leading edge and 1 to 2 ft. laterally. If the site of sodding is to be mowed, the use of wood pegs or biodegradable staples is recommended over metal staples for anchoring to reduce problems caused by mowing equipment hitting metal staples should they get lifted over time from the sod surface.

After rolling, sod shall be irrigated to a depth sufficient to thoroughly wet the underside of the sod pad and the 4 inches below the sod.

Maintenance

During the first week, inspect daily and if rainfall is inadequate, then water the sod as often as necessary to maintain moist soil to a depth of at least 4 inches below the sod. Subsequent waterings may be necessary to ensure establishment and maintain adequate growth.

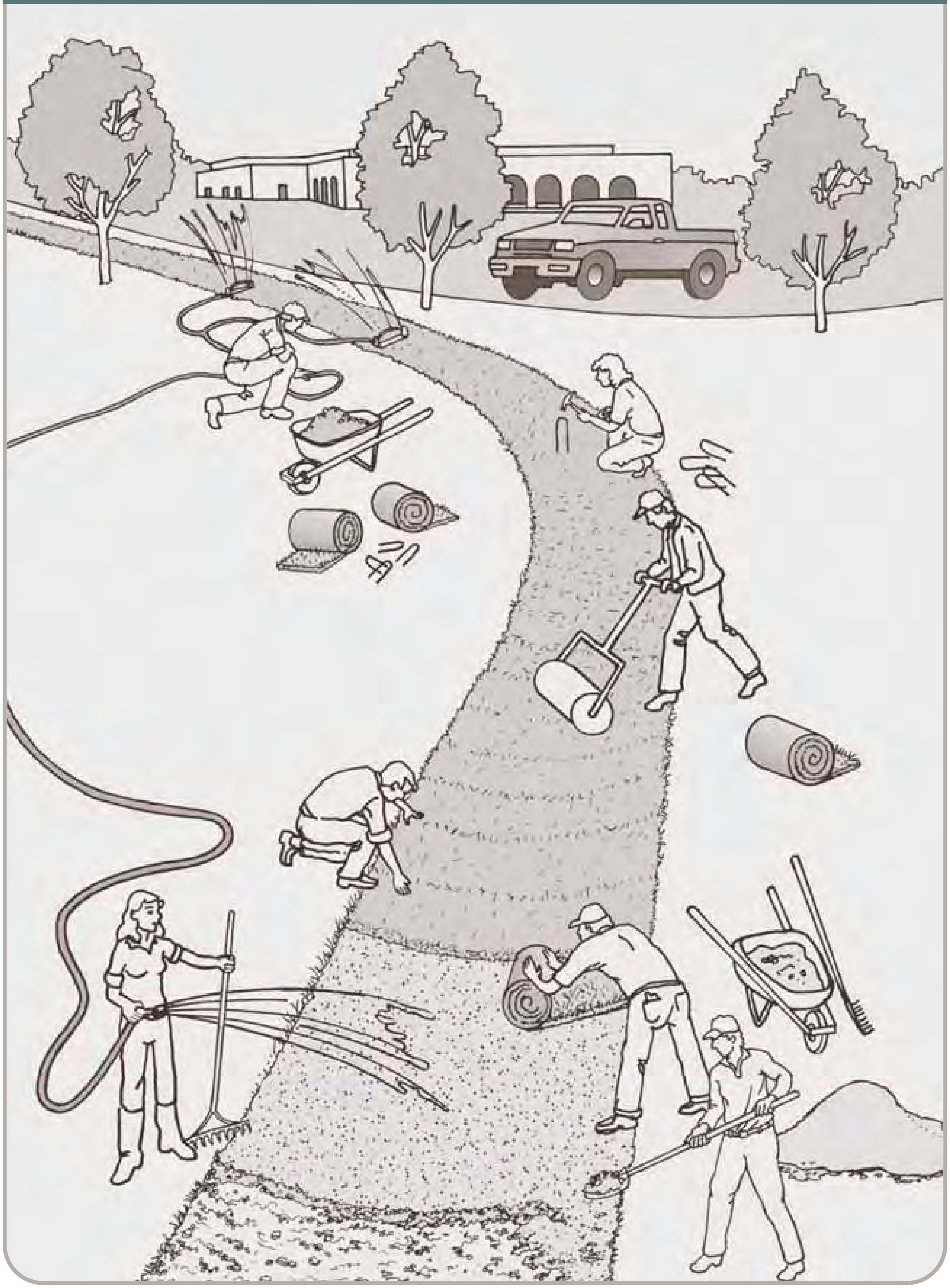
After the first week, inspect sodded area at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater during the first growing season.

Where sod has died or has been moved or where soil erosion has occurred, determine if the failure was caused by inadequate irrigation, poorly prepared surface, improper anchoring, excessive sedimentation or excessive flows. If the failure was caused by concentrated flow, check water velocities and duration to ensure it does not exceed 5 fps or a duration greater than 1 hour at or near 5 fps. Install additional measures to control water and sediment, repair erosion damage, and reinstall sodding with anchoring.

Do not mow until the sod is firmly rooted, usually 2 to 3 weeks. Do not remove more than 1/3 of the grass leaf at any one cutting.

Long term maintenance of the sod should be commensurate with the planned use of the area. For liming and fertilization, follow soil test recommendations when possible.

Figure SO-1 Sod Installation



Definition

Planting trees, shrubs, or ground covers for stabilization of disturbed areas.

Purpose

- To aid in protecting and stabilizing soil.
- To intercept precipitation and retard runoff while providing increased plant diversity, food and shelter for wildlife, and improved air quality; to develop high quality riparian buffers and enhanced site aesthetics.

Applicability

- On steep or irregular terrain, where mowing to maintain an herbaceous plant cover is not feasible.
- Where ornamental plantings are desired to improve site aesthetics.
- In shady areas where turf establishment is difficult.
- Where woody plants are desirable for soil conservation, plant diversity, or to create or enhance wildlife habitat.
- Where permanent plantings will reduce the extent of lawn and lawn maintenance requirements.
- Where riparian or other functional buffers need to be extended, re-established or created.
- Where wind breaks are needed.

Planning Considerations

The initial function of any vegetation to be established on disturbed soils is to prevent soil detachment and subsequent erosion. However, other factors are considered when choosing whether to plant grass and/or other herbaceous vegetation, or whether woody landscape plantings should be utilized.

Some disadvantages to using grass are:

❍ *Permanent grass cover requires periodic mowing to prevent the area from being occupied with shrubs and tree seedlings through the process of natural succession.*

❍ *Grass cover does little to control access by pedestrians or vehicles. In areas of heavy pedestrian use, soil compaction may result in death of the plants, increasing erosion potential.*

❍ *Grass provides limited value for wildlife. However, extensive turf may also provide an attractive feeding habitat for wildlife which may become a nuisance. (e.g. Canada Geese).*

Landscape plantings of trees, shrubs, and ground covers have particular attributes which provide benefits that grass or herbaceous cover cannot. These benefits include:

❍ *Improving air quality;*
❍ *Modifying air circulation patterns;*
❍ *Reducing heating and cooling costs;*
❍ *Providing shade;*
❍ *Preventing blinding reflections;*
❍ *Softening architectural features;*
❍ *Screening undesirable views;*
❍ *Controlling or screening undesirable noises;*
❍ *Calming and controlling traffic;*
❍ *Providing wildlife food and shelter; and*
❍ *Restoring natural conditions to a disturbed site.*

Landscape planting plan

If landscape plantings are intended, then a landscape planting plan should be developed. The landscape planting plan should identify the species, location, number of each planting specified to be planted, the type of planting stock (i.e. bare-root, balled and burlapped, etc.), and the timing for planting.

Newly transplanted trees and shrubs which are carefully selected to match the site conditions will need the least aftercare, and will become established quickly. Conversely, plants put under stress by being transplanted into an environment they are not well adapted to will need extraordinary and long term maintenance. The following characteristics should be taken into account when developing a landscape planting plan and selecting plant material:

Adaptability to Site Conditions: Proper selection of landscape plants requires a careful study of the characteristics of the site, a thorough knowledge of the species available and hardy to the area, and a thorough knowledge of all the potential insect, disease, and cultural problems which may weigh against the plant selected for the required function.

Site characteristics such as soil type, surface and subsurface drainage, and light availability are primary limiting factors that determine if a given plant will survive. Other site specific factors such as exposure to salt at shoreline or roadsides, high winds, polluted air, or heat from reflected sun may limit plant survivability. The specific conditions at each site must be taken into account when selecting the appropriate plant for the site.

Hardiness Zones: Woody landscape plants must be hardy to the area in which they are planted in order to survive. Hardiness zones are geographical areas mapped according to the approximate range of average annual minimum temperatures. Plants adaptable to conditions in specific zones are said to be hardy in those zones (see **Figure LP-1**). Connecticut has three hardiness zones, reflecting the milder conditions along the southwestern shoreline, cooler weather in the eastern and western highlands, and a transitional area dominating the bulk of the central and eastern portions of the state.

Mature Height and Spread: To minimize future maintenance and replacement costs and to enhance long term plant health, select plants to match the species to the site, and place plants to provide adequate space for the plant to grow to its natural mature size.

Consideration must be given to the height and location of overhead utilities, the location and depth of underground facilities, lines of sight around intersections of roadways, road and sidewalk clearance needed for snow removal operations, clearance from buildings, and all other potential situations where the maturing plant will become an obstruction, nuisance, or hazard.

If the space allotted to the plant selected is inadequate, suitable periodic maintenance pruning must be planned in accordance with the needs of the species, limitations of the site, or the intended effect. Normally, plants installed for erosion control purposes are not intended to be pruned, and should be selected and placed with knowledge and consideration of mature sizes.

Growth and Establishment Rate: Some trees and shrubs attain their mature sizes very rapidly, whereas others are slow to grow to mature size. Some shrubs and vines will become established quite rapidly, with growth characteristics like rooting from the growing tips of the stem and sprouting from root systems and underground stems. Knowing how fast a tree, shrub, or vine will become established and how quickly it will grow to mature size is important in order to select the right plant, and the number of plants (spacing) for the particular situation. Growth and establishment rates are also linked to how well the plant has been selected to match the site conditions. Plants that are well adapted to the site will become established quicker, live longer and will require less aftercare.

Ornamental Characteristics, Sanitation: Since these Guidelines are intended to be concerned primarily with landscape planting as it relates to soil erosion and sediment control, no attempt has been made to provide guidance on plant selection for ornamental or aesthetic purposes. However, plants in a landscape design can and should be selected for specific functional attributes which contribute to the goal of soil erosion and sediment control.

Functional characteristics of specific plants should be considered carefully so that the plant chosen will fulfill its intended role. For instance, to control soil erosion, plants with rapidly growing aggressive root systems may be selected. To absorb sound or screen views in winter conditions, deep, dense planting of evergreens may be selected. To filter dust from summer winds, a deciduous tree with coarse, hairy leaves could be chosen for its enhanced ability to trap airborne dust. Plants that provide a variety of nuts and berries as sources of food for wildlife may contribute significantly to the habitat value of a particular location.

Undesirable attributes of plants must also be considered. Aggressive root systems beneficial in one application may create problems in other applications where the roots may enter and obstruct underground pipelines. Root penetration from trees and shrubs may create internal pathways for water in earthen dams and dikes, and roots may also damage sidewalks, structures, pavement, and underground utility installations. Trees with large leaves or that drop excessive quantities of seed pods, nuts, fruits, or other debris may be undesirable for aesthetic, safety, or convenience reasons. Potential clogging of drainage systems with debris from trees must be considered in selecting street trees. Tree species that don't drop troublesome parts, and trees with smaller, thinner leaves, or with leaves that drop gradually are preferred in situations where clogging of drainage systems is a primary concern.

Timing of Transplanting: When plants may be transplanted depends on how they are grown and supplied. Balled and burlapped and container grown plants can be planted any time of the year, provided that the soil at the planting site is not waterlogged or frozen.

Deciduous trees are normally dug and balled for transplanting in the early spring, before flowers or leaves develop. Some species transplant best in either the spring or fall of the year, and balled in burlap stock may not be available other than during the optimal season for transplanting. Normally, spring flowering trees are not dug while flowering, so summer availability of field grown balled and burlapped trees is usually somewhat restricted to those dug early in the season.

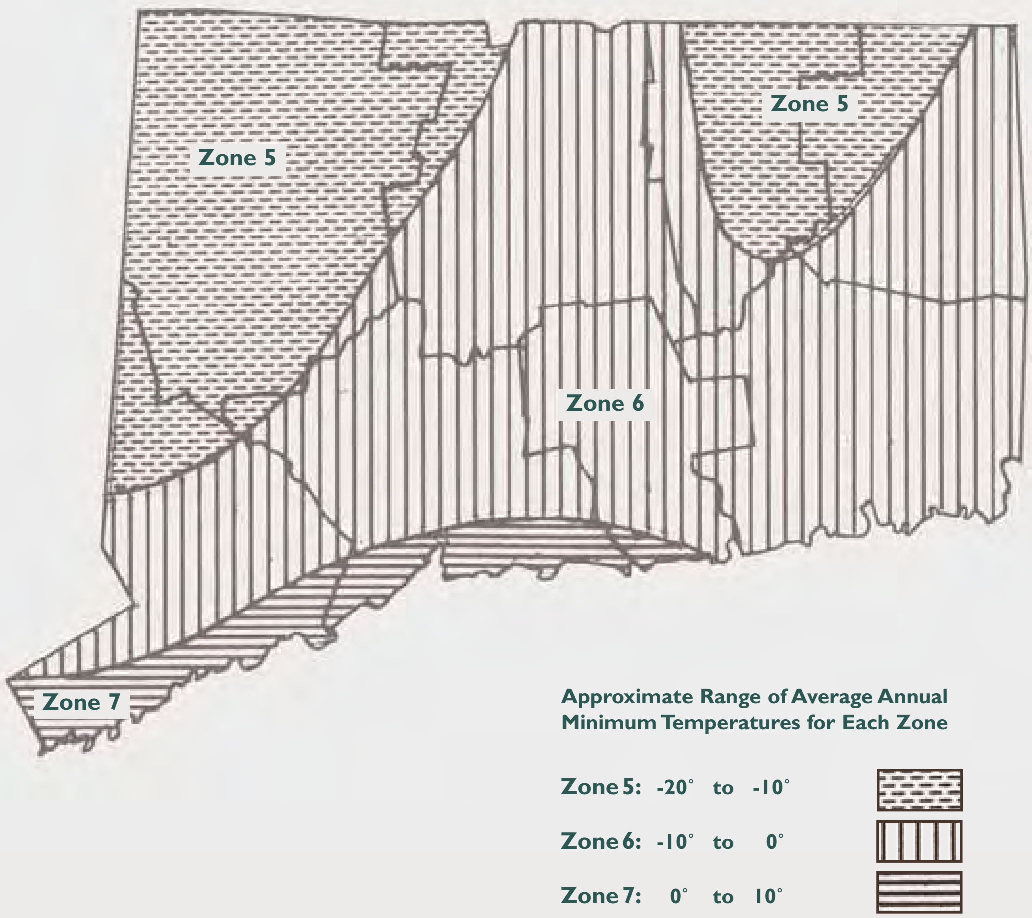
Balled and burlapped plants may lose 90% or more of their root system from the digging operation. If dug during the active summer growth period, significant stress may be placed on the plant. For this reason, digging and balling operations normally cease during the summer months. Summer digging of deciduous trees may be done, but requires special preparation and aftercare to minimize potentially fatal stresses on the plant. Evergreens may also be dug and balled in burlap in the early spring, but are also successfully dug and transplanted in summer after new growth has hardened off.

Trees and shrubs to be planted as bare-root plants should be handled only when dormant in spring, or after leaf fall in autumn.

Landscape Plant Forms, Standards, and Sources: Landscape plants may be bought as balled in burlap or similar material, containerized, or as bare rooted stock. All plants shall comply with the American Standard for Nursery Stock (ANSI Z60.1), produced by the American Association of Nurserymen, which provides a comprehensive and consistent set of measurement and specification standards for all types of plant material.

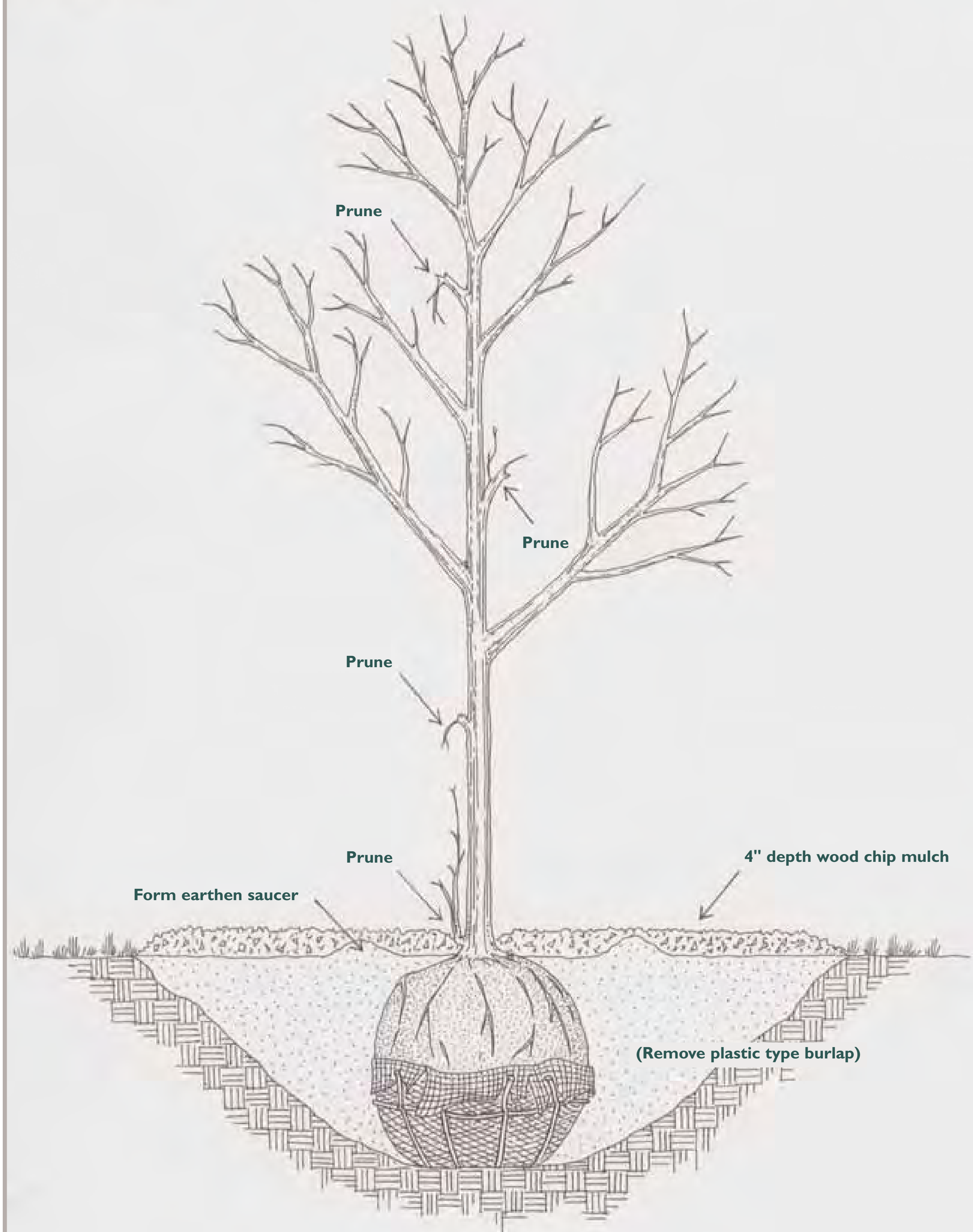
The plants identified in **Figure LP-4, Figure LP-5** and **Figure LP-6** are usually available at commercial nurseries balled in burlap, or in containers. Trees and shrubs may also be purchased from the state nursery or from county Soil and Water Conservation Districts.

Figure LP-1 Hardiness Zone Map of Connecticut



Source: Adapted from USDA-NRCS FOTG Section I iii Maps. July 1994.

Figure LP-2 Transplanting Balled and Burlapped Plants



A broad range of plant material is available to fulfill the desired functions of a landscape planting. Although some plants known to be hardy to Connecticut are included in the list below, information on additional appropriate plants may be obtained from Connecticut licensed Arborists, a landscape architects licensed to practice in Connecticut, the USDA Natural Resources Conservation Service, the Connecticut Agricultural Experiment Station, and the Connecticut Cooperative Extension System.

Invasive Species: Certain introduced shrubs, like Autumn Olive (Elaegnus umbellata), Honeysuckles (Lonicera spp), Multiflora Rose (Rosa multiflora), Winged Euonymus (Euonymus alatus), and Asiatic Bittersweet (Celastrus orbiculatus) have been identified as undesirable because they are not native, and are invasive into otherwise naturally vegetated areas. Native plants are preferred in most soil erosion and sediment control applications. The Center for Conservation and Biodiversity at The University of Connecticut maintains a list entitled: "Invasive, Non-Native Plant Species Occurring in Connecticut", listed as Publication #1, which should be consulted to avoid selecting undesirable, non-native invasive plants.

Specifications

Delivery and Storage of Materials

Upon receipt of plant stock, check to see that adequate protection during transit has been provided. If shipped by open truck, the plants should have been covered with a tarpaulin or canvas to minimize desiccation from exposure to the sun and wind. When delivery is made by an enclosed vehicle, the plants should have been carefully packed and adequately ventilated to prevent "sweating" of the plants. Physical injuries should have been prevented by careful packing.

In all cases, plants must be kept cool and moist until planting.

Insofar as practical, all plant material should be planted on the day of delivery. Plants which must be temporarily stored on site should be kept in the shade and protected from drying winds. For balled stock, root balls must be protected by covering the root ball with soil or other acceptable material and must be kept moist. Container stock held on site may also require watering if planting is delayed. Bare root plant may be stored in a cool, shaded area for as long as 10 days. If bare root plants must be kept for longer than 10 days, they should be "heeled in" (temporarily planted in a trench) until they can be permanently planted. All stock should be handled carefully and as few times as possible.

Transplanting Procedures

Transplanting Balled in Burlap Plant Material: **Figure LP-2** shows the proper planting of balled and burlapped plant material, using a deciduous tree as an illustration.

Stock Examination: Determining Proper Planting Depth - Proper planting depth of a plant balled in burlap may vary depending upon how the plant was dug and balled. Each plant should be examined to determine if the plant was dug and balled properly. To do this, locate the crown of the plant - the point where the root mass or first major root originates from the stem. This point should be at or slightly below the top of the soil. Also use this point as a reference to determine if excess soil cover has been placed over the root ball by improper digging and balling.

Ball sizes should always be of a diameter and depth to encompass enough of the fibrous and feeding root system as necessary for the full recovery of the plant. Recommended ball depth to diameter ratios are shown in **Figure LP-3**. Under certain soil and regional conditions, plants have roots systems of proportionally less depth and greater diameter. Those require a more shallow but wider ball to properly encompass the roots. Conversely, in other soils and in certain regions roots develop greater depth and less spread, requiring an exceptionally deep ball which may be smaller in diameter and greater in depth than the size recommended.

Compare the ball size in relation to the size of the plant, using the current American Standard for Nursery Stock (ANSI Z60.1) and note the size of the roots cut when dug to be balled in burlap. Undersize root balls or large cut roots are a clue that digging may have been improper, and that actual root mass may be inadequate to support the plant during its establishment period.

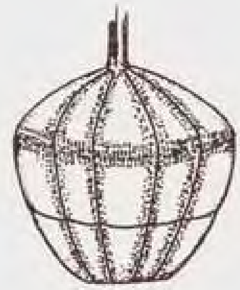
Site Preparation (see **Figure LP-2**): Thoroughly examine the root ball to determine the proper planting depth for each plant (see Stock Examination above). Excavate a planting site whose top width is 3 times the width of the root ball to a depth that is no deeper than the proper planting depth with sloped sides tapering to the surface. The soil under the root ball should remain undisturbed, or if disturbed, should be tamped prior to planting, to prevent settling of the root ball. Since most new roots will grow horizontally from the root ball, compacted soil under the ball will not inhibit rooting.

Planting site preparation should focus on providing the highest quality environment possible for root development during the first year or two after transplanting. Long term survival depends on selecting the proper species for the site. More intensive site preparation will be necessary in urban soil conditions and on disturbed sites than when planting in high quality undisturbed soil.

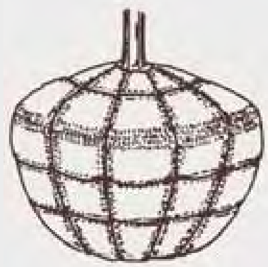
Handling and Setting the Plant: Set the plant in the planting site so that it is plumb, level, and centered. Do not use the trunks of trees as levers to adjust the position of the root ball, as this may fracture the root ball and damage roots. Instead, move the root ball itself, being careful not to pull on ropes which may lay against bark (especially in spring, when bark slips easily).

When the plant is properly positioned in the planting site, **cut all twines and other tying material encircling the trunk**. For natural burlap wrapping pull it back and cut off the excess and discard, do not tuck it into the hole where it can cause problems with air pockets and moisture retention, both of which may lead to rotted roots. Remove synthetic burlap completely. To test fabric to see if it is synthetic, burn an edge with a match. If it melts, it is synthetic and must be completely removed.

Figure LP-3 Ball Depth to Diameter Ratio



Diameter less than 20". Depth not less than 75% of diameter or 3/4 of width.



Diameter 20 to 30". Depth not less than 66.6% or 2/3 of width.

Diameter 31 to 48". Depth not less than 60% or 3/5 of width.
Balls with a diameter of 30" or more should be drum laced.

Wire baskets are commonly used to contain and transport some balled and burlapped plant material. Cut and remove as much of the wire basket as possible to avoid future interference with root growth.

Backfilling, Watering and Mulching: After all tying materials and wire baskets are removed as appropriate, backfill the site to original grade with original soil. Soil amendments are unnecessary in most planting situations. Water the backfill soil thoroughly, allowing the water to settle the soil, removing air pockets. Do not pack with feet or tools. Use enough water to ensure thorough saturation of the soil. Add soil to bring the soil level back up to grade when the water has infiltrated. As a temporary measure to aid in establishment, a low (3" to 6") rim of tamped soil can be built to help hold water for subsequent watering. Locate the inside edge of the rim at or outside the edge of the root ball. Mulch the disturbed area with **Landscape Mulch** (see **Figure LP-2**).

Fertilization: Under normal circumstances, it is not recommended to fertilize woody plants upon initial planting.

Staking: Staking or guying trees using wire covered with rubber hose sections is not recommended in most circumstances. Failure to remove stakes and wires has caused severe damage to trees by girdling the trees at the point of wire attachment. By allowing the tree to flex somewhat in the wind, the tree will be able to develop a proper taper and anchoring roots to naturally resist movement in the wind. Staking and guying may become necessary due to loose root balls, unusually high or persistent prevailing winds, or other specific conditions. In these cases, use of a flexible and biodegradable type of tree tying material is preferred.

Transplanting Bare Root Plant Material

Figure LP-7 shows how to properly plant bare rooted plants and shows the proper minimum root spread for bare root deciduous shrubs. Dig the hole deep and wide enough to accommodate all the roots, and allow them to spread out without bunching or curling. (No "J"- shaped roots.) If the roots are excessively long, they may be pruned back to a length of 10 to 12 inches. Place the plant at the same depth in the soil at which it was planted when rooted in the nursery. Add soil as necessary to fill planting hole to existing grade. Water thoroughly after planting. Make sure that there are no turned up roots or air pockets in the soil.

Either use **Landscape Mulch** or prepare the site by very low cutting of grass and weeds to reduce initial competition. It is very important to prevent grasses, vines, and other vegetation from competing with the newly transplanted plants for sunlight, water, and soil nutrients.

While this section is meant to refer primarily to the planting of relatively small, bare root shrubs, larger plants including trees may be obtained as bare root stock. When larger shrubs or trees are planted bare root, staking and guying will likely be necessary. As above, use of a flexible and biodegradable type of tree tying material is preferred to the traditional hose and wire system.

Transplanting Container Grown Plants

Stock Examination: For plants grown in containers, carefully remove the plant from the container, and inspect the root mass to determine if the plant has well developed roots, and to be sure it has not been recently repotted to a larger pot size. Containerized stock should have well developed roots, but should not be pot bound, which causes roots to encircle the container, resulting in difficulties in establishment.

Site Preparation: Site preparation for container grown plants is the same as for balled and burlapped plants.

Handling and Setting the plant: When container grown plants have well developed root systems that encircle the pot, either loosen the roots or slice the root ball with a sharp knife vertically three or four times, cutting about an inch deep. This will promote new roots to develop and spread out, rather than continuing to follow the circular rooting pattern. If excess soil in the pot had buried the original soil level just above the crown of the plant, be sure to adjust the planting depth to place the plant back at or slightly above the original soil level.

Backfilling, Watering and Mulching: Backfill the site to original grade with original soil. Soil amendments are unnecessary in most planting situations. Water the backfill soil thoroughly, allowing the water to settle the soil, removing air pockets. Do not pack the soil tightly with feet or tools. Use enough water to ensure thorough saturation of the soil. Add soil to bring the soil level back up to grade when the water has infiltrated. Mulch the disturbed area with **Landscape Mulch**.

Fertilization: Under normal circumstances, it is not recommended to fertilize woody plants upon initial planting.

Maintenance

Maintenance of trees, shrubs, and ground covers is an exhaustive topic which is not addressed by these Guidelines. Instead, the most critical maintenance needs for the first year of a newly transplanted plant are described below.

Inspection Requirements

Inspect plants until they are established or at least monthly for 1 year following planting, and more frequently during hot dry periods for mulch adequacy, soil moisture and general plant condition. When a plant has regrown a sufficient root system such that it can withstand normal variations in climate and soil conditions, and has resumed normal growth, it is considered to be established. An established plant will exhibit normal growth patterns of bud break and leaf fall, and will have resumed a growth rate considered normal for the species.

Larger plants, especially balled in burlap trees which have lost a significant amount of their roots systems upon transplanting will need the most attention during the initial establishment period.

Mulch and Water

Apply additional landscape mulch around landscape plants as needed to keep soil covered and to inhibit weed growth. Keeping all newly transplanted plants adequately mulched is important to moderate fluctuations in soil moisture and temperature. Trees that are mulched will recover from transplanting, become established, and resume normal growth more quickly than trees planted without the benefit of mulch.

Water plants during hot dry periods when soil around the plants begins to dry out. If leaves of recent landscape plantings are wilted, severe water deficiency is indicated, and permanent damage to the plantings may result if supplemental water is not provided promptly. For successful establishment of summer plantings, adequate watering during the balance of the summer and into the fall is especially important.

Note: *A useful rule of thumb in Connecticut is that new plantings should receive at least 1 inch of rain per week.*

Pruning

Prune to remove only dead or damaged limbs on newly planted trees unless an arborist has recommended otherwise. Pruning the top of the tree will severely weaken the tree's ability to grow a healthy new root system in the new site. This is especially important for trees balled in burlap, which lose a large portion of their original root system when the are dug from the field. For new roots to form from plants grown in containers, top pruning should be delayed for at least a year. Ideally, newly planted trees should not be pruned until after their third year, and then only to remove dead and weak branches, and to train the tree's future growth by removing or pruning any wayward branches which will lead to future problems, or detract from the natural shape of the plant.

Insect and Disease Control

All plants in the natural environment are host to a wide variety of insect and disease organisms. When insects or disease problems on a plant become threatening to the life or practical value of the plant, corrective or preventative actions may become necessary. When a problem occurs, positive identification of the host, and then of the insect or disease problem is vital to successfully resolving the problem. Plants should be selected to avoid common insect or disease problems by choosing those species resistant to common plant diseases, or unpalatable to common insect problems.

The Cooperative Extension System or a state licensed arborist can help identify insect and disease problems and suggest solutions.

Figure LP-4 Trees for Landscape Planting

Common Name (Botanical Name)	Leaf type[1]	Height	Soil Moisture Preferred: Wet	Moist	Dry	pH range	Users: Lawns	Seashore	Street	Shade tolerance	Salt tolerance[2]	Pollution Tolerance[2]: O_3	SO_2	F	Remarks
BEECH *(Fagus grandifolia)*	D	70-120		X		6.5-7.5	X			Fair	S	-	S	-	Long-lived. Has edible nuts. Needs lots of space.
BIRCH, BLACK, WHITE and GRAY *(Betula spp.)*	D	50-80	X	X		4.0-5.0	X			Good	-	S	S	-	Prefers deep, moist soils such as stream banks. Graceful form.
CEDAR, EASTERN RED *(Juniperus virginiana)*	E	20-50	X	X	X	6.0-6.5	X			Good	-	T	T	T	Long-lived.
CHERRY, JAPANESE *(Prunus serrulata)*	D	15-20		X		6.5-7.5	X	X		Good	-	-	-	T	Very showy pink or white flowers. Usually grafted on 6-7 ft. stem.
CRABAPPLE *(Malus spp.)*	D	15-20		X		6.5-7.5	X	X	X	Fair	I	S	S	-	White or pink flowers. Many varieties, some with edible fruit.
DOGWOOD, FLOWERING *(Cornus kousa)*	D	30-40		X		5.0-6.5	X	X		Good	-	T	T	T	Ideal street tree. White or pink flowers. Has poor drought resistance.
HAWTHORN *(Crataegus spp.)*	D	15-25		X		6.0-7.5	X	X		Fair	I	-	S	-	Thorny, Washington and Lavalle types are good ornamentals. Tolerates parking lot conditions. Has some insect and disease problems.
LOCUST, HONEY *(Gleditsia tri-acanthos inermis)*	D	50-75	X	X	X	6.5-7.5	X	X	X	Good	T	S	-	-	Sturdy, wind-firm tree. Overused in urban areas.
MAPLE, HEDGE *(Acer campestre)*	D	20-30		X	X	6.5-7.5	X	X		Good	-	T	T	I	Prefers well-drained, deep fertile soil. May be used in clipped hedges.
MAPLE, RED *(Acer rubrum)*	D	50-80	X	X		4.5-7.5	X	X	X	Good	S	T	T	-	Grows rapidly when young. Good tree for suburbs but not city.
MAPLE, SUGAR *(Acer saccharum)*	D	50-70	X	X	X	6.5-7.5	X			Fair	I	T	T	-	Outstanding fall foliage. Suburban, but not city tree. Slow-growing and shapely. Intolerant of salt.
OAK, PIN *(Querus palustris)*	D	60-80	X	X	X	5.5-6.5	X	X		Good	T	S	S	I	Most easily transplanted of the oaks.
OAK, RED NORTHERN *(Querus rubra borealis)*	D	70-90		X	X	4.5-6.0	X	X	X	Good	T	T	T	I	Most rapid-growing oak. Needs room.
OAK, SCARLET *(Querus coccinea)*	D	60-80			X	6.0-6.5	X	X		Good	T	S	T	I	Prefers sandy or gravelly soils.
OAK, WHITE *(Querus alba)*	D	60-80		X	X	6.5-7.5	X	X	X	Fair	T	S	S	I	Long-lived, stately tree. Grows slowly.
PINE, AUSTRIAN *(Pinus nigra)*	E	30-50		X	X	4.0-6.5	X		X	Good	T	-	-	-	Very hardy and rapid-growing. Will tolerate shallow soil and drought.
PINE, JAPANESE BLACK *(Pinus thunbergii)*	E	30-50		X	X	4.0-6.5	X		X	Fair	T	-	-	-	Disease problems.
PINE, SCOTCH *(Pinus sylvestris)*	E	60-90			X	4.0-6.5	X			Good	I	S	S	S	Disease problems.
PINE, WHITE *(Pinus strobus)*	E	80-100			X	4.0-6.5	X			Fair	S	S	S	S	Very attractive, rapid-growing tree. Prefers deep sandy loam. Subject to white pine blister rust.
YEW, JAPANESE *(Taxus cuspidata)*	E	15-20		X		6.0-6.5	X			Good	-	T	-	I	Hedges and borders. Preferred food of white-tailed deer.

[1] D is deciduous plants
E is evergreen or coniferous plant

[2] Pollution tolerance and salt tolerance: "S" Sensitive. Will show physical damage.
"T" Tolerant.
"I" Intermediate. Damage depends on growing conditions and exposure to pollutant.
"-" No information at this time.

Source: USDA-NRCS

Figure LP-5 Shrubs for Landscape Planting

Common Name (Botanical Name)	Leaf type[1]	Drainage Tolerance	Shade tolerance	pH range	Mature Height	Uses
AMERICAN CRANBERRY BUSH *(Viburnum trilobum)*	D	Moderately Well-Drained to Poorly Drained	Fair	6.5-7.5	6-7	Hedges and borders. Flowers inconspicuous, red berries, winter food for birds. Fruits in 4-5 years.
ARROWWOOD *(Viburnum recognitum or dentatum)*	D	Well-Drained to Poorly Drained	Good	5.5-7.0	5-10	Hedges and borders.White flowers, blue to blue-black berries. Screens or naturalized mass. Edible by both birds and humans
BAYBERRY *(Myrica pensylvanica)*	E	Droughty to Moderately Well-Drained	Poor	5.0-6.0	6-8	Revegetating sand dunes; ornamental for droughty areas. Flowers inconspicuous, waxy grey berries. Fixes nitrogen in soil.
BEACH PLUM *(Prunus maritima)*	D	Droughty to Moderately Well-Drained	Fair	6.0-8.0	7	Revegetating sand dunes and droughty areas. Flowers white, fruit purple, plum-like and edible. Fruit used for jelly and baking, also favored by wildlife.
BLUEBERRY HIGHBUSH *(Vaccinium corymbosum)*	D	Droughty to Somewhat Poorly Drained	Good	4.5-5.5	8-12	Borders and hedges or individual. Flowers white to pinkish, berries blue-black.
BLUEBERRY LOWBUSH *(Vaccinium angustifolium or vacillan)*	D	Droughty to Somewhat Poorly Drained	Good	4.5-5.5	1-3	An excellent ground cover. Flowers white, berries blue.
BRISTLY LOCUST "ARNOT" *(Robinia fertilis)*	D	Droughty to Moderately Well-Drained	Fair	5.0-7.5	6	Steep slopes, gravelly infertile areas. Fixes nitrogen. Spread by sprouting from roots. Flowers pink, seeds in pods.
GRAY DOGWOOD *(Cornus racemosa)*	D	Droughty to Poorly Drained	Fair	4.5-6.0	7-10	Good for stream banks.
CORALBERRY *(Symphoricarpos orbiculatus)*	D	Droughty to Well-Drained	Fair	4.5-6.0	4-6	Flowers yellow.
ELDERBERRY *(Sambucus canadensis)*	D	Well-Drained to Poorly Drained	Fair	6.0-7.5	12	Provides food for birds and deer. Flowers white, fruit edible purple berries. Fruit in 4-5 years.
FIRETHORN *(Pyracantha coccinea)*	E	Droughty to Moderately Well-Drained	Fair	6.0-8.0	10-15	Southern CT only. Screens, barriers. Flowers white, fruit orange or red berries. Food for songbirds. Low-growing and upright types available.
HORIZONTAL JUNIPER *(Juniperus spp.)*	E	Droughty to Well-Drained	Poor	5.0-6.0	1-2	Used as ground cover or ornamental. Set plants 2 feet apart for cover in 2-3 years. Flowers and fruit inconspicuous.
JAPANESE YEW *(Taxus cuspidata)*	E	Moderately Well-Drained to Somewhat Poorly Drained	Good	6.0-6.5	15-20	Used for hedges and screens. Flowers and fruit inconspicuous.
MOUNTAIN LAUREL *(Kalmia latifolia)*	E	Droughty to Somewhat Poorly Drained	Fair	4.5-5.5	7-15	Erect shrub, naturalized mass. Flowers white, pink to deep rose, fruit inconspicuous and poisonous to both humans and animals in quantity.
RED OSIER DOGWOOD *(Cornus stolonifera)*	D	Moderately Well-Drained to Poorly Drained	Fair	4.5-6.0	4-6	Good for stream banks, damp soils.
RUGOSA ROSE *(Rosa rugosa)*	D	Droughty to Moderately Well-Drained	Fair	6.0-7.0	3-5	Stabilizing sand dunes and landscaping. Flowers white to pink, fruits red hips in 1-2 years. Food and cover for songbirds and rabbits. Sprawling growth habit, but not aggressive.
SHADBUSH *(Amelanchier canadensis)*	D	Well-Drained to Somewhat Poorly Drained	Fair	5.5-6.5	3-6	Natural mass, specimen. Flowers white, fruit red to black.

continued

Figure LP-5 Shrubs for Landscape Planting (con't)						
Common Name (Botanical Name)	**Leaf type[1]**	**Drainage Tolerance**	**Shade tolerance**	**pH range**	**Mature Height in Ft.**	**Uses**
SHORE JUNIPER "EMERALD SEA" *(Juniperus conferta)*	E	Droughty to Well-Drained	Fair	5.0-6.0	1	Stabilizing sand dunes and sandy road banks. Flowers and fruits inconspicuous.
SIEBOLD FORSYTHIA *(Forsythia suspensa seibold)*	D	Droughty to Well-Drained	Poor	4.5-6.0	4-6	Over used. Flowers yellow, fruit inconspicuous.
SWEETFERN *(Comptonia peregrina)*	D	Droughty to Moderately Well-Drained	Fair	5.0-6.0	3-4	Natural masses. Flowers inconspicuous.
SWEET PEPPERBUSH *(Clethra alnifolia)*	D	Moderately Well-Drained to Poorly Drained	Good	5.5-6.5	3-8	Borders and hedges. Flowers white, fruit inconspicuous.
WINTERBERRY *(Ilex verticillata)*	D	Well-Drained to Poorly Drained	Fair	5.0-6.0	10	Ornamental screens. Flowers inconspicuous, fruits red berries in 3-4 years. Winter food for songbirds.
WYTHEROD VIBURNUM *(Viburnum cassinoides)*	D	Well-Drained to Somewhat Poorly Drained	Good	5.5-6.5	4-6	Natural mass. Flowers white, fruit green to black. Very showy in fall.

[1] E-Evergreen D-Deciduous

Source: USDA-NRCS

Figure LP-6 Vines and Ground Covers for Landscape Planting

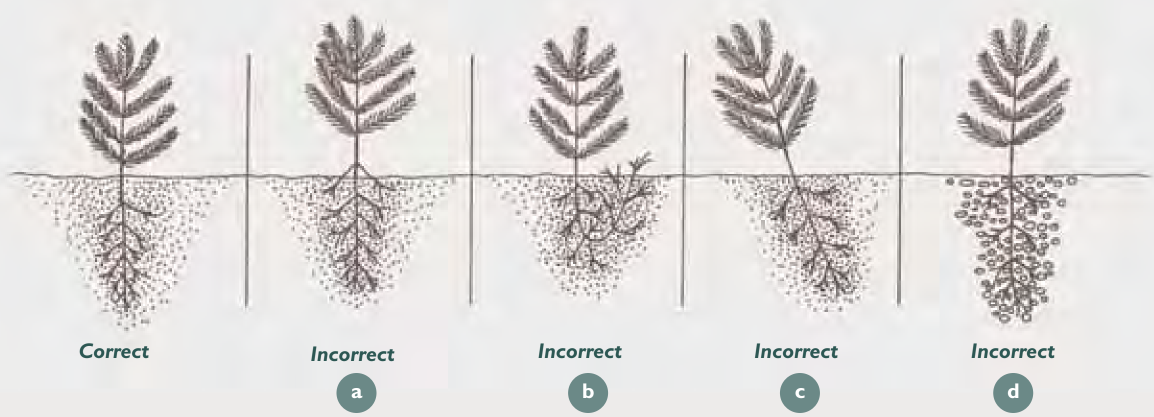
Common Name (Botanical Name)	Leaf Type[1]	Drainage Tolerance	Shade Tolerance	pH Range	Characteristics
BEARBERRY *(Arctostaphylos uva-ursi)*	E	Droughty to Well Drained	Good	4.5-6.0	Trailing groundcover. Low-fertility sandy areas, dunes, flowers inconspicuous. Set plants 18 in. apart for cover in 2-4 years.
BUGLEWEED *(Ajuga reptans)*	E	Well Drained to Moderately Well Drained	Excl.	6.0-7.5	Small, low-growing broad-leafed herbaceous plants, in bronze or green, flowers blue, white or red spiles. Set plants 1 ft. apart for cover in 1 year.
CROWN VETCH *(Coronilla varia)*	D	Droughty to Moderately Well Drained	Fair	4.0-7.5	Slow growing, 1-2 ft. high. Prefers sun, 2-3 years to form a cover. Flowers pink.
DAYLILY *(Hemerocallis fulva)*	D	Droughty to Poorly Drained	Fair	6.0-8.0	Grass-like foliage, flowers orange, showy. Unusually adaptable and free of pests and disease.
DUSTY MILLER (Beach Wormwood) *(Artemisia stelleriana)*	E	Droughty to Well Drained	Poor	6.0-7.5	Silvery foliage, 1-2 ft. tall, flowers inconspicuous. Spreads by underground stems. Stabilizing groundcover on coastal dunes. Set plants 2 ft. apart for cover in 2 years.
ENGLISH IVY *(Hedera helix)*	E	Droughty to Moderately Well Drained	Good	6.0-8.0	Low maintenance vine for large areas, flowers inconspicuous. Will climb on trees, walls, etc. Set plants or rooted cuttings 1 ft. apart for cover in 2 years.
LILY-OF-THE-VALLEY *(Convallaria majalis)*	E	Droughty to Somewhat Poorly Drained	Excl.	4.5-6.0	Low maintenance cover for partial or full shade, flowers fragrant white bells on short stalks. Set plants 1 ft. apart for cover in 2-3 years.
LILY-TURF *(Liriope specata)*	E	Droughty to Poorly Drained	Good	4.5-6.0	Grass-like low maintenance cover for droughty, infertile soils. Spreads by underground stems. Available in variegated form. Set plants 6-12 in. apart for cover in 2 years.
PACHYSANDRA *(Pachysandra terminalis)*	E	Well Drained to Moderately Well Drained	Excl.	4.5-5.5	Low-growing, attractive cover for borders and as lawn substitute under trees and other shady areas. Flowers small white spikes. Set plants 1 ft. apart for cover in 1-2 years.
PERIWINKLE (Vinca) *(Vinca minor)*	E	Well Drained to Moderately Well Drained	Excl.	6.0-7.5	Lawn substitute for shady areas. Small blue flowers. Spreads by stolons; not aggressive. Grows in full sun as well as shade. Set plants 1 ft. apart for cover in 1-2 years.
SMALL-LEAVED COTONEASTER *(Cotoneaster microphylla)*	E	Well Drained to Moderately Well Drained	Fair	6.0-7.0	Prostrate shrub, tiny white flowers. Informal cover for large areas. Set plants 2 ft. apart for cover in 2 years.
VIRGINIA CREEPER *(Parthenocissus quinquefolia)*	D	Droughty to Well Drained	Fair	5.0-7.5	Ground cover for dunes and other dry areas; will climb trees. Flowers inconspicuous. Attractive crimson foliage in fall. Berries eaten by songbirds. Set plants 18" apart for cover in 1-2 years.

[1] E-Evergreen D-Deciduous

Source: USDA-NRCS

Figure LP-7 Planting Bare Root Stock

1. **Insert bar at angle shown and push forward to upright position.**
2. **Remove bar and place seedling at correct depth.**
3. **Insert bar two inches toward planter from seedling.**
4. **Pull bar toward planter firming soil at bottom of roots.**
5. **Push bar forward from planter firming soil at top of roots.**
6. **Fill in last hole by stamping with heel.**
7. **Firm soil around seedling with feet.**
8. **Test planting by pulling lightly on seedling.**



- **a. Don't expose roots to air during freeze or plant in frozen ground.**
- **b. Don't bend roots so that they grow upwards out of the ground.**
- **c. Plant seedlings upright – not at an angle.**
- **d. Always plant in soil – never loose leaves or debris. Pack soil tightly.**

Source: Virginia Erosion and Sediment Control Handbook, 1992.

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Planning Considerations

The short term non-living soil protection measures are **Temporary Soil Protection, Mulch for Seed, Landscape Mulch, Temporary Erosion Control Blanket (ECB), Permanent Turf Reinforcement Mat (TRM),** and **Stone Slope Protection.** These measures serve the common function of preventing erosion by providing a non-living cover to erodible surfaces. With the exception of some **TRM**, these measures are intended to dissipate the erosive energy of raindrops. With the exception of the **Temporary Soil Protection** and **Stone Slope Protection** measures, they are intended to promote the establishment and/or maintenance of a vegetative cover.

Temporary Soil Protection is a biodegradable mulch that is applied to a disturbed surface for the sole purpose of protecting the soil for less than 5 months when the establishment of a vegetative cover is not possible (usually during winter and mid-summer).

Mulch for Seed and **Landscape Mulch** measures also use biodegradable mulches but are intended for use when seeding and with landscape planting, respectively.

TECBs are biodegradable mulches that are manufactured with a netting for anchoring to create a blanket that is used as a substitute for **Mulch for Seed** where mulch anchoring is needed, and may also be used as a substitute for **Temporary Soil Protection**.

PTRMs are geotextiles that are laid on or within the soils surface to permanently assist in holding the roots of herbaceous plants when exposed to water velocities that would normally erode the soil around the roots. They are used in grass-lined swales and are applied with **Permanent Seeding** and anchored mulches or during **Sodding** just beneath the sod. Their primary function is to increase the swale's performance limits.

ECB and **TRM** are geotextiles and some products are hybrids of both measures. Careful attention to the manufacturer's recommendations for use is required.

The **Stone Slope Protection** measure calls for applying stone or stone aggregates on unstable soils where unfavorable soil conditions exist for the establishment and growth of plants. It is not used where concentrated flows are expected. It may be used as a substitute for **Landscape Mulch**.

Figure 1 is provided to assist in the selection of mulch material by comparing and contrasting the types of biodegradable mulches commonly used in the **Temporary Soil Protection**, **Mulch for Seed** and **Landscape Mulch** measures.

Figure Planning I Mulching Section Chart

Mulch Type	Exposure Period	How Applied	Limitations / Considerations
Temporary Soil Protection - temporary soil cover when seeding dates cannot be met			
straw/hay	0-6 months	by hand or blown by machine	• preferred over other mulches • requires anchoring in windy areas • hay will typically supply weed seeds, straw will not
cellulose fiber*	not recommended	not recommended	• used only as a tackifier for other mulch material
wood chips	> 1 year	by hand or graded by machine	• restricted to slopes 3 on 1 or flatter • must be removed or tilled into ground before seeding or planting • may reduce soil fertility during decay process requiring subsequent fertilization for plant growth • lasts longer than straw/hay • no anchoring required
bark chips / shredded bark	0-1 year	by hand	• same as wood chips
Mulch for Seed - temporary soil cover until seeds germinate and grow sufficiently to stabilize soil			
straw/hay	0-6 months	by hand or blown by machine	• requires anchoring in windy areas • hay will supply weed seeds, straw will not • may provide better shading against hot summer sun for seeding done at the beginning of summer
cellulose fiber*	0-6 months	sprayed in slurry with water	• no volunteer weed seeds, lawn seeding • wood fiber per unit cost generally more expensive than paper fiber, but requires less product for equivalent coverage • may be used in summer with seed only if adequate irrigation is planned
wood chips	not recommended	not recommended	not recommended
bark chips/ shredded bark	not recommended	not recommended	not recommended
Landscape Mulch - soil cover inhibiting weed growth around planted trees, shrubs & vines			
straw/hay	not recommended	not recommended	not recommended
cellulose fiber*	not recommended	not recommended	not recommended
wood chips	> 1 year	by hand or graded by machine	• may reduce soil fertility during decay process, requiring application of nitrogen • slippage may occur on steeper slopes if wood chips are applied over a large area
bark chips/ shredded bark	0-1 year	by hand	• same as wood chips

* see Specifications text on special concerns of various cellulose mulches

4-Short Term Non-living Soil Protection

Temporary Soil Protection (TSP)

Definition
Application of a degradable material that will protect the soil surface on a temporary basis without the intention of promoting plant growth.

Purpose
To prevent erosion by dissipating the erosive energy of raindrops and encouraging sheet flow over the soil surface.

Applicability
- When grading of the disturbed area will be suspended for a period of 30 or more consecutive days, but less than 5 months, stabilize the site within 7 days of the suspension of grading through the use of mulch or other materials appropriate for use as a temporary soil protector.
- For surfaces that are not to be reworked within 5 months but will be reworked within 1 year, use **Temporary Seeding**, **Mulch for Seed** or when slopes are less than 3:1, wood chips, bark chips or shredded bark.
- For surfaces that are to be reworked after 1 year, use **Permanent Seeding** and **Mulch for Seed**

Planning Considerations

See Mulching Selection Chart found in the Group Planning Considerations.

Specifications

Materials

Temporary soil protection materials include but are not limited to mulches, tackifiers, and nettings and shall be:

- *biodegradable or photo-degradable within 2 years but without substantial degradation for 5 months;*
- *free of contaminants that pollute the air or waters of the State when properly applied;*
- *free of foreign material, coarse stems and any substance toxic to plant growth or which interferes with seed germination; and*
- *capable of being applied evenly such that it provides 100% initial soil coverage and still adheres to the soil surface, does not slip on slopes when it rains or is watered, does not blow off site, and dissipates raindrop splash.*

Mulches within this specification include, but are not limited to:

Hay: The dried stems and leafy parts of plants cut and harvested, such as alfalfa, clovers, other forage legumes and the finer stemmed, leafy grasses. The average stem length should not be less than 4 inches. Hay that can be windblown should be anchored to hold it in place.

Straw: Cut and dried stems of herbaceous plants, such as wheat, barley, cereal rye, or brome. The average stem length should not be less than 4 inches. Straw that can be windblown should be anchored to hold it in place.

Wood Chips: Chipped wood material from logs, stumps, brush or trimmings including bark, stems and leaves having a general maximum size of 0.5 inch by 2 inches and free of excessively fine or long stringy particles as well as stones, soil and other debris. No anchoring is required. If seeding is performed where wood chips have been previously applied, prior to the seeding the wood chips should be removed or tilled into the ground and additional nitrogen applied. Nitrogen application rate is determined by soil test at time of seeding (anticipate 12 lbs. nitrogen per ton of wood chips).

Bark Chips, Shredded Bark: Tree bark shredded as a by product of timber processing having a general maximum size of 4 inches and free of excessively fine or long stringy particles as well as stone and other debris. Material use is the same as wood chips.

May also include corn stalks, leaves and other similar materials provided they meet the requirements of the materials section within this specification.

Note: *Wood and bark by-products may generate contaminated runoff if improperly stored for extended periods. These materials should only be stored on free draining, gently sloping soils, and only for short periods of time.*

If subsequent seeding is performed where cellulose dense mulches (e.g. leaves, excelsior, woodchips, barkchips) have been applied, then prior to seeding either remove the mulch or till it into the ground with the application of nitrogen.

Cellulose fiber is not recommended for use, except as a tackifier for other mulch materials.

Tackifiers within this specification include, but are not limited to:

Water soluble materials that cause mulch particles to adhere to one another, generally consisting of either a natural vegetable gum blended with gelling and hardening agents or a blend of hydrophilic polymers, resins, viscosifiers, sticking aids and gums. **Emulsified asphalts are specifically prohibited for use as tackifiers due to their potential for causing water pollution following its application**.

Nettings within this specification include but are not limited to:

Prefabricated openwork fabrics made of cellulose cords, ropes, threads, or biodegradable synthetic material that is woven, knotted or molded in such a manner that it holds mulch in place until temporary soil protection is no longer needed. Examples of netting are tobacco netting (used where flows are not concentrated) and jute netting (typically used in drainageways).

Substitute Measures

Where tackifiers or nettings are needed to anchor mulch, a **Temporary Erosion Control Blanket** or **Stone Slope Protection** may be substituted, providing 100% of the disturbed soil is covered.

Site Preparation

Prior to mulching, complete the required grading and install and/or repair other sediment control measures needed to control water movement within the area to be mulched.

Application

Spreading: Spread mulch material uniformly by hand or machine resulting in 100% coverage of the disturbed soil.

When spreading hay mulch by hand, divide the area to be mulched into approximately 1,000 square feet and place 2 to 3 bales of hay in each section to facilitate uniform distribution.

When spreading woodchips on slopes, it is particularly important not to spread the chips too thick. Excessive applications tend to slip or slump when saturated.

See **Figure TSP-1** for suggested application rates of specific mulches when used as temporary soil protection.

Figure TSP–1 Suggested Temporary Soil Protection Application Rates for 100% Cover

Mulch	Rate
Hay/Straw	2 – 3 Tons/acre
Wood Chips/ Shredded Bark	6 cu. yds./1000 sq. ft.

Anchoring: Apply tackifiers and/or netting either with the mulch or immediately following mulch application. Expect the need for tackifiers or netting along the shoulders of actively traveled roads, hill tops and long open slopes not protected by wind breaks.

When using netting the most critical aspect is to ensure that the netting maintains substantial contact with the mulch and the mulch, in turn, maintains continuous contact with the soil surface. Without such contact, the material is useless and erosion can be expected to occur. Install in accordance with manufacturer's recommendations.

Maintenance

Inspect temporary soil protection area at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater for mulch movement and rill erosion.

Where soil protection falls below 100%, reapply soil protection within 48 hours. Determine the cause of the failure. If mulch failure was the result of wind, consider applying a tackifier or netting. If mulch failure was caused by concentrating water, install additional measures to control water and sediment movement, repair erosion damage, re-apply mulch with anchoring or use Temporary Erosion Control Blankets.

Inspections should take place until work resumes.

Mulch For Seed (MS)

Definition

Application of a mulch that will protect the soil surface on a temporary basis and promote the establishment of temporary or permanent seedings.

Purpose

- To prevent erosion by dissipating the erosive energy of raindrops and encourage a sheet flow over the soil surface.
- To aid in the growth of herbaceous vegetation by reducing evaporation of water, enhancing absorption of water, helping to anchor seed in place, providing protection against extreme heat and cold and improving soil texture as it decomposes.

Applicability

Used with **Temporary Seeding** and **Permanent Seeding** measures.

Planning Considerations

See Mulching Selection Chart found in the Group Planning Considerations.

Specifications

Materials

Mulch for seed, including tackifiers and nettings used to anchor much, shall be:

- *biodegradable or photo-degradable within 2 years but without substantial degradation over a period of 6 weeks,*
- *free of contaminants that pollute the air or waters of the State when properly applied,*
- *free of foreign material, coarse stems and any substance toxic to plant growth or which interferes with seed germination, and*
- *capable of being applied evenly such that it provides 80%-95% soil coverage and still adheres to the soil surface, does not slip on slopes when it rains or is watered, does not blow off site, dissipates raindrop splash, holds soil moisture, moderates soil temperatures and does not interfere with seed growth.*

Types of mulches within this specification include, but are not limited to:

Hay: The dried stems and leafy parts of plants cut and harvested, such as alfalfa, clovers, other forage legumes and the finer stemmed, leafy grasses. Stem length should not average less than 4 inches. Hay that can be windblown must be anchored. Preferred mulch when seeding occurs outside of the recommended seeding dates.

Straw: Cut and dried stems of herbaceous plants, such as wheat barley, cereal rye, or broom. The average stem length should not be less than 4 inches. Straw that can be windblown should be anchored to hold it in place.

Cellulose Fiber: Fiber origin is either virgin wood, post-industrial/pre-consumer wood or post consumer wood complying with materials specification (collectively referred to as "wood fiber"), newspaper, kraft paper, cardboard (collectively referred to as "paper fiber") or a combination of wood and paper fiber. Paper fiber, in particular, shall not contain boron, which inhibits seed germination. The cellulose fiber must be manufactured in such a manner that after the addition to and agitation in slurry tanks with water, the fibers in the slurry become uniformly suspended to form a homogeneous product. Subsequent to hydraulic spraying on the ground, the mulch shall allow for the absorption and percolation of moisture and shall not form a tough crust such that it interferes with seed germination or growth. Generally applied with tackifier and fertilizer. Refer to manufacturer's specifications for application rates needed to attain 80%-95% coverage without interfering with seed germination or plant growth. Not recommended as a mulch for use when seeding occurs outside of the recommended seeding dates.

Other mulches also include corn stalks and other similar organic materials provided they meet the requirements listed in the first paragraph of this section. Does not include materials such as wood chips, bark chips or cocoa hulls.

Tackifiers within this specification include, but are not limited to:

Water soluble materials that cause mulch particles to adhere to one another, generally consisting of either a natural vegetable gum blended with gelling and hardening agents or a blend of hydrophilic polymers, resins, viscosifiers, sticking aids and gums. Good for areas intended to be mowed. Cellulose fiber mulch may be applied as a tackifier to other mulches, provided the application is sufficient to cause the other mulches to adhere to one another. **Emulsified asphalt is specifically prohibited for use as tackifier due to its potential for causing water pollution following its application.**

Nettings within this specification include, but are not limited to:

Prefabricated openwork fabrics made of cellulose cords, ropes, threads, or biodegradable synthetic material that is woven, knotted or molded in such a manner that it holds mulch in place until vegetation growth is sufficient to stabilize the soil. Generally used in areas where no mowing is planned. Examples of netting are tobacco netting (used where flows are not concentrated) and jute netting (typically used in drainageways).

Substitute Measures

Where mulch anchoring is required a **Temporary Erosion Control Blanket** may be used.

Site Preparation

Follow requirements of **Permanent Seeding** or **Temporary Seeding**.

Application

Timing: Applied immediately following seeding. Some cellulose fiber may be applied with seed to assist in marking where seed has been sprayed, but expect to apply a second application of cellulose fiber to meet the requirements of **Mulch for Seed**.

Spreading: Mulch material shall be spread uniformly by hand or machine resulting in 80%-95% coverage of the disturbed soil when seeding within the recommended seeding dates. Applications that are uneven can result in excessive mulch smothering the germinating seeds. For hay or straw anticipate an application rate of 2 tons per acre. For cellulose fiber follow manufacturer's recommended application rates

Figure MS-1 Estimating Mulch Cover

The following procedure was adapted from the pamphlet entitled "Farming with Residues" by the U.S. Department of Agriculture Soil Conservation Service dated September 1991.

1. Use any line that is equally divided into 100 parts. Fifty foot cable transect lines are available for this purpose. Another tool is a 50-foot tape measure using the 6-inch and foot marks also works well.
2. Stretch the line across the area to be sampled. Count the number of marks (tabs or knots) that have mulch showing under them when sighting directly above one end of the mark. It is important to use the same point on each mark for accuracy.
3. Walk the entire length of the rope or wire. The total number of marks with mulch under them is the percent cover.
4. Repeat the procedure at least 3 times in different areas and average the findings.

to provide 80%-95% coverage.

When seeding outside the recommended seeding dates, increase mulch application rate to provide between 95%-100% coverage of the disturbed soil. For hay or straw anticipate an application rate of 2.5 to 3 tons per acre.

See **Figure MS-1** for a procedure to estimate the adequacy of mulch coverage.

When spreading hay mulch by hand, divide the area to be mulched into approximately 1,000 square feet and place 1.5-2 bales of hay in each section to facilitate uniform distribution.

For cellulose fiber mulch, expect several spray passes to attain adequate coverage, to eliminate shadowing, and to avoid slippage (similar to spraying with paint).

Machine clogging can occur if product is improperly loaded or if leftover product is left in machine without cleaning. Comply with the manufacturer's recommendations for application requirements and mulch material specifications.

Anchoring: When needed, mulch anchoring is applied either with the mulch as with cellulose fiber or applied immediately following mulch application. Expect the need for mulch anchoring along the shoulders of actively traveled roads, hill tops and long open slopes not protected by wind breaks.

When using netting, the most critical aspect is to ensure that the netting maintains substantial contact with the underlying mulch and the mulch, in turn, maintains continuous contact with the soil surface. Without such contact, the material is useless and erosion occurs. Install in accordance with manufacturer's recommendations.

Maintenance

Inspect mulched areas at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater until the grass has germinated to determine maintenance needs

Where mulch has been moved or where soil erosion has occurred, determine the cause of the failure. If it was the result of wind, then repair erosion damage (if any), re-apply mulch (and seed as needed) and consider applying a netting or tackifier. If mulch failure was caused by concentrating water, install additional measures to control water and sediment movement, repair erosion damage, re-apply mulch and consider applying a netting or tackifier or use the **Temporary Erosion Control Blanket** measure.

Once grass has germinated, inspections should continue as required by **Temporary Seeding** and **Permanent Seeding.**

Landscape Mulch (LM)

Definition
Application of a mulch that protects the soil surface on a long term basis and promotes the growth of landscape plantings.

Purpose
- To prevent erosion by dissipating the erosive energy of raindrops and encouraging infiltration.
- To promote growth of plantings and woody vegetation by reducing evaporation of water, enhancing absorption of water, controlling weeds, providing protection against extreme heat and cold and improving soil texture.
- To provide a temporary cover for disturbed soil.

Applicability
Used only with landscape plantings (see **Landscape Planting** measure) and existing woody vegetation.

Planning Considerations
Providing adequate organic mulch will enable a newly transplanted tree to become established and grow faster than an equivalent tree which is not mulched during the establishment period.

Plan mulch to be of sufficient depth to block the light that triggers weed seed germination and to prevent those that germinate deep under the mulch from surviving. Since weeds become established within the mulch matrix a barrier under the mulch is of limited value. The use of black plastic under landscape mulch is not advised because the plastic impedes water and gas exchange in the soil, often creating a soil environment that is more conducive to disease organisms. However, woven geotextiles that are manufactured specifically for use as a weed barrier may be used, particularly when the Stone Slope Protection measure is used as a substitute for landscape mulch.

See Mulching Selection Chart found in the Group Planning Considerations.

Specifications

Materials
Mulch materials must be:
- ❍ *biodegradable over a period of several years but without substantial degradation within 1 year;*
- ❍ *free of contaminants that pollute the air or waters of the State when applied;*
- ❍ *free of foreign material, and any substance toxic to plant growth; and*
- ❍ *capable of being applied evenly such that it provides 100% soil coverage and still adheres to the soil surface without a mulch anchor, does not slip on slopes when it rains or is watered, does not blow off site, dissipates raindrop splash, retains soil moisture, moderates soil temperatures and inhibits the growth of herbaceous plants.*

Types of mulches within this specification include, but are not limited to:

Wood Chips: Chipped wood material from logs, stumps, brush or trimmings including bark, stems and leaves having a general maximum size of 0.5 inch by 2 inches and free of excessively fine or long stringy particles as well as stones, soil and other debris.

Bark Chips, Shredded Bark: Tree bark shredded as a by product of timber processing having a general maximum size of 4 inches and free of excessively fine or long stringy particles as well as stone and other debris.

Note: *Wood and bark by-products may generate contaminated runoff if improperly stored for extended periods. These materials should only be stored on free draining, gently sloping soils, and only for short periods of time.*

May also include cocoa hulls and other similar materials provided they meet the requirements listed in the first paragraph of this section.

Does not include materials such as hay or cellulose fiber that is used in Mulch for Seed measure.

Substitute Measures

Stone Slope Protection measure may be used as a substitute for **Landscape Mulch**. Use with caution due to concerns about heat absorption and light reflection.

Site Preparation

Follow requirements of **Landscape Planting** measure and/or **Tree Protection** measure.

Application

Timing: For trees and shrubs apply after the installation of any weed barrier and within 7 days after planting. For vines and ground covers apply after the installation of any weed barrier either before planting or within 7 days after planting. Periodic reapplication is necessary when the mulch has decayed sufficiently to expose underlying soil or when it no longer inhibits herbaceous growth.

Spreading: Spread the mulch materials uniformly to a depth of at least 4 inches over the area disturbed by the hole excavated for planting the tree / shrub or over the entire area that has been or will be planted with vines or ground covers. See **Figure LMu-1** for suggested application rates for wood chips and shredded bark. Do not pile mulch against any tree or shrub trunk. Avoid excessive depths on slopes where mulch could slip when saturated.

Figure LMu–1 Suggested Landscape Mulch Application Rates for 100% Cover

Mulch	Rate
Wood Chips/ Shredded Bark	10 cu yds./1000 sq. ft.

Maintenance

Inspect 2 to 3 months after the first application and then once a year for mulch movement, rill erosion and decay.

Where mulch has been moved by concentrated waters, install additional measures to control water and sediment movement, repair erosion damage, remove any unwanted vegetation and re- apply mulch.

If mulch has decayed exposing underlying soil, repair any erosion damage, remove any unwanted vegetation and reapply mulch.

Temporary Erosion Control Blanket (ECB)

Definition

A manufactured blanket composed of biodegradable / photodegradable natural or polymer fibers and/or filaments that have been mechanically, structurally or chemically bound together to form a continuous matrix.

Purpose

To provide temporary surface protection to newly seeded and/or disturbed soils to absorb raindrop impact and to reduce sheet and rill erosion and to enhance the establishment of vegetation.

Applicability

- On disturbed soils where slopes are 2:1 or flatter.
- Where wind and traffic generated air flow may dislodge standard, unarmored mulches.
- May be used as a substitute for **Temporary Soil Protection**.
- May be used as a substitute for **Mulch for Seed**.

Planning Considerations

When considering the use of ECB keep in mind the blanket's capability to conform to ground surface irregularities. If the blanket is not capable of developing a continuous contact with the soil then it must be applied to a fine graded surface. Some blankets will soften and when wetted reconform to the ground. Also, when the ground is frozen, proper anchoring can be difficult, if not impossible.

Care must be taken to choose the type of blanket which is most appropriate for the specific need of the project. With the abundance of erosion control blankets available, it is impossible to cover all of the advantages, disadvantages and specifications of all manufactured blankets. There is no substitute for a thorough understanding of the manufacturer's instructions and recommendations in conjunction with a site visit by the erosion and sedimentation plan designer prior to and during installation to verify a product's appropriateness.

The success of temporary erosion control blankets is dependent upon strict adherence to the manufacturer's installation recommendations. As such, a final inspection should be planned to ensure that the lap joints are secure, all edges are properly anchored and all staking/stapling patterns follow the manufacturer's recommendations.

Specifications

Materials

Temporary erosion control blankets shall be composed of fibers and/or filaments that:

❍ *are biodegradable or photodegradable within two years but without substantial degradation over the period of intended usage (five months maximum);*

❍ *are mechanically, structurally or chemically bound together to form a continuous matrix of even thickness and distribution that resist raindrop splash and when used with seedings allows vegetation to penetrate the blanket;*

❍ *are of sufficient structural strength to withstand stretching or movement by wind or water when installed in accordance with the manufacturer's recommendations;*

❍ *are free of any substance toxic to plant growth and unprotected human skin or which interferes with seed germination;*

❍ *contain no contaminants that pollute the air or waters of the State when properly applied; and*

- *provide either 80%-95% soil coverage when used as a substitute for* ***Mulch for Seed*** *or 100% initial soil coverage when used as a substitute for* ***Temporary Soil Protection*** *measure.*

Materials shall be selected as appropriate for the specific site conditions in accordance with manufacturer's recommendations. Use of any particular temporary erosion control blanket should be supported by manufacturer's test data that confirms the blanket meets these material specifications and will provide the short term erosion control capabilities necessary for the specific project.

Site Preparation and Installation

(see **Figure ECB-1**)

Prepare the surface, remove protruding objects and install temporary erosion control blankets in accordance with the manufacturer's recommendations. Ensure that the orientation and anchoring of the blanket is appropriate for the site.

The blanket can be laid over areas where sprigged grass seedlings have been inserted into the soil. Where landscape plantings are planned, lay the blanket first and then plant through the blanket in accordance with Landscape Planting measure.

Inspect the installation to insure that all lap joints are secure, all edges are properly anchored and all staking or stapling patterns follow manufacturer's recommendations.

Maintenance

Inspect temporary erosion control blankets at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater for failures. Blanket failure has occurred when (1) soils and/or seed have washed away from beneath the blanket and the soil surface can be expected to continue to erode at an accelerated rate, and/or (2) the blanket has become dislodged from the soil surface or is torn.

If washouts or breakouts occur, re-install the blanket after regrading and re-seeding, ensuring that blanket installation still meets design specifications. When repetitive failures occur at the same location, review conditions and limitations for use and determine if diversions, stone check dams or other measures are needed to reduce failure rate.

Repair any dislodged or failed blankets immediately.

When used as a substitute for **Mulch for Seed**, continue to inspect as required by the seeding measure. When used as a substitute for **Temporary Soil Protection**, continue to inspect until it is replaced by other erosion control measures or until work resumes.

Figure ECB-1
Example of Temporary Erosion Control Blanket Installation

Temporary Erosion Control Blanket (ECB)

Permanent Turf Reinforcement Mat (TRM)

Definition
A manufactured mat composed of non-biodegradable polymer or synthetic fibers mechanically, structurally or chemically bound together to form a continuous matrix.

Purpose
- To provide permanent turf reinforcement where design flows exceed the stability of the soils and/or proposed vegetation.
- To enhance the establishment of vegetation as the final surface protection.

Applicability
- In channels where design velocities exceed the stability limits of the soil and/or vegetation, and a soft-armored approach is desired.
- On unstable soils where intermittent flow exists.
- On disturbed soils with slopes 2:1 or flatter. On shorelines above a protected or stable toe to reduce soil erosion.

Planning Considerations
As a rule of thumb, when flows over exposed soils exceed 2 feet per second and flows over proposed turf areas exceed 5-6 feet per second, then soil erosion can be expected. Permanent turf reinforcement mats can be one way to reduce the erosion potential, and can be used in conjunction with other erosion control measures such as **Vegetated Waterway** and **Permanent Diversion**.

Permanent turf reinforcement mats are manufactured in several styles. They can be flat or three dimensional matrixes, laid either on top of or within the soil surface layer. Where permanent turf reinforcement mats are primarily used in areas of concentrated flows, an engineered design is required. Permanent turf reinforcement mats require the application of vegetative soil cover measures.

The requirement for permanent turf reinforcement mats should be identified during the development of the erosion and sediment control plan. Also, permanent turf reinforcement mats may be used as a corrective measure in areas of concentrated flows where repeated failures of vegetative cover have occurred.

Some permanent turf reinforcement mats are manufactured with a temporary erosion control blanket attached to them and do not require a separate mulch application. Permanent turf reinforcement mats should be expected to last the life expectancy specified in the manufacturer's recommendations. Care must be taken to choose the type of mats which are most appropriate for the specific need of the project. A thorough understanding of the manufacturer's instructions and recommendations is needed to verify a product's appropriateness.

Design Criteria
Where turf reinforcement mats are used in areas of concentrated flows an engineered design is required. For other applications refer to the manufacturer's recommendations.

Materials
Permanent turf reinforcement mats shall:

❍ *consist of ultraviolet light resistant polymer or synthetic fibers mechanically, structurally, and/or chemically bound together for a continuous matrix of consistent thickness;*

❍ *contain no contaminants that pollute the air or waters of the state when properly installed; and*

- *be free of any substance toxic to plant growth and unprotected human skin or which interferes with seed germination.*

Materials shall be selected as appropriate for the specific site conditions in accordance with manufacturer's recommendations. Use of any particular permanent turf reinforcement mat should be supported by manufacturer's test data that confirms the mat will provide the long term erosion control capabilities necessary for the specific project.

Installation Requirements

Prepare site and install in accordance with manufacturer's requirements. **Figure TRM-1** shows a typical installation for a grass-lined channel.

Establish vegetative cover in accordance with the applicable measure found in the Vegetative Soil Cover Control Measure Group of these Guidelines. Modify the sequence of application to meet the manufacturer's requirements for the specific installation.

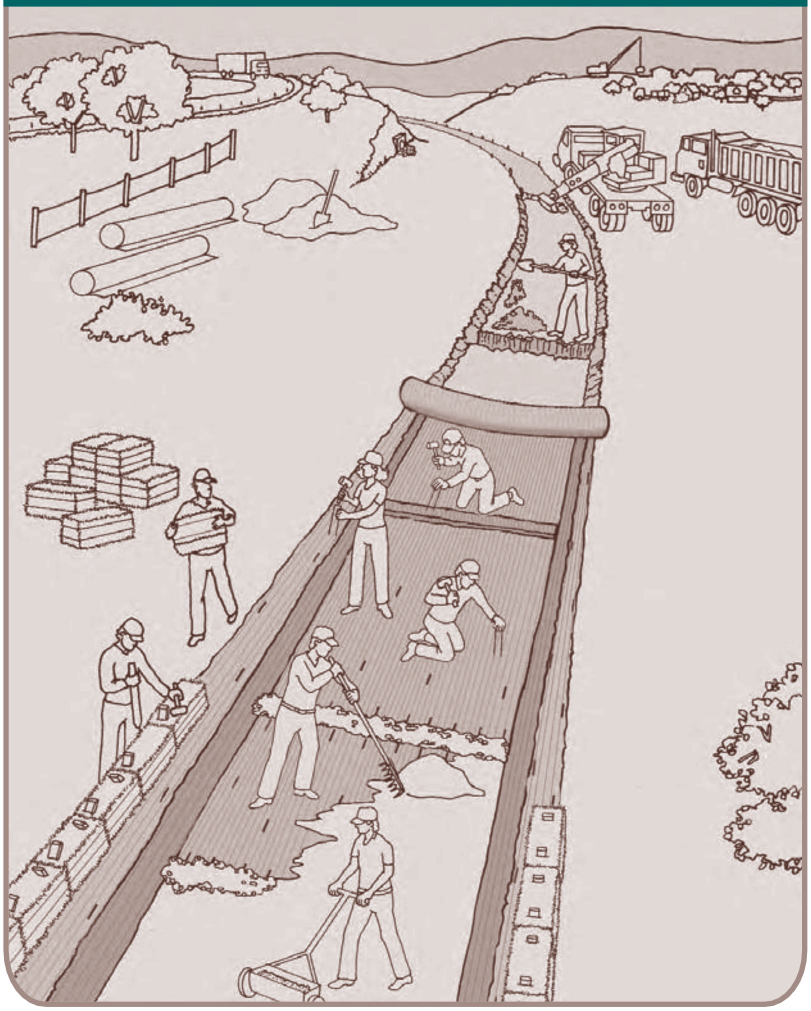
Inspect the installation to ensure that the mat is in direct contact with the prepared soil surface, all lap joints are secure, all edges and interior mats are properly anchored and/or treated, backfilling follows the manufacturer's requirements, and the vegetative soil measures used have been correctly applied.

Maintenance

Inspect permanent turf reinforcement mats at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater for failures until the turf has become established. Mat failure has occurred when soils and/or seed have washed away from beneath or within the mat resulting in a soil surface that can be expected to continue to erode or when the mat has become dislodged from the soil surface. When repetitive failures occur at the same location, review conditions and limitations of turf reinforcement mats and determine if additional controls, (e.g. diversions, stone barriers) are needed to ensure success. Repair mat failures within one work day.

After the turf has become established, inspect annually or after major storm events.

Figure TRM-1 Example of TRM Channel Application



Stone Slope Protection (SSP)

Definition
Applying stone aggregates for permanent protection on slopes where vegetative soil cover measures are either impractical or difficult to establish.

Purpose
To permanently reduce runoff and erosion, prevent soil compaction and prevent shallow surface slope failures by providing a non-vegetative stone cover over the soil surface.

Applicability
- Where highly erodible soils provide for unfavorable conditions for plant establishment and growth. Where herbaceous plant growth is to be discouraged or controlled.
- Not for use in concentrated flow areas or as a replacement for riprap or other measures designed to control slope stability. Use slope stabilization measures in the Stabilization Structures Functional Group and **Subsurface Drain** measure. May be used in combination with other slope stabilization measures and subsurface drains.
- For use on slopes 2:1 or flatter. For slopes steeper than 2:1 and for slopes with excessive seepage, an engineer's review of slope stability is required (see **Riprap** measure).

Planning Considerations
Typically, stone slope protection is used when there has been difficulty in establishing vegetation caused by adverse soil conditions or where competing vegetation is to be discouraged, as with landscape plants. It may take the place of Landscape Mulch, thus requiring less maintenance.

An engineering review is required when the slope to be protected is steeper than 2:1 or when excessive seepage is expected. If the engineering review results in a concern about slope stability, then other slope stabilization measures shall be utilized, possibly in combination with this measure.

Specifications

Materials
Stone used in stone slope protection shall consist of crushed stone or gravel that meets the gradations for DOT #3 coarse aggregate (see **Figure SP-1**) conforming to the DOT Standard Specifications Section M.01.01.

Site Preparation
Bring areas to be stabilized to final grade in accordance with the approved plan. Install and/or repair other sediment control measures as needed to control water movement into the area to be covered with stone.

Application
Slope the area on which the stone is to be placed to a reasonably true surface prior to placing any stone. Spread the stone by any suitable means which will not crush the stone. Shape the stone to a smooth uniform finished grade. Provide 100% coverage of the disturbed soil with the stone.

Figure SP–1 DOT #3 Coarse Aggregate

Square Mesh Sieves	% Passing by Weight
2.5"	100
2.0"	90–100
1.5"	35–70
1.0"	0–15
0.5"	0–5

Maintenance
Coarse aggregate conforming to DOT Standard Specifications Section M.01.01 will not deteriorate, but may fail by slippage or displacement. If slippage or displacement occur, conduct an engineering analysis to determine the cause. Overland water flow, excessive seepage, deep slope failure or surficial structural failure should be investigated by an engineer. Repair failed areas and/or implement alternate measures to obtain stability.

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Planning Considerations

The stabilization structures measures are **Retaining Wall, Riprap, Gabions, Permanent Slope Drain, Channel Grade Stabilization Structure, Temporary Lined Chute** and **Temporary Pipe Slope Drain.** Stabilization structures have the primary function of preventing soil erosion when slope gradients are considered to be too steep or water velocities on the slope are too high for the slope to remain stable with a vegetative cover. The measures in this group can be generally divided into two subgroups: slope stabilization structures and grade stabilization structures. Slope stabilization structures are applied to stabilize slopes and grade stabilization structures are applied to stabilize channels and areas where concentrated flows will occur.

Retaining Wall, Riprap and Gabions measures are capable of being applied to both slopes and channels. **Permanent Slope Drain**, **Channel Grade Stabilization Structure**, and **Temporary Lined Chute** are used only for channelized flow.

The **Retaining Wall** measure involves the construction of a structurally designed wall of various materials usually at the bottom of a slope to prevent bank failure due to shallow bedrock, steepness, seepage or other soil conditions and to lessen the slope gradient above the wall.

The **Riprap** measure is the use of rock to stabilize slopes with seepage problems and to protect a soil surface from the erosive forces of concentrated runoff or high velocity stream flows.

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The **Gabions** measure takes riprap or other hard durable rock and places it in a flexible wire mesh basket composed of rectangular cells. It can be used in place of the Riprap measure and can be a material used in the **Retaining Wall** measure.

The **Permanent Slope Drain** measure involves an open or closed structure or series of structures, such as pipes, culverts and manholes, that convey water flows through excessive grade changes.

The **Channel Grade Stabilization Structure** measure is an open structure used to control the grade and head cutting in natural or artificial channels. It is not used, however, to regulate the flow in a channel or to regulate the water level in a channel.

The **Temporary Lined Chute** measure consists of an open channel lined with a non-erosive material on slopes steeper than 5:1 where the drainage area is less than 36 acres and its use is for less than one year. When these limitations are exceeded, the use of other measures from the stabilization function group and waterways functional group are required.

The **Temporary Pipe Slope Drain** utilizes a flexible or ridge pipe to convey water down a slope from a contributing drainage area of 5 acres or less for a period of time no greater than 6 months. It is commonly used in association with temporary diversions.

Not contained within these Guidelines are any measures relating to the use of soil reinforcement materials for slope stabilization. Due to the variety of these materials, standards and specifications have not yet been identified. If used, they require a carefully engineered design that complies with the manufacturer's specifications.

All these measures require an engineered design. All requirements of state law and permit requirements of local, state and federal agencies must be met. These structures should be planned and installed along with, or as part of, other conservation practices in an overall surface water disposal system. Where possible, attention should be given to maintaining or improving habitat for fish and wildlife.

For measures in this group that are to receive concentrated flows, plan to avoid constructing the measure when the local weather forecast predicts rainfall to occur during the time of construction. Local forecasts may be obtained by listening of local radio and television stations, the National Weather Service broadcasts (162.400 MHZ for CT generally, 162.475 MHZ for northeastern CT., 162-550 MHZ for Southeastern and Southwestern CT) or from the Internet at http://www.nws.noaa.gov.

Definition

A wall that provides stability to a slope, constructed of mortared block or stone, cast-in-place concrete, timber, reinforced earth, gabions, precast concrete modular units or similar structures.

Purpose

To prevent erosion and slope failure on steep slopes and stream banks.

Applicability

- Where erosion or slope failure may occur due to excessive loadings, steepness, seepage or other unstable soil conditions.
- Where site constraints won't allow slope stabilization by flattening and seeding.

Planning Considerations

Retaining walls are used where site constraints, such as wetland or property boundaries, prevent slope flattening and seeding. Sequence the construction so that the retaining walls are installed with minimum delay. Disturbance of areas where retaining walls are to be placed should be undertaken only when final preparation and placement of the retaining walls can follow immediately behind the initial disturbance.

Selection of materials and type of wall should be based on hazard potential, load conditions, soil parameters, groundwater conditions, site constraints, material availability, cost and aesthetics.

Design Criteria

Consider foundation bearing capacity, sliding, overturning, drainage and loading systems. For prefabricated units, shop drawings should be submitted by the fabricator to the engineer for consideration in the design analysis.

Safety

Safety railings may be required by local building codes.

Bearing Capacity

Maintain a minimum factor of safety of 1.5 for the ratio of the allowable bearing capacity to the designed loading. Spread footings and other methods may be used to meet bearing factor requirements.

Sliding

Use a minimum safety factor of 2.0 against sliding. This factor may be reduced to 1.5 when passive pressures on the front of the wall are ignored.

Overturning

Use a minimum safety factor of 1.5 as the ratio of the resisting moment (that which tends to keep the wall in place) to the overturning moment.

Drainage

Unless adequate provisions are designed to control both surface and groundwater behind the retaining wall, a substantial increase in active pressures tending to slide or overturn the wall will result. Provide surface drainage when backfill or natural ground is higher than the top of the wall. Provide subsurface drainage systems with adequate outlets behind the retaining walls as needed to reduce hydrostatic loadings. Design subsurface drains to prevent piping of backfill or existing soils.

Load systems

Consider several different loads or combination of loads when designing a retaining wall. In addition to soil and hydrostatic loadings, consider live loads, surcharge loads and sloped fill loads.

Additional Design Considerations for Retaining Walls Along Stream Banks.

Bottom scour: Control bottom scour in a channel before any retaining wall type of bank protection can be considered feasible. This is not necessary if the retaining wall can be safely and economically constructed to a depth below the anticipated lowest depth of bottom scour.

Starting and ending points: Start and end the retaining wall at a stabilized or controlled point on the stream.

Channel alignment: Consider changes in channel alignment only after an evaluation is made of the effect such changes will have upon land use, storm sewer systems, hydraulic characteristics and other existing structures.

Installation Requirements

Concrete Walls (see Figure RW-1)

1. Prepare foundations by excavating to the lines and grades shown on the drawings and removing all objectionable material.

2. Compact subgrade and keep it moist at least 2 hours prior to placement of concrete.

3. Use steel reinforcing in accordance with the schedule on the drawings and keep it free of rust, scale or dirt.

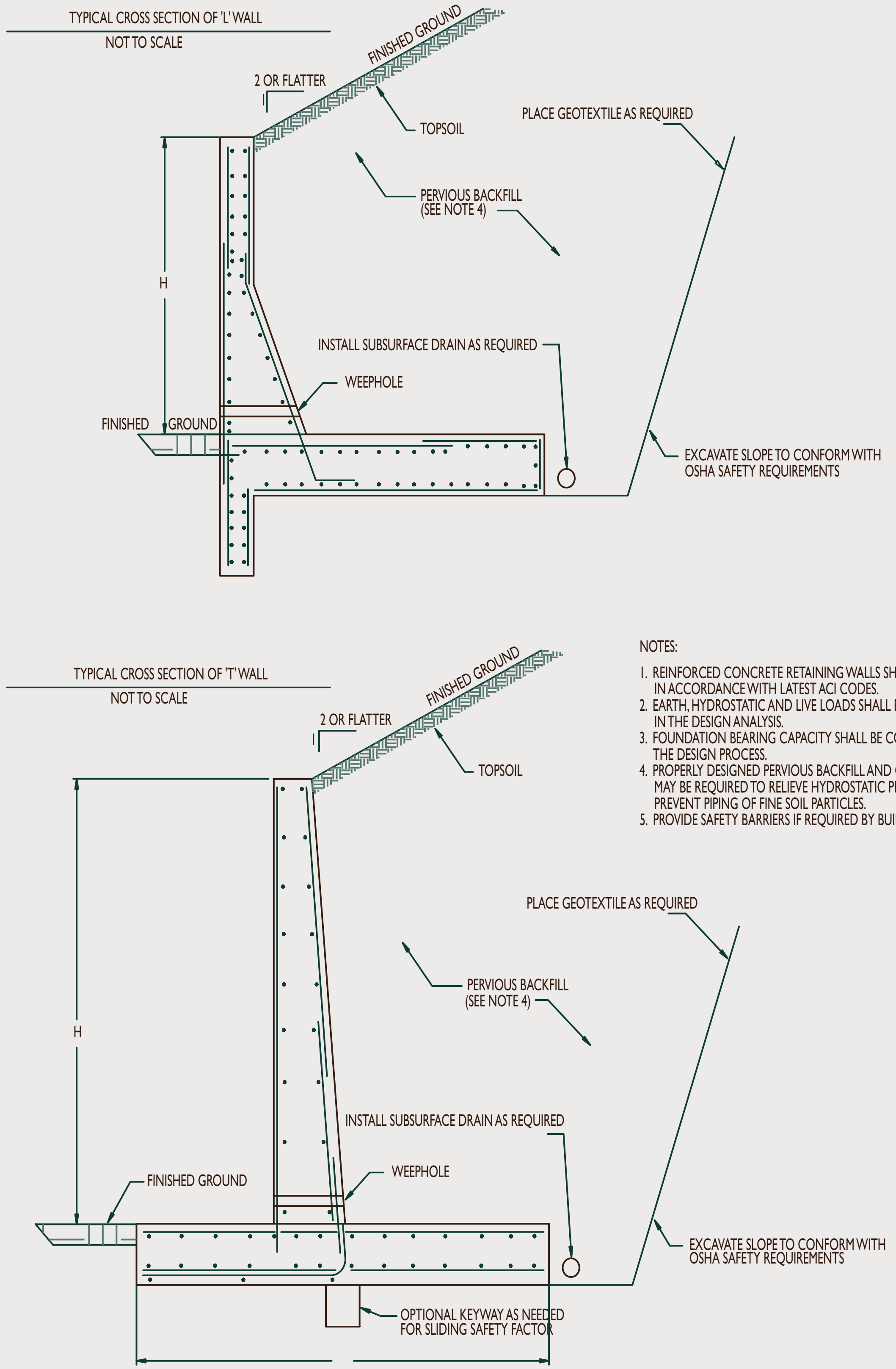
4. Chamfer exposed edges 0.75 inches.

5. Install underdrain filter to meet the gradations shown on the drawings.

6. Provide weep holes for drain outlets as shown on the drawings.

7. Pour and cure concrete in accordance with American Concrete Institute specifications.

Figure RW-1 Concrete Retaining Walls

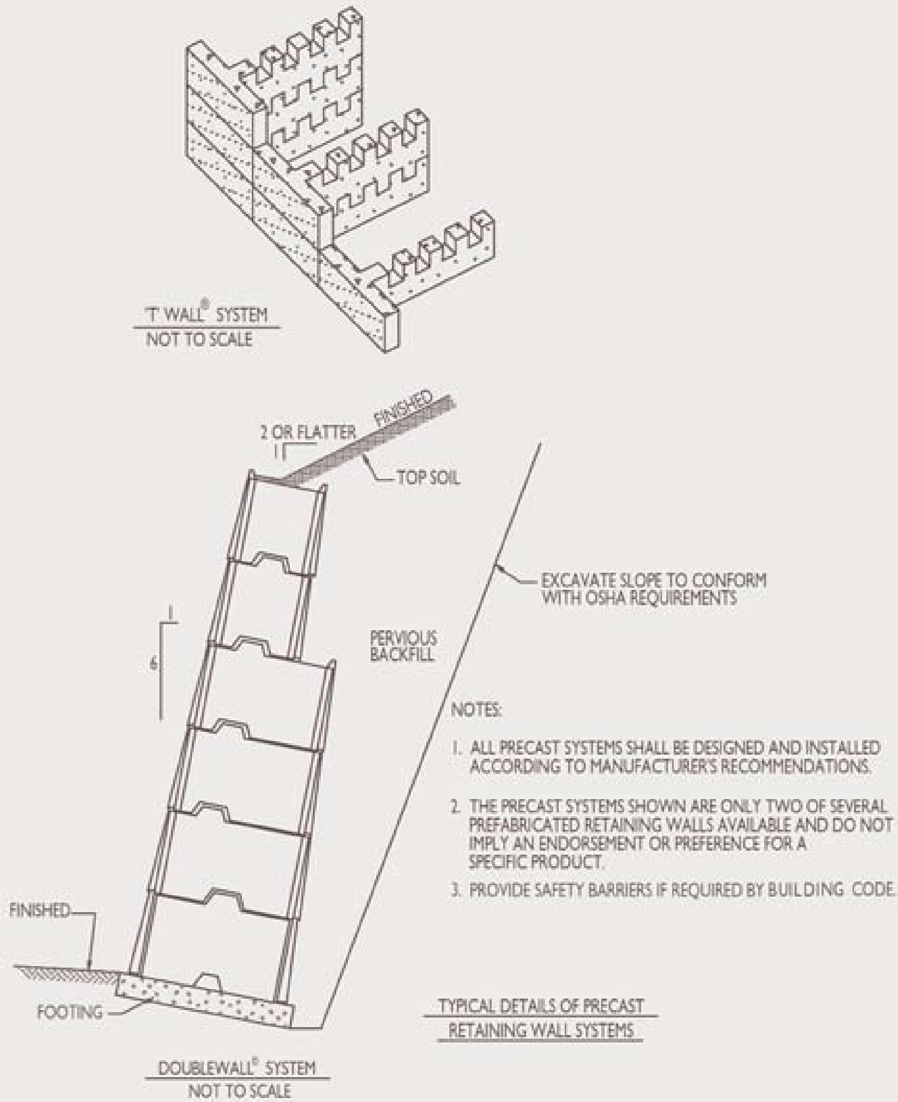


NOTES:

1. REINFORCED CONCRETE RETAINING WALLS SHALL BE DESIGNED IN ACCORDANCE WITH LATEST ACI CODES.
2. EARTH, HYDROSTATIC AND LIVE LOADS SHALL BE CONSIDERED IN THE DESIGN ANALYSIS.
3. FOUNDATION BEARING CAPACITY SHALL BE CONFIRMED IN THE DESIGN PROCESS.
4. PROPERLY DESIGNED PERVIOUS BACKFILL AND GEOTEXTILE MAY BE REQUIRED TO RELIEVE HYDROSTATIC PRESSURES AND PREVENT PIPING OF FINE SOIL PARTICLES.
5. PROVIDE SAFETY BARRIERS IF REQUIRED BY BUILDING CODE

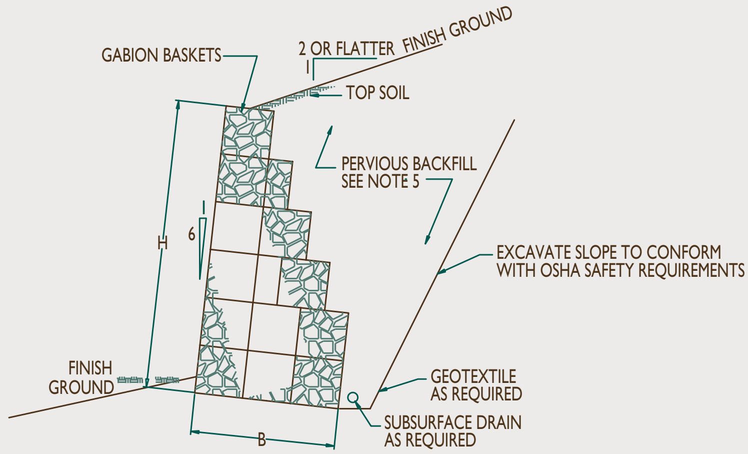
Source: USDA-NRCS

Figure RW-2 Precast Retaining Walls



Source: USDA-NRCS

Figure RW-3 Gabion Retaining Walls



TYPICAL CROSS SECTION FOR SURCHARGED WALL
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NOTES:

1. SIZES OF INDIVIDUAL GABION BASKETS TO BE DETERMIND ON A CASE BY CASE BASIS,
2. 'H' AND 'B' DIMENSION INDIVIDUALLY DESIGNED BASED UPON EARTH AND HYDROSTATIC LOADINGS.
3. FOUNDATION BEARING CAPACITY TO BE CONFIRMED IN THE DESIGN PROCESS.
4. WIRE BASKETS SHALL CONFORM WITH CT DOT SPECIFICATIONS SECTION 7.04 OR USDA NRCS SPECIFICATION 64.
5. PROPERLY DESIGNED PERVIOUS BACKFILL AND GEOTEXTILE MAY BE REQUIRED TO RELIEVE HYDROSTATIC PRESSURES AND PREVENT PIPING OF FINE SOIL PARTICLES.
6. PROVIDE SAFETY BARRIERS IF REQUIRED BY BUILDING CODE.

Source: USDA-NRCS

Definition

A permanent, erosion-resistant ground cover of large, loose, angular stone.

Purpose

- To protect the soil surface from the erosive forces of concentrated runoff, high velocity stream flows and wave action.
- To slow the velocities, enhance the potential for infiltration, and provide habitat diversity.
- To stabilize slopes with seepage problems.

Applicability

- On soil-water interfaces where soil conditions, expected flow conditions (including water turbulence, velocity and waves), and expected vegetative cover, etc., are such or will be such that the soil will erode under the design flow conditions.
- At storm drain outlets, on channel banks and/or bottoms, roadside ditches, permanent slope drains, at the toe of slopes, or to stabilize streams.

Planning Considerations

Since riprap is used where erosion potential is high, sequence construction so that the riprap is placed with a minimum of delay. Plan to disturb areas where riprap is to be placed only when final preparation and placement of the riprap will follow immediately behind the initial disturbance. Where riprap is used for outlet protection, plan to place the riprap before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to function.

All legal and permit requirements of local, state and federal agencies must be met.

Design Criteria

Sizes - Equivalent Spheres

Riprap sizes can be designated by either the diameter or the weight of the stones. They can also be designated by established published standards, such as that found in the DOT Standards and Specifications Section M.02.06 (see **Figure RR-1**). It is often misleading to think of riprap in terms of diameter, since the stones should be angular instead of spherical. It is simpler to specify the diameter of an equivalent size of spherical stone. **Figure RR-3** lists some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon an assumed bulk weight of 2.65 grams per cubic centimeter (165 lbs./ft.3).

A diameter of stone in the mixture is specified for which some percentage, by weight, will be smaller. For example, d_{85} refers to a mixture of stones in which 85% of the stone by weight would be smaller than the diameter specified. Most designs are based on d_{50} (see **Figure RR- 2**). In other words, the design is based on the average size of stone in the mixture.

Gradation

Riprap gradations shall be specified by either the DOT Standard Specifications, or other established published standards. Regardless of the standard used, riprap shall be composed of a well-graded mixture down to the one-inch size particle such that 50% of the mixture by weight shall be larger than the d_{50} size as determined from the design procedure. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The DOT riprap standards are examples of well graded mixtures (see **Figure RR-1**).

After determining the riprap size that will be stable under the flow conditions, consider that size to be a minimum and then, based on riprap gradations actually available in the area, select the size or gradations that equal or exceed the minimum size.

Thickness

The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter but not less than 12 inches.

Quality of Stone

Individual rock fragments shall be dense, sound and free from cracks, seams and other defects conducive to accel-

Figure RR-1 DOT Standard Riprap Sizes

Standard Riprap: This material shall conform to the following requirements:

(A) Not more than 15% of the riprap shall be scattered spalls and stones less than 6 inches (150 mm) in size.

(B) No stone shall be larger than 30 inches (760 mm) in size, and at least 75% of the mass shall be stones at least 15 inches (380 mm) in size.

Intermediate Riprap: This material shall conform to the following gradation:

Stone Size (English) / (metric)	% of mass
18" or over / 460mm or over	0
10" to 18" / 255mm to 460mm	30-50
6" to 10" / 150mm to 255mm	30-50
4" to 6" / 100mm to 150mm	20-30
2" to 4" / 50mm to 100mm	10-20
less than 2" / less than 50mm	0-10

Modified Riprap: this material shall conform to the following gradation:

Stone Size (English) / (metric)	% of mass
10" or over / 255mm or over	0
6" to 10" / 150mm to 255mm	30-50
4" to 6" / 100mm to 150mm	30-50
2" to 4" / 50mm to 100mm	20-30
1" to 4" / 25mm to 50mm	10-20
less than 1" / less than 50mm	0-10

Source: Section M.02.06, State of Connecticut Department of Transportation, Standard Specifications for Roads and Bridges and incidental Construction, Forms 815, 1995.

Figure RR-2 Examples of Average Stone Size for d_{50}

Modified d_{50}	=	0.42 feet or 5 inches
Intermediate d_{50}	=	0.67 feet or 8 inches
Standard d_{50}	=	1.25 feet or 15 inches

erated weathering. The rock fragments shall be angular in shape. The least dimension of an individual rock fragment shall be not less than one-third the greatest dimension of the fragment. The stone shall be of such quality that it will not disintegrate on exposure to water or weathering, be chemically stable, and shall be suitable in all other respects for the purpose intended. The bulk specific gravity (saturated surface-dry basis) of the individual stones shall be at least 2.65.

Note: *DOT Standard Specifications do not accept rounded stone or broken concrete for riprap.*

Riprap at Outlets

Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structures are contained in the **Outlet Protection** measure. A properly designed bedding, filter, and/or geotextile underlining is required for riprap used as outlet protection. Where the native material meets the requirements for granular free draining bedding material, no additional filter or geotextile is required.

Riprap for Channel Stabilization

Riprap for channel stabilization shall be designed to be stable for the condition of bank-full flow in the reach of channel being stabilized (see **Permanent Lined Waterway** measure). The design procedure, which is extracted from the Federal Highway Administration's Design of Roadside Channels with Flexible Linings, is one accepted method. Other generally accepted published methods may be used.

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

The riprap size to be used in a channel bend shall extend upstream from the point of curvature a minimum of 0.4 times the water surface width, and downstream from the point of tangency a distance of at least 5 times the channel bottom width. The riprap may extend across the bottom and up both sides of the channel or only protect the outside bank, depending upon specific design requirements.

Where riprap is used only for bank protection and does not extend across the bottom of the channel, riprap shall be keyed into the bottom of the channel to a minimum additional depth equal to 1.5 times the maximum size stone (see **Figure RR-4**).

For riprapped and other lined channels, the height of channel lining above the design water surface shall be based on the size of the channel, the flow velocity, the cur-

Figure RR-3 Size of Riprap Stone

Weight (lbs.)	Mean Spherical Diameter (ft.)	Rectangular Shape Length (ft.)	Width, Height (ft.)
50	0.8	1.4	0.5
100	1.1	1.75	0.6
150	1.3	2.0	0.67
300	1.6	2.6	0.9
500	1.9	3.0	1.0
1000	2.2	3.7	1.25
1500	2.6	4.5	1.5
2000	2.75	5.4	1.8
4000	3.6	6.0	2.0
6000	4.0	6.9	2.3
8000	4.5	7.5	2.5
20000	6.1	9.9	3.3

Source: USDA-NRCS

vature, inflows, wind action, flow regulation, etc. (see **Figure RR-5**).

The height of the bank above the design water surface varies in a similar manner, depending on the above factors plus the type of soil.

Riprap for Slope Stabilization

Riprap for slope stabilization shall be designed so that the natural angle of repose of the stone mixture is steeper than the gradient of the slope being stabilized (see **Figure RR-6** for angles of repose for various shaped riprap).

Riprap for Lakes and Ponds Subject to Wave Action

Riprap may be used for shoreline protection on lakes and ponds subject to wave action. The waves affecting the shoreline may be wind-driven or created by boat wakes.

For more in-depth design criteria concerning these installations, see the U.S. Army Corps of Engineers Shore Protection Manual (59) or U.S.D.A. Natural Resources Conservation Service Technical Release # 69 Riprap for Slope Protection Against Wave Action.

Filter Blankets or Bedding

A filter blanket or bedding is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement through the riprap.

Filter blankets or bedding should always be provided where seepage from underground sources threatens the stability of the riprap.

A filter blanket or bedding can be either granular stone layer(s), a geotextile or both. A determination of the need for a filter blanket is made by comparing particle sizes of the overlying material and the underlying material in accordance with the criteria below.

(1) Granular filter layer: A granular (stone) bedding is a viable option when the following relationship exists:

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

and,

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

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

(2) **Geotextile (Specifically Intended to Prevent Piping)**: May be used in conjunction with a layer of coarse aggregate. The geotextile shall not be used on slopes steeper than 1-1/2 : 1 as slippage may occur. The following particle size relationships must exist:

(a) For geotextile adjacent to base materials containing 50% or less (by weight) of fine particles (less than 0.075mm):

i) $$\frac{d_{85}\,base\ (mm)}{EOS\ geotextile(mm)} > 1$$

where EOS = Equivalent Opening Size to a U.S. Standard Sieve Size

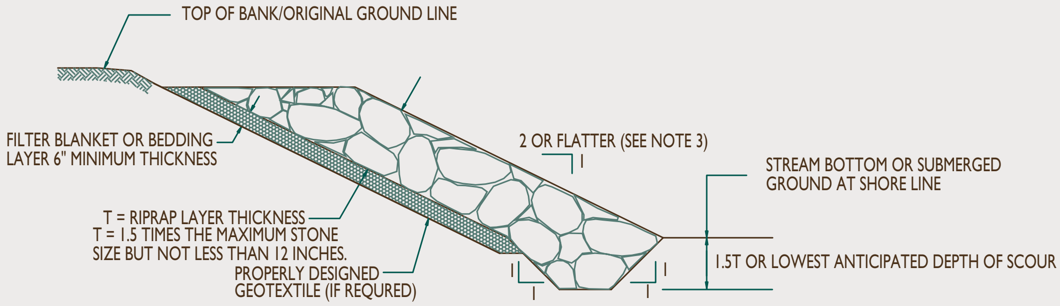
ii) Total open area of geotextile is less than 36%.

(b) For geotextile adjacent to all other soils:
a) EOS less than U.S. Standard Sieve No. 70.
b) Total open area of geotextile is less than 10%.

No geotextile should be used with an EOS smaller than U.S. Standard Sieve No. 100.

(3) Additional design criteria for geotextiles are contained in the latest edition of Designing with Geosynthetics by Robert M. Koerner.

Figure RR-4 Riprap for Channel and Shoreline Stabilization



NOTES:

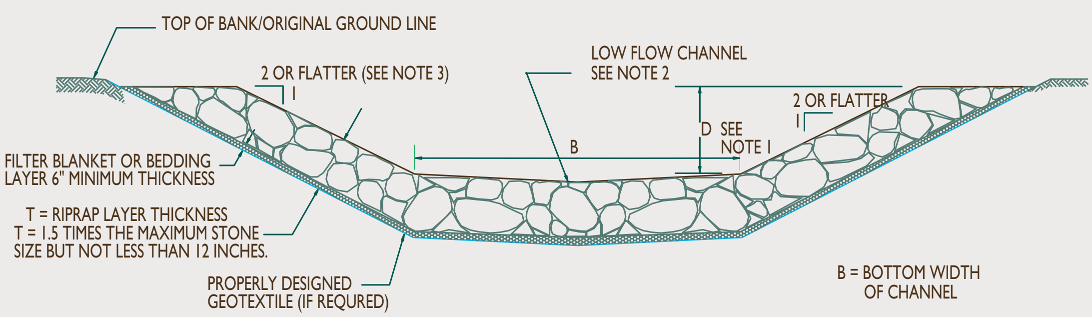
1. FOR A CHANNEL OR RIVER APPLICATION THE TOTAL HEIGHT OF RIPRAP REVETMENT IS DEPENDENT UPON THE DESIGN DEPTH OF FLOW PLUS FREEBOARD.
2. FOR A SHORELINE APPLICATION THE TOTAL HEIGHT OF RIPRAP REVETMENT IS DEPENDENT UPON THE DESIGNED WAVE HEIGHT PLUS FREEBOARD.
3. SIDE SLOPES STEEPER THAN 2:1 WILL REQUIRE ADDITIONAL ANALYSIS.

TYPICAL CROSS-SECTION OF RIPRAP REVETMENT

(NOT TO SCALE)

Source: USDA-NRCS

Figure RR-5 Riprap for Armored Channel Stabilization



TYPICAL CROSS-SECTION OF RIPRAP LINED CHANNEL

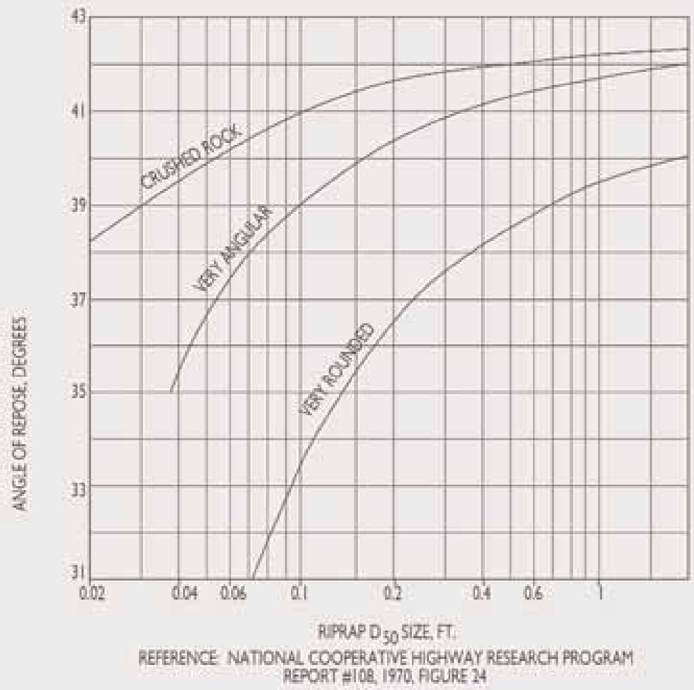
(NOT TO SCALE)

NOTE:

1. THE TOTAL HEIGHT OF RIPRAP LINING IS DEPENDENT UPON THE DESIGN DEPTH OF FLOW PLUS RUNUP DUE TO CHANNEL CURVATURE, PLUS FREEBOARD.
2. IN CHANNELS WITH SIGNIFICANT BOTTOM WIDTHS, LOW FLOW CHANNELS MAY BE INCORPORATED IN THE TEMPLATE.
3. SIDE SLOPES STEEPER THAN 2:1 WILL REQUIRE ADDITIONAL ANALYSIS.

Source: USDA-NRCS

Figure RR-6 Angle of Repose of Riprap in Terms of Size and Shape of Stone



Source: USDA-NRCS

Installation Requirements

Subgrade Preparation

Prepare the subgrade for the riprap, bedding, filter or geotextile to the required lines and grades. Compact any fill required in the subgrade to a density approximating that of the surrounding undisturbed material. Remove brush, trees, stumps and other objectionable material.

Geotextile

For geotextile filters, use only geotextiles that were stored in a clean dry place, out of direct sunlight, with the manufacture's protective cover in place to insure the geotextile was not damaged by ultraviolet light. Place the geotextile in accordance with the manufacturer's recommendations.

Filter Blanket or Bedding

Immediately after slope preparation, install the filter or bedding materials. Spread the filter or bedding materials in a uniform layer to the specified depth. Where more than one distinct layer of filter or bedding material is required, spread the layers so that there is minimal mixing between materials.

Stone Placement

Immediately after placement of the filter blanket, bedding and/or geotextile, place the riprap to its full course thickness in one operation so that it produces a dense well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry, controlled dumping of successive loads during final placing, or by a combination of these methods. Do not place the riprap in layers or use chutes or similar methods to dump the riprap which are likely to cause segregation of the various stone sizes.

Take care not to dislodge the underlying material when placing the stones. When placing riprap on a geotextile take care not to damage the fabric. If damage occurs, remove and replace the damaged sheet. For large stone, 12 inches or greater, use a 6-inch layer of filter or bedding material to prevent damage to the material from puncture.

Ensure the finished slope is free of pockets of small stones or clusters of large stones. Hand placing may be necessary to achieve the required grades and a good distribution of stone sizes. Ensure the final thickness of the riprap blanket is within plus or minus 0.25 of the specified thickness.

Maintenance

Inspected periodically to determine if high flows have caused scour beneath the riprap or filter blanket or dislodged any of the riprap or filter blanket materials. Once a riprap installation has been completed, it should require very little maintenance. Periodic removal of large trees may be required to insure the integrity of the riprap

Gabions (G)

Definition

Flexible wire mesh baskets composed of rectangular cells filled with riprap or other selected (hard, durable) rock.

Purpose

- To protect soils from the erosive forces of concentrated runoff or wave action.
- To slow the velocity of concentrated runoff.
- To stabilize slopes.

Applicability

For use in channels, stream deflectors, grade control structures, revetments, retaining walls, abutments, stonecheck dams, and similar installations.

Planning Considerations

Gabions are used where erosion potential is high. Therefore, construction must be sequenced so that the gabions are constructed with the minimum possible delay. A pH below 5 for the soil and water may determine whether an additional protective coating is required for the wire.

Design Criteria

General

The design shall be in accordance with accepted engineering practices. Geotextiles and filter blankets used with the gabions shall be designed for specific soil conditions and rockfill sizes. See **Riprap** measure for geotextile, bedding and filter blanket requirements. **Figure G-1** and **Figure G-2** show the use of gabions for retaining walls and revetments, respectively.

Materials

Minimum material specifications shall meet the requirements of DOT Standard Specifications Section 7.04, entitled "Gabions" and of the manufacturer. Materials may alternately conform to the most recent version of the USDA Natural Resources Conservation Service Construction Specification 64 entitled "Wire Mesh Gabions and Mattresses." For aesthetic purposes facing stone may be rounded or otherwise shaped, providing it is larger than the largest gabion mesh opening.

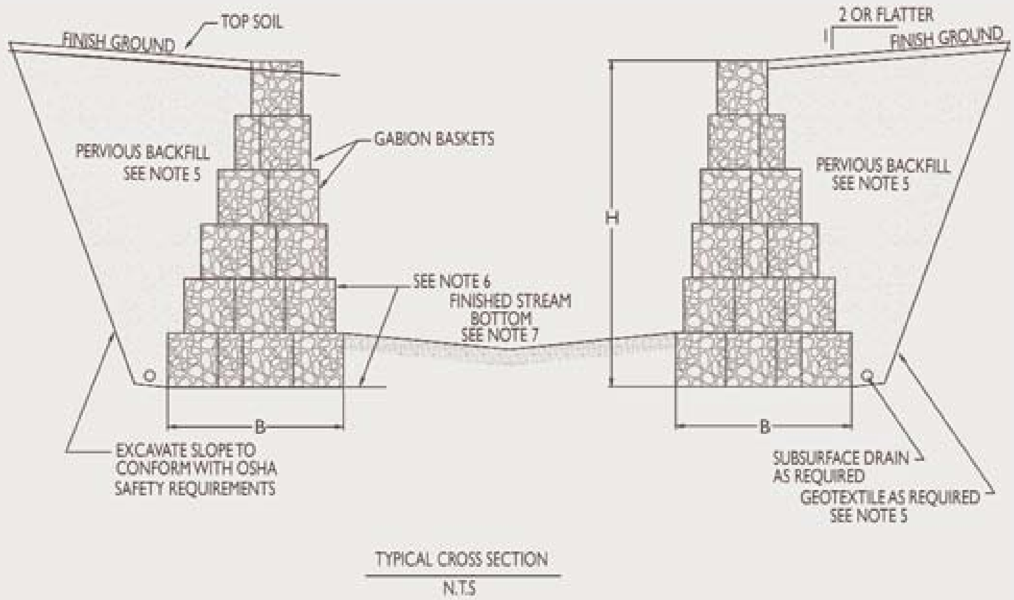
Installation Requirements

Installation shall be in accordance with either DOT Standard Specifications Section 7.04, or the USDA Natural Resources Conservation Service Construction Specification 64.

Maintenance

Periodic inspection for signs of corrosion of wire, undercutting or excessive erosion at transition areas is essential and repair must be carried out promptly.

Figure G-1 Gabion Use for Streambank Protection and Retaining Walls

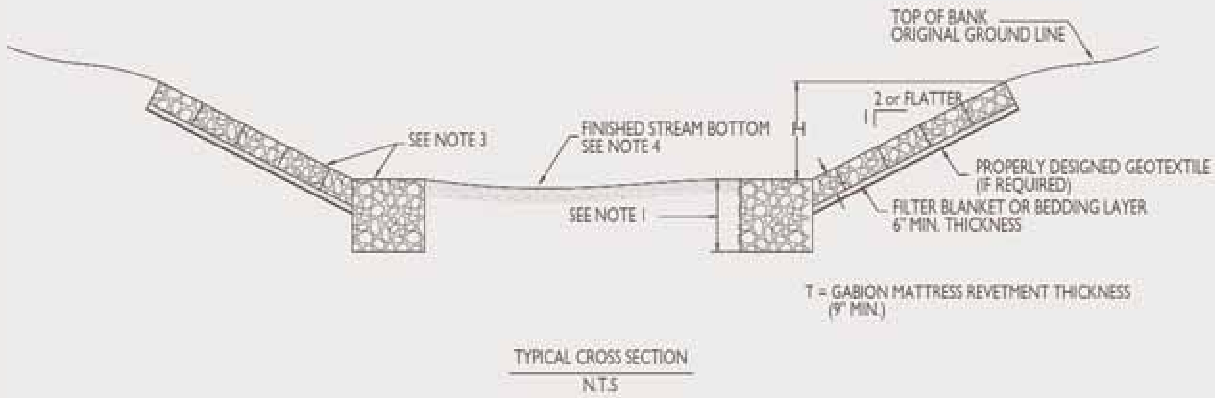


NOTES:

1. SIZES OF INDIVIDUAL GABION BASKETS TO BE DETERMINED ON A CASE BY CASE BASIS.
2. 'H' AND 'B' DIMENSIONS INDIVIDUALLY DESIGNED BASED UPON EARTH AND HYDROSTATIC LOADINGS.
3. FOUNDATION BEARING CAPACITY TO BE CONFIRMED IN THE DESIGN PROCESS.
4. WIRE BASKETS SHALL CONFORM WITH CT DOT SPECIFICATIONS SECTION 7.04 OR USDA NRCS SPECIFICATION 64.
5. PROPERLY DESIGNED PERVIOUS BACKFILL AND GEOTEXTILE MAY BE REQUIRED TO RELIEVE HYDROSTATIC PRESSURES AND PREVENT PIPING OF FINE SOIL PARTICLES.
6. THE BOTTOM OF THE BASE BASKET SHALL BE AT LEAST THE DEPTH OF ANTICIPATED SCOUR. THE FACE OF BOTTOM BASKETS MAY REQUIRE GROUT OR GUNITE PROTECTION TO PREVENT ABRASION AND INCREASE GABION WIRE LONGEVITY.
7. STREAM BOTTOM MAY REQUIRE RIPRAP OR GABION MATTRESS FOR STABILITY.
8. PROVIDE SAFETY BARRIERS IF REQUIRED BY CODE.

Source: USDA-NRCS

Figure G-2 Gabion Revetment



NOTES:

1. SIZE OF ANCHOR OR TOE BASKET TO BE DETERMINED ON A CASE-BY-CASE BASIS. THE BOTTOM OF THE BASKET SHALL BE AT LEAST THE DEPTH OF ANTICIPATED SCOUR.
2. THE TOTAL HEIGHT OF GABION REVETMENT IS DEPENDENT UPON THE DESIGN FLOW DEPTH PLUS FREEBOARD.
3. FACE OF ANCHOR BASKET AND LOWER REVETMENT BASKETS MAY REQUIRE GROUT OR GUNITE PROTECTION TO PREVENT ABRASION AND INCREASE GABION WIRE LONGEVITY.
4. STREAM BOTTOM MAY REQUIRE RIPRAP OR GABION MATTRESS FOR STABILITY.
5. WIRE BASKETS SHALL CONFORM WITH CT DOT SPECIFICATIONS SECTION 7.04 OR USDA SPECIFICATION 64.

Source: USDA-NRCS

Gabions (G)

Permanent Slope Drain (PSD)

Definition
A permanent open or enclosed structure or series of structures consisting of pipe(s), culvert(s) and/or manhole(s) used to convey water from a higher elevation to a lower elevation.

Purpose
- To convey water through excessive grade changes.
- To convey stormwater runoff down a slope without causing erosion problems within the slope.

Applicability
Within and upon cut and fill slopes where the soil and existing or planned vegetative cover will not handle concentrated runoff flows without erosion.

Planning Considerations
Consider potential problems caused by frost heaving and ice affecting the function of the permanent slope drain. Also consider existing downstream erosion and hydraulic conditions to ensure that problems are neither created nor made worse.

When coordinating with other construction activities remember the construction sequence for a permanent slope drain must begin from the outlet and proceed to the inlet, installing outlet protection first.

Design Criteria
Design the permanent slope drain according to generally accepted engineering standards (e.g. the SCS National Engineering Handbook – Part 650, DOT Drainage Manual).

Unstable conditions downstream shall not be created by the permanent slope drain. Outlet energy dissipation structures shall be provided to prevent downstream erosion (see **Outlet Protection** measure).

Assess downstream tailwater conditions to ensure adequate capacity at the outlet of the permanent slope drain.

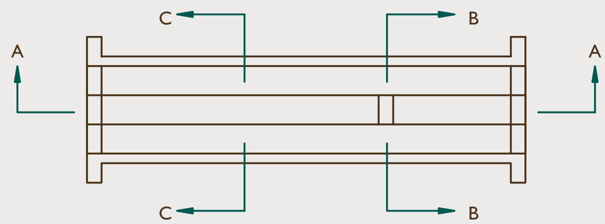
When designing a permanent slope drain to correct an existing slope failure, a water handling plan is necessary. It may include the installation of a temporary pipe slope drain (see **Temporary Pipe Slope Drain** measure) or temporary lined chute (see **Temporary Lined Chute** measure), dewatering measures and the installation of other temporary soil erosion and sediment controls.

Installation Requirements
1. Install and maintain temporary soil erosion and sediment controls. Implement a water handling plan as site conditions may dictate.
2. Begin construction at the outlet installing outlet protection and placing the structure on or within undisturbed soil or on well compacted fill, according to generally accepted engineering standards. Continue construction to the inlet.
3. Stabilize all disturbed areas upon completion of construction of the permanent slope drain.

Maintenance
During construction of the permanent slope drain inspect associated temporary erosion and sediment controls at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater for failure. Make repairs and adjustment to erosion controls as needed.

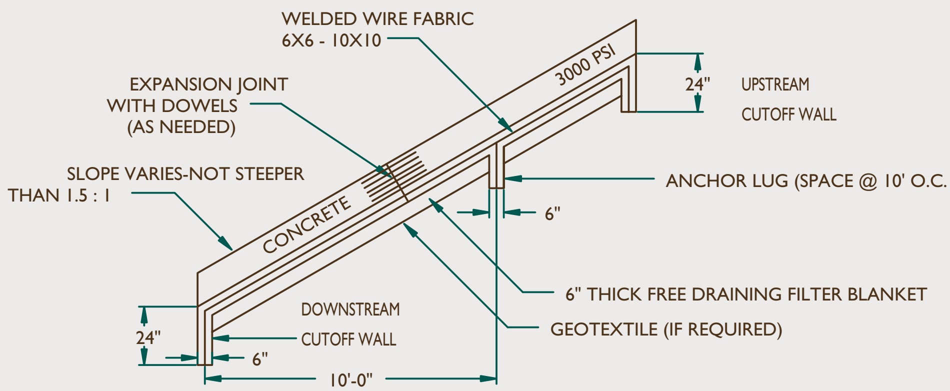
Inspect the completed permanent slope drain annually and after each major storm for damage and deterioration. Repair damages immediately. Ongoing maintenance should include removal of debris around the inlet and outlet to the structure, and periodic removal of road sands, sediment and debris.

Figure PSD-1 Example of Permanent Slope Drain



PLAN VIEW

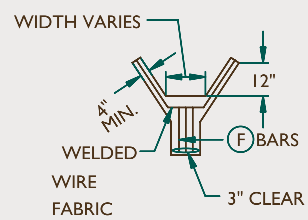
N.T.S.



SECTION A-A

N.T.S.

NOTE: ENERGY DISSIPATOR NEEDED AT OUTLET
(SEE OUTLET PROTECTION MEASURES)

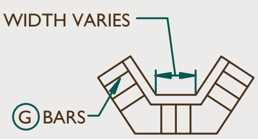


SECTION B-B

(THROUGH ANCHOR LUG)
N.T.S.

*10' - 0" C-C MAXIMUM TYPICAL SPACING BETWEEN ANCHOR LUGS. WHERE CUTOFF WALL IS NOT REQUIRED, ANCHOR LUG SHALL BE A MAXIMUM OF 2' FROM END OF CHANNEL.

MARK	SIZE	LENGTH	SHAPE	SPACING
(F)	#4	1'-8"	STRAIGHT	6"
(G)	#4	1'-8"	STRAIGHT	6"
Dowel	#4	1'-6"	STRAIGHT	6"



SECTION C-C

(THROUGH CUTOFF WALL)
N.T.S.

Source: USDA-NRCS

Channel Grade Stabilization Structure (CSS)

Definition
A permanent open structure used to control the grade and head cutting in natural or artificial channels.

Purpose
- To stabilize the grade and control erosion in natural or artificial channels.
- To prevent the formation or advance of gullies.

Applicability
- In areas where the concentration and flow velocity of water requires a structure or series of structures to stabilize the grade in channels or to control gully erosion.
- For channel side-inlet structures needed to lower the water from a higher elevation, a surface drain, or a waterway to a lower outlet channel.
- Does not apply to structures designed to control the rate of flow or to regulate the water level in channels.

Planning Considerations
The nature of existing and future fisheries resources should be considered and may dictate design criteria. For example, to provide fish passage, a series of smaller structures that do not prevent fish passage may be needed in place of one larger structure. Alternately, the design of the structure may include a fish ladder.

In urban and developing areas, safety concerns should be addressed. These may involve the installation of fencing, trash racks or other appropriate barriers to protect the public.

In highly visible public areas and those associated with recreation, careful consideration should be given to landscape resources. Land forms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Excavated material and cut slopes should be shaped to blend with the natural topography. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points. See **Figure CSS-1** for an example of a grade stabilization structure.

Design Criteria
Drop spillways shall be designed according to accepted engineering practice. Spillway stability shall consider bearing capacity and resistance to flotation, sliding and overturning.

The minimum design storm shall be a 10-year frequency storm of 24-hour duration. Local and state highway facilities may require a higher design storm. If pre-development flooding problems exist, or if the consequences of flooding are severe, or if drainage systems which convey larger storms converge with the channel drained by the drop spillway, consideration should be given to increasing the capacity beyond the 10-year frequency.

Structures shall not create unstable conditions upstream or downstream.

Toe wall drop structures can be used if the vertical drop is 4 feet or less, flows are intermittent, downstream grades are stable, and tail water depth at design flow is less than one-third the vertical drop.

The capacity of the structure in relation to existing road culverts falls within the jurisdiction of responsible road authority.

Installation Requirements
1. Prior to construction, develop a water handling plan and, as may be necessary, seek approval by the regulating agency.

2. Implement the water handling during construction.

3. Construct the structure in accordance with the approved design.

4. Stabilize all areas disturbed during construction as necessary to prevent erosion.

Maintenance
Inspect the structure daily during construction for adequacy of the water handling plan and erosion and sediment controls. Inspect the completed structure annually and after each major rainfall for damage and deterioration. Repair damage immediately. Ongoing maintenance should include removal of debris around the structure.

Figure CSS-1 Example of Grade Stabilization Structure

Channel Grade Stabilization Structure (CSS)

Temporary Lined Chute (TC)

Definition

A temporary channel constructed with a non-erosive material, such as concrete, bituminous concrete, riprap, sacked concrete, gabions, half round pipes, revetment erosion control mats with cement grout or similar materials used to carry concentrated runoff down a slope.

Purpose

To temporarily convey concentrated storm water runoff down a slope without causing erosion problems on or below the slope.

Applicability

- For drainage areas less than or equal to 36 acres.
- Where the intended use is less than one year.
- For protection of disturbed cut or fill slopes where planned vegetative cover is not established and/or permanent drainage controls have not been completed.
- On slopes no steeper than 1.5:1 and no flatter than 5:1. For slopes flatter than 5:1 use **Temporary Lined Channel**, **Vegetated Waterway** or **Permanent Lined Waterway** where appropriate.

Planning Considerations

Temporary lined chutes should be planned and installed along with, or as part of, other erosion control practices in an overall surface water control plan. If the chute is anticipated to be needed for more than 1 year use Permanent Lined Waterway measure, **Permanent Slope Drain** measure, or consider revising the sequence of construction to eliminate the need for a temporary lined chute. For drainage areas less than 5 acres the **Temporary Pipe Slope Drain** measure may be used as an alternative to a temporary lined chute. If the drainage area exceeds 36 acres then either split the drainage area or use alternate measures such as Permanent Lined Waterway measure.

Design Criteria

Slope Limitations

Temporary lined chutes shall be designed for placement on undisturbed or well compacted slopes that are not steeper than 1:1.5 and not less than 5:1.

Sizing Limitations

Design criteria are divided into two groups depending on the size of the drainage area. Group A is limited to a maximum area of 18 acres, and Group B may be used for drainage areas between 14 and 36 acres. Within each group the height of the lining at the entrance, depth of the chute down the slope, and length of the inlet and outlet sections are constant (See **Figure TC-1**). These are determined by the selection of a bottom width. The bottom width of the chute is dependent upon the size of the drainage area involved.

Use **Figure TC-1** to determine the sizing requirements for chute and associated group based on drainage area and proposed bottom width.

The selected size shall be identified in the E&S plan. For dimensions, grades, and construction details of concrete chutes see **Figure TC-2.**

Channel Linings

The lining shall consist of riprap, bituminous concrete or other comparable non-erodible material as described below. Design temporary chute linings with inlet and outlet protection to prevent erosion, to withstand the loading imposed by site conditions, and to meet durability requirements for the proposed maintenance program. Provide for adequate filter blankets, geotextile, or both, for these types of channel linings.

(a) **Riprap** shall be designed in accordance with the **Riprap** measure.

(b) **Bituminous concrete** linings shall be designed with a minimum thickness of 2 inches and in accordance with accepted engineering practices for structural adequacy.

(c) **Portland Cement Concrete** shall be 2500 PSI minimum with 2.5 inches minimum thickness.

(d) **Sacked concrete** shall be designed for both structural and hydraulic stability.

(e) **Gabions** shall be designed in accordance with the Gabions measure.

Figure TC-1 Chute Size Determination

Group A			Group B		
Size	Bottom Width b (ft)	Maximum Drainage Area[1] (acres)	Size	Bottom Width b (ft)	Maximum Drainage Area[1] (acres)
A-2	2	5	B-4	4	14
A-4	4	8	B-6	6	20
A-6	6	11	B-8	8	25
A-8	8	14	B-10	10	31
A-10	10	18	B-12	12	36
Height at entrance (H) = 1.5 feet Depth of Chute (d) = 8 inches Length of inlet & outlet section (L) = 6 feet			Height at entrance (h) = 2 feet Depth of Chute (d) = 10 inches Length of inlet & outlet section (L) = 10 feet		

[1] Criteria for extending the maximum allowable drainage area listed above:

If good mulch cover (equivalent to landscape mulch or temporary soil protection) is maintained over a minimum of 75% of the drainage area throughout the life of the structure, then the drainage areas listed above may be increased by 25%, providing the 36 acres drainage area limit is not exceeded.

If good grass cover (i.e. well established turf) or woodland cover is maintained over a minimum of 75% of the drainage area throughout the life of the structure, then the drainage areas listed above may be increased by 50%, providing the 26 acre drainage area limit is not exceeded.

Source: USDA-NRCS

(f) **Erosion control blankets and turf reinforcement mats**, when used, shall be designed in accordance with manufacture's recommendations.

Inlet Design

(a) The top of the earth lining at the entrance to the chute shall not be lower at any point than the top of the lining at the entrance of the chute ("H" as shown in **Figure TC-2**).

(b) The lining of the side slopes at the chute entrance shall extend the distance H above the lining invert as shown in **Figure TC-2.**

(c) The entrance floor at the upper end of the chute shall have a minimum slope toward the outlet of 0.25 inch per foot.

(d) Design the cutoff wall at the entrance so that it is continuous with the lining.

Outlet Design

The minimum requirements for outlet protection are shown in **Figure TC-2**. Verify adequacy of outlet stabilization using **Outlet Protection** measure. Design the cutoff wall at end of the discharge aprons so that it is continuous with the lining.

Installation Requirements

1. Install the chute on undisturbed soil, if possible, or if not possible, on well compacted fill.

2. Begin construction of the chute at its lower end. Compact or place the lining so that it is free of voids and reasonably smooth.

3. Construct the cutoff walls at the entrance and at the end of the discharge aprons so that they are continuous with the lining.

4. Stabilize all areas disturbed by construction immediately after work is completed.

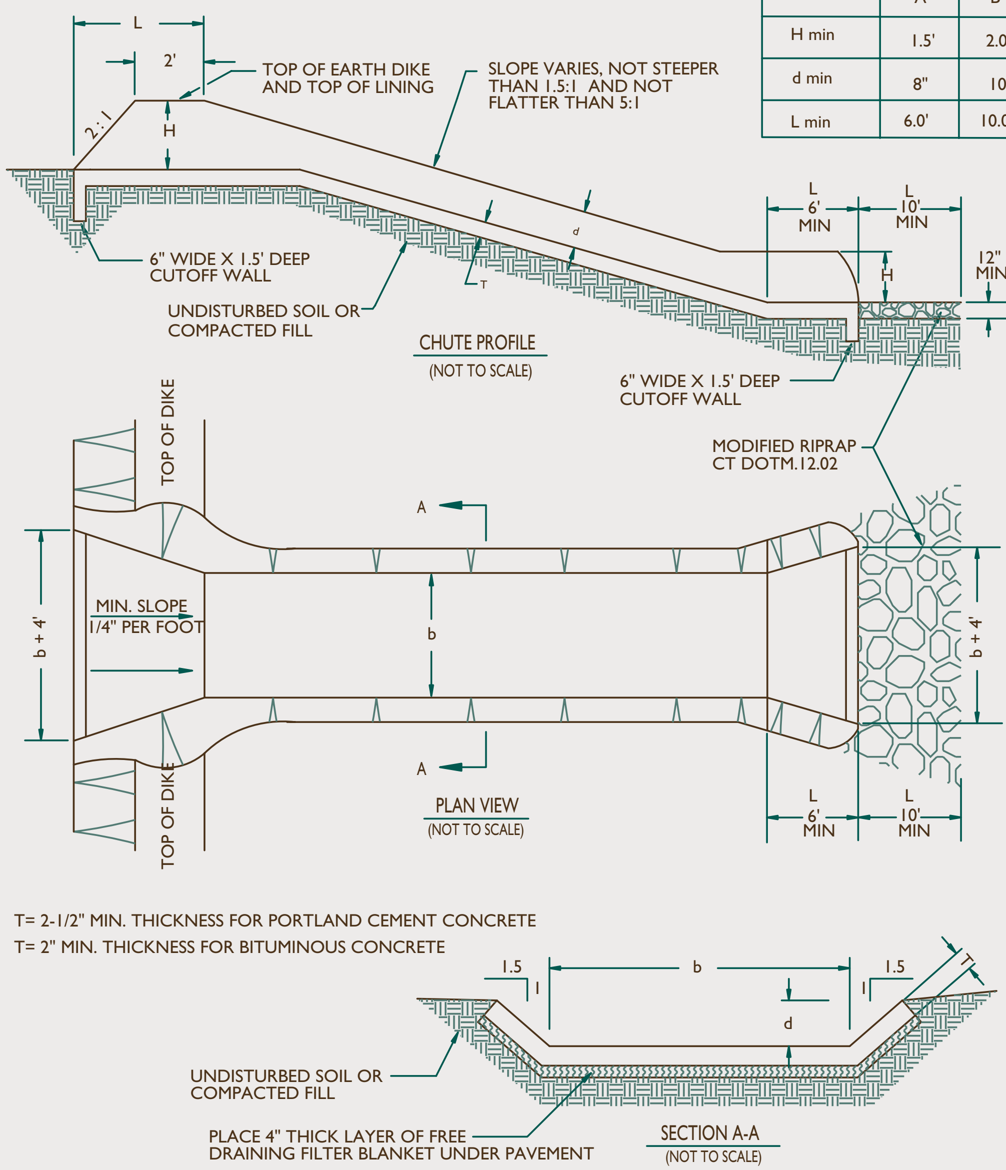
Maintenance

Inspect the temporary lined chute at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater for erosion damage. Repair as needed. If repeated failure occurs, check design limitations and installation requirements. Correct deficiencies as needed.

Prevent construction traffic across the chute and avoid the placement of any material on the chute.

Figure TC-2 Temporary Paved Chute Plan and Profile

DIMENSION	SIZE GROUP	
	A	B
H min	1.5'	2.0'
d min	8"	10"
L min	6.0'	10.0'



CHUTE SIZE IS DESIGNATED WITH A LETTER AND A NUMBER, SUCH AS A-6, WHICH MEANS SIZE GROUP A WITH A 6 FT. BOTTOM WIDTH (b). FOR STRUCTURE DIMENSIONS, SEE TABLE.

Source: USDA-NRCS

Temporary Pipe Slope Drain (TSD)

Definition
A flexible or rigid pipe used to conduct water from the top of a slope to the toe of the slope.

Purpose
- To convey water over excessive grade changes.
- To convey concentrated stormwater runoff flows down the face of a slope without causing erosion problems either on or at the toe of the slope.

Applicability
- On cut or fill slopes where the soil or existing vegetative cover will not withstand concentrated runoff flows.
- For use less than 6 months.
- Where the contributing drainage area is 5 acres or less.

Planning Considerations
Temporary pipe slope drains should be planned and installed along with, or as part of, other conservation practices in an overall surface water disposal system. This measure should be used only for the temporary conveyance of water and consideration should be given to the final stabilization of the area during the initial planning stages. Temporary pipe slope drains are commonly used in conjunction with temporary diversions (see Diversion Functional Group) which direct water to the drain.

Design Criteria
The maximum allowable drainage area per drain is 5 acres.

Material used in the temporary pipe slope drain shall be heavy duty flexible (see **Figure TSD-2**) or rigid conduit (see **Figure TSD-3**) designed for the purpose with hold down grommets or rigid pipe supplied with anchors. Additionally, use only one size pipe for any single installation.

The bottom of the pipe slope drain shall be flush with the toe of the diversion berm (see **Figure TSD-3**).

The pipe slope drains shall be sized according to **Figure TSD-1** and shall be provided with watertight fittings.

Water directed into the temporary slope drain shall be in accordance with temporary diversion measures found in the Diversion Functional Group, where applicable. However, at a minimum, the height of the berm at the centerline of the inlet shall be equal to the diameter of the pipe (D) plus 12 inches. Where the berm height is greater than 18 inches at the inlet, it shall be sloped 3:1 or flatter.

The area immediately below the outlet of the pipe slope drain shall be protected from erosive discharges with appropriate energy dissipators. For drainage areas greater than 1 acre, hay bale check dams and geotextile silt fences are not appropriate.

Figure TSD-1 Size of Slope Drain

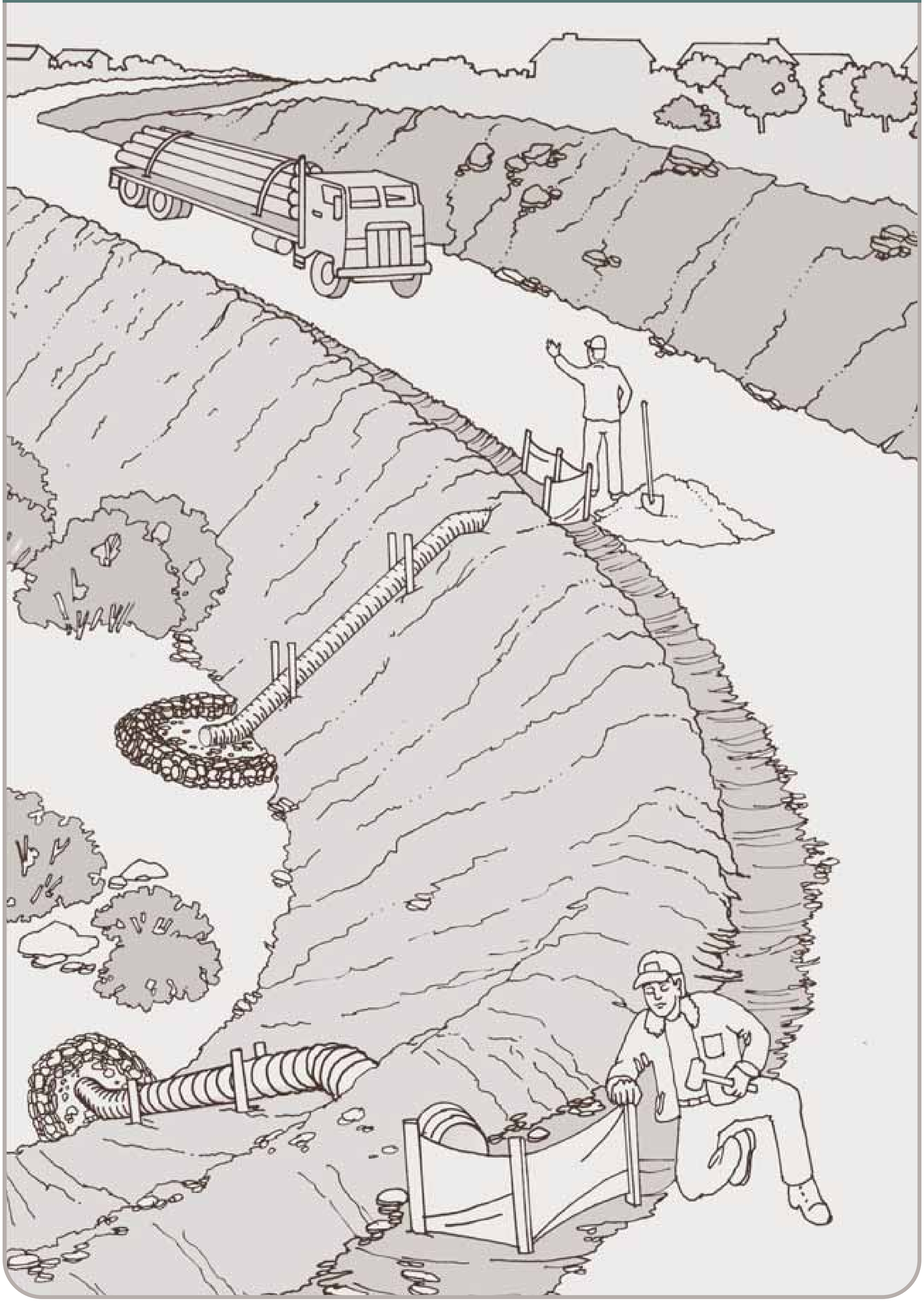
Maximum Drainage Area (Acres)	Pipe Diameter, D (in.)
0.5	12
2.5	18
5.0	24

Source: USDA-NRCS

Installation Requirements
1. Install a temporary pipe slope drain on a cut or a stable fill slope during or immediately after construction of diversion berms.
2. Stabilize the area from the top of the berm, around and under the entrance section of the drain to prevent erosion and piping failure at the inlet.
3. Anchor the pipe slope drain securely. Space anchors a maximum of 10 feet on center.
4. Securely fasten the sections of pipe together with watertight fittings.

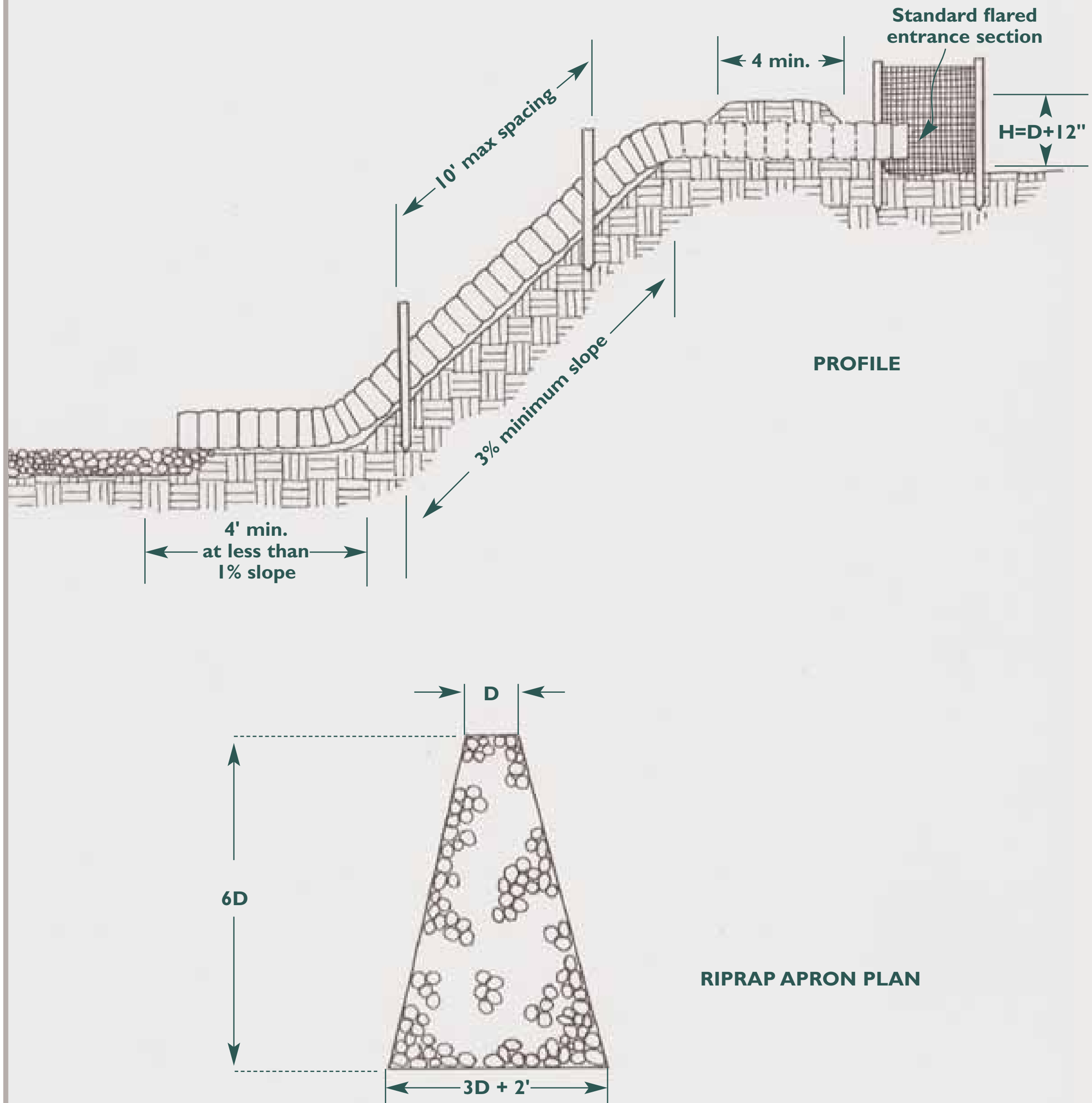
Maintenance
Inspect the temporary pipe slope drain at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater to determine maintenance needs. Repair damage as necessary. Avoid the placement of any material on top of the pipe and prevent vehicular traffic from crossing the slope drain.

Figure TSD-2 Example of Temporary Pipe Slope Drain



Temporary Pipe Slope Drain (TSD)

Figure TSD-3 Example of Temporary Pipe Slope Drain



CONSTRUCTION SPECIFICATIONS

1. The pipe slope drain shall have a slope of 3% or steeper.
2. Top of the earth dike over the inlet pipe and all dikes carrying water to the pipe shall be at least 1 foot higher than the top of the pipe.
3. Add 0.3 foot to dike height for settlement.
4. Soil around and under the slope pipe shall be hand tempered in 4–inch lifts.
5. The pipe shall be plastic or corrugated metal pipe with watertight 12–inch wide connecting bands or flange connections.
6. Pipe anchors to be placed at 10–foot maximum spacing.
7. Riprap to be 6 inches in a layer at least 12 inches thickness and pressed into the soil.
8. Periodic inspection and required maintenance must be provided after each rain event.

TO MAIN TOC

Planning Considerations

The measures included in this group are **Vegetated Waterway, Temporary Lined Channel, Permanent Lined Waterway and Temporary Stream Crossing**.

Vegetated Waterways are limited to drainage areas of 50 acres or less and are used where they can carry the peak flow from a 10-yr frequency, 24-hr duration storm without erosion. They not intended for Waterways with perennial flow. They may be used with **Permanent Turf Reinforcement Matting** for added protection.

Temporary Lined Channels are limited to drainage areas no greater than 100 acres when the flow line of the channel is 2% or greater. If the flow line is less than 2%, then the contributing area can be increased to 1 square mile. The measure requires performing a risk assessment that is based upon one developed by the Connecticut Department of Transportation in its Drainage Manual to determine the design standards for the channel. It requires a minimum design standard of a 2-year frequency, 24-hour duration storm. It is limited to a maximum of 2 years intended use.

The Permanent Lined Waterway is used when the limitations of the **Vegetated Waterway** and **Temporary Lined Channel** are exceeded. However, its application is also limited to a maximum design discharge of 200 cfs. It requires a minimum design standard of a 10-year frequency, 24-hour duration storm, although higher design standards may be required by regulating agencies.

The **Temporary Stream Crossing** is similar to the temporary lined channel in that it also requires performing a risk assessment to establish the design standard and has a drainage limitation of 1 square mile. It also requires a minimum design standard of a 2-year frequency, 24-hour duration storm. However, its intended use is up to 3 years rather than 2 years.

Plan to avoid the construction of any measure within this group when the local weather forecast predicts rainfall to occur during the time of construction. Local forecasts may be obtained by listening of local radio and television stations, the National Weather Service broadcasts (162.400 MHz for CT generally, 162.475 MHz for northeastern CT., 162.550 MHz for southeastern and southwestern CT and 162.500 MHz for northwestern CT) or from the Internet at http://www.nws.noaa.gov.

Definition

A natural or constructed channel or swale shaped or graded in earth materials and stabilized with non-woody vegetation for the non-erosive conveyance of water.

Purpose

To provide for the conveyance of water while preventing damage by erosion or flooding.

Applicability

- Where the contributing drainage area does not exceed 50 acres.
- Where the design discharge does not exceed 100 cfs.
- For man-made channels such as roadside ditches and drainageways.
- Not for use in perennial streams.

Planning Considerations

Sequence and schedule construction to ensure the vegetation within the waterway is established before it is used to convey flow. Also, the drainage area contributing to the waterway must be stabilized with proper erosion and sediment controls installed to prevent sedimentation of the waterway. Repeated erosional failures of the waterway can be expected if these two conditions are not addressed. Consider using other measures such as **Sodding**, **Temporary Diversion**, **Permanent Turf Reinforcement Mat** (including a three dimensional geosynthetic turf reinforcement), **Subsurface Drain** (to permit the growth of suitable vegetation and to eliminate wet spots), grade stabilization structures and other management practices (e.g. irrigation) to hasten the establishment of the grass cover.

Give consideration to channel width, side slopes, and depth as they affect the use of maintenance equipment. For areas to be mowed, the steepest recommended slope is 3:1.

Design Criteria

Peak Runoff

Design the vegetated waterway according to generally accepted engineering standards (e.g. the NRCS National Engineering Handbook - Part 650, DOT Drainage Manual).

Design the minimum runoff to safely carry the peak flow expected from a 10-year frequency, 24-hour duration storm or lesser duration storm where the storm duration exceeds the time of concentration. If a contributing drainage system is designed to a design standard greater than the 10-year frequency storm, then design the vegetated waterway to that higher standard. If pre-development flooding problems exist or if the consequences of flooding are severe, then consider increasing the capacity beyond the 10-year frequency storm. If drainage systems which convey larger frequency storms converge with the waterway, design the waterway to the same design frequency as the contributing drainage system.

Compute the velocity and capacity using Manning's formula and the Continuity Equation.

Velocity

Design the waterway so that the peak velocity from the design frequency storm shall not exceed the maximum permissible velocity for a vegetative lining given in **Figure VW-1**. Determine the maximum permissible velocity for design flow by the most erodible soil texture exposed and the type of vegetation expected and maintained in the channel.

Determine the minimum capacity and maximum velocity by using the appropriate vegetative retardant factors listed in **Figure VW-2.**

Dimensions

To select channel dimensions use **Figure VW-5** through **Figure VW-18**.

Base the dimensions of the waterway on: the minimum capacity, the channel slope, the maximum permissible velocity, the vegetation, the soil; ease of crossing and maintenance; and site conditions such as water table, depth to rock or possible sinkholes.

Figure VW-1 Maximum Permissible Velocity (ft./sec.)				
Soil Texture	Channel Vegetation Condition[1]			
	Poor	Fair	Good	Stone Center
Sand, silt loam, sandy loam, loamy sand, loam and muck	2.0	2.5	3.5	8.0
Silty clay loam, sandy clay loam, clay, clay loam, sandy clay, silty clay	3.0	4.0	5.0	8.0

[1]For channels with geosynthetic turf reinforcement, permissible velocities shall be designed on a product-specific basis and for long duration flows (>24 hours).

Source: USDA-NRCS

The minimum top width shall be 5 feet. The maximum bottom width of a vegetated waterway is 15 feet unless multiple or divided waterways, stone center, or other means are provided to control the meandering of low flows.

Cross Section Design

Trapezoidal and "v-shaped" waterways are often used where space is limited.

Parabolic waterways are often used where space is available for a wide, shallow channel with low velocity flow. Stone center waterways should be used where higher velocities or persistent flows are expected.

Vegetated waterways with stone centers (see **Figure VW-3**) are useful where there is a persistent but not permanent low flow in the channel. For a channel designed to a 10-year frequency storm, the stone center shall be wide enough to safely pass a 2-year frequency storm. For a channel designed to a 25-year frequency storm, the stone center shall be wide enough to safely pass a 10-year frequency storm. The stone center shall have 6 inches of gravel bedding or a properly designed geotextile under the stone. If the d_{75} of the stone is 8 inches or greater then a bedding over the geotextile shall be considered in the design to protect the geotextile from puncture during stone placement. The d_{75} of the stone shall be determined from HEC-15. The minimum d_{75} size shall be 3 inches. The d_{100} size shall be 1.5 times the d_{75} size. The d_{15} size shall be 3 inches or one third the d_{75} size, whichever is larger. The stone center shall have a minimum thickness of 12 inches or the d_{100} size, whichever is larger. The stone shall be hard and durable.

Grading

Require the grading of all areas adjacent to the waterways to drain toward the waterway.

Outlet

The outlet shall be stable for the design storm discharge without erosion or flood damage.

Permanent Cover

Establish a permanent vegetative cover on all vegetated waterways in accordance with the measure for

Figure VW-2 Vegetative Retardant Factors and Manning's "n" Value

Range of Vegetation Height During Different Periods of the Year	Vegetative Retardant Factors For Determining Minimum Capacity	Vegetative Retardant Factors For Determining Maximum Allowable Velocity
Good Stand		
between 6" and 1"	D	E
between 10" and 2"	C	D
between 24" and 2"	B	D
Fair or Poor Stand		
between 10" and 1"	D	E
between 24" and 2"	C	D
between 30" and 2"	B	D

Source: USDA-NRCS

Permanent Seeding or **Sodding**. Where the permanent vegetative cover is established by seeding, extend the seeding to at least the design top width and include any other areas disturbed by construction activities. For seeded channels with no stone centers use Temporary Erosion Control Blanket measure to hold seed in place and protect root bases from scour during the establishment period.

Installation Requirements

Check weather forecasts to ensure a storm is not predicted during the time of construction. Delay construction until after the threat of rainfall has passed.

Site Preparation

Remove all trees, brush, stumps and other unsuitable materials and dispose of properly so as not to interfere with construction or proper functioning of the waterway.

Begin construction at the outlet installing outlet protection and continue construction to the inlet.

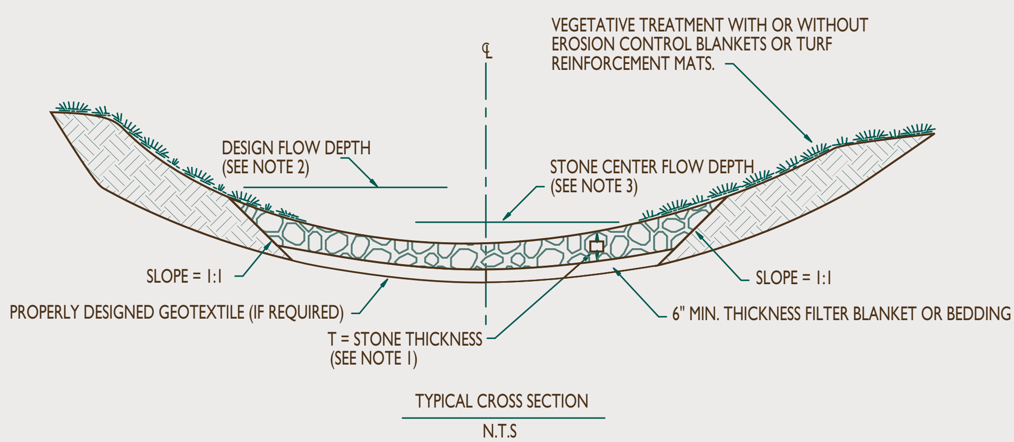
Excavate or shape the channel to the design grade and cross-section.

Compact any fills and rills to prevent unequal settlement.

Remove any excess soil.

For a waterway stabilized with permanent seedings, prepare the seedbed in accordance with the requirement of the **Permanent Seeding** measure. For a channel sta-

Figure VW-3 Diagram of Vegetated Waterway with Stone Center

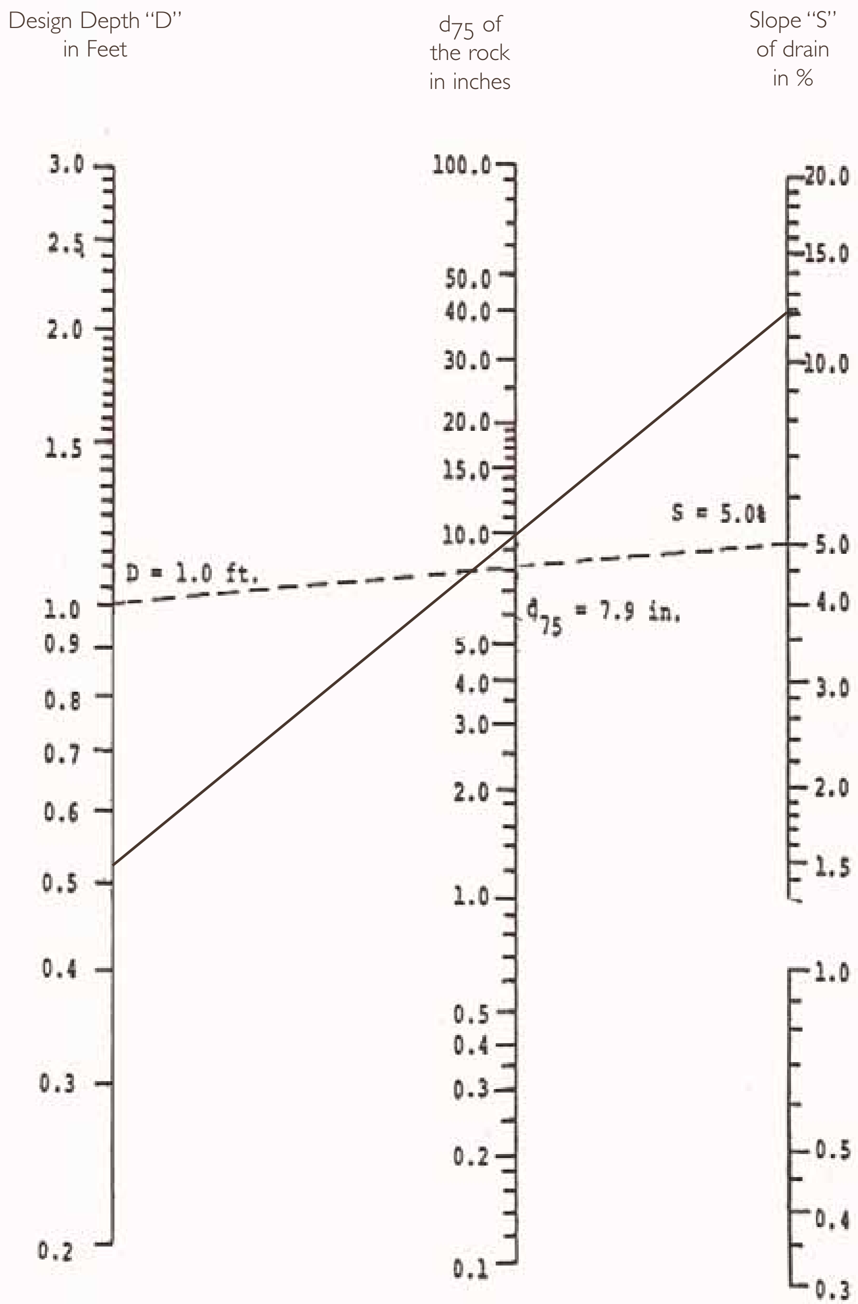


NOTES:

1. MINIMUM STONE LAYER THICKNESS = 1.5 TIMES D_{75} (FROM FIGURE VW-4) BUT NOT LESS THAN 12".
2. THE TOTAL WATERWAY DEPTH IS DEPENDENT UPON THE DESIGN DEPTH OF FLOW PLUS RUNUP DUE TO CHANNEL CURVATURE PLUS FREEBOARD.
3. FOR A 10 YR. CAPACITY WATERWAY, THE STONE CENTER SHALL CONTAIN A 2 YR. RUNOFF EVENT; FOR A 25 YR. CAPACITY WATERWAY, THE STONE CENTER SHALL CONTAIN A 10 YR. RUNOFF EVENT.

Source: USDA-NRCS

Figure VW-4 Determination of Rock Size for Stone Center Waterway



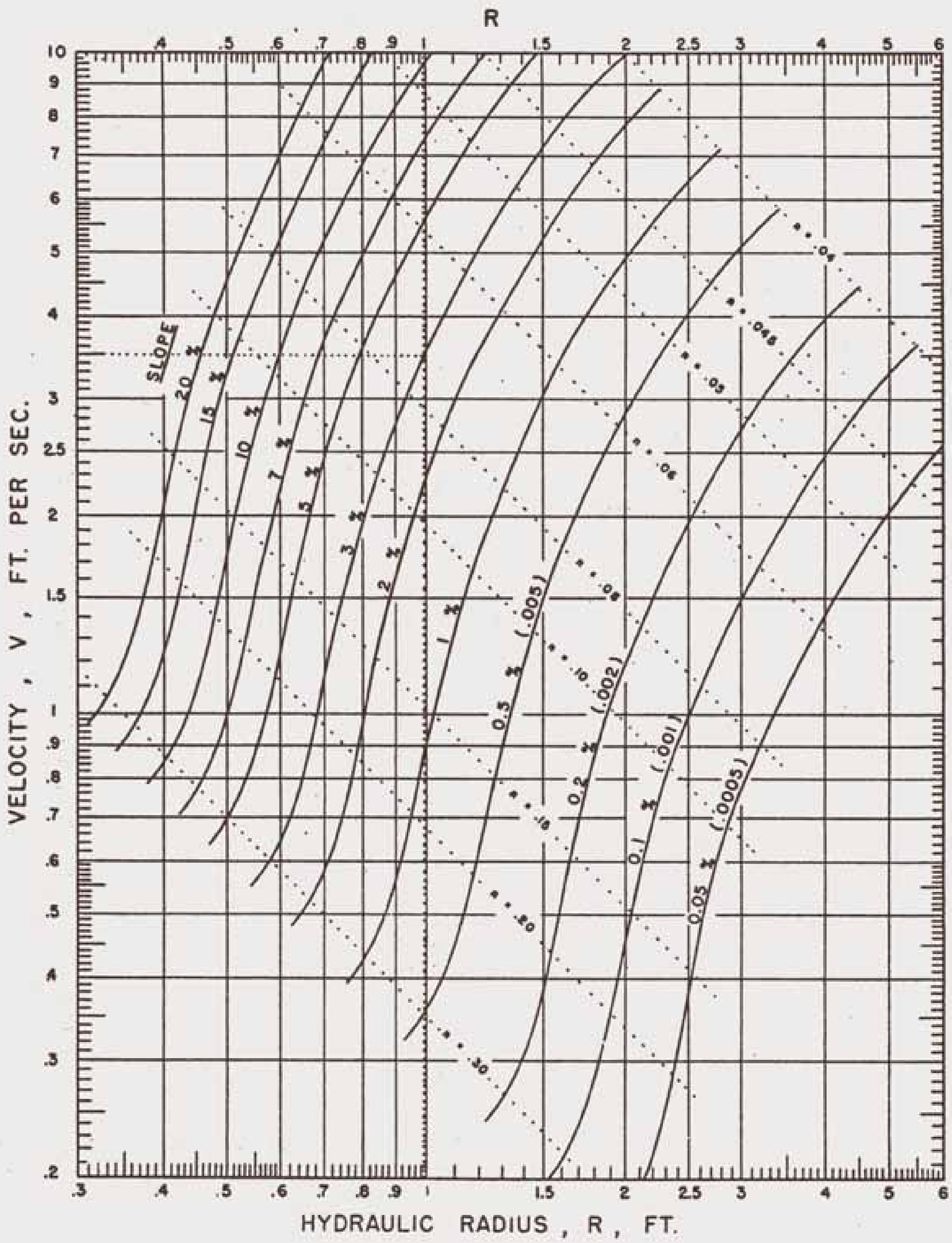
EXAMPLE - "D" = 1.0 Feet "S" = 5%

Place straight edge at "D" value in Design Depth Column and at "S" value in Slope Column. Read d_{75} Rock Size in middle column as 7.9 inches; say 8 inches.

Source: USDA-NRCS

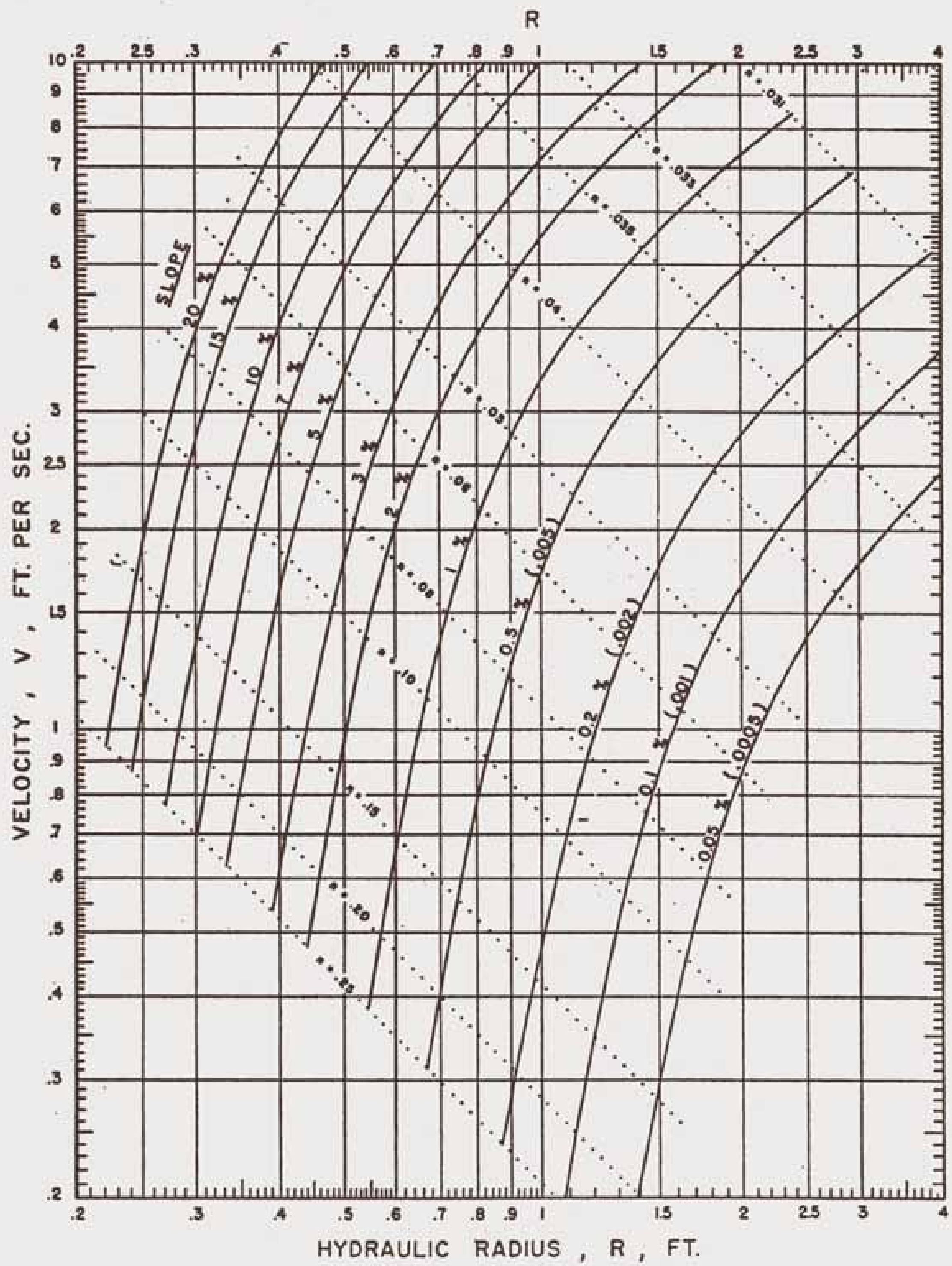
Vegetated Waterway (VW)

Figure VW-5 Solution of the Manning Formula for Retardant B (High Vegetative Retardant)



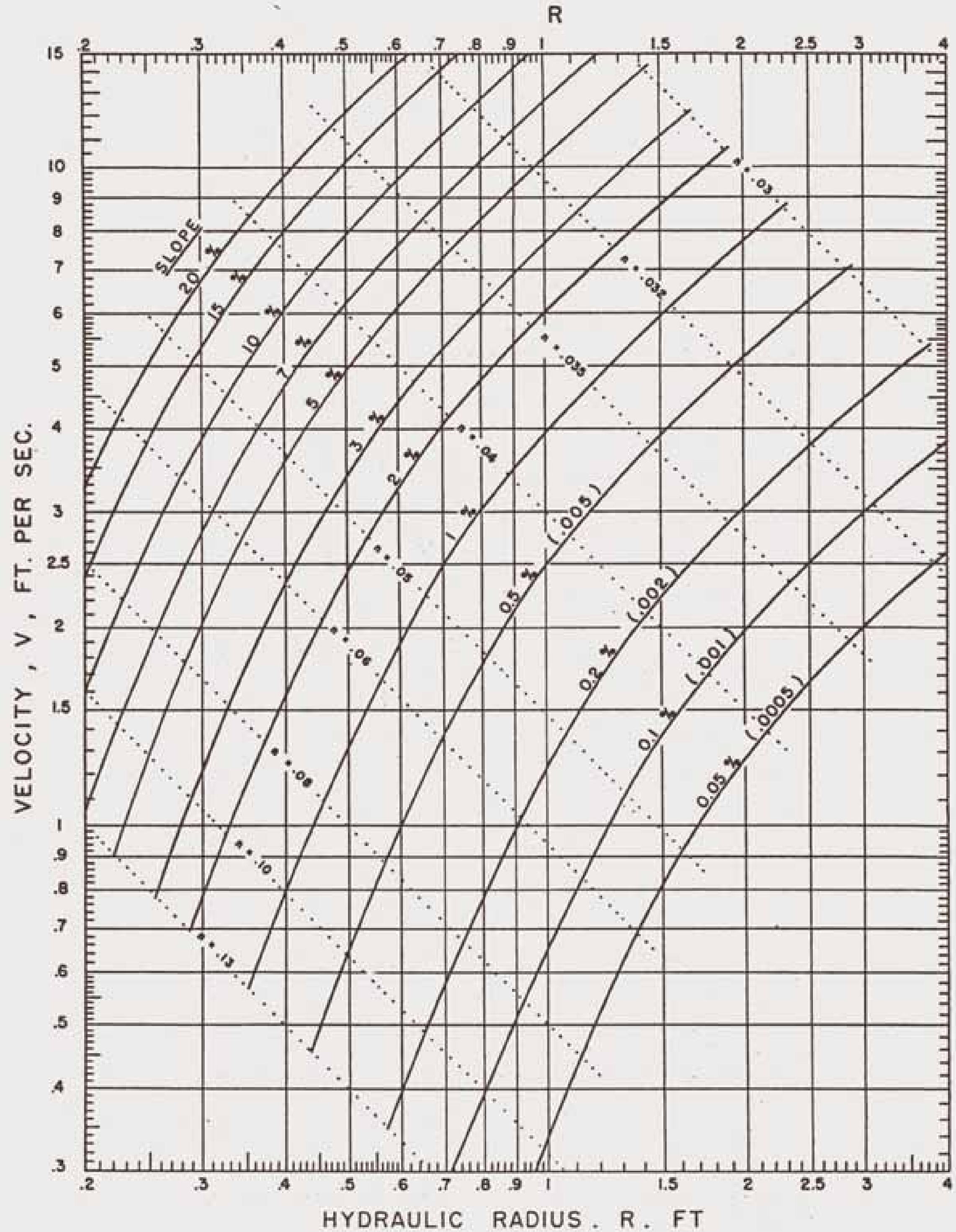
Source: USDA-NRCS

Figure VW-6 Solution of the Manning Formula for Retardant C (Moderate Vegetative Retardant)



Source: USDA-NRCS

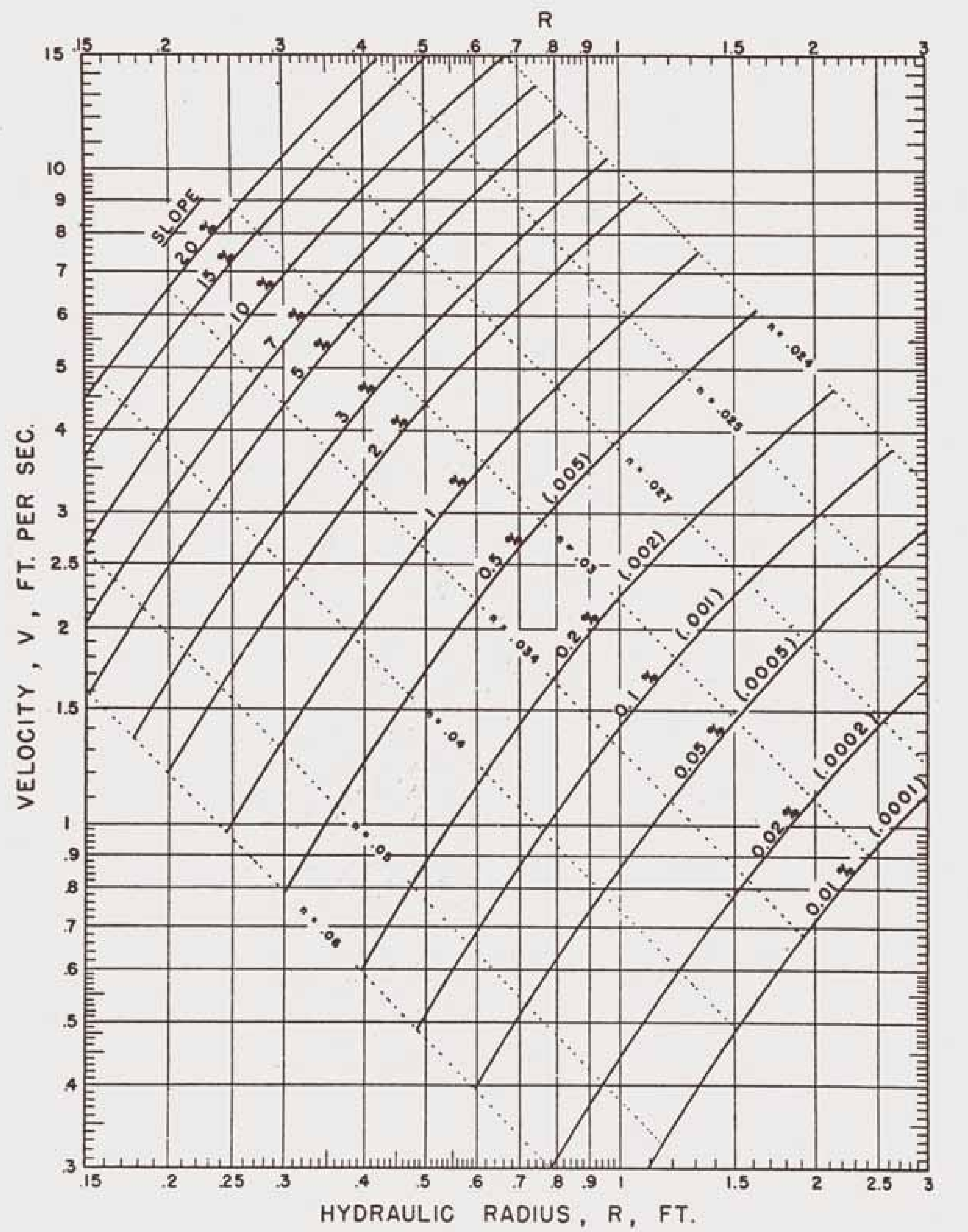
Figure VW-7 Solution of the Manning Formula for Retardant D (Low Vegetative Retardant)



Source: USDA-NRCS

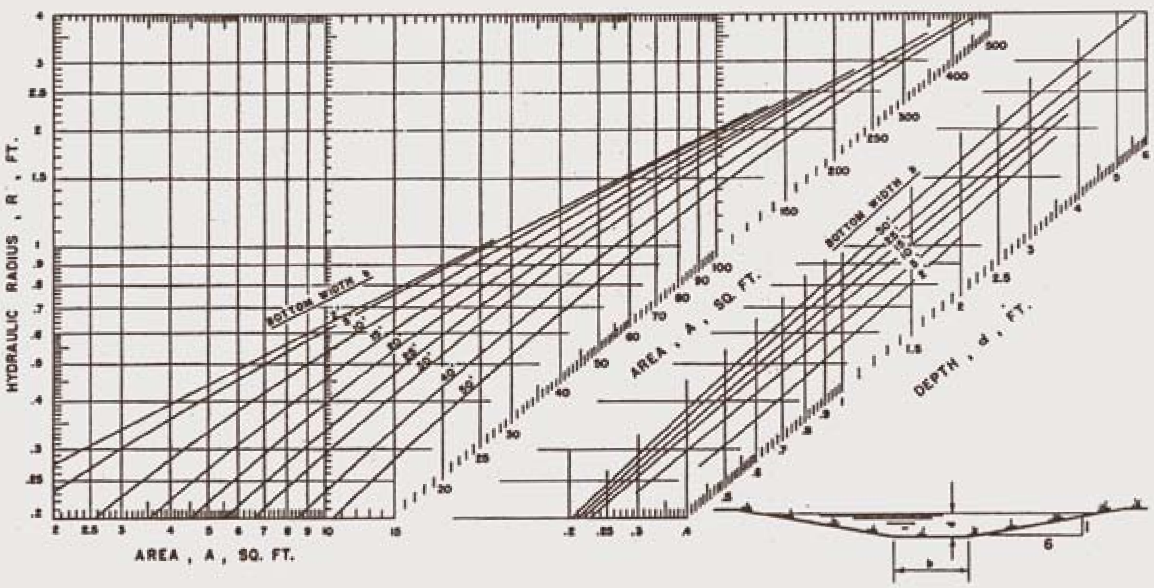
Vegetated Waterway (VW)

Figure VW-8 Solution of the Manning Formula for Retardant E (Very Low Vegetative Retardant)



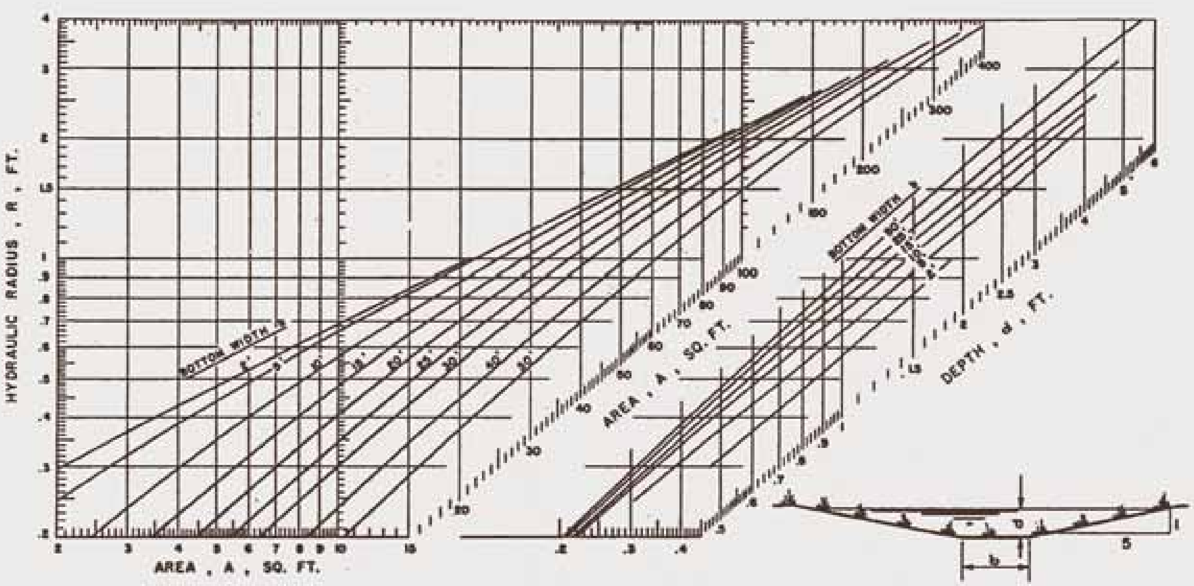
Source: USDA-NRCS

Figure VW-9 Dimensions of Trapezoidal Channels with 6 to 1 Side Slopes



Source: USDA-NRCS

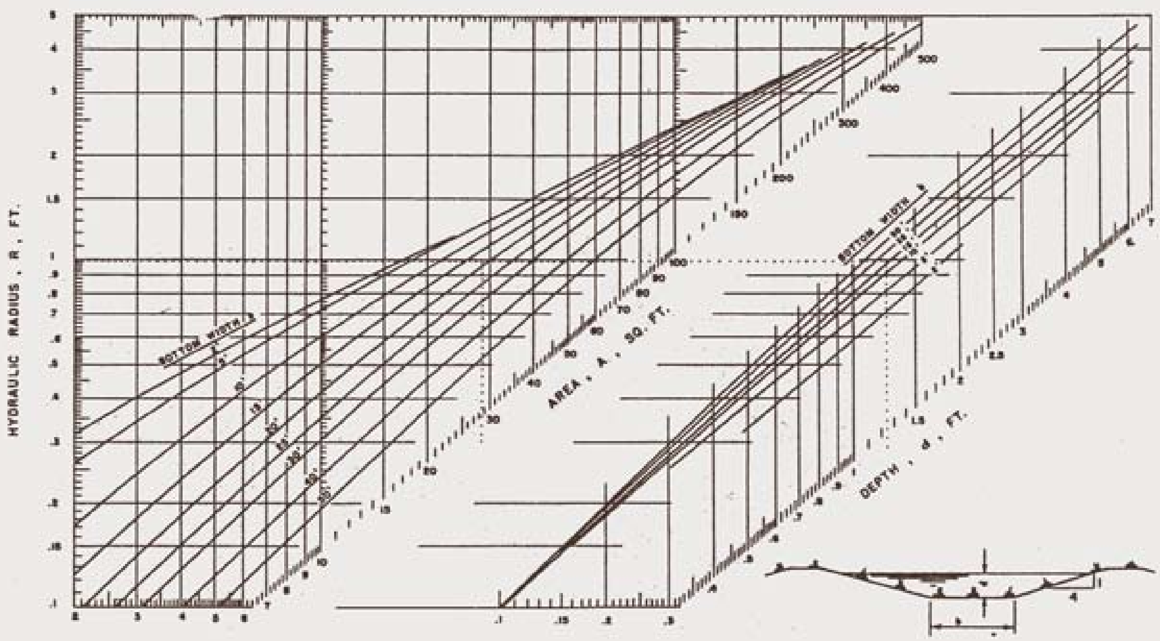
Figure VW-10 Dimensions of Trapezoidal Channels with 5 to 1 Side Slopes



Source: USDA-NRCS

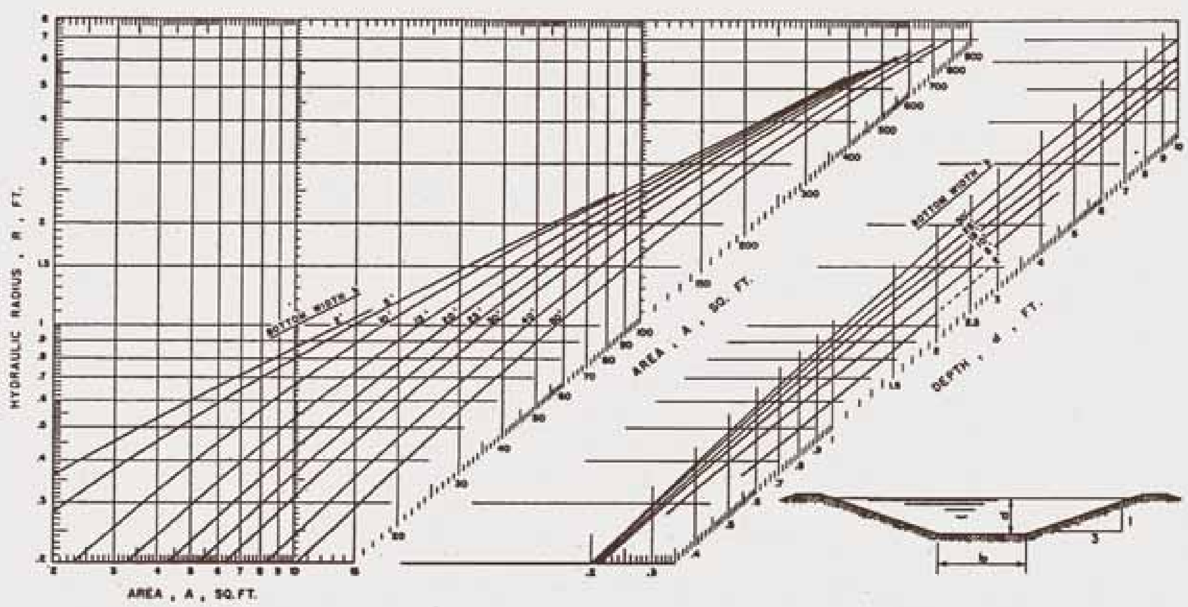
Vegetated Waterway (VW)

Figure VW-11 Dimensions of Trapezoidal Channels with 5 to 1 Side Slopes



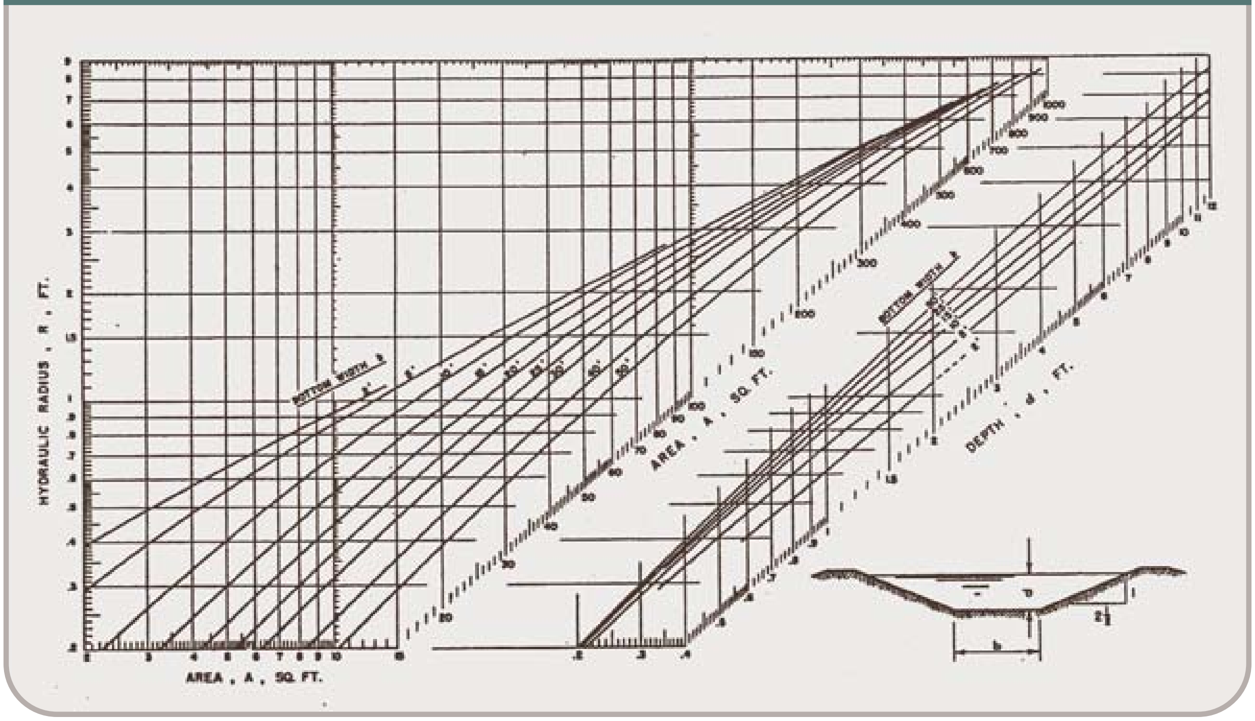
Source: USDA-NRCS

Figure VW-12 Dimensions of Trapezoidal Channels with 3 to 1 Side Slopes



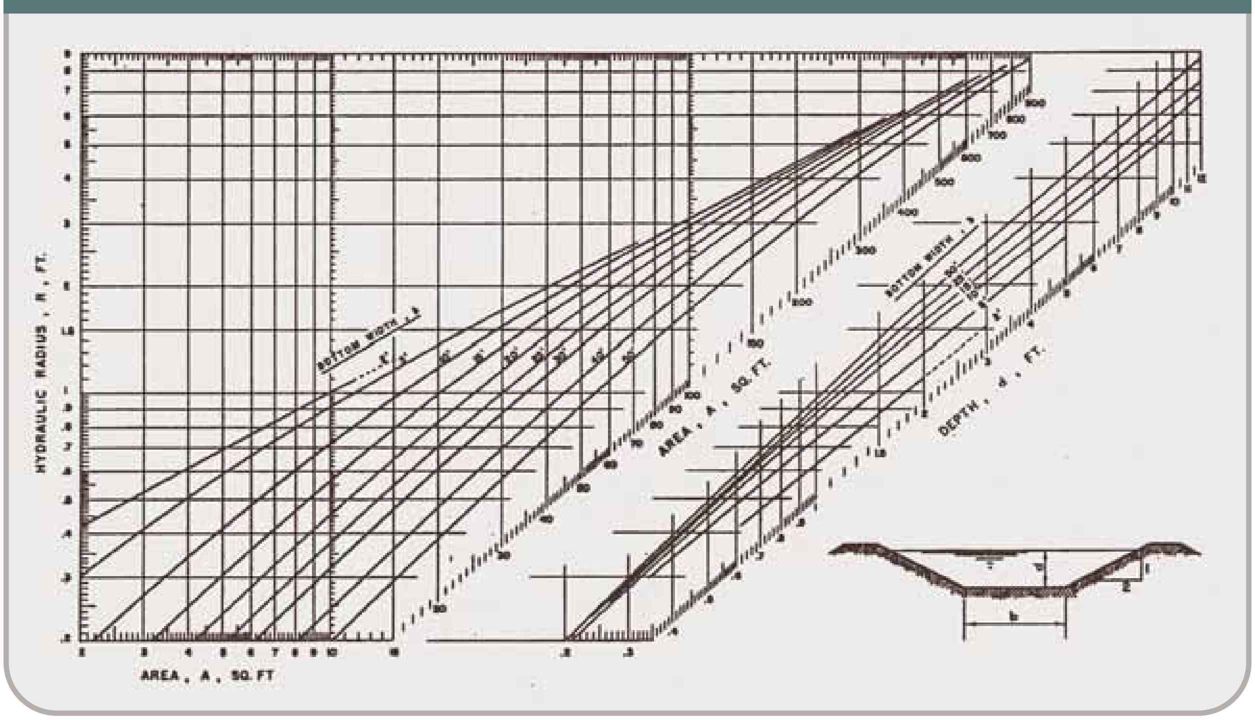
Source: USDA-NRCS

Figure VW-13 Dimensions of Trapezoidal Channels with 2-1/2 to 1 Side Slopes



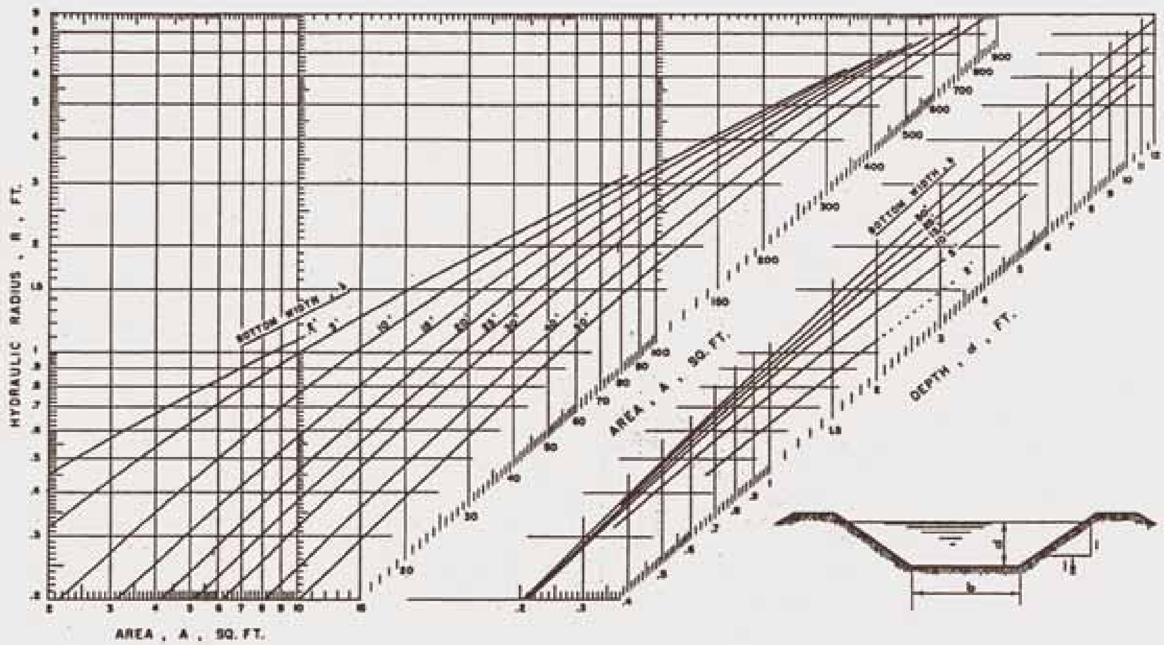
Source: USDA-NRCS

Figure VW-14 Dimensions of Trapezoidal Channels with 2 to 1 Side Slopes



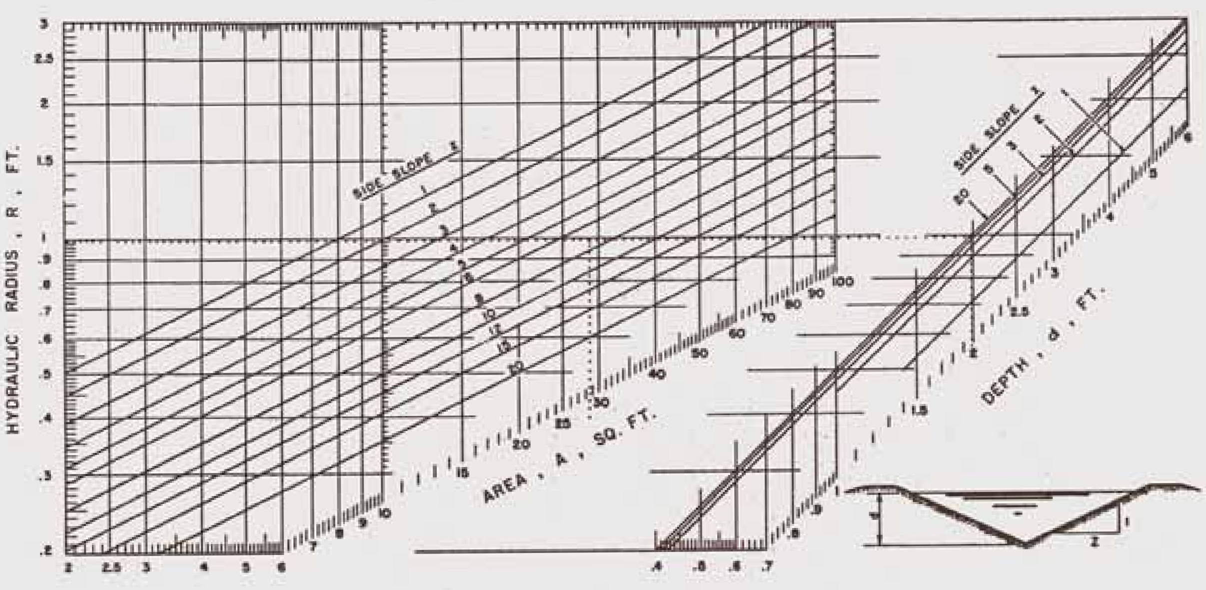
Source: USDA-NRCS

Figure VW-15 Dimensions of Trapezoidal Channels with 1-1/2 to 1 Side Slopes



Source: USDA-NRCS

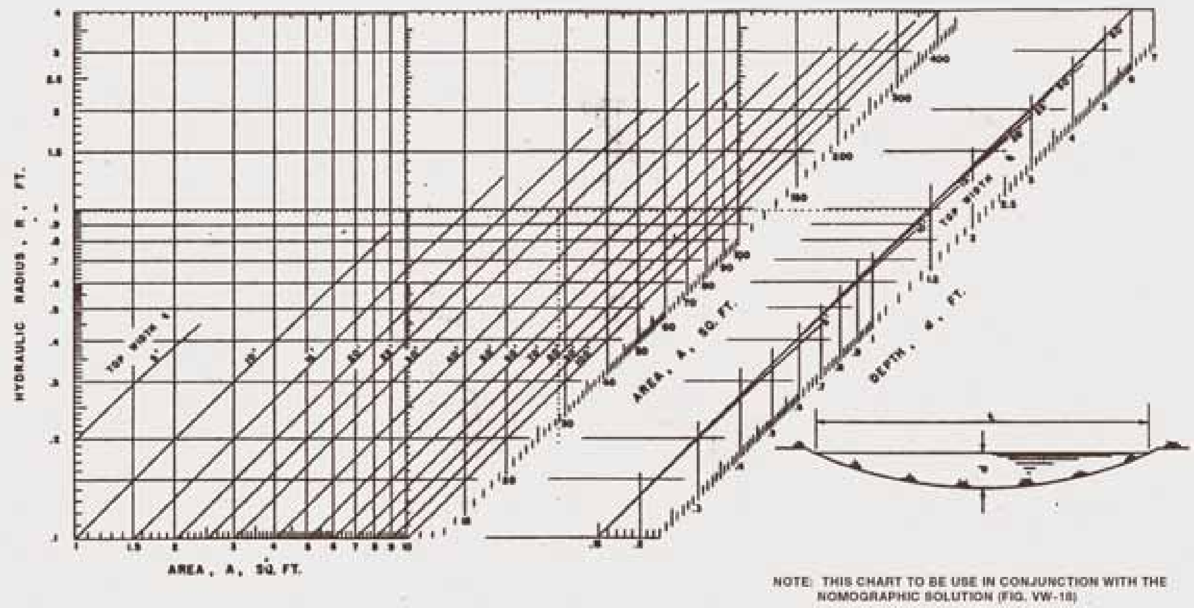
Figure VW-16 Dimensions of Triangular Channels



Source: USDA-NRCS

Vegetated Waterway (VW)

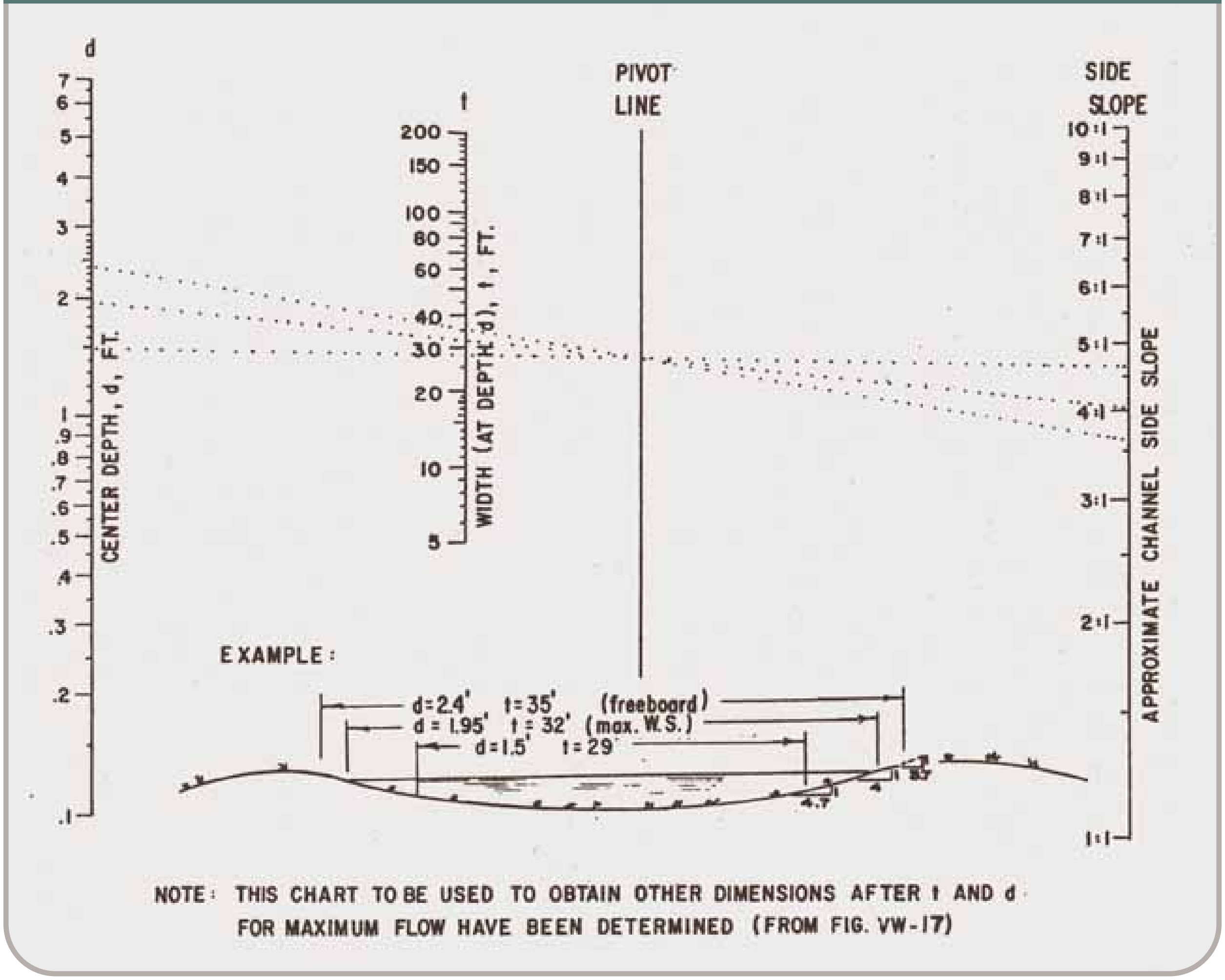
Figure VW-17 Dimensions of Parabolic Channels



Source: USDA-NRCS

Vegetated Waterway (VW)

Figure VW-18 Solution for Dimensions of Parabolic Channels



Source: USDA-NRCS

Vegetated Waterway (VW)

Temporary Lined Channel (TLC)

Definition
A channel designed to convey flows on a short term basis and lined with a flexible impermeable geomembrane or other erosion resistant covering.

Purpose
To provide temporary conveyance of water through a stable channel either until a stable permanent channel is established or until site construction that required the temporary relocation has been completed.

Applicability
- For drainage areas less than 100 acres where the gradient of the flow line of the channel is greater than 2%.
- For drainage areas less than 1 square mile where the gradient of the flow line of the channel is less than 2%.
- Where the temporary relocation of a drainage way is needed to complete other construction work or to allow for the establishment of vegetation in a permanent channel.
- Use limited to 60 days when lined with flexible impermeable geomembrane.
- Use limited to 2 years when lined with a permanent channel lining as referenced in **Permanent Lined Waterway** measure.

Planning Considerations
Temporary lined channels differ from temporary diversions in that temporary diversions are intended only to convey stormwater collected from areas no greater than 5 acres and temporary lined channels are intended to convey watercourses from substantially larger areas. Like temporary diversions they assist in isolating off-site flows from construction activities.

Choosing a flexible impermeable geomembrane, such as a plastic sheeting, over other linings is generally dependent upon watershed size, length of use and flow characteristics. When geomembrane applicability limitations are exceeded, use permanent channel linings. While the same channel linings used in the **Permanent Lined Waterway** measure may be used in this measure, these linings are sufficiently expensive to consider alternate construction methodologies or construction sequences that avoid the need for a temporary lined channel.

No matter the channel lining used, a risk assessment is required to determine proper channel size. The risk assessment used in the Design Criteria provides for a smaller sized channel over that normally required because the time of exposure is limited when using a temporary lined channel. If the time of use for this measure is at all questionable, opt for a more conservative approach. The best approach is to plan construction schedules and sequences so that the need for temporary lined channels is as short as possible to reduce the exposure to storms that exceed the design storm provided by the risk assessment. In any event, if the intended use exceeds 2 years, the channel is no longer considered temporary, and a permanent measure must be utilized.

Design Criteria

Determining the Design Storm Using a Risk Assessment
The design storm is determined by using the procedures outlined in Appendix J, "Risk Assessment Adapted from CT DOT Drainage Manual." Using the form "Design Frequency Risk Analysis" assign a value of 1 to each of the factors in the Impact Rating Table except "Property Damage". Property damage is assessed by predicting the areas that can be damaged should the channel capacity be exceeded or the channel lining fail. This includes an evaluation of potential flood damage upstream or adjacent to the channel and damage downstream to properties and water resources that might receive sediment should the channel fail. The property damage value shall be chosen as follows:

5 points cropland, parking lots, recreational areas, undeveloped land, forest land

10 points private or public structures, appurtenances such as sewage treatment systems and water supply areas (public and private well heads and reservoirs), utility structures either above or below ground, trout management areas, streams stocked by DEP, ponds located immediately downstream before the confluence with other watercourses, wetlands greater than 5 acres in size.

When the assigned risk falls between two design frequency delineations, choose the higher of the two design frequencies. For example a design risk of 30% for 18 months falls between the 3-year and 5-year. Therefore, choose the 5-year design frequency.

Once the design storm is chosen, design the temporary lined channel according to generally accepted engineering standards (e.g., NRCS Field Office Technical Guide - Section IV, the SCS National Engineering Handbook - Part 650, DOT Drainage Manual).

Design the minimum runoff to carry the peak flow expected from a 2-year frequency, 24-hour duration storm without erosion.

Lining Selection

Lining is required to protect the channel from erosion and shall be in conformance with the manufacture's recommendations for use in flow conditions.

Impermeable geomembranes: made of plastic sheeting or similar material at least 6 mils thick.

Permanent Channel Linings: an erosion resistant lining of concrete, stone, or other permanent material. Required when use exceeds 60 days or the watershed exceeds 100 acres. See **Permanent Lined Waterway** measure for design requirements.

Installation Requirements

Check weather forecasts to insure a storm is not predicted during the time of construction. Delay construction until after the threat of rainfall has passed.

Impermeable Channel Linings

Shape and prepare the channel to receive the lining.

Remove all rocks, stones, debris, sticks, or any other material exposed that could puncture the lining.

Bury the upper end of the lining in a trench at least 6 inches deep. At least every 40 feet of channel length a fold of the plastic lining shall be buried in a trench at least 6 inches deep. The edges of the lining shall be buried in a 6-inch trench or at least 6 inches of soil mounded over the edges of the plastic.

Permanent Channel Linings

See **Permanent Lined Waterway** measure for installation requirements.

Maintenance

For temporary channels containing impermeable geomembranes, inspect daily for undercutting of and damage to the lining. Repair and patch as needed. For temporary channels containing permanent channel linings, inspect at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater. Repair as needed.

Permanent Lined Waterway (PW)

Definition

A permanent waterway, including chutes and flumes, with an erosion resistant lining composed of concrete, stone, or other appropriate durable material.

Purpose

- To provide for the safe non-erosive conveyance of concentrated surface water runoff to an appropriate receiving channel, without damage by erosion or flooding.
- To safely convey concentrated storm water runoff down the slope by use of a lined chute, flume or waterway.

Applicability

- Where the contributing drainage area does not exceed 200 acres.
- Where the design discharge does not exceed 200 cfs.
- Where the velocity of concentrated runoff is of such magnitude that a lining is needed to prevent erosion of the channel.
- Where excessive grades, channel wetness, prolonged base flow, seepage, or soil piping would cause erosion.
- Where vegetative slopes will not prevent erosion caused by people, animals, or vehicles.
- Where property values or adjacent facilities warrant the extra cost to contain design runoff in a limited space.
- In natural channels, waterways, drainageways, roadside ditches and other man-made channels that are modified or constructed and where vegetation alone will not prevent erosion.
- Major streams need full design considerations and calculations.

Planning Considerations

The installation of this measure should come only after the capacity and velocity have been determined by a detailed design. The measure should be installed and stabilized prior to the introduction of flows.

The design of the waterway is based upon the peak volume and velocity of flow expected in the channel. If conditions are appropriate, vegetation, riprap, concrete or combinations thereof may be used. While concrete channels are efficient and easy to maintain, they remove runoff so quickly that channel erosion and flooding may result downstream. Vegetated or riprap channels reduce this problem by more closely duplicating a natural system. See the **Vegetated Waterway** measure for further discussion of vegetated waterways.

In addition to the primary design considerations of capacity and velocity, a number of other important factors should be taken into account when selecting a cross section and lining. These factors include land availability, compatibility with land use and surrounding environment, safety, maintenance requirements, outlet conditions, soil erodibility factor and tailwater conditions. If a riprap design is chosen, a geotextile or graded filter may be used to act as a separator and stabilizer between the riprap and the subbase. If a concrete lining is chosen, the concrete must be placed on a firm, well drained foundation to prevent cracking or failure. A 6-inch gravel blanket is recommended under a concrete lining.

Plan on installing non-reinforced concrete or mortared flagstone linings only on low shrink-swell soils that are well drained or where subgrade drainage facilities are installed.

On stream bank erosion sites, there are many different structural stabilization techniques which can be used successfully. Good site planning normally requires staying away from streams. Properly designed and installed bank toe protection can provide excellent stabilization for stream banks if bank failure is a problem and site constraints prevent vegetative treatments.

A primary cause of stream channel erosion is the increased frequency of bank-full flows. When designing for stream bank stabilization consider preserving or developing viable aquatic habitats.

When this measure is intended to function as a paved chute or flume then it should be planned and installed along with, or as part of, other conservation practices in an overall surface water conveyance system.

Consideration must be given to protecting structures against buoyancy failures. The potential for buoyancy failure due to hydrostatic uplift forces exists in channels constructed in periodically saturated areas (basically all channels will experience saturation of the subgrade by virtue of the function of the channel) and especially if a submerged outfall condition exists.

Lined chutes or flumes should be utilized and constructed carefully. Field experience has shown a significant number of post construction problems with these controls. If the subbase contains unsuitable material, the chute or flume may be subject to undermining and fracturing. If high outlet velocities are expected, it may be appropriate to install a system of pipe slope drains to slow the exit velocity of the measure and to reduce erosion potential.

Design Criteria

Discharge

The minimum waterway capacity shall be adequate to carry the peak rate of runoff from a 10-year frequency 24-hour duration storm. Local and state highway facilities may require a higher design standard. If pre-development flooding problems exist, or if the consequences of flooding are severe, or if drainage systems which convey larger storms converge with the channel in question, consideration should be given to increasing the capacity beyond the 10-year frequency.

Waterway capacity shall be computed using Manning's formula and the Continuity Equation. Note: For help in using these formulas and in choosing Manning's "n" values see **Design Example**.

Velocity

Channels should be designed so that the velocity of flow from a 10-year frequency storm shall not exceed the permissible velocity for the type of lining used.

Riprap-lined channels can be designed to withstand most flow velocities by choosing a stable stone size. The procedures for selecting a stable stone size for channels and installation is contained in the **Riprap** measure. All riprap shall be placed on a geotextile or gravel blanket (see **Riprap** measure for details). Transition from a riprap lining to vegetative lining must be carefully designed to meet the allowable velocities of each type of lining.

Concrete-lined channels are usually smaller than grass-lined channels and are sometimes referred to as permanent lined chutes or flumes. However, concrete lined channels have flow velocities higher than grassed lined channels and can produce more downstream erosion and flooding. While concrete-lined channels can be designed to carry high flow velocities, be aware that the flow velocity at the outlet of the paved section must not exceed the permissible flow velocity of the receiving channel. Concrete channels shall be at least 4 inches thick and meet all applicable DOT criteria found in DOT Standard Specifications Section 8.05. FHWA HEC 15 also contains information on engineering calculations for channel design.

Design flow depth and maximum velocities should be consistent with **Figure PW-1.** See **Figure PW-10** for an example of a permanent lined chute or flume.

Figure PW-1 Maximum Velocity

Design Flow Depth	Maximum Velocity
0 - 0.5'	25 fps
0.5 - 1.0'	15 fps
>1.0'	10 fps

Source: USDA-NRCS

Critical Slope

A critical slope is the slope of the channel bottom required to produce a water surface equal to critical depth. Except for short transition sections, slopes in the range of 0.7 to 1.3 of the critical slope shall be avoided. Lined waterways with velocities exceeding those found at critical depth shall discharge into an energy dissipator to safely reduce velocity to less than the velocity found at critical depth.

Cross Section Design (see **Figure PW-5** and **Figure PW-6**)

"V" shaped channels are generally used where the quantity of water to be handled is relatively small, such as drainageways and roadside ditches. A vegetative lining may suffice where velocities in the ditch are low. For steeper slopes where high velocities are encountered, a riprap, concrete or bituminous concrete lining may be appropriate.

Parabolic channels are often used where the quantity of water to be handled is larger and where space is available for a wide, shallow channel with low velocity flow. Riprap should be used where higher velocities are expected and where some dissipation of energy (velocity) is desired. Combinations of vegetation and riprap (a.k.a. vegetated channel with stone center) are also useful where there is a continuous low flow in the channel (see **Vegetated Waterway** measure).

Trapezoidal and rectangular channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity. (Trapezoidal and rectangular channels are generally lined with concrete or riprap.)

Freeboard

Use a minimum freeboard of 0.25 ft. if no out-of-bank damage would be expected. Increase freeboard in areas where high damage can be expected from out of bank flow.

Side Slopes

For unlined and riprap lined channels, the steepest recommended side slopes are 2:1, as shown in **Figure PW-2.**

Figure PW-2 Channel Lining Recommended Side Slopes	
Lining	**Steepest Recommended Side Slope**
Riprap	2 to 1
Non-Reinforced Concrete - Hand placed, formed concrete Height of lining 1.5 feet or less	vertical
Hand-placed, screened concrete or mortared in-place flagstone Height of lining less than 2 feet	1 to 1
Height of lining more than 2 feet	2 to 1
Reinforced slip form concrete - Height of lining less than 3 feet	1 to 1

Source: USDA-NRCS

Lining Thickness

Riprap - maximum stone size + thickness of filter or bedding (see **Figure PW-3**)

Concrete - 4 inches + 6 inches bedding.

Flagstone - 4 inches including mortar bed + 6 inches bedding

Figure PW-3 Riprap Lining Specifications

Riprap Specification	Maximum Stone Size	Minimum Thickness	Minimum Bedding Thickness
standard	30 inches	36 inches	12 inches
intermediate	18 inches	18 inches	6 inches
modified	10 inches	12 inches	6 inches

Source: DOT Standard Specifications Section M12.02 and DOT Drainage Manual

Contraction Joints

Contraction joints in concrete linings, if required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet. Provide for uniform support to the joint to prevent unequal settlement.

Filters or Bedding

If soil conditions dictate, filters, bedding, and/or geotextiles shall be used to prevent piping. Subsurface drains may be used, as required, to reduce uplift pressure and to collect water. Filters, bedding, geotextiles, and drains shall be designed according to riprap and subsurface drain criteria. Subsurface weep holes shall be used with impervious linings.

Materials

Riprap and flagstone shall be of a stone that is dense and hard and durable enough to withstand exposure to air, water, freezing and thawing and be chemically stable (see **Riprap** measure for further riprap materials requirements). Flagstone shall be flat for ease of placement, and have the strength to resist exposure and breaking.

Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product shall be required. Specify a mix that can be certified as suitable to produce a minimum strength of at least 3,000 lb./in^3 the concrete mix shall contain air entertainment. Cement used shall be Portland Types I, II, or if required Types IV or V. See **Figure PW-10** for example of a permanent concrete lined chute or flume.

Mortar used for mortared in place flagstone shall consist of a workable mix of cement, sand and water with a water-cement ratio of not more than six gallons of water per sack of cement.

Outlet

The outlet must handle the design flow without flooding or erosion. The outlet shall be stable for the 10-year, 24-hour storm discharge. Outlets of all channels shall be protected from erosion. Transition from a man-made lining, such as concrete and riprap, to a vegetated or non-vegetated lining shall be taken into consideration. Appropriate measures shall be taken to dissipate the energy of the flow to prevent scour of the receiving channels. See **Outlet Protection** measure.

Related Structures

Side inlets, permanent slope drains, and energy dissipators shall meet the hydraulic and structural requirements for the site.

Installation Requirements

1. Remove and properly dispose of all trees, brush, stumps, roots, obstructions and other unsuitable materials so as not to interfere with construction or proper functioning of the permanent lined waterway.

2. Install temporary erosion and sediment controls to protect the site of the permanent lined waterway from sediment deposition while the contributing drainage area is unstable.

3. Excavate or shape the channel to the proper grade and cross-section. Consider phasing of channel construction in order to minimize time of exposure in lengthy projects.

4. Compact any fills to prevent excessive settlement.

5. Remove and dispose of any excess soil properly.

Riprap-lined Channels

Install riprap in accordance with the **Riprap** measure.

Concrete-lined Channels

Construct concrete-lined channels in accordance with all applicable DOT specifications. The following items highlight those specifications:

1. Place concrete only when the subgrade is moist.

2. Provide tranverse joints for crack control at approximately 10-15 foot intervals and when more than 45 minutes elapse between times of consecutive concrete placements. Make all sections at least 6 feet long. Crack control joints may be formed by using a 0.125 inch thick removable template, by sawing to a depth of at least 0.75 inch, or by an approved “leave in” type insert.

3. Install expansion joints every 100 feet.

Maintenance

Until the contributing drainage area is stabilized, inspect within 24 hours of the end of a storm with a rainfall

Design Procedure

Open Channel Flow

(from FHWA HEC-15)

To calculate the flow in an open channel, assume that the quantity of flow in the channel does not change with time and that the cross-sectional area and slope of the channel remain constant.

1. Determine design discharge (Q_d) based on hydraulic computations. Use a 10-year frequency discharge.

2. Determine Maximum Permissible Velocity (V_{max}). See Figure PW-4.

3. Select channel shape and slope. (S_o).

4. Determine d_{max} for the selected lining and slope (use HEC-15 Maximum Permissible Depth (MPD) charts). Note: d_{max} does not apply to concrete lined channels.

5. Calculate area (A) and hydraulic radius (R) for the selected channel geometry and d_{max}.

6. Determine Manning's "n". Manning's roughness coefficient, "n", is determined by the type of channel lining selected. Ranges of "n" factors for various structural linings are listed in **Appendix A** of "Design Charts for Open-Channel Flow, Hydraulic Design Series No. 3" published by the U.S. Department of Transportation. Generally, for a given lining the lower values should be used to calculate velocity and the higher values should be used to calculate capacity of the channel. See **Figure PW-7** for determining Manning's "n".

7. Calculate design velocity (Vd) from R and S_o using Manning's equation or nomographs widely available.

$$V = \frac{1.49}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} \qquad \text{(Manning's Equation)}$$

Where

V = the average velocity in the channel (ft./sec.)
n = Manning's roughness coefficient, based upon the lining of the channel.
R = the hydraulic radius (feet) = A ÷ wp
where
A = cross sectional area
wp = wetted perimeter.
S = the slope of the channel (ft/ft)

8. Calculate allowable discharge (Q_a) using the **Continuity Equation:**

$$Q_a = VA$$

Where

Q_a =the allowable discharge
V = the average velocity in the channel (ft./sec.)
A = cross sectional area of flow

9. Check V_d against V_{max}. If $V_d > V_{max}$, select larger channel or use more stable lining.

10. Compare allowable discharge (Q_a) with design discharge (Q_d). If $Q_a >> Q_d$ the channel is over designed. If $Q_a < Q_d$, the channel is inadequate.

Figure PW-4 Maximum Permissible Velocity (ft./sec.)		
Riprap Type[1]	Size	Maximum Permissible Velocity
Modified	d_{50} <0.42 feet	8 ft./sec.
Intermediate	0.42 feet< d_{50} <0.67 feet	10 ft./sec.
Standard	0.67 feet≤ d_{50}	14 ft./sec.

[1] Riprap types as defined in DOT Standard Specifications. Other gradations may be designed which also met the d_{50} criteria.

Source: DOT Drainage Manual

Design Example

Given: Q_d = 100cfs
S_a (slope) = 1%
Channel shape = Trapezoidal w/ 2:1 side slopes
Z = 2 (see **Figure VW-14**)
Type of Lining = Concrete w/ float finish
'n' = 0.013 - 0.017 (see **Figure PW-7**)

Find: Channel Size and Depth of Flow

Solution: Solve by trial and error. Using the Continuity Equation ($Q = AV$), Manning's equation (V = (1.49/n) x $R^{2\backslash 3}$ x $S^{1\backslash 2}$) and the formulas in **Figure PW-9**.

Try: Bottom Width = 6 ft. Depth of Flow = 1.4 ft.

Area A = bd + zd^2 = 6 x 1.4 + 2 x 1.42 = 12.32 sq. ft.

Hydraulic Radius $R = A / wp$ where wp = wetted perimeter

R =(bd + zd^2) / (b +2d (z2+1)1\2) = 12.32 / 12.26 = 1.004 use 1.0

V_d = (1.49 / 0.017) x 1.0 x 0.1 = 8.8 ft./sec.

$Q_a = VA$ = 8.8 x 12.32 = 108.4 cfs > Q_d of 100 cfs, OK.

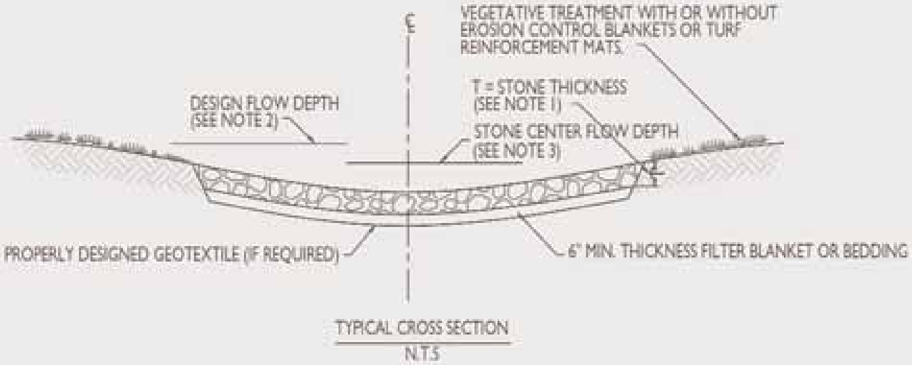
Use a minimum freeboard of 0.25 ft. if no out of bank damage would be expected. Increase freeboard in areas where high damage can be expected from out of bank flow.

Construction Dimensions:

Side slopes = 2:1; Bottom Width = 6 ft.; Depth = 1.65 feet; Lining thickness = 4 inches;
Concrete = 3000 psi (air entrained); Cement = Portland Type 1; Aggregate maximum size = 1-1/2 inches; Use contraction joints every 15 feet; use 6 inches gravel bedding under all concrete.

Note: For a riprap lined waterway, see **Riprap** measure.

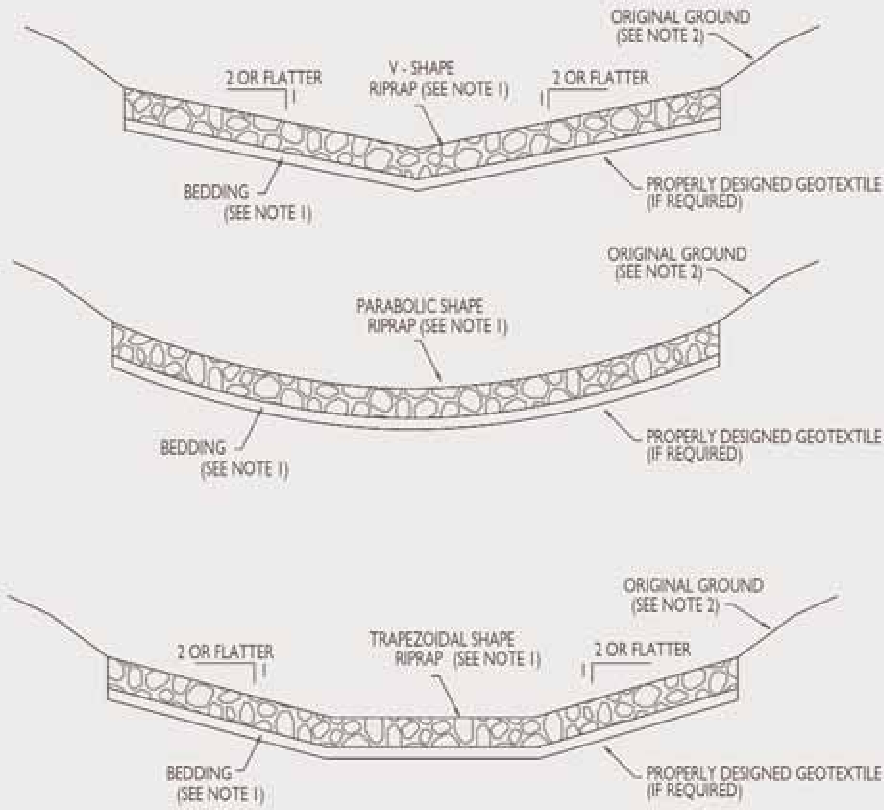
Figure PW-5 Waterways with Stone Centers



NOTES:
1. MINIMUM STONE LAYER THICKNESS = SEE FIGURE PW-3.
2. THE TOTAL WATERWAY DEPTH IS DEPENDENT UPON THE DESIGN DEPTH OF FLOW PLUS RUNUP DUE TO CHANNEL CURVATURE PLUS FREEBOARD.
3. FOR A 10 YR. CAPACITY WATERWAY, THE STONE CENTER SHALL CONTAIN A 2 YR. RUNOFF EVENT. FOR A 25 YR. CAPACITY WATERWAY, THE STONE CENTER SHALL CONTAIN A 10 YR. RUNOFF EVENT.

Source: USDA-NRCS

Figure PW-6 Typical Waterway Cross Sections



NOTES:
1. FOR MINIMUM RIPRAP AND BEDDING LAYER THICKNESS' SEE FIGURE PW-3.
2. VEGETATIVE TREATMENT WITH OR WITHOUT EROSION CONTROL BLANKETS OR TURF

Source: USDA-NRCS

Figure PW-7 Manning's "n" Coefficients

For riprap-lined channels, "n" can be determined from the following equation:

$$n = (0.0395)d_{50}^{\frac{1}{6}}$$

Where,

n = Manning's roughness coefficient

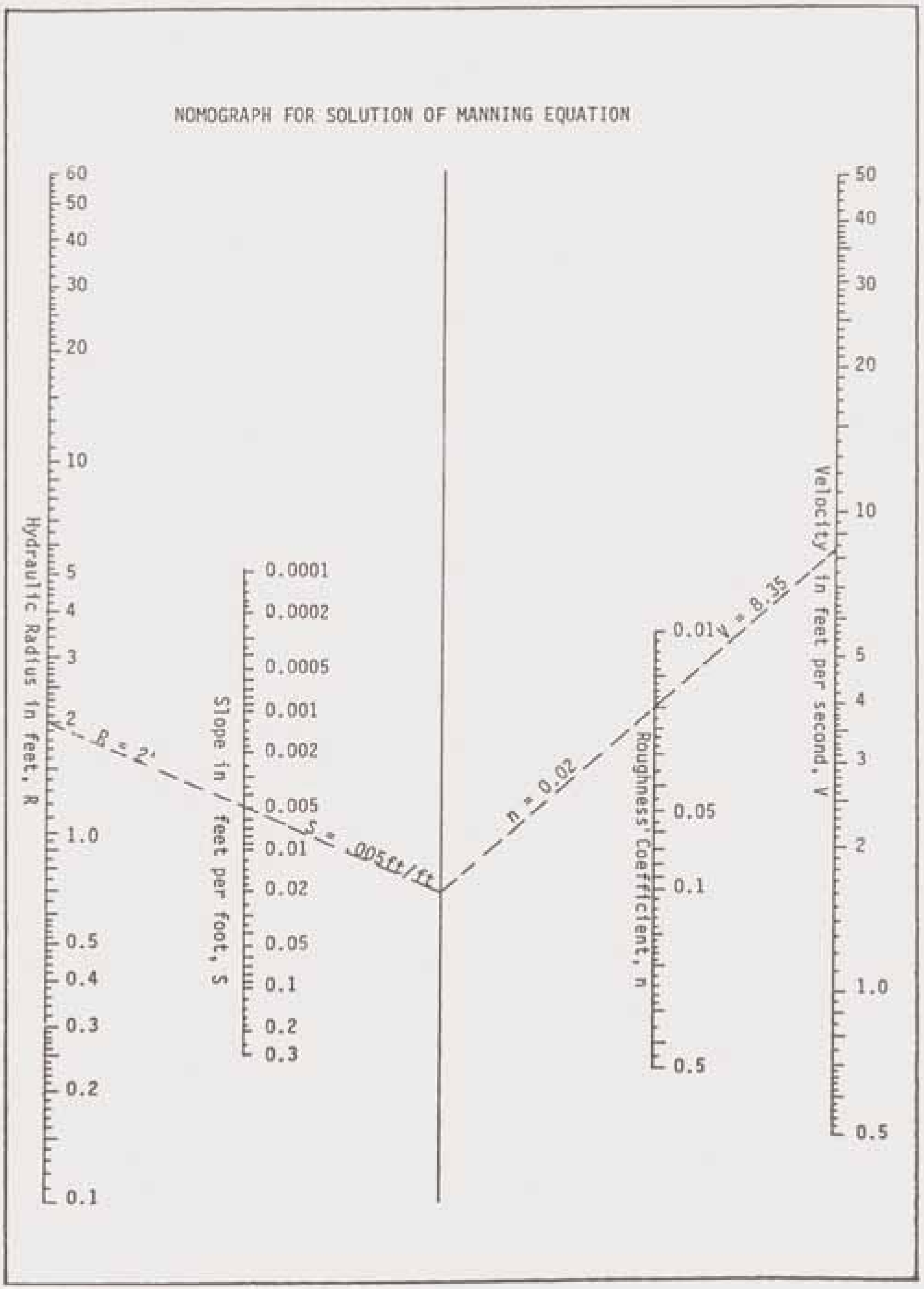
d_{50} = the median size stone in the gradation of riprap (feet)

The following table identifies Manning "n" coefficients for specific linings derived from the USDA-NRCS and the DOT Standard Specifications M.12.02 (riprap).

Lining type	"n"
Concrete	
Trowel Finish	0.012 - 0.014
Float Finish	0.013 - 0.017
Gunite	0.016 - 0.022
Flagstone	0.020 - 0.025
Riprap	
Modified (d_{50}=0.42)	0.034
Intermediate (d_{50}=0.67)	0.037
Standard (d_{50}=1.25)	0.041

Permanent Lined Waterway (PW)

Figure PW-8 Nomograph for Solution of Manning Equation

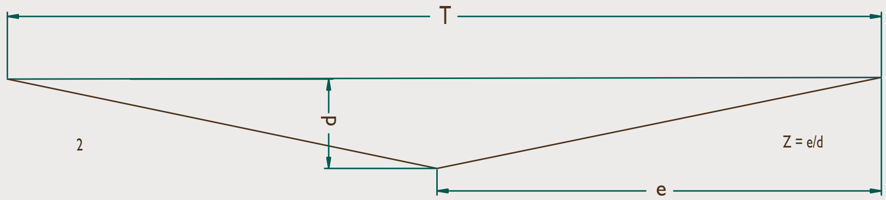


Source: Virginia Erosion and Sediment Control Handbook, 1992.

Permanent Lined Waterway (PW)

Figure PW-9 Channel Geometry Equations

V - SHAPE

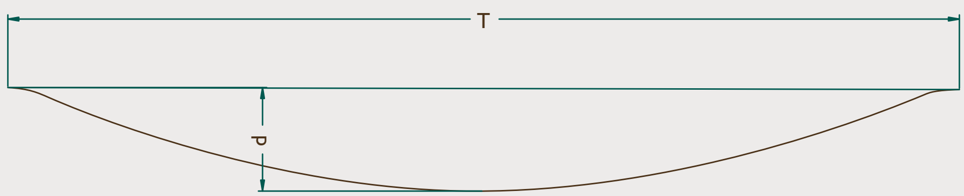


CROSS - SECTIONAL AREA (A) = Zd^2

TOP WIDTH (T) = 2dZ

HYDRAULIC RADIUS (R) = $\frac{Zd}{2\sqrt{Z^2+1}}$

PARABOLIC SHAPE

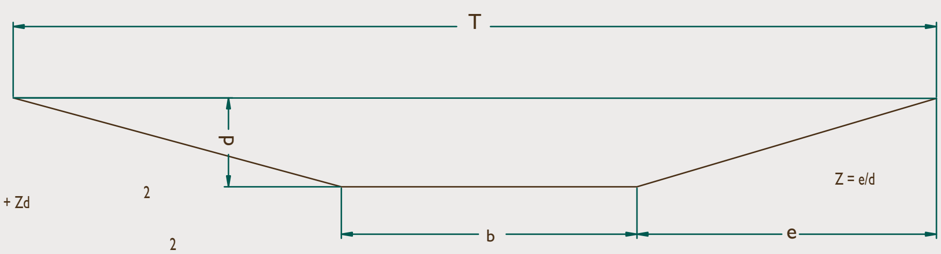


CROSS - SECTIONAL AREA (A) = 2/3 Td

TOP WIDTH (T) = 1.5 A/d

HYDRAULIC RADIUS (R) = $\frac{T^2 d}{1.5T^2 + 4d^2}$

TRAPEZOIDAL SHAPE



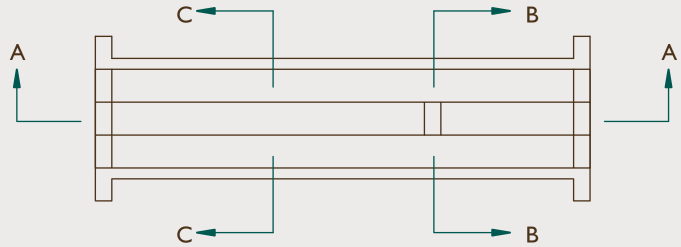
CROSS - SECTIONAL AREA (A) = $bd + Zd^2$

TOP WIDTH (T) = b + 2dZ

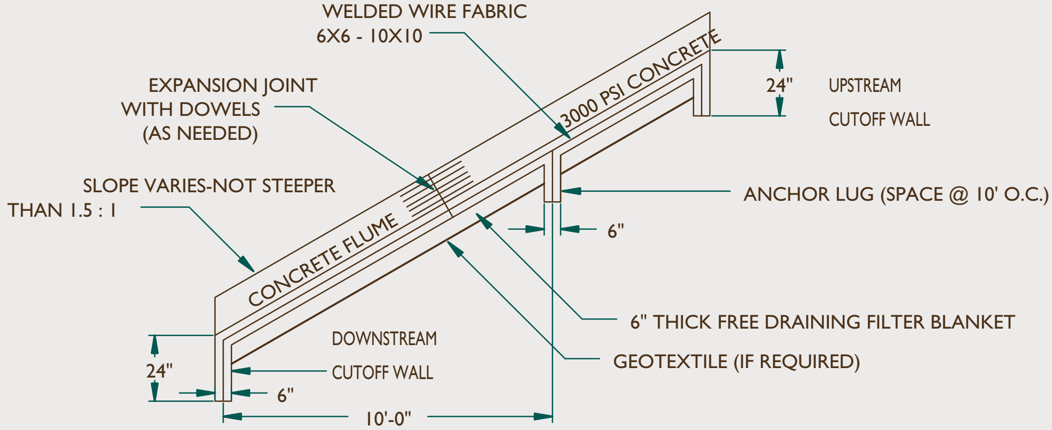
HYDRAULIC RADIUS (R) = $\frac{bd + Zd^2}{b + 2d\sqrt{Z^2+1}}$

Source: USDA-NRCS

Figure PW-10 Example of Permanent Lined Chute or Flume

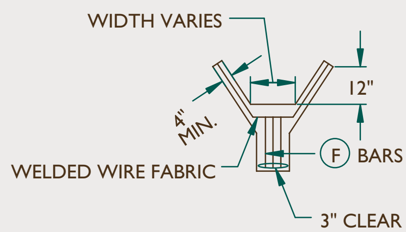


PLAN VIEW
N.T.S.



SECTION A-A
N.T.S.

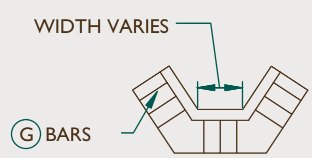
NOTE: ENERGY DISSIPATOR NEEDED AT OUTLET
(SEE OUTLET PROTECTION MEASURES)



*10' - 0" C-C MAXIMUM TYPICAL SPACING BETWEEN ANCHOR LUGS. WHERE CUTOFF WALL IS NOT REQUIRED, ANCHOR LUG SHALL BE A MAXIMUM OF 2' FROM END OF CHANNEL.

SECTION B-B
(THROUGH ANCHOR LUG)
N.T.S.

MARK	SIZE	LENGTH	SHAPE	SPACING
(F)	#4	1'-8"	STRAIGHT	6"
(G)	#4	1'-8"	STRAIGHT	6"
Dowel	#4	1'-6"	STRAIGHT	6"



SECTION C-C
(THROUGH CUTOFF WALL)
N.T.S.

Source: USDA-NRCS

Temporary Stream Crossing (TSC)

Definition
A temporary bridge, or culvert(s), across a watercourse for use by construction traffic.

Purpose
- To provide a means for construction traffic to cross streams without causing turbidity.
- To keep sediment generated by construction traffic out of the stream.

Applicability
- For streams with drainage areas less than one square mile. For drainage areas exceeding one square mile use generally accepted engineering standards (e.g. NRCS Field Office Technical Guide - Section IV, the SCS National Engineering Handbook - Part 634, Hydraulic Engineering, DOT Drainage Manual) which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.

Planning Considerations
Temporary stream crossings are necessary to prevent construction vehicles from damaging stream banks and continually tracking sediment and other pollutants into the stream. However, these structures are also undesirable in that they represent a channel constriction which can cause flow backups or washouts during periods of high flow. For this reason, the temporary nature of stream crossings is stressed. They should be in place for the shortest practical period of time and be removed as soon as their function is completed.

The specifications contained in this measure pertain primarily to flow capacity and resistance to washout of the structure. From a safety and utility standpoint, the designer must also be sure that the crossing is capable of withstanding the expected loads from heavy construction equipment. Additionally, the design plans and installation shall comply with applicable federal, state and local laws and regulations.

A temporary bridge crossing is a structure made of wood, metal, or other materials which provides access across a stream or waterway. A temporary culvert crossing is a structure consisting of stone and a section(s) of circular pipe, pipe arches, or oval pipes of reinforced concrete, corrugated metal, or structural plate, which is used to convey flowing water through the crossings.

Bridges are preferred over culvert installations. Normally, bridge construction causes the least amount of disturbance to the stream bed and banks when compared to the other types of crossings. They can also be quickly removed and reused. In addition, temporary bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings.

There is some disturbance within the stream during construction and removal of the temporary culvert crossing. The stone, along with the temporary culverts, can be salvaged and reused.

Multiple smaller culverts may be used in place of a single larger culvert if the hydraulic capacity is equivalent or greater. However, remember that smaller multiple culverts are more susceptible to being obstructed with debris during flooding events. They can increase the risk of blockage resulting in overtopping and erosion of the roadway creating damages that exceed the difference in costs between multiple small culvert and one large culvert.

Water bars are required for the crossing and other erosion and sediment controls may be needed.

Design Criteria
Temporary stream crossings may be either bridges or culvert(s) and associated rock fill.

For temporary culvert crossings that will remain in place for 90 days or less, in lieu of a formal hydraulic design the structure shall have the ability to convey without erosion the flow from a 2-year frequency storm or to replicate the cross sectional area of the natural channel. The minimum culvert size is 18 inches.

Minimum Design Flows
If the structure will remain in place 90 days to 3 years, the design storm is determined by using the procedures outlined in Appendix J, "Risk Assessment Adapted

From CT DOT Drainage Manual." Using the form "Design Frequency Risk Analysis" determine all factors in the Impact Rating Table as described except "Property Damage." Property damage is assessed by predicting the areas that can be damaged should the crossing capacity be exceeded. This includes an evaluation of potential flood damage upstream or adjacent to the channel and damage downstream to properties and water resources that might receive sediment should the stream crossing fail. The property damage value shall be chosen as follows:

5 points cropland, parking lots, recreational areas, undeveloped land, forest land

10 points private or public structures, appurtenances such as sewage treatment systems and water supply areas (public and private well heads and reservoirs), utility structures either above or below ground, trout management areas, streams stocked by DEP, ponds located immediately downstream before the confluence with other watercourses, wetlands greater than 5 acres in size.

When the assigned risk falls between two design frequency delineations choose the higher of the two design frequencies. For example, a design risk of 30% for 18 months falls between the 3-year and 5-year. Therefore, choose the 5-year design frequency.

The structure shall be designed to pass the design storm without erosion. If the structure must remain in place over 3 years, it must be designed as a permanent measure in accordance with accepted engineering standards and practices. The installation of the temporary stream crossing shall not impact structures in close proximity to the crossing by causing a rise in the water surface elevation for the chosen design storm.

Crossing Load Limitations

The materials used to construct the crossing must be able to withstand the anticipated loading of the construction traffic.

Crossing Width

The crossing shall be designed for single lane traffic only, with a minimum width of 12 feet and a maximum of 20 feet. For culvert crossings the length of the culvert(s) shall include the width needed for single lane traffic plus the side slopes.

Crossing Alignment

The temporary stream crossing shall be at right angles to the stream. Where approach conditions dictate, the centerline of the stream crossing may be aligned so that it is no greater than 15% from a line drawn perpendicular to the stream flow.

Crossing Approaches

The centerline of both roadway approaches shall coincide with the centerline of the crossing with sufficient length to accommodate the equipment to be used on the crossing. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing grade.

The approaches to the structure shall consist of a minimum thickness of 6 inches of well graded, free draining gravel or crushed stone equal to the width of the travel way.

Temporary Bridge Crossing Criteria

Design the elevation of the temporary bridge structure at or above top of bank elevation to prevent the entrapment of floating materials and debris. Additionally, the abutment shall be parallel to and tied into stable banks.

Design the bridge to span the entire channel. If the channel width exceeds 8 feet (as measured from top of bank to top of bank), then a footing, pier or bridge support within the waterway may be included in the design. One additional footing, pier or bridge support is permitted for each additional 8-foot width of channel. No footing, pier or bridge support is allowed within the channel for waterways which are less than 8 feet wide.

Provide specifications for decking materials, bridge stringers and a bridge anchor of sufficient strength to support the anticipated load. Identify if run planking and curbs or fenders along the outer sides of the deck are required. Materials may include logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.

Temporary Culvert Crossing Criteria

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

Culvert Length: In no case shall the culvert exceed 40 feet in length. If the crossing approach grades require extensive fills then consider using a bridge rather than a culvert for the crossing structure.

Culvert Slope: The slope of the culvert shall match the existing channel bottom slope.

Culvert Backfill: Culvert backfill requires the use of well graded, free draining gravel or crushed stone to form the crossing and a geotextile, if necessary, specifically intended for road stabilization between the fill and the native soil. Provide specifications for the geotextile such that it can adequately distribute loads, retain fines and provide separation between the backfill and the native soil. See **Construction Entrance** measure for required physical qualities of the geotextile. The depth of cover over the culvert shall be a minimum of 24 inches and may be increased if anticipated loads require designed fill depths to be greater. For culvert(s) on a temporary stream crossing expected to be used in excess of 14 days, the backfill shall be protected from erosion with riprap designed in accordance with the **Riprap** measure.

Installation Requirements

Check weather forecasts to insure a storm is not predicted during the time of construction. Delay construction until after the threat of rainfall has passed.

Temporary Bridge Crossing (see **Figure TSC-1).**

1. Keep clearing and excavation of the stream bed and banks to a minimum.

2. Place abutments parallel to and tied into stable banks.

3. Place all decking members perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Butt decking materials tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.

4. If required, secure run planking by fastening to the length of the span. Provide one run plank for each track of the equipment wheels. Run planks are sometimes needed to properly distribute loads.

5. If required, install curbs or fenders along the outer sides of the deck. Curbs or fenders provide additional safety.

6. Anchor bridges securely at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that flood waters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.

7. Install stone for bridge approaches, construct water bars at the beginning of each approach and associated controls (see **Water Bar** Measure).

8. For bridges that are to remain in place more than 30 days apply measures that protect disturbed soils from erosion. The choice of measure used is in part dependent upon the length of time the crossing will be used.

9. For manufactured bridges follow manufacturer's recommendations.

Temporary Culvert Crossing (see **Figure TSC-2**)

1. Keep clearing and excavation of the stream bed and banks to a minimum.

2. When a geotextile is to be used, place it on the stream bed and stream banks prior to placement of the pipe culvert(s) and fill. Cover the geotextile in the stream bed and extend a minimum of six inches and a maximum of one foot beyond the end of the culvert and bedding material

3. Install the culvert on the natural stream bed.

4. Extend the culvert(s) a minimum of one foot beyond the upstream and downstream toe of the backfill placed around the culvert.

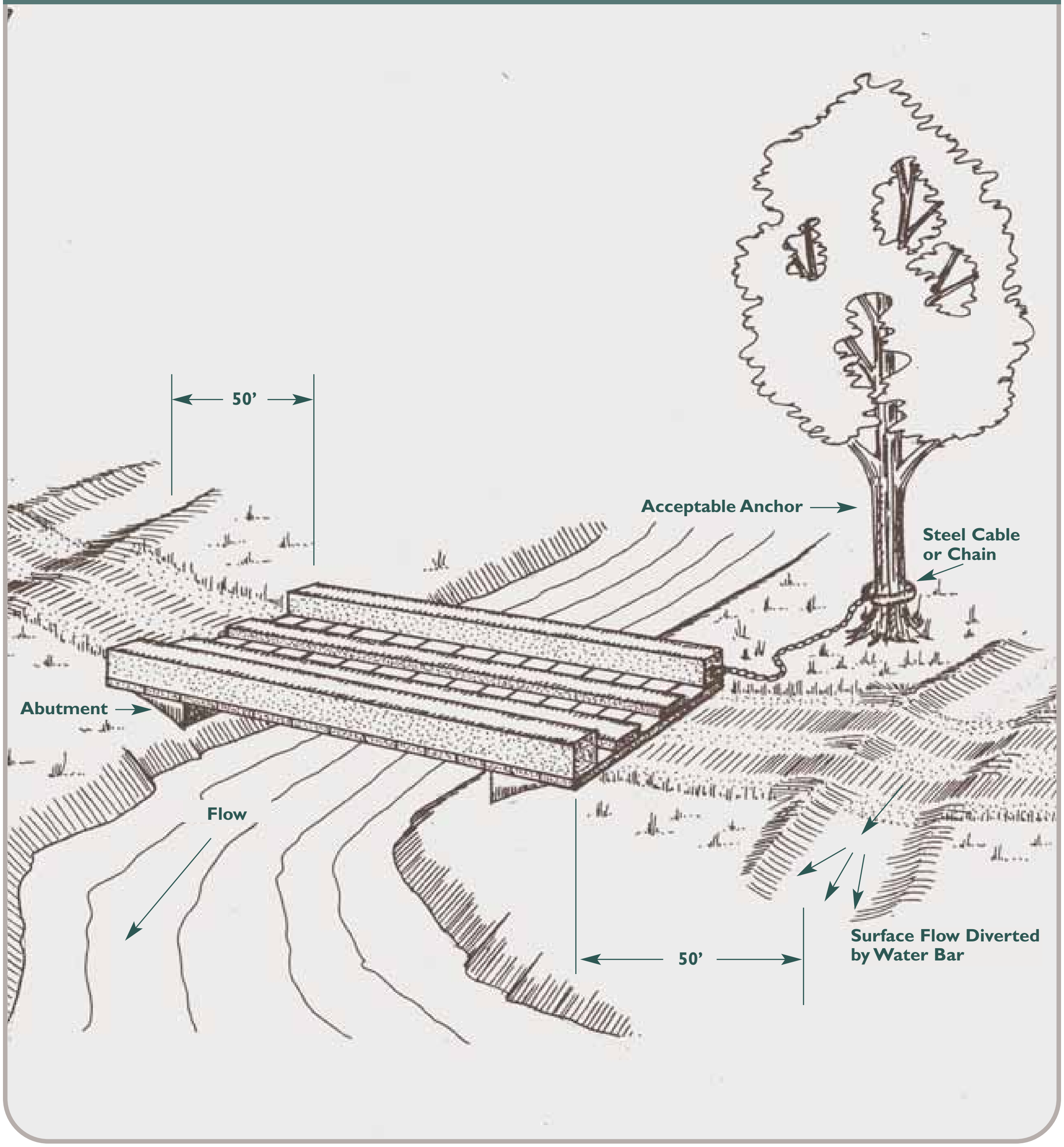
5. Cover the culvert(s) with a minimum of 24 inches of backfill. If multiple culverts are used, separate them by at least 12 inches of compacted fill.

Maintenance

Inspect and perform any repair work at the end of each day that the temporary stream crossing and approaches are exposed to vehicular traffic. When the crossing is not used for a week or more, inspect at least once a week and within 24 hours after any rainfall greater than 0.5 inch. Check for washouts at culverts, crossing approaches and failing associated controls. Immediately repair all damage. Where structural damage or repeated washouts of the temporary stream crossing occur, an engineering review is required to determine the cause of the failures and adjustments made to the structure or erosion and sediment controls as needed to prevent future failures.

When the temporary stream crossing is no longer needed, immediately remove all structures, associated fill materials and geotextiles keeping in-stream work to a minimum. Upon removal of the structure, immediately shape the stream to its original cross-section, protect the banks from erosion, and remove of all construction materials and apply soil protection measures to unstable soils.

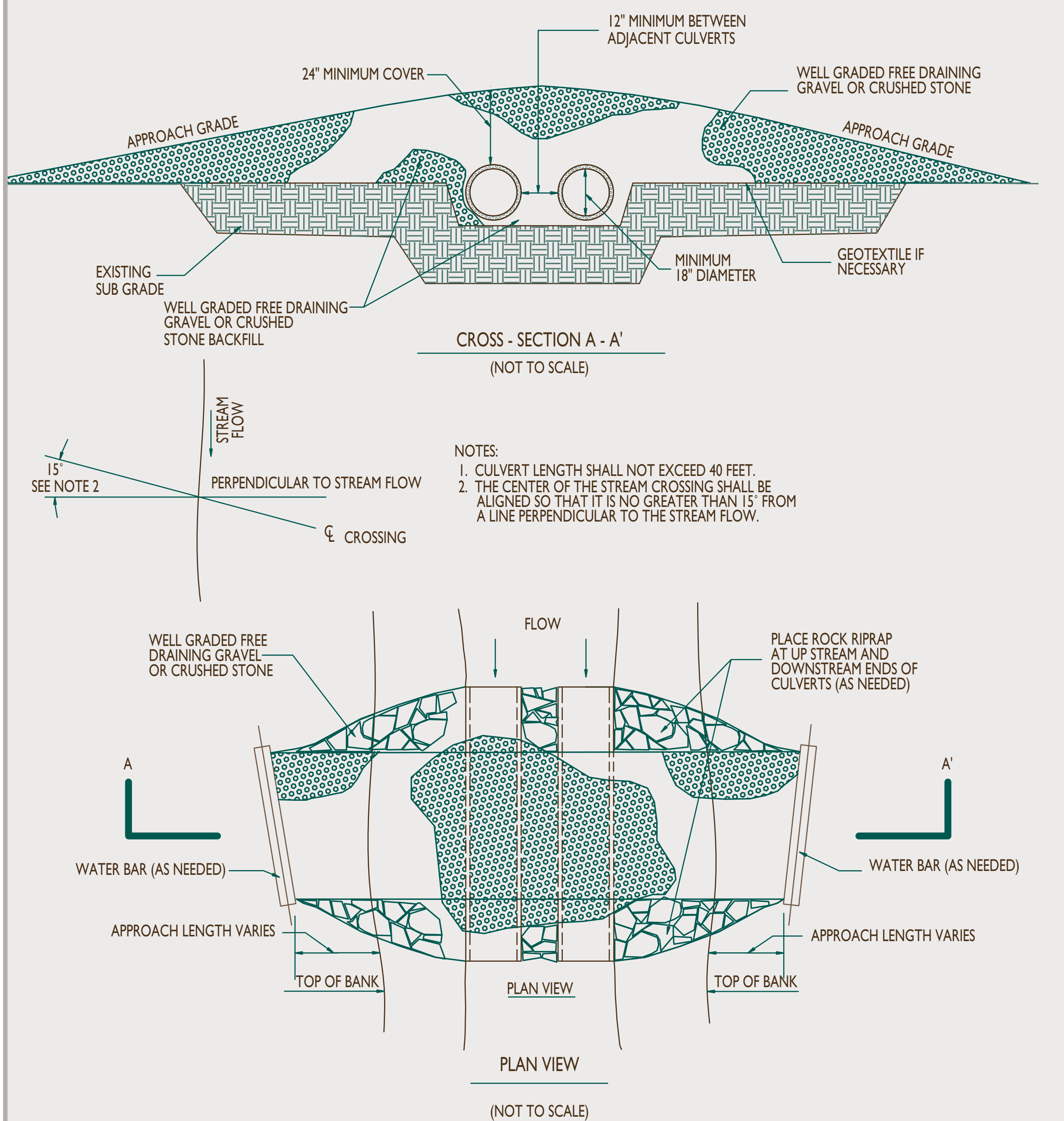
Figure TSC-1 Temporary Bridge Crossing



Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

Temporary Stream Crossing (TSC)

Figure TSC-2 Temporary Culvert Crossing



Source: USDA-NRCS

TO MAIN TOC

Planning Considerations

The diversion measures are **Temporary Fill Berm, Water Bar, Temporary Diversion** and **Permanent Diversion**. These measures serve the common function of redirecting and controlling the direction of water flow.

Diversions are used to direct runoff away from or around sensitive construction areas and to fragment drainage areas to reduce the need for a **Temporary Sediment Basin**.

Diversions are preferable to other types of man-made storm water conveyance systems because they more closely simulate natural flow patterns and characteristics. Flow velocities are generally kept to a minimum.

The **Temporary Fill Berm** is a non-engineered measure that is a very temporary berm used at the top of active fill slopes whose drainage area at the point of discharge is less than 3 acres. Its intended use is less than 5 days for any specific fill berm. The use of a berm starts when it is constructed and ends when new fill is placed. When filling is complete and it is determined that a diversion is needed at the top of fill to protect the fill until it is stabilized then a **Temporary Diversion** is needed.

continued on next page

continued from previous page

The **Water Bar** is a non-engineered measure consisting of a channel with a supporting earthen ridge used on access and construction roads to intercept flows in the roadway that have a drainage area less than 1 acre and to force these flows off the roadway. When the drainage area is greater than one acre or the diversion is needed for more than one year, plan on using a **Temporary Stream Crossing, Permanent Diversion** and/or **Permanent Lined Waterway**.

The **Temporary Diversion** measure is a channel and associated berm used anywhere in and around the construction site where control of water flow is needed. It is limited to 1 year or less for use and a contributing drainage area of 5 acres or less. When the drainage area exceeds 1 acre, an engineered design is required. When the use exceeds 1 year or the drainage area exceeds 5 acres a **Permanent Diversion** is used.

The **Permanent Diversion** is an engineered measure that is used when a permanent installation is needed or when the implementation criteria are exceeded for a temporary diversion.

Diversion needs should be identified during the development of the erosion and sediment control plan. When used for keeping clean waters segregated from construction waters, grading and stabilization of diversions should be placed early in the construction sequence before other grading work occurs. For example, a **Temporary Fill Berm** may need to be replaced with a **Temporary Diversion** and **Temporary Pipe Slope Drains** after final grades are reached, to be maintained until the slope is stabilized and then removed.

As with any earthen structure, it is very important to establish adequate vegetation as soon as possible after installation. It is equally important to stabilize the drainage area above the diversion so that sediment will not enter and accumulate in the diversion channel.

All diversions require a stable discharge point. Temporary diversions installed internally to the construction area generally require a sediment barrier or trap at their point of discharge. Diversions installed around the perimeter may also require such controls if the diversion channel or berm is not stabilized before use. Temporary diversions used to protect unstable slopes may need **Temporary Pipe Slope Drains** to insure drainage areas to the diversion remain below the design requirements.

7-Diversions

Temporary Fill Berm (TFB)

Definition

A very temporary berm of soil placed at the top of an unprotected fill slope.

Purpose

To divert runoff from unprotected fill slopes during construction to a stabilized outlet or sediment-trapping facility.

Applicability

- On active earth fill slopes where the drainage area at the top of fill drains toward the exposed slope and where ongoing fill operations make the use of a **Permanent Diversion** unfeasible.
- Where the intended use is 5 days or less. For use longer than 5 days use **Temporary Diversion** or other measure.
- Where the drainage area at the point of discharge is less than 3 acres.

Planning Considerations

Good timing is essential to fill construction. The filling operation should be completed as quickly as possible and the permanent slope stabilization measures installed. With prompt and proper construction, the landowner or contractor will save both time and money in building, repairing and stabilizing the fill area. The longer the time period for construction and stabilization, the more prone the fill will be to being damaged by erosion. Repairing the damage adds additional time and expense to the project. At times the erosion on these slopes can be difficult to reach with standard equipment.

The temporary fill berm is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed By directing runoff water to a predetermined point of discharge problems can be reduced at the discharge point and steps taken to minimize potential damage. This measure can also reduce time and money spent repairing slopes by reducing their exposure to rilling during fill slope construction. A stable outlet is critical to the proper function of the temporary fill berm. If the runoff is diverted over the fill itself, the practice will cause erosion by concentrating water at a single point.

Points of discharge must be directed to a sediment impoundment or barrier. Clean off-site water should be diverted around or culverted through the construction site If a **Temporary Pipe Slope Drain** is used, the drainage area at the point of discharge can sometimes be kept below 1 acre, which allows for a geotextile silt fence or hay bale barrier as the sediment control. However, if the drainage area exceeds 1 acre, sediment traps and/or sediment basins must be used.

Once the slope is brought to a final grade the **Temporary Fill Berm** may need to be replaced with a **Temporary Diversion**, and associated water control measures such as **Temporary Pipe Slope Drain** or **Temporary Lined Chute** may be needed until the slope is stabilized.

Specifications

Limitations

Use the following criteria for installing the measure:

❍ *The drainage area at the point of discharge is 3 acres or less. (Drainage area at the point of discharge can be controlled by using the* ***Temporary Pipe Slope Drain*** *measure.)*

❍ *The berm is at least 9 inches high with a base width of at least 3.0 feet.*

❍ *The up slope side of the berm slope is no steeper than 3:1, the down slope side of the berm slope is no steeper than 1:1, and the down slope toe of the berm is not closer than 2 feet from the top of the fill slope.*

❍ *The flow line controlled by the berm has a positive grade no steeper than 2%.*

Construction

Construct and shape the temporary fill berm following the completion of fill placement on any given day. A grader or dozer with its blade tilted may be run near the top of the fill slope, creating a berm along the top of the fill slope as depicted in **Figure TFB-1**.

Install erosion controls at the point of discharge as conditions dictate. Associated erosion control measures may include a **Temporary Pipe Slope Drain** to carry runoff down an unstable slope, and a **Geotextile Silt Fence**, **Hay Bale Barrier** or **Temporary Sediment Trap** to filter runoff and detain sediments.

Maintenance

Inspect the temporary fill berm and associated controls at the end of each work day to ensure the criteria for installing the measure have been met. Determine if repair or modification of the berm and associated measures are needed. Make modification and/or repair as needed.

This measure is temporary and under most situations will be covered the next work day. The maintenance required should be minimal. The contractor should avoid the placement of any material over the structure while it is in use. Construction traffic should not be permitted to cross the temporary fill berm.

Figure TFB-1 Illustration of Temporary Fill Berm

Water Bar (WB)

Definition
A channel with a supporting berm on the down slope side constructed across a construction access road, driveway, log road or other access way.

Purpose
- To minimize the concentration of sheet flow across and down sloping roadways and access ways, or similar sloping and unstable areas.
- To shorten the continuous flow length within a sloping right-of-way.

Applicability
- On construction access road, driveway, log road or other access way.
- Where the drainage area to each separate water bar is less than 1 acre. For drainage areas greater than 1 acre, use **Permanent Diversion** measure or **Permanent Lined Waterway** measure modified to remain stable during vehicular traffic or **Temporary Stream Crossing** measure.

Planning Considerations
The construction of utility lines, construction roads, access ways or roadways often require the clearing of long strips of ground over sloping terrain. The volume and velocity of storm water runoff tend to increase on these cleared strips of ground increasing the potential for erosion. To compensate for this loss of vegetation, it is usually a good practice to break up the flow length within the cleared strips so that runoff does not have a chance to concentrate and therefore cause erosion.

At proper intervals, water bars can significantly reduce the amount of erosion which can occur before the area is permanently stabilized. If the slope is composed of highly erodible soils, it may be appropriate to space the water bars closer than stated in the following measure.

Plan to construct the water bar to ensure there is sufficient clearance for the vehicles intend to use the access road. Consider the height of the vehicle's clearance in relation to the distance between the vehicle axles.

Unless the water bar discharges into a heavily vegetated area of sufficient length to adequately filter runoff, plan to settle or filter runoff water through a geotextile silt fence, hay bale barrier or temporary sediment trap. Since many access ways or roadways are constructed through heavily vegetated areas, runoff can often be diverted into a vegetated filter or buffer strip (see **Vegetated Filter** measure).

Specifications

Materials
For access ways or roadways where little or no construction traffic is expected, the water bars may be constructed of earth fill, gravel or graded stone.

Height
From the bottom of the channel to the crest of the berm the minimum vertical distance is 9 inches and the maximum is 18 inches (see **Figure WB-2**).

Side Slopes
Side slopes are 2:1 or flatter. Adjust the side slopes to accommodate vehicle clearance and wheel base requirements.

Base
Minimum base width of the berm is 6 feet (see **Figure WB-2**).

Length
Span the water bar completely across the access way or roadway.

Spacing
Figure WB-1 is used to determine the maximum spacing of the water bar.

Figure WB-1 Spacing of Water Bars

% Slope of access way or roadway	Spacity (feet)
1%	400
2%	245
5%	125
10%	78
15%	58

Grade
Provide positive drainage with 2% or less slope along the up slope side of the water bar (see **Figure WB-2**).

Outlet

Discharge the water bar to a stabilized outlet, sediment-trapping facility, or a vegetated filter of adequate size.

Construction

1. Install the water bar as soon as the access way or roadway has been cleared and/or graded.

2. Tamp or compact all earthen berm portions of the water bar.

3. When slopes vary between water bars, space the water bars using the maximum spacing given for the steepest gradient found between the water bars.

4. Adjust the field location of the outlet as needed to utilize a stabilized outlet area, without violating the spacing restrictions.

Maintenance

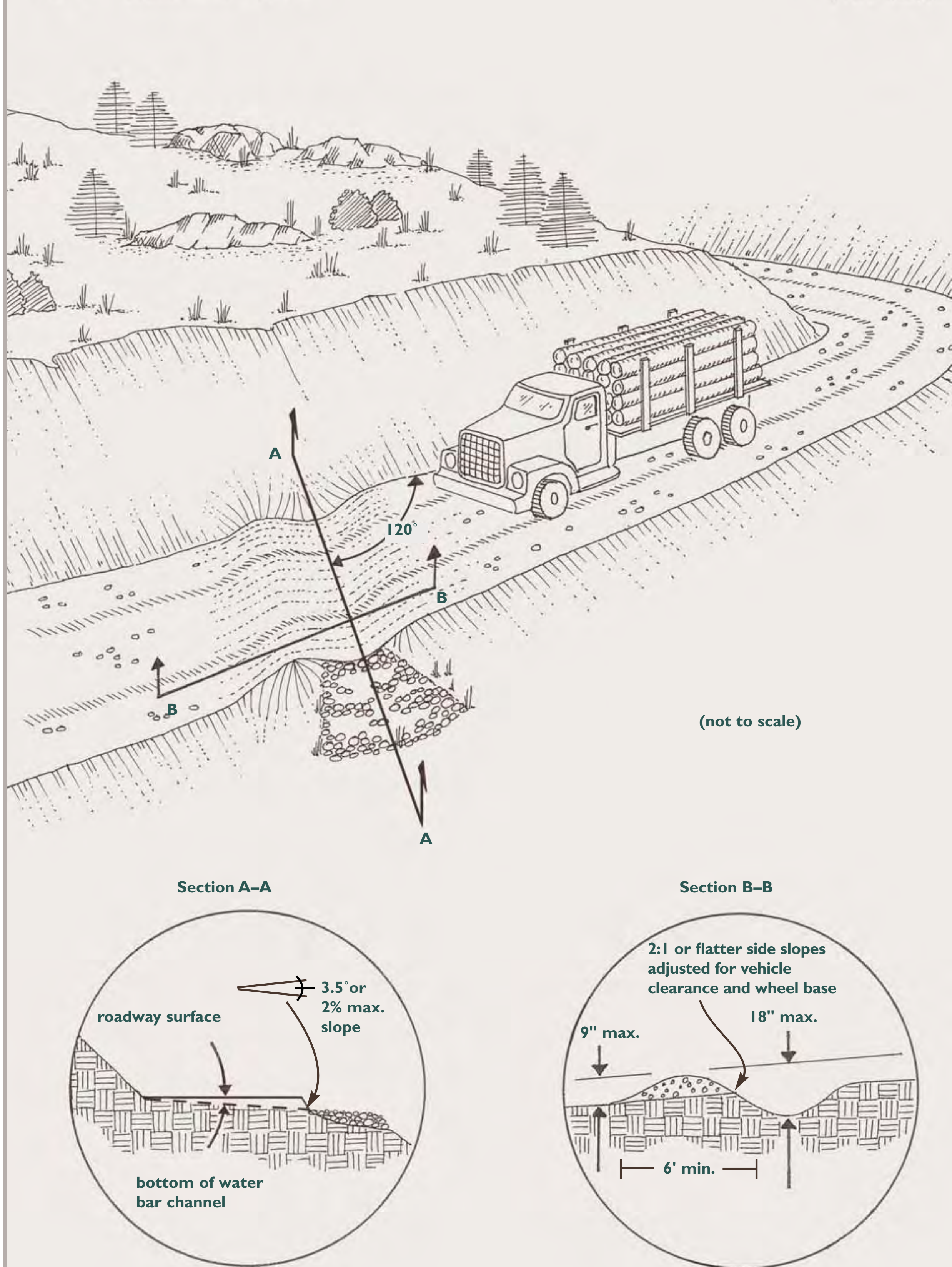
For water bars receiving drainage from disturbed areas, inspect and perform any repair work at the end of each day that the water bar is exposed to vehicular traffic and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater. For water bars receiving drainage from stable areas inspect and perform any repair work at the end of each day that the water bar is exposed to vehicular traffic or annually, whichever comes first.

Immediately reshape and repair any observed damage to the water bar.

If sediment deposits reach approximately one-half the height of the water bar, remove the accumulated sediments.

When the water bars have served their usefulness they may be removed.

Figure WB-2 Water Bar Details



Temporary Diversion (TD)

Definition

A temporary channel with a berm of tamped or compacted soil placed in such a manner so as to divert flows.

Purposes

- To divert sediment-laden runoff from a disturbed area to a sediment-trapping facility such as a temporary sediment trap, sediment basin or vegetative filter.
- To direct water originating from undisturbed areas away from areas where construction activities are taking place.
- To fragment disturbed areas thereby reducing the velocity and concentration of runoff.

Applicability

- Where the drainage area at the point of discharge is 5 acres or less. For drainage areas greater than 5 acres use **Permanent Diversion** measure.
- Where the intended use is 1 year or less. For uses greater than 1 year use **Permanent Diversion** measure.

Planning Considerations

A temporary diversion is used to divert sheet flow to a stabilized outlet or a sediment-trapping facility. It is also used during the establishment of permanent vegetative cover on sloping disturbed areas. When used at the top of a slope, the structure protects exposed slopes by directing runoff away from the disturbed areas. When used at the base of a disturbed slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

Temporary diversions must be installed as a first step in the land-disturbing activity and must be functional prior to disturbing the land they are intended to protect.

Where channel grades within the temporary diversion exceed 2%, stabilization of the channel is necessary to prevent erosion of the temporary diversion itself (e.g., temporary seeding, temporary erosion control blankets, riprap, etc.). The channel and berm must have a positive grade to assure drainage, but if the gradient is too great, precautions must be taken to prevent channel erosion due to high-velocity flows behind the berm. The cross-section of the channel should be of a parabolic or trapezoidal shape to prevent a high velocity flows which could arise in the bottom of a "V" shaped ditch.

This practice is economical because it uses materials available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the berm with vegetation. Temporary diversions are durable, inexpensive, and require little maintenance when constructed properly. When used in conjunction with a **Temporary Sediment Trap**, temporary diversions become a logical choice for a control measure when the control limits for silt fences or hay bale barriers have been exceeded.

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

Design Criteria

No engineered design is required for a temporary diversion if the contributing drainage area is 1 acre or less.

If the contributing drainage area exceeds 1 acre and is 5 acres or less, design the temporary diversion to the **Permanent Diversion** measure standards using the 2-year frequency storm as the design storm.

Specifications

For engineered temporary diversions, construct the temporary diversion in accordance with the design standards and specifications. For all non-engineered temporary diversions, comply with the following specifications.

Height

The minimum height from the bottom of the channel to the top of the berm shall be at least 18 inches and the berm constructed of compacted material.

Side Slopes and Top Width

Side slopes shall be 3:1 or flatter inside and 1:1 or flatter outside. The top width of the berm shall be 1 foot.

Grade and Stabilization

The flow line behind the berm shall have a positive grade. Channel grades flatter than 2% require no stabilization. Channels with grades steeper than 2% require stabilization in accordance with stabilization specifications found in the **Permanent Diversion** measure. Temporary diversions shall be stabilized according to the duration of their intended use (see Short Term Non-Living Soil Protection Functional Group).

Outlets

Regardless of design, release the diverted runoff to a stable outlet or channel. Where diverted runoff is expected to be carrying a sediment load, the runoff shall be released to a sediment impoundments (see Sediment Impoundments and Barriers Functional Group).

Construction

Install erosion controls at the outlet where sediment laden runoff is expected.

Construct the temporary diversion (see **Figure TD-1**). After grading the berm, tamp or compact it to prevent failure.

Apply stabilization measures (may include temporary or permanent seed and mulch) immediately following construction.

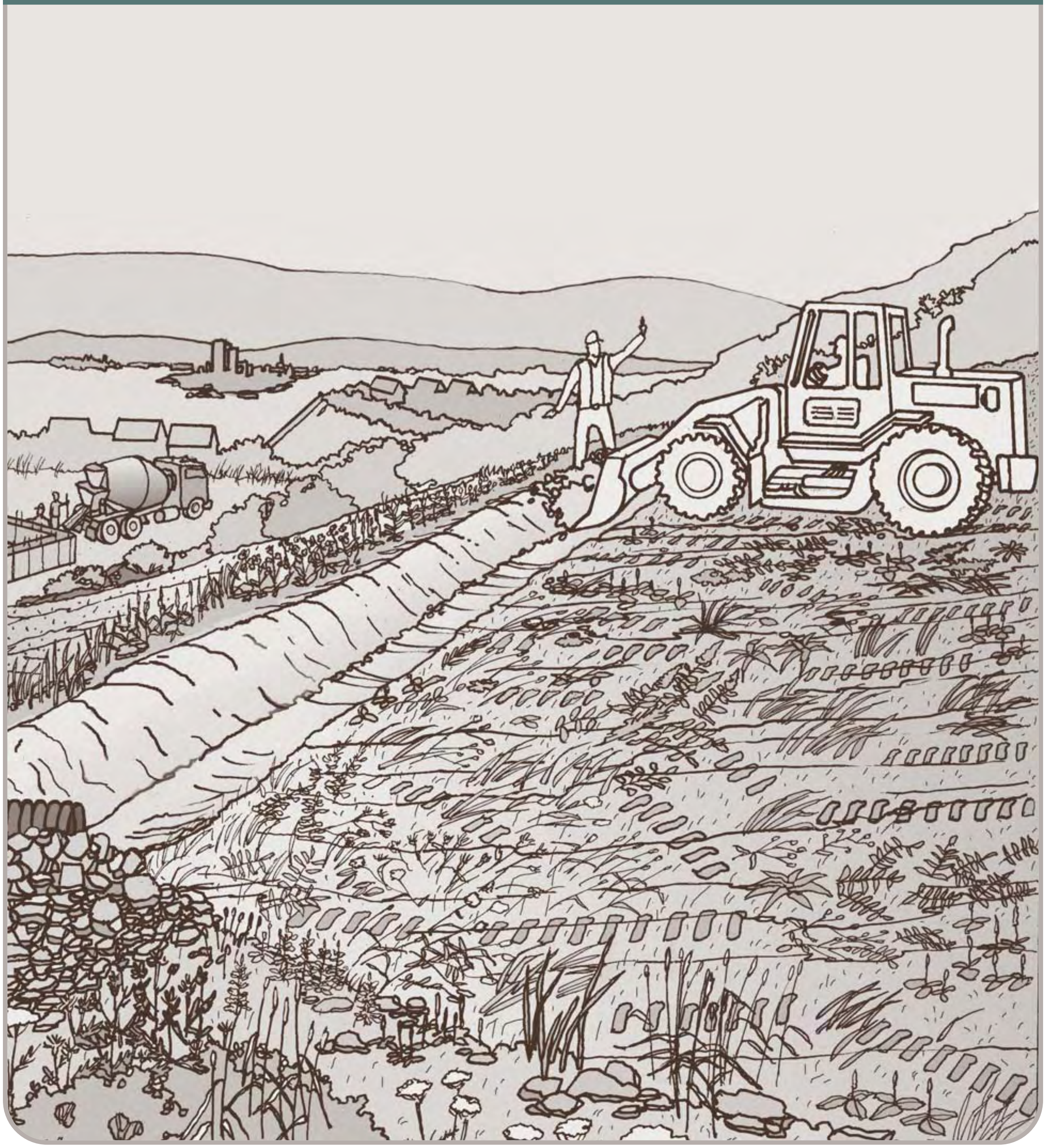
Maintenance

When the temporary diversion is located within close proximity to ongoing construction activities, inspect the temporary diversion at the end of each work day and immediately repair damages caused by construction equipment. Otherwise inspect the temporary diversion and any associated measures weekly or immediately after 0.5 inch of rain falls within a 24-hour period to determine maintenance needs.

Repair the temporary diversion and any associated measures within 24 hours of observed failure. Failure of the temporary diversion has occurred when the diversion had been damaged by either construction equipment, erosion or siltation such that it no longer meets the criteria established under the **Specifications** section or provided in the engineered design (if any).

When repetitive failures occur at the same location, review conditions and limitation for use and determine if additional measures are needed to reduce failure rates or if alternate measures are indicated to replace the temporary diversion.

Figure TD-1 Requirements for Non-Engineered Temporary Diversions



Permanent Diversion (PD)

Definition
A channel constructed across a slope with a supporting earthen ridge on the lower side.

Purpose
- To increase slope length and reduce erosive velocities.
- To intercept and divert storm water runoff to a stabilized outlet.
- To protect downgradient areas from erosion and sedimentation.

Applicability
- Where the contributing watershed is 25 acres or less. For watersheds with a drainage area greater than 25 acres, either use **Permanent Lined Waterway** or **Vegetated Waterway**.
- Where the diversion is to be included as an integral part of a permanent water management system.
- Where runoff from areas of higher elevation may damage property, cause erosion, or interfere with the establishment of vegetation on lower areas.
- Where surface and/or shallow subsurface flow is damaging sloping uplands.
- Where the slope length needs to be reduced to control excessive overland flow velocities and minimize soil loss.

Planning Considerations
Diversions are useful tools for managing surface water flows and preventing soil erosion. On moderately sloping areas, they may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion. They may be placed at the top of cut or fill slopes to keep runoff from upland drainage areas off the slope. They can also be used to protect structures, parking lots, adjacent properties, and other special areas from flooding. When properly coordinated into the landscape design of a site, permanent diversions can be visually pleasing as well as functional. (see **Figure PD-2**)

The supporting ridge of the permanent diversion may be constructed from soil excavated from the channel if the soil excavated meets the installation requirements for ridge construction. If it is known at the planning stage that the soil will not meet the installation requirements, then plan on importing soil which is adequate to meet the installation requirements.

Should permanent seeding (as opposed to stabilizing with stone) of the top and outside of the ridge be planned for ridge stabilization, then plan on requiring the use of topsoil and seed bed preparation in accordance with the **Topsoiling** and **Permanent Seeding** measure.

Maintenance requirements should be planned in accordance with the intended use.

Design Criteria
Design the permanent diversion according to generally accepted engineering standards (e.g., NRCS National Engineering Handbook – Part 650, the NRCS Field Office Technical Guide – Section IV, DOT Drainage Manual).

Location
Determine the permanent diversion location by considering outlet conditions, topography, land use, soil type, length of slope, seepage planes (i.e., seepage breakout locations where seepage is expected to be a problem) and the development layout.

Capacity
Design the minimum capacity to safely carry the peak flow expected from a 10-year frequency, 24-hour duration storm with a freeboard of at least 0.3 feet. (see **Figure PD-1**).

Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high-risk areas, and those designed to function in connection with other storm water management systems, shall be designed at a minimum to safely carry the peak flow from a 25- year frequency, 24-hour duration storm with a freeboard of at least 0.3 feet.

If a contributing or receiving drainage system is designed to a standard greater than the 10-year frequency storm, then design the permanent diversion to that higher standard. If pre-development flooding problems exist or if the consequences of flooding are severe, then consider increasing the capacity beyond the 10-year frequency storm. If drainage systems which convey larger storms converge with the diversion in question, design the diversion to the same design storm as the contributing drainage system.

Channel Design

The diversion channel may be parabolic, trapezoidal or "V" shaped and shall be designed in accordance with the **Vegetated Waterway** measure or **Permanent Lined Waterway** measure.

Ridge Design

The supporting ridge cross-section shall meet the following criteria (see **Figure PD-1**):

1. The side slopes shall be no steeper than 2:1.
2. The width at the design water elevation shall be a minimum of 4 feet.
3. The minimum freeboard shall be 0.3 feet.
4. The design shall include a 10% settlement factor.

Provide for soil stabilization of the top and outside portions of the ridge in accordance with the intended use.

Outlet

Provide the permanent diversion with a stable outlet which will reduce the energy of concentrated discharge so as not to cause downstream erosion.

Installation Requirements

Site Preparation

Remove and dispose of all trees, stumps, obstructions, and other objectionable material so as not to interfere with the proper functioning of the diversion.

Excavate or shape the diversion to line, grade, and cross-section as required to meet the criteria specified herein. Ensure the diversion profile is free of irregularities which will impede flow, cause scouring and/or sediment deposition.

Place, grade and compact fill to prevent unequal settlement. Fill shall be composed of soil which is free from excessive organics, debris, large rocks (over 3-inch diameter) or other objectionable materials.

Spread or dispose of all earth removed and not needed in construction.

Stabilize Diversion

Stabilize the diversion in accordance with the design plans.

Install Sediment Controls for Contributing Areas

Install sediment controls to trap sediment before it enters the diversion. Field experience has demonstrated that many newly constructed vegetated channels become damaged from sediment deposition and require costly repairs as a result of improper up slope protection and control measures.

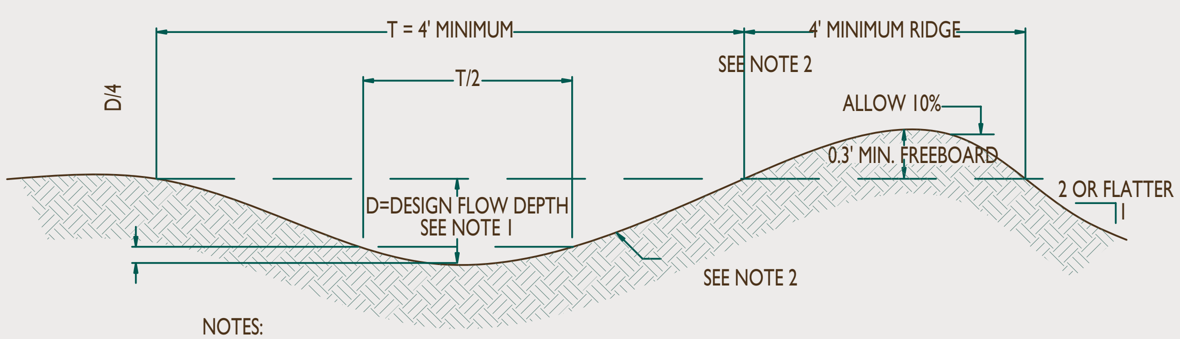
Maintenance

Inspect the permanent diversion at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater during construction of the site and until the diversion is permanently stabilized. For seeded and mulched channels, see **Permanent Seeding** measure Maintenance Section for initial establishment and first mowing requirements. Check for seed and mulch movement and/or rill erosion. For sodded channels, see **Sodding** measure Maintenance Section.

Repair damage to vegetated channels immediately. Remove sediment from the channel and make repairs as necessary.

After construction is complete and the diversion is stable, inspect the permanent diversion annually and after each major rainfall for damage and deterioration. Repair damages immediately. Ongoing maintenance should include the removal of accumulated sediment

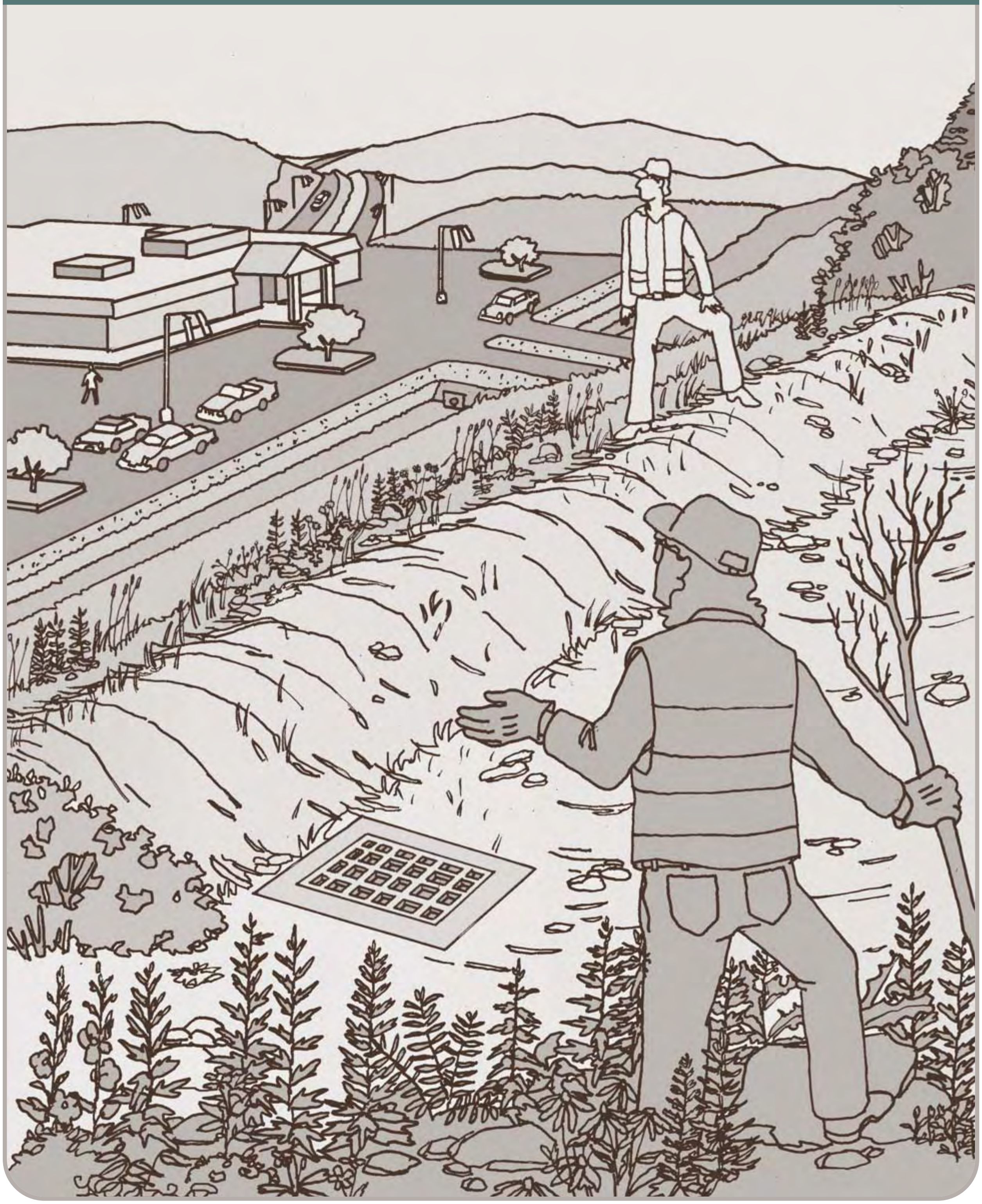
Figure PD-1 Permanent Diversion



NOTES:
1. MINIMUM DESIGN CAPACITY SHALL CONVEY A 10 YR. - 24 HOUR PEAK FLOW WITHOUT EROSION.
2. INSTALL EROSION CONTROL BLANKETS OR TURF REINFORCEMENT MATS AS NEEDED FOR EROSION RESISTANCE.

Source: USDA-NRCS

Figure PD-2 Illustration of Permanent Diversion Intercepting Overland Flow



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Planning Considerations

The diversion measures are **Temporary Fill Berm, Water Bar, Temporary Diversion** and **Permanent Diversion**. These measures serve the common function of redirecting and controlling the direction of water flow.

Diversions are used to direct runoff away from or around sensitive construction areas and to fragment drainage areas to reduce the need for a **Temporary Sediment Basin**.

Diversions are preferable to other types of man-made storm water conveyance systems because they more closely simulate natural flow patterns and characteristics. Flow velocities are generally kept to a minimum.

The **Temporary Fill Berm** is a non-engineered measure that is a very temporary berm used at the top of active fill slopes whose drainage area at the point of discharge is less than 3 acres. Its intended use is less than 5 days for any specific fill berm. The use of a berm starts when it is constructed and ends when new fill is placed. When filling is complete and it is determined that a diversion is needed at the top of fill to protect the fill until it is stabilized then a **Temporary Diversion** is needed.

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The **Water Bar** is a non-engineered measure consisting of a channel with a supporting earthen ridge used on access and construction roads to intercept flows in the roadway that have a drainage area less than 1 acre and to force these flows off the roadway. When the drainage area is greater than one acre or the diversion is needed for more than one year, plan on using a **Temporary Stream Crossing, Permanent Diversion** and/or **Permanent Lined Waterway**.

The **Temporary Diversion** measure is a channel and associated berm used anywhere in and around the construction site where control of water flow is needed. It is limited to 1 year or less for use and a contributing drainage area of 5 acres or less. When the drainage area exceeds 1 acre, an engineered design is required. When the use exceeds 1 year or the drainage area exceeds 5 acres a **Permanent Diversion** is used.

The **Permanent Diversion** is an engineered measure that is used when a permanent installation is needed or when the implementation criteria are exceeded for a temporary diversion.

Diversion needs should be identified during the development of the erosion and sediment control plan. When used for keeping clean waters segregated from construction waters, grading and stabilization of diversions should be placed early in the construction sequence before other grading work occurs. For example, a **Temporary Fill Berm** may need to be replaced with a **Temporary Diversion** and **Temporary Pipe Slope Drains** after final grades are reached, to be maintained until the slope is stabilized and then removed.

As with any earthen structure, it is very important to establish adequate vegetation as soon as possible after installation. It is equally important to stabilize the drainage area above the diversion so that sediment will not enter and accumulate in the diversion channel.

All diversions require a stable discharge point. Temporary diversions installed internally to the construction area generally require a sediment barrier or trap at their point of discharge. Diversions installed around the perimeter may also require such controls if the diversion channel or berm is not stabilized before use. Temporary diversions used to protect unstable slopes may need **Temporary Pipe Slope Drains** to insure drainage areas to the diversion remain below the design requirements.

Temporary Fill Berm (TFB)

Definition

A very temporary berm of soil placed at the top of an unprotected fill slope.

Purpose

To divert runoff from unprotected fill slopes during construction to a stabilized outlet or sediment-trapping facility.

Applicability

- On active earth fill slopes where the drainage area at the top of fill drains toward the exposed slope and where ongoing fill operations make the use of a **Permanent Diversion** unfeasible.
- Where the intended use is 5 days or less. For use longer than 5 days use **Temporary Diversion** or other measure.
- Where the drainage area at the point of discharge is less than 3 acres.

Planning Considerations

Good timing is essential to fill construction. The filling operation should be completed as quickly as possible and the permanent slope stabilization measures installed. With prompt and proper construction, the landowner or contractor will save both time and money in building, repairing and stabilizing the fill area. The longer the time period for construction and stabilization, the more prone the fill will be to being damaged by erosion. Repairing the damage adds additional time and expense to the project. At times the erosion on these slopes can be difficult to reach with standard equipment.

The temporary fill berm is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed By directing runoff water to a predetermined point of discharge problems can be reduced at the discharge point and steps taken to minimize potential damage. This measure can also reduce time and money spent repairing slopes by reducing their exposure to rilling during fill slope construction. A stable outlet is critical to the proper function of the temporary fill berm. If the runoff is diverted over the fill itself, the practice will cause erosion by concentrating water at a single point.

Points of discharge must be directed to a sediment impoundment or barrier. Clean off-site water should be diverted around or culverted through the construction site If a **Temporary Pipe Slope Drain** is used, the drainage area at the point of discharge can sometimes be kept below 1 acre, which allows for a geotextile silt fence or hay bale barrier as the sediment control. However, if the drainage area exceeds 1 acre, sediment traps and/or sediment basins must be used.

Once the slope is brought to a final grade the **Temporary Fill Berm** may need to be replaced with a **Temporary Diversion**, and associated water control measures such as **Temporary Pipe Slope Drain** or **Temporary Lined Chute** may be needed until the slope is stabilized.

Specifications

Limitations

Use the following criteria for installing the measure:

❍ *The drainage area at the point of discharge is 3 acres or less. (Drainage area at the point of discharge can be controlled by using the* ***Temporary Pipe Slope Drain*** *measure.)*

❍ *The berm is at least 9 inches high with a base width of at least 3.0 feet.*

❍ *The up slope side of the berm slope is no steeper than 3:1, the down slope side of the berm slope is no steeper than 1:1, and the down slope toe of the berm is not closer than 2 feet from the top of the fill slope.*

❍ *The flow line controlled by the berm has a positive grade no steeper than 2%.*

Construction

Construct and shape the temporary fill berm following the completion of fill placement on any given day. A grader or dozer with its blade tilted may be run near the top of the fill slope, creating a berm along the top of the fill slope as depicted in **Figure TFB-1**.

Install erosion controls at the point of discharge as conditions dictate. Associated erosion control measures may include a **Temporary Pipe Slope Drain** to carry runoff down an unstable slope, and a **Geotextile Silt Fence**, **Hay Bale Barrier** or **Temporary Sediment Trap** to filter runoff and detain sediments.

Maintenance

Inspect the temporary fill berm and associated controls at the end of each work day to ensure the criteria for installing the measure have been met. Determine if repair or modification of the berm and associated measures are needed. Make modification and/or repair as needed.

This measure is temporary and under most situations will be covered the next work day. The maintenance required should be minimal. The contractor should avoid the placement of any material over the structure while it is in use. Construction traffic should not be permitted to cross the temporary fill berm.

Figure TFB-1 Illustration of Temporary Fill Berm

Definition

A channel with a supporting berm on the down slope side constructed across a construction access road, driveway, log road or other access way.

Purpose

- To minimize the concentration of sheet flow across and down sloping roadways and access ways, or similar sloping and unstable areas.
- To shorten the continuous flow length within a sloping right-of-way.

Applicability

- On construction access road, driveway, log road or other access way.
- Where the drainage area to each separate water bar is less than 1 acre. For drainage areas greater than 1 acre, use **Permanent Diversion** measure or **Permanent Lined Waterway** measure modified to remain stable during vehicular traffic or **Temporary Stream Crossing** measure.

Planning Considerations

The construction of utility lines, construction roads, access ways or roadways often require the clearing of long strips of ground over sloping terrain. The volume and velocity of storm water runoff tend to increase on these cleared strips of ground increasing the potential for erosion. To compensate for this loss of vegetation, it is usually a good practice to break up the flow length within the cleared strips so that runoff does not have a chance to concentrate and therefore cause erosion.

At proper intervals, water bars can significantly reduce the amount of erosion which can occur before the area is permanently stabilized. If the slope is composed of highly erodible soils, it may be appropriate to space the water bars closer than stated in the following measure.

Plan to construct the water bar to ensure there is sufficient clearance for the vehicles intend to use the access road. Consider the height of the vehicle's clearance in relation to the distance between the vehicle axles.

Unless the water bar discharges into a heavily vegetated area of sufficient length to adequately filter runoff, plan to settle or filter runoff water through a geotextile silt fence, hay bale barrier or temporary sediment trap. Since many access ways or roadways are constructed through heavily vegetated areas, runoff can often be diverted into a vegetated filter or buffer strip (see **Vegetated Filter** measure).

Specifications

Materials

For access ways or roadways where little or no construction traffic is expected, the water bars may be constructed of earth fill, gravel or graded stone.

Height

From the bottom of the channel to the crest of the berm the minimum vertical distance is 9 inches and the maximum is 18 inches (see **Figure WB-2**).

Side Slopes

Side slopes are 2:1 or flatter. Adjust the side slopes to accommodate vehicle clearance and wheel base requirements.

Base

Minimum base width of the berm is 6 feet (see **Figure WB-2**).

Length

Span the water bar completely across the access way or roadway.

Spacing

Figure WB-1 is used to determine the maximum spacing of the water bar.

Figure WB-1 Spacing of Water Bars

% Slope of access way or roadway	Spacity (feet)
1%	400
2%	245
5%	125
10%	78
15%	58

Grade

Provide positive drainage with 2% or less slope along the up slope side of the water bar (see **Figure WB-2**).

Outlet

Discharge the water bar to a stabilized outlet, sediment-trapping facility, or a vegetated filter of adequate size.

Construction

1. Install the water bar as soon as the access way or roadway has been cleared and/or graded.

2. Tamp or compact all earthen berm portions of the water bar.

3. When slopes vary between water bars, space the water bars using the maximum spacing given for the steepest gradient found between the water bars.

4. Adjust the field location of the outlet as needed to utilize a stabilized outlet area, without violating the spacing restrictions.

Maintenance

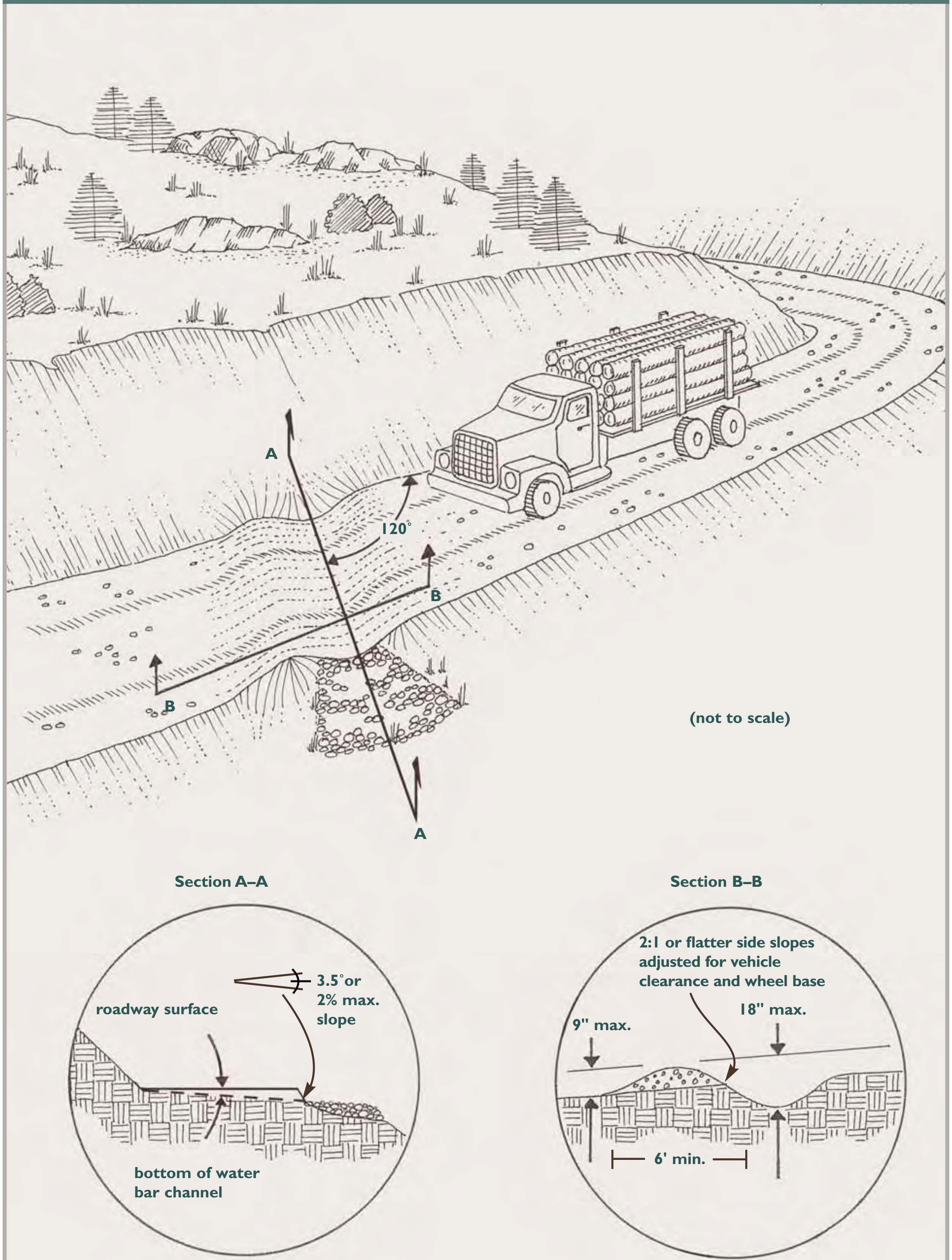
For water bars receiving drainage from disturbed areas, inspect and perform any repair work at the end of each day that the water bar is exposed to vehicular traffic and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater. For water bars receiving drainage from stable areas inspect and perform any repair work at the end of each day that the water bar is exposed to vehicular traffic or annually, whichever comes first.

Immediately reshape and repair any observed damage to the water bar.

If sediment deposits reach approximately one-half the height of the water bar, remove the accumulated sediments.

When the water bars have served their usefulness they may be removed.

Figure WB-2 Water Bar Details



Temporary Diversion (TD)

Definition
A temporary channel with a berm of tamped or compacted soil placed in such a manner so as to divert flows.

Purposes
- To divert sediment-laden runoff from a disturbed area to a sediment-trapping facility such as a temporary sediment trap, sediment basin or vegetative filter.
- To direct water originating from undisturbed areas away from areas where construction activities are taking place.
- To fragment disturbed areas thereby reducing the velocity and concentration of runoff.

Applicability
- Where the drainage area at the point of discharge is 5 acres or less. For drainage areas greater than 5 acres use **Permanent Diversion** measure.
- Where the intended use is 1 year or less. For uses greater than 1 year use **Permanent Diversion** measure.

Planning Considerations
A temporary diversion is used to divert sheet flow to a stabilized outlet or a sediment-trapping facility. It is also used during the establishment of permanent vegetative cover on sloping disturbed areas. When used at the top of a slope, the structure protects exposed slopes by directing runoff away from the disturbed areas. When used at the base of a disturbed slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

Temporary diversions must be installed as a first step in the land-disturbing activity and must be functional prior to disturbing the land they are intended to protect.

Where channel grades within the temporary diversion exceed 2%, stabilization of the channel is necessary to prevent erosion of the temporary diversion itself (e.g., temporary seeding, temporary erosion control blankets, riprap, etc.). The channel and berm must have a positive grade to assure drainage, but if the gradient is too great, precautions must be taken to prevent channel erosion due to high-velocity flows behind the berm. The cross-section of the channel should be of a parabolic or trapezoidal shape to prevent a high velocity flows which could arise in the bottom of a "V" shaped ditch.

This practice is economical because it uses materials available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the berm with vegetation. Temporary diversions are durable, inexpensive, and require little maintenance when constructed properly. When used in conjunction with a **Temporary Sediment Trap**, temporary diversions become a logical choice for a control measure when the control limits for silt fences or hay bale barriers have been exceeded.

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

Design Criteria
No engineered design is required for a temporary diversion if the contributing drainage area is 1 acre or less.

If the contributing drainage area exceeds 1 acre and is 5 acres or less, design the temporary diversion to the **Permanent Diversion** measure standards using the 2-year frequency storm as the design storm.

Specifications
For engineered temporary diversions, construct the temporary diversion in accordance with the design standards and specifications. For all non-engineered temporary diversions, comply with the following specifications.

Height
The minimum height from the bottom of the channel to the top of the berm shall be at least 18 inches and the berm constructed of compacted material.

Side Slopes and Top Width
Side slopes shall be 3:1 or flatter inside and 1:1 or flatter outside. The top width of the berm shall be 1 foot.

Grade and Stabilization
The flow line behind the berm shall have a positive

grade. Channel grades flatter than 2% require no stabilization. Channels with grades steeper than 2% require stabilization in accordance with stabilization specifications found in the **Permanent Diversion** measure. Temporary diversions shall be stabilized according to the duration of their intended use (see Short Term Non-Living Soil Protection Functional Group).

Outlets

Regardless of design, release the diverted runoff to a stable outlet or channel. Where diverted runoff is expected to be carrying a sediment load, the runoff shall be released to a sediment impoundments (see Sediment Impoundments and Barriers Functional Group).

Construction

Install erosion controls at the outlet where sediment laden runoff is expected.

Construct the temporary diversion (see **Figure TD-1**). After grading the berm, tamp or compact it to prevent failure.

Apply stabilization measures (may include temporary or permanent seed and mulch) immediately following construction.

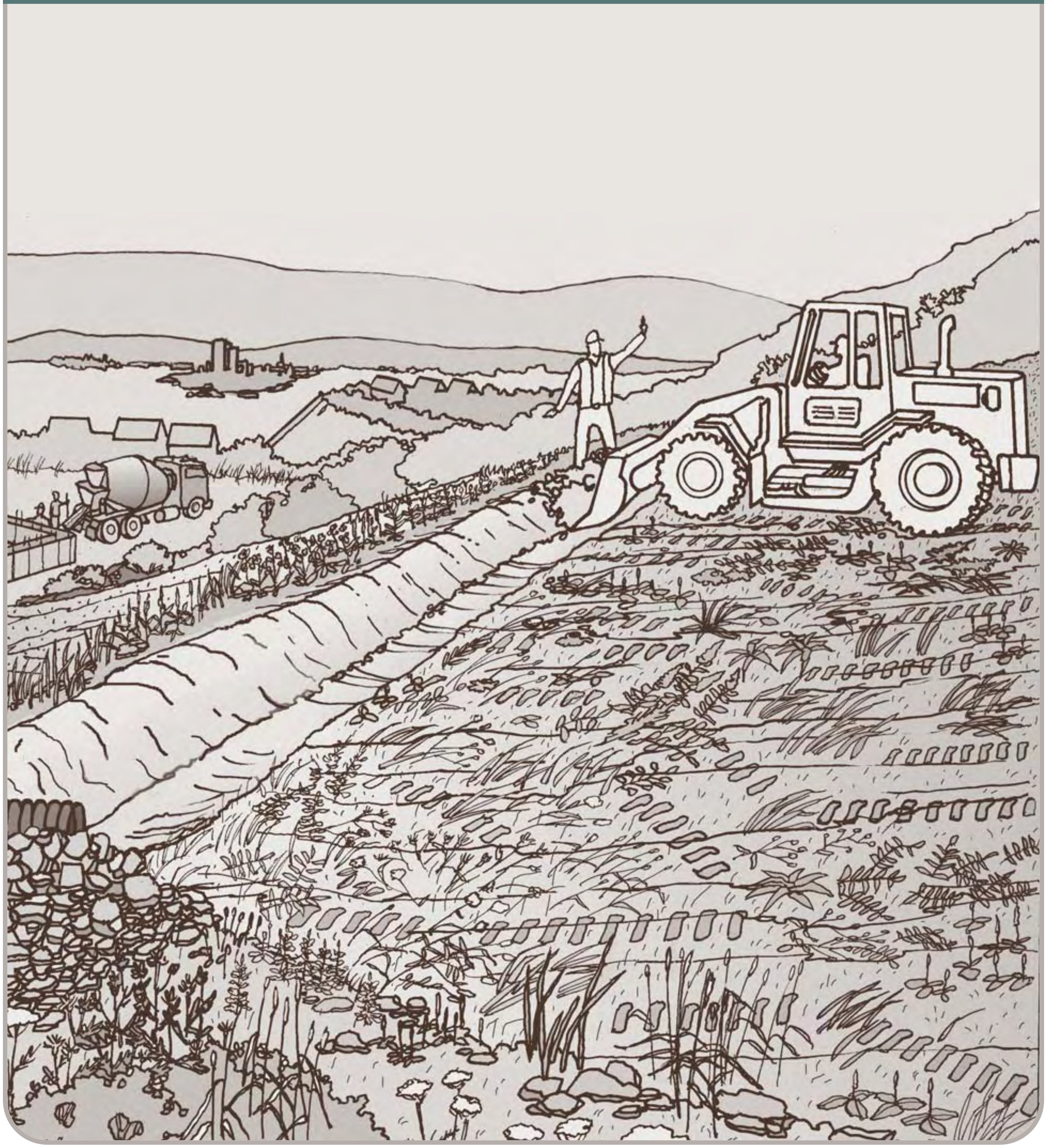
Maintenance

When the temporary diversion is located within close proximity to ongoing construction activities, inspect the temporary diversion at the end of each work day and immediately repair damages caused by construction equipment. Otherwise inspect the temporary diversion and any associated measures weekly or immediately after 0.5 inch of rain falls within a 24-hour period to determine maintenance needs.

Repair the temporary diversion and any associated measures within 24 hours of observed failure. Failure of the temporary diversion has occurred when the diversion had been damaged by either construction equipment, erosion or siltation such that it no longer meets the criteria established under the **Specifications** section or provided in the engineered design (if any).

When repetitive failures occur at the same location, review conditions and limitation for use and determine if additional measures are needed to reduce failure rates or if alternate measures are indicated to replace the temporary diversion.

Figure TD-1 Requirements for Non-Engineered Temporary Diversions



Permanent Diversion (PD)

Definition

A channel constructed across a slope with a supporting earthen ridge on the lower side.

Purpose

- To increase slope length and reduce erosive velocities.
- To intercept and divert storm water runoff to a stabilized outlet.
- To protect downgradient areas from erosion and sedimentation.

Applicability

- Where the contributing watershed is 25 acres or less. For watersheds with a drainage area greater than 25 acres, either use **Permanent Lined Waterway** or **Vegetated Waterway**.
- Where the diversion is to be included as an integral part of a permanent water management system.
- Where runoff from areas of higher elevation may damage property, cause erosion, or interfere with the establishment of vegetation on lower areas.
- Where surface and/or shallow subsurface flow is damaging sloping uplands.
- Where the slope length needs to be reduced to control excessive overland flow velocities and minimize soil loss.

Planning Considerations

Diversions are useful tools for managing surface water flows and preventing soil erosion. On moderately sloping areas, they may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion. They may be placed at the top of cut or fill slopes to keep runoff from upland drainage areas off the slope. They can also be used to protect structures, parking lots, adjacent properties, and other special areas from flooding. When properly coordinated into the landscape design of a site, permanent diversions can be visually pleasing as well as functional. (see **Figure PD-2**)

The supporting ridge of the permanent diversion may be constructed from soil excavated from the channel if the soil excavated meets the installation requirements for ridge construction. If it is known at the planning stage that the soil will not meet the installation requirements, then plan on importing soil which is adequate to meet the installation requirements.

Should permanent seeding (as opposed to stabilizing with stone) of the top and outside of the ridge be planned for ridge stabilization, then plan on requiring the use of topsoil and seed bed preparation in accordance with the **Topsoiling** and **Permanent Seeding** measure.

Maintenance requirements should be planned in accordance with the intended use.

Design Criteria

Design the permanent diversion according to generally accepted engineering standards (e.g., NRCS National Engineering Handbook – Part 650, the NRCS Field Office Technical Guide – Section IV, DOT Drainage Manual).

Location

Determine the permanent diversion location by considering outlet conditions, topography, land use, soil type, length of slope, seepage planes (i.e., seepage breakout locations where seepage is expected to be a problem) and the development layout.

Capacity

Design the minimum capacity to safely carry the peak flow expected from a 10-year frequency, 24-hour duration storm with a freeboard of at least 0.3 feet. (see **Figure PD-1**).

Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high-risk areas, and those designed to function in connection with other storm water management systems, shall be designed at a minimum to safely carry the peak flow from a 25- year frequency, 24-hour duration storm with a freeboard of at least 0.3 feet.

If a contributing or receiving drainage system is designed to a standard greater than the 10-year frequency storm, then design the permanent diversion to that higher standard. If pre-development flooding problems exist or if the consequences of flooding are severe, then consider increasing the capacity beyond the 10-year frequency storm. If drainage systems which convey larger storms converge with the diversion in question, design the diversion to the same design storm as the contributing drainage system.

Channel Design

The diversion channel may be parabolic, trapezoidal or "V" shaped and shall be designed in accordance with the **Vegetated Waterway** measure or **Permanent Lined Waterway** measure.

Ridge Design

The supporting ridge cross-section shall meet the following criteria (see **Figure PD-1**):

1. The side slopes shall be no steeper than 2:1.
2. The width at the design water elevation shall be a minimum of 4 feet.
3. The minimum freeboard shall be 0.3 feet.
4. The design shall include a 10% settlement factor.

Provide for soil stabilization of the top and outside portions of the ridge in accordance with the intended use.

Outlet

Provide the permanent diversion with a stable outlet which will reduce the energy of concentrated discharge so as not to cause downstream erosion.

Installation Requirements

Site Preparation

Remove and dispose of all trees, stumps, obstructions, and other objectionable material so as not to interfere with the proper functioning of the diversion.

Excavate or shape the diversion to line, grade, and cross-section as required to meet the criteria specified herein. Ensure the diversion profile is free of irregularities which will impede flow, cause scouring and/or sediment deposition.

Place, grade and compact fill to prevent unequal settlement. Fill shall be composed of soil which is free from excessive organics, debris, large rocks (over 3-inch diameter) or other objectionable materials.

Spread or dispose of all earth removed and not needed in construction.

Stabilize Diversion

Stabilize the diversion in accordance with the design plans.

Install Sediment Controls for Contributing Areas

Install sediment controls to trap sediment before it enters the diversion. Field experience has demonstrated that many newly constructed vegetated channels become damaged from sediment deposition and require costly repairs as a result of improper up slope protection and control measures.

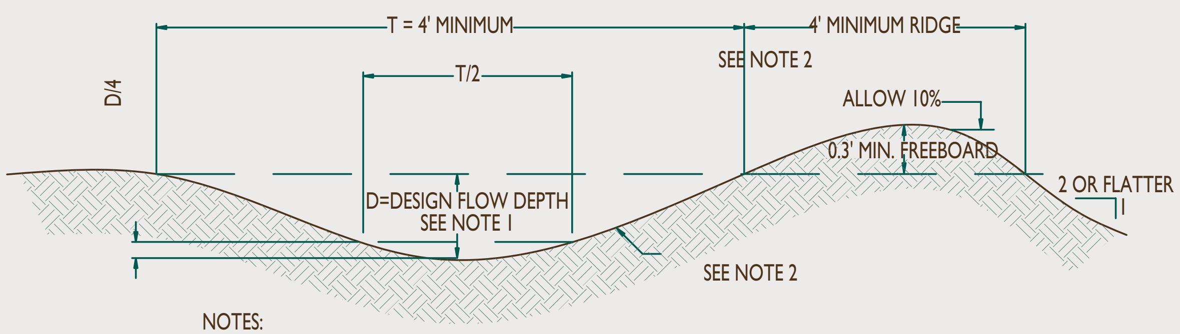
Maintenance

Inspect the permanent diversion at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater during construction of the site and until the diversion is permanently stabilized. For seeded and mulched channels, see **Permanent Seeding** measure Maintenance Section for initial establishment and first mowing requirements. Check for seed and mulch movement and/or rill erosion. For sodded channels, see **Sodding** measure Maintenance Section.

Repair damage to vegetated channels immediately. Remove sediment from the channel and make repairs as necessary.

After construction is complete and the diversion is stable, inspect the permanent diversion annually and after each major rainfall for damage and deterioration. Repair damages immediately. Ongoing maintenance should include the removal of accumulated sediment

Figure PD-1 Permanent Diversion

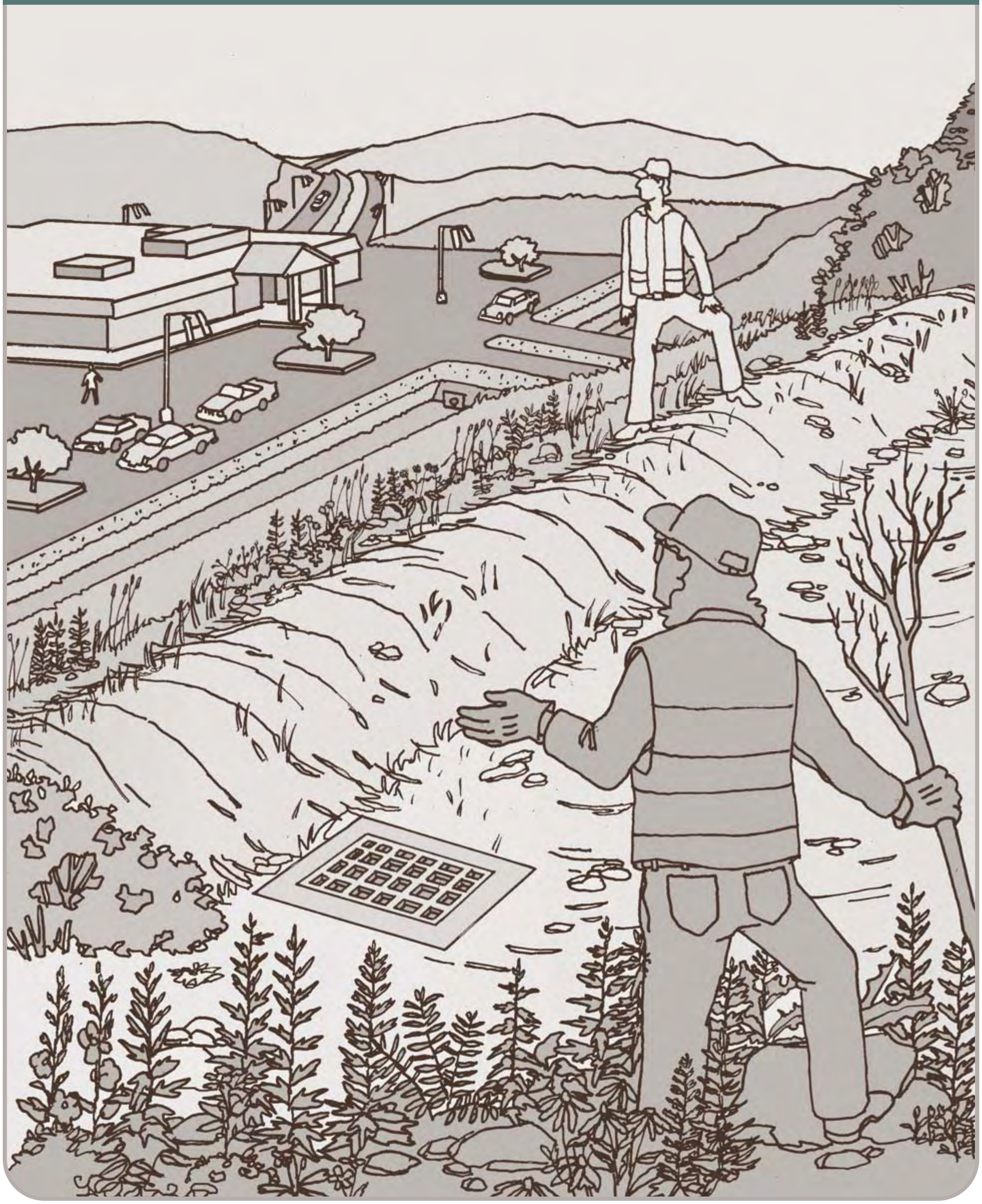


NOTES:

1. MINIMUM DESIGN CAPACITY SHALL CONVEY A 10 YR. - 24 HOUR PEAK FLOW WITHOUT EROSION.
2. INSTALL EROSION CONTROL BLANKETS OR TURF REINFORCEMENT MATS AS NEEDED FOR EROSION RESISTANCE.

Source: USDA-NRCS

Figure PD-2 Illustration of Permanent Diversion Intercepting Overland Flow



5-8 Subsurface Drains

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Planning Considerations

The only measure included in this group is **Subsurface Drain**. See the measure for planning considerations.

8-Subsurface Drain

Subsurface Drain (SD)

Definition

An underground water conveyance system consisting of a perforated conduit, such as pipe, tubing, tile or a stone filled trench installed beneath the ground to intercept and convey ground water (see **Figure SD-1**).

Purpose

- To prevent sloping soils from becoming excessively wet causing sloughing.
- To improve the bearing capacity of soils.
- To reduce frost heaving of fine grained soils.
- To prevent hydrostatic pressures from developing behind retaining walls, foundations or floor slabs and to reduce cracking and heaving of pavement.
- To relieve artesian pressures.
- To lower water tables in vegetated waterways and diversions in order to maintain stable vegetative conditions.
- To drain storm water detention areas or structures.

Applicability

- Used in areas having a high water table where benefits of lowering or controlling groundwater or surface runoff are desired.
- Where soil permeability is sufficient to permit installation of an effective and economically feasible system.
- Not intended for use within septic system setbacks, in areas of ground water pollution, or to drain inland wetlands or tidal wetlands without prior authorization.

Planning Considerations

Subsurface drains are generally installed within a slope to lower the water table (see **Figure SD- 2**).

Subsurface drainage systems are either relief drains or interceptor drains (sometimes called curtain drains) or a combination of both. Relief drains are used either to lower the water table in order to keep structures (e.g. basements) dry or to improve the growth of vegetation. They are generally installed along a slope, draining in the direction of the slope and are provided with a stable outlet. They can be installed in a parallel pattern, a herringbone pattern, or a random pattern (see **Figure SD-3**).

Interceptors are used to remove water as it seeps down a slope, to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and are provided with a stable outlet.

A lowering of the groundwater table through the installation of a subsurface drain may have legal implications in that it may dewater adjacent wetlands as well as affect the property rights of adjacent owners. Damage may also occur at or near the point of discharge. Also, consolidation of soils and settlement of the soils and the structures they support can occur in some cases.

The design drawings and installation shall comply with applicable federal, state and local laws and regulations. The landowner or developer is responsible for obtaining required permits. Drains shall comply with septic system setback and setbacks established for known ground water pollution.

Design Criteria

The design and installation of subsurface drains shall be based on detailed surveys and investigations. Where failure could cause damage to structures such as roadways, buildings or utilities a more detailed engineering design may be required than that provided below.

Capacity

The required capacity for interceptor drains shall be determined by **Figure SD-4**.

Size of Drain

If a pipe is used in the drain installation, the minimum size shall be 4" diameter. If a stone filled trench is used without a conduit, the minimum size of the voids in the stone of the drain shall be equivalent to a 4" diameter conduit. The designer should check with the reviewing and approving authorities for differing minimum and maximum sizes of conduit. Manning's formula may be used to size the drain when the hydraulic grade line is parallel to the bottom grade of the drain (see **Equation SD-1**).

Figure SD-1 Subsurface Drains With and Without a Conduit

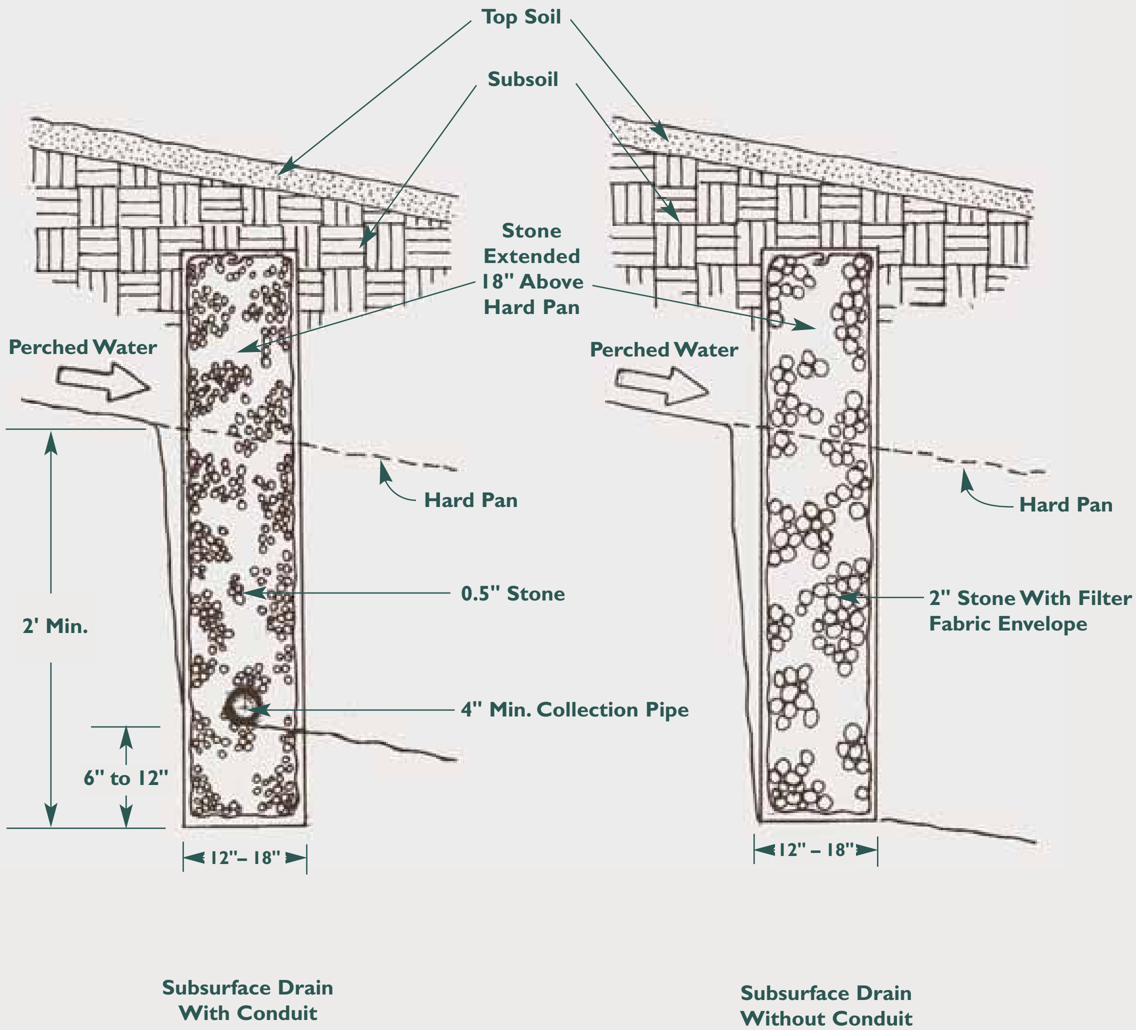
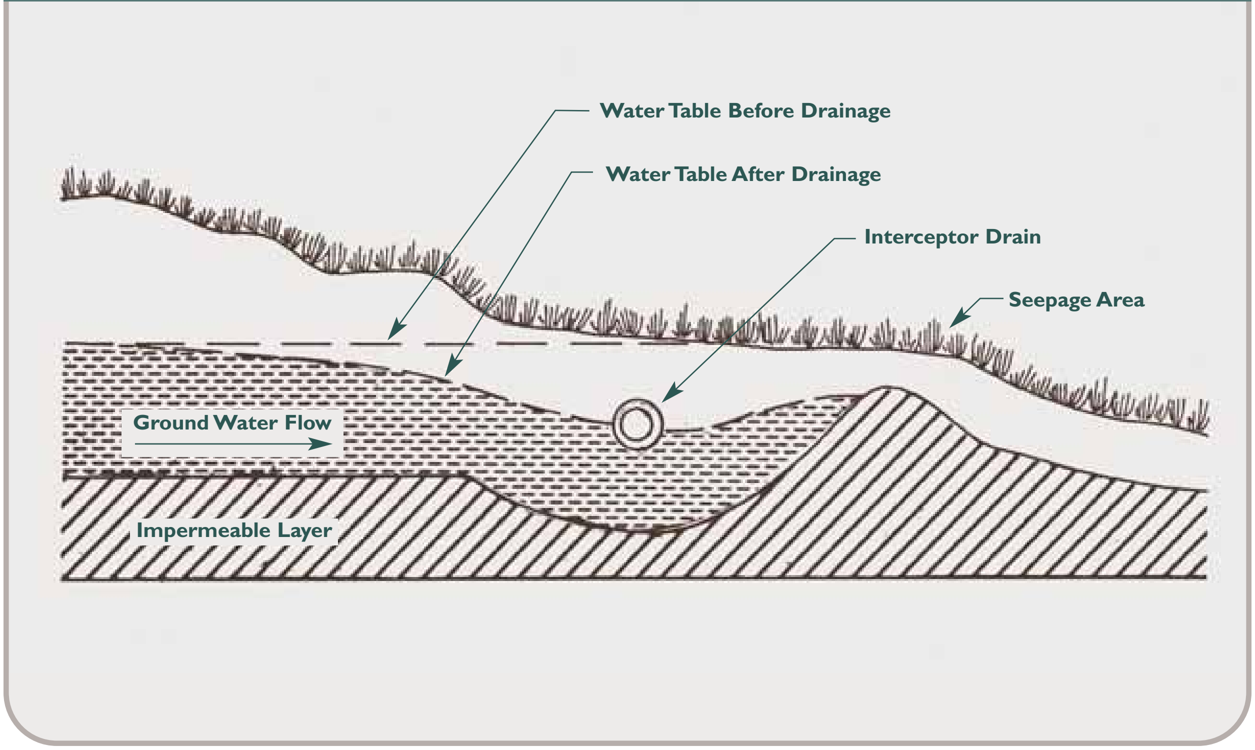
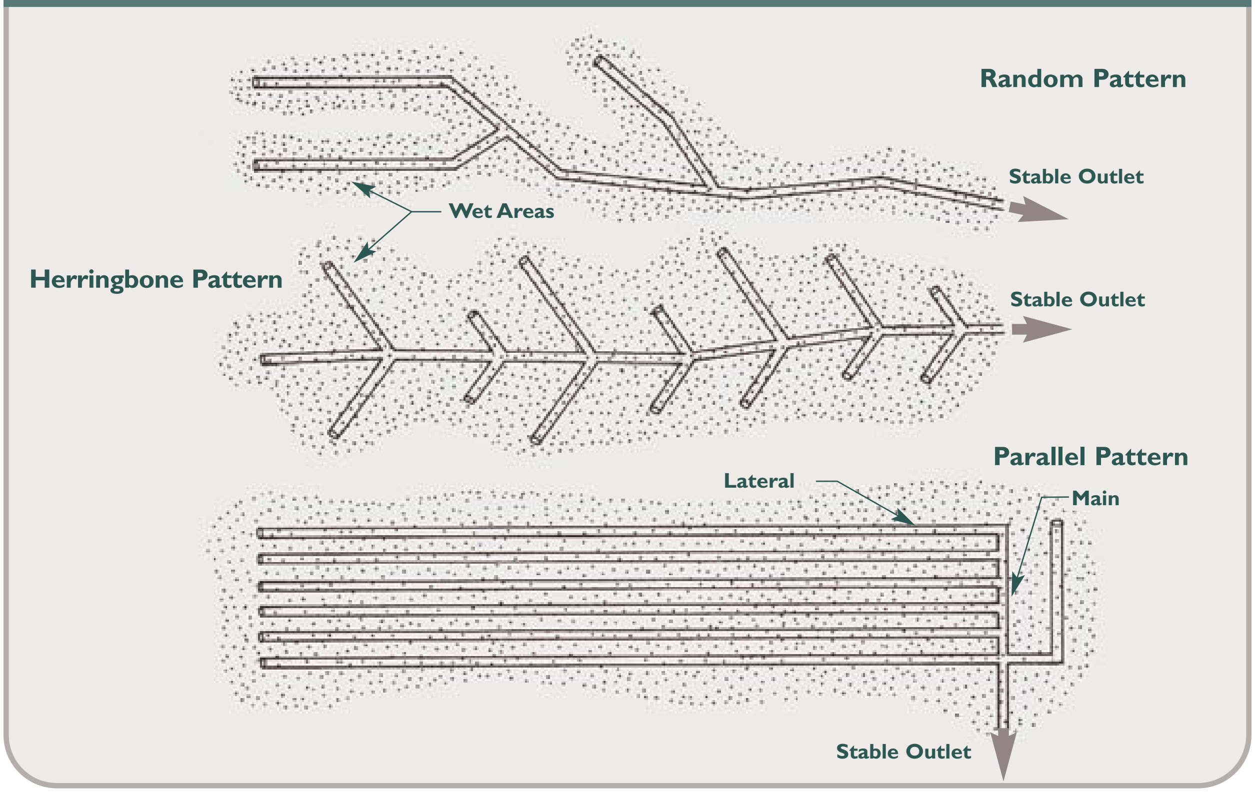


Figure SD-2 Effect of Subsurface Drainage on the Water Table



Source: USDA-NRCS

Figure SD-3 Subsurface Drain Layouts



Source: USDA-NRCS

Equation (SD-1) Manning's Formula

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

Where Q = volume of flow
V = the average velocity in the drain (ft./sec.)
A = Cross-sectional area of the flow within the pipe
n = Manning's roughness coefficient, based upon the lining of the drain
(n=.011 for PVC pipe, n=.015 for corrugated plastic pipe, n=.025 for corrugated metal pipe)
R = the hydraulic radius (feet)
S = the slope of the drain (feet/foot)

Simple interceptor drains or random drains may be designed without calculating a discharge "Q", if the total length of drains does not exceed the maximum lengths in **Figure SD-5**, provided surface flow or unusually heavy spring flows are not added to the drain. Note: When using design grades flatter than 0.5%, a sand-aggregate envelope and/or a geotextile wrap is recommended around the pipe to prevent migration of fines into the pipe.

Use **Figure SD-7**, **Figure SD-8** and **Figure SD-9** for determining drain pipe diameters for various tile materials.

Figure SD-4 Inflow Rates

Soil Texture	Unified Soil Classification[1]	Inflow rate of 1,000 ft. of line in cfs[2]
Coarse Sand & Gravel	GP, GW, SP, SW	0.15 to 1.00
Sandy Loam	SM, SC, GM, GC	0.07 to 0.25
Silt Loam	CL, ML	0.04 to 0.10
Clay and Clay Loam	CL, CH, MH	0.02 to 0.20

[1] Obtain Unified Soil Classification from the County Soil Survey or perform laboratory analysis.
[2] Required inflow rates for interceptor lines on sloping land should be increased by 10% for slopes 2% to 5%, 20% for slopes 5% to 12% and 30% for slopes over 12%.

Source: USDA-NRCS

Figure SD-5 Design of Random or Interceptor Drains

Minimum Grade of Drain (%)	Maximum Length (feet) 4" Drain	Maximum Length (feet) 6" Drain
0.1	300'	800'
0.2	400'	1200'
0.3	500'	1500'
0.4	600'	1700'
0.5	700'	1900'
1.0	900'	2700'
1.5	1100'	3300'
2.0	1300'	3800'
2.5	1500'	4200'
3.0	1600'	4600'
4.0	1800'	5400'
5.0	2000'	5800'

Location

Subsurface drains shall not be installed in areas where there is danger of pollutants entering the line. Refer to state health code for minimum distance between subsurface drains and septic drain fields.

Note: *Do not install drains where contaminated and/or hazardous soils may exist.*

Relief drains: Relief drains should be located through the center of wet areas. They should drain in the same direction as the slope.

Interceptor drains: Interceptor drains should be located on the uphill side of wet areas. They should be installed across the slope and drain to the side of the slope.

Depth

The minimum depth of cover over conduits shall be 24 inches. This minimum depth shall apply to normal ground levels and may exclude sections of line near the outlet, or sections laid through minor depressions. The minimum depth of cover may be reduced if stronger load resistant pipe is used or if a sleeve is installed around the drain. This may also be used where heavy vehicle crossings are expected. A relief drain will need to be installed deep enough to lower the groundwater surface to the levels desired. An interceptor drain will need to be installed deep enough to intercept and remove the water as intended.

Figure SD-6 Maximum Recommended Velocities by Soil Texture Without Piping Protection

Soil Texture	Velocity (ft./sec.)
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silty clay loam	6.0
Clay and clay loam	7.0
Coarse sand or gravel	9.0

Source: USDA-NRCS

Spacing

Relief drains – Design relief drains in a uniform pattern having equal spacing between drains at a uniform depth. Spacing between drains is dependent on soil permeability and the depth of the drain. (NAVDOCS-7.1 can be consulted as a reference.)

Interceptor drains – Interceptor drains may be either singular or multiple. If multiple drains are used, the required spacing is dependent upon the site condition and desired results. The best approach is to install the first drain, then if seepage or high water table problems occur down slope, install an additional drain an appropriate distance down slope.

Minimum Velocity and Grade

For systems whose drainage velocity is less than 1.4 feet per second the design should incorporate filters or sediment clean outs. Relief wells or breather pipes should be installed at abrupt changes in grade to equalize pressures and facilitate clearing of the pipe.

On sites where topographic conditions require that drain lines or the discharge conduits from the drain lines need to be placed on steep grades and the design velocities will be greater than indicated in **Figure SD-6**, special measures shall be used to protect against soils surrounding the pipe from entering the pipe, thus creating a "piping" failure in the soils around the pipe. The protective measures may include one or more of the following:

(1) sealing joints and using a watertight pipe or non-perforated continuous pipe, or

(2) enclosing continuous perforated pipe or pipe with geotextile material and/or properly graded sand and gravel.

Envelopes and Filters

Envelopes shall be used around subsurface drains where required for proper bedding of the conduit, piping protection, or where necessary to improve the flow characteristics of ground water into the conduit. Filters for drains are used to facilitate passage of water to the drain and to prevent movement of fine particles of silt and sand into the drain. The engineer determines if conditions warrant the designing and installation of a filter. Materials used for envelopes do not **always** need to meet the gradation requirements of filters, but they shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit. Envelopes shall **at a minimum** consist of sand-gravel materials, all of which shall pass a 1.5 inch sieve, 90% to 100% shall pass a 0.75 inch sieve, and not more than 10% shall pass a No. 60 sieve. The thickness of the envelope shall be at least 4 inches.

A good filter should be well graded from coarse to fine and within a limited size range of particles. Concrete sand, as specified by the American Association of State Highway Officials (AASHO), has been found to meet the requirements of an adequate filter for most soil conditions encountered. This material is essentially a mixture of medium and coarse sand with fine and medium gravel, in which the particles are well graded from a minimum size of about 1/6 mm (grains held on a No. 100 sieve) to a maximum of about 9.5 mm. If proposed, locally available gravel should be checked for the gradations as specified in the design. A sand-gravel filter, in addition to its filtering action, provides excellent bedding material for cushioning tile and pipe when laid in the stony soils frequently encountered.

Geotextiles may be used provided opening sizes, strength, durability, and permeability are adequate to provide filtering and capacity requirements throughout the expected life of the system.

Filter material, other than the manufactured types, shall completely encase the pipe with a thickness of at least 4 inches. The trench in which the drain is to be placed shall be a minimum of 12 inches wide and shall be excavated below grade a depth equal to the thickness of filter. The trench shall then be filled to the grade of the pipe with the filter material before laying the pipe. After the pipe is laid, the trench shall be filled with filter material to the required depth. Place filter material over the drain to within 1 foot of the ground surface when interception through heavy soil is desired and found practical. If surface water interception is desired, the filter material shall extend to the finished ground line.

For typical sections of subsurface drains refer to **Figure SD-10**, **Figure SD-11** and **Figure SD- 12**.

Outlet

An outlet for the drainage system shall be made available, either by gravity flow or by pumping.

The outlet shall be protected against erosion and undermining of the conduit, against damage during adverse weather conditions such as sunlight, submergence, or ice, and against entry of rodents or other animals into the subsurface drain system.

A section of pipe without open joints or perforations shall be used at the outlet end of the drain. The minimum length of outlet pipe shall be 8 feet. Non-perforated corrugated polyethylene drainage piping is not structurally strong enough nor weather resistant for use as the outlet pipe. Only rigid pipe or flexible pipe that can withstand anticipated loading and is resistant to damage from ultra violet light, fire, weathering and vandals shall be used.

Exposed PVC outlets shall be protected against damage by the use of headwalls, shading from the sun's rays or painting with a dark colored latex paint. PVC outlet pipe shall have a minimum wall thickness of 0.24 inch for 4 inch, 0.28 inch for 6 inch, and 0.32 inch for 8 inch.

The outlet pipe shall be cantilevered over the outlet ditch at least one foot above the normal elevation of low flow in the outlet channel. At least two-thirds of the pipe length shall be encased in backfill. No envelope material shall be used around the outlet pipe.

If ice or floating debris is a threat, the outlet shall be recessed to protect the cantilevered portion from the current in the ditch.

Headwalls used for drain outlets shall be designed to minimize washouts and undermining.

Animal guards shall have openings that are at a minimum 1.5 inches in both directions, with a maximum opening of 2 inches in one direction. Horizontal bars are preferred. Free swinging animal guards are also an acceptable alternative.

Prefabricated Curtain Drains

Several types of prefabricated curtain drains have been recently developed. Materials shall be selected as appropriate for the specific site conditions in accordance with manufacturer's recommendations.

Installation Requirements

1. Install perimeter erosion and sediment control measures as required.
2. Construct the trench starting at the outlet end working up the grade continuous with no reverse grades or low spots.
3. Install animal guards on the outlet pipe to prevent animals from entering the drain.
4. Stabilize soft or yielding soils under the drain with gravel or other bedding material.
5. Lay pipe to design grade and install relief wells and breather pipes as designed.
6. Do not use deformed, warped, or otherwise unsuitable pipe.
7. Place envelopes and filter material as specified with at least 4 inches of material on all sides of the pipe.
8. Immediately backfill after placement of the pipe. Hand labor is usually required to prevent crushing the pipe during backfilling operations. No sections of pipe shall remain uncovered overnight or during a rainstorm. Place backfill material in the trench in such a manner that the drain pipe is not displaced or damaged. Do not use backfill containing any stones larger than 2-inch diameter within 2 feet of the pipe.
9. Stabilize all areas disturbed by construction.

Maintenance

Inspect the outlets to subsurface drains annually to ensure that they are free-flowing, not clogged with sediment and the animal guards are in place. Keep the outlet clean and free of debris. Keep any surface inlets open and free of sediment and other debris. Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees.

Subsurface Drain: Design Examples

a. **Example 1**

A permanent diversion is to be constructed up slope of a house to divert runoff away from the house and to protect the house from surface water flooding. The diversion will outlet into a stone center waterway. The area up slope of the diversion location is in woods and is to remain in woods and will not be disturbed. The diversion will be constructed on Paxton fine sandy loam. The diversion will be seeded with a lawn grass mixture. The diversion will be a part of the backyard of the house and is expected to be mowed with the yard. The diversion will have a grade of 1%.

The Paxton soil has a fragipan (hard, relatively impervious layer) at a depth of about 2 feet and it is anticipated that a seep line will develop where the back yard is excavated into original ground. To intercept this seepage, perforated corrugated plastic pipe is planned. The pipe will extend the width of the lot (200 feet) plus an additional 200 feet to a suitable outlet.

Example solution: Determine the size of the piping from **Figure SD-5**. Using slope = 1%, length 400 feet, **is less than 900 feet**, select 4” size pipe.

b. **Example 2**

This problem is the same situation as above except that a large spring is present near the property line and the beginning of the drain. The flow from this spring is measured to be about 10 gallons per minute. The slope of the land uphill from the drain line is about 4%.

Example solution: Use **Figure SD-4.**

Soil = fine sandy loam, therefore use an average inflow rate of 0.16 cfs/1,000 feet. Increase by 10% because of 4% land slope uphill from drain.

Calculate inflow rate:
Equation SD-2

$$\text{Inflow Rate} = \frac{\text{Average Inflow Rate}}{1{,}000 \text{ ft}} \times \text{Pipe Length (ft)} \times \text{Increase}$$

$$= \frac{0.16 \text{ cfs}}{1{,}000 \text{ ft}} \times 400 \text{ ft} \times 1.10$$

$$= 0.07 \text{ cfs}$$

Convert inflow rate from spring 10 gal/min. to cfs.

$$10 \ \frac{gal}{\text{min}} \times \frac{1.0 \text{ ft}^3}{7.44 \text{ gal}} \times \frac{1.0 \text{ min}}{60 \text{ sec}} = .022 \text{ cfs}$$

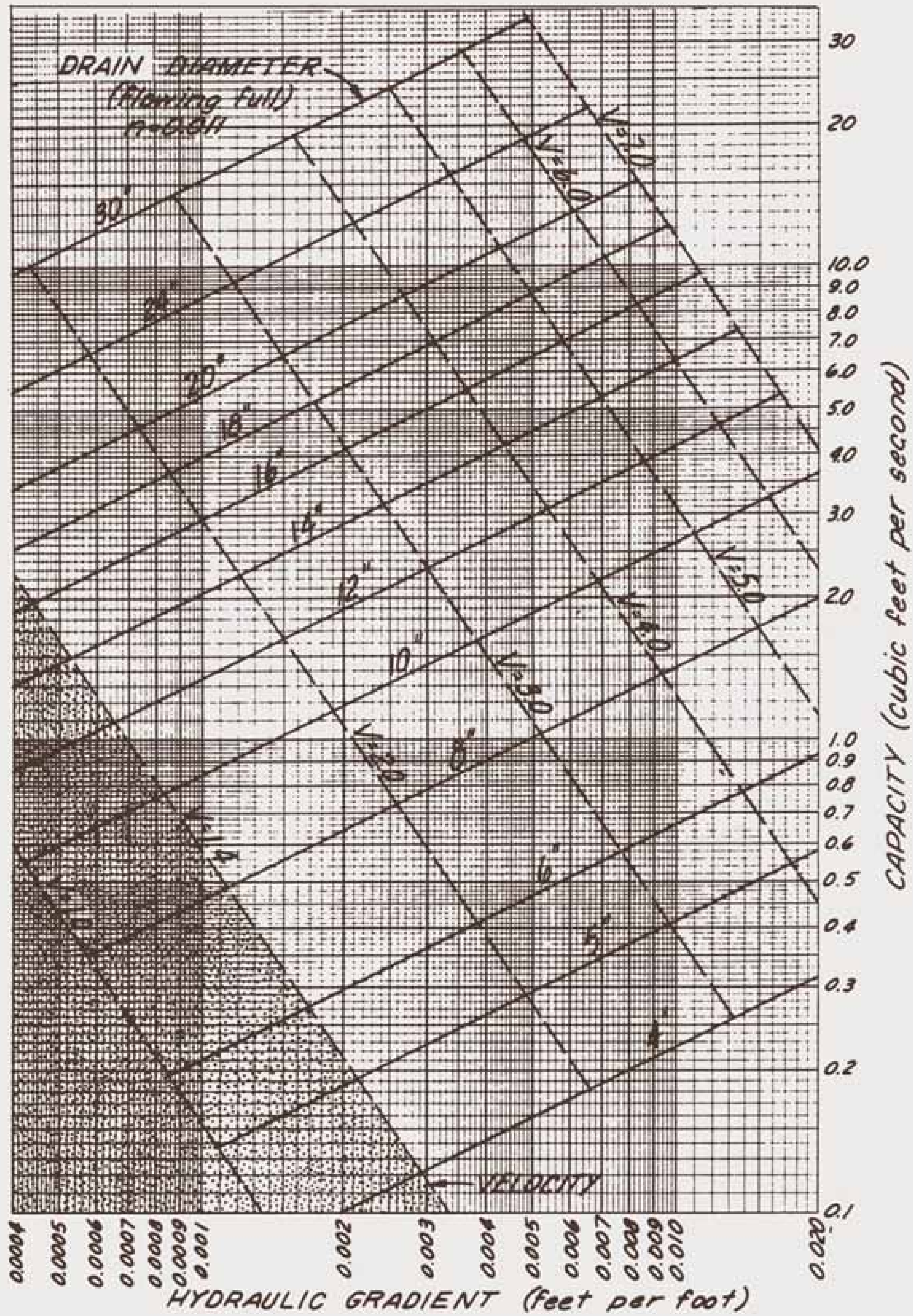
Select pipe size from **Figure SD-8** (n= 0.015 for corrugated plastic pipe).

Slope = 1%, discharge = 0.07 cfs. + 0.022 cfs. = 0.092 cfs

Find 4” corrugated plastic pipe is adequate. Note that velocity in the pipe will be about 1.7 feet per second.

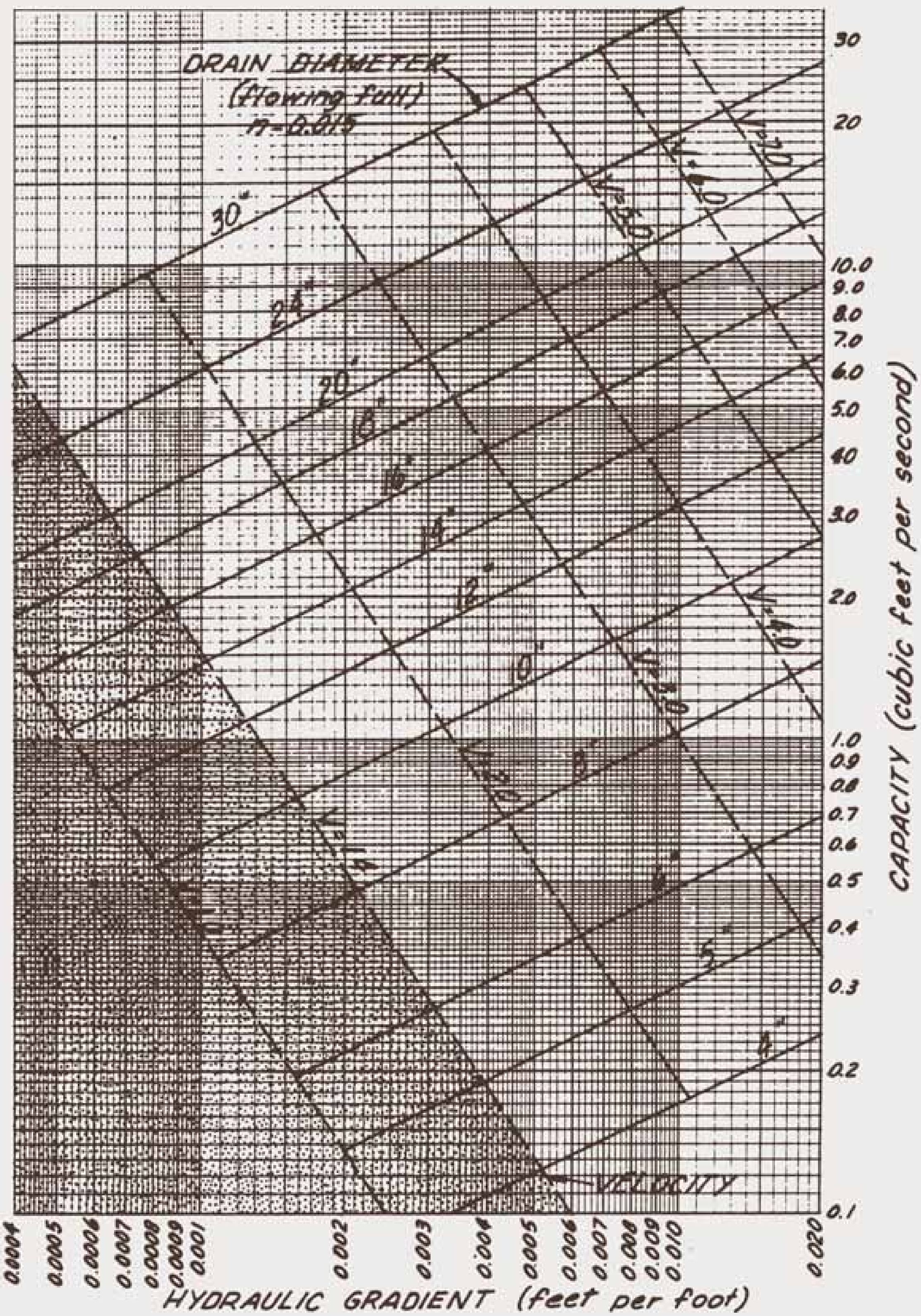
Source: USDA-NRCS

Figure SD-7 Drainage Capacity Chart for Smooth Plastic, Clay, or Concrete Tile (n=0.011)



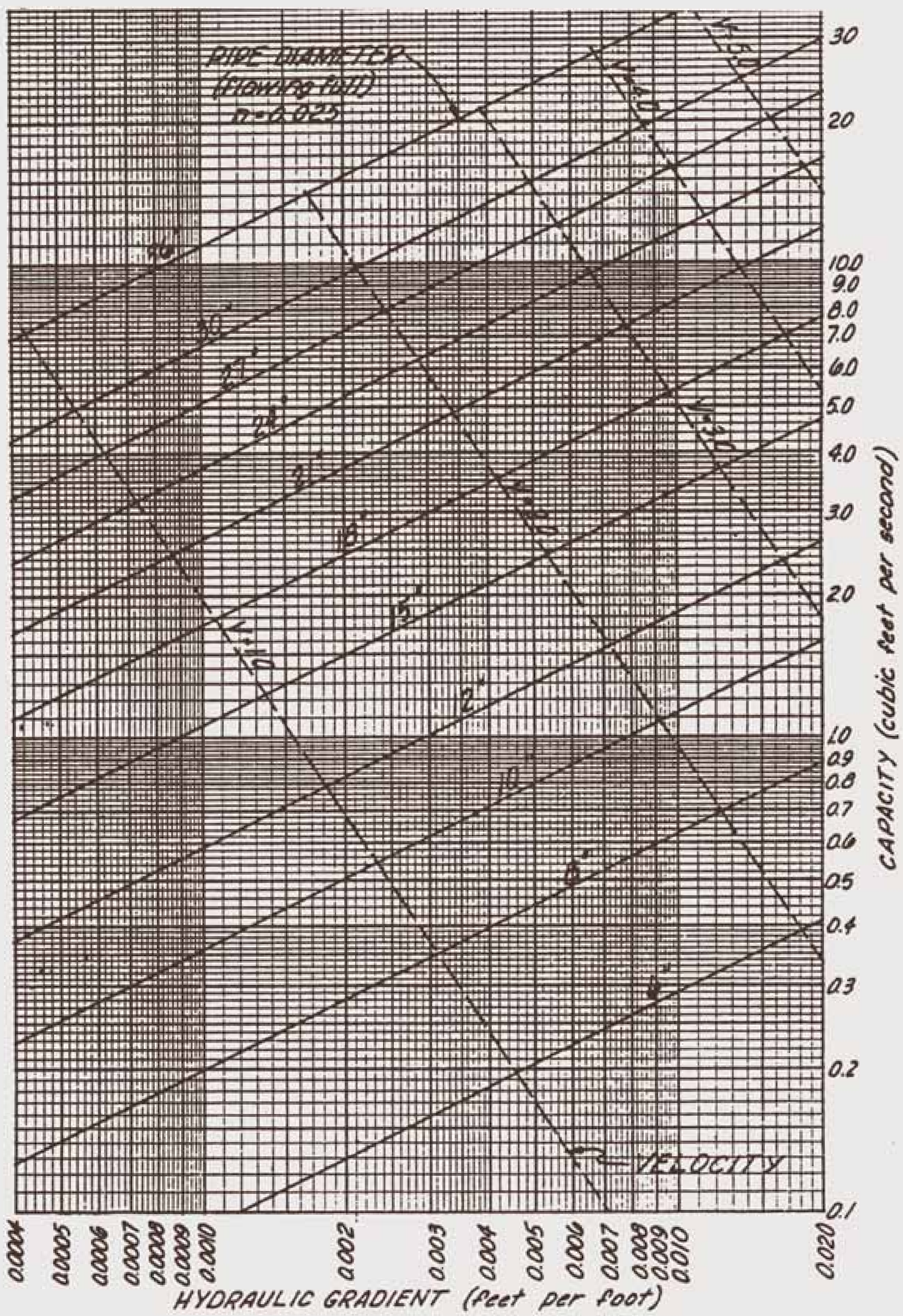
Source: USDA-NRCS

Figure SD-8 Drainage Capacity Chart for Corrugated Plastic Pipe (n=0.015)



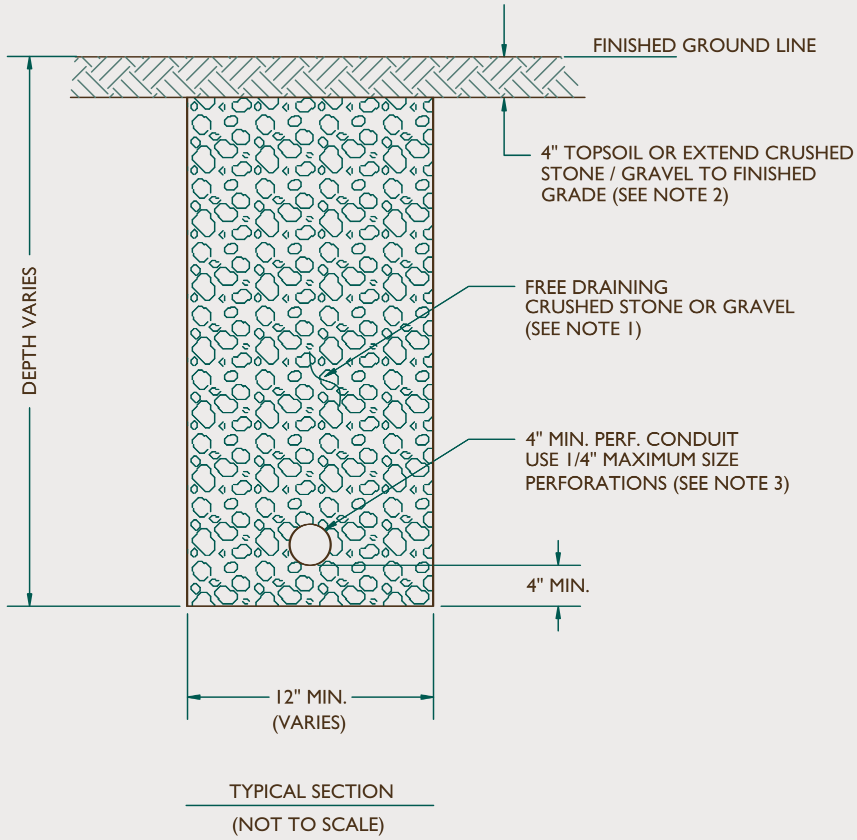
Source: USDA-NRCS

Figure SD-9 Drainage Capacity Chart for Corrugated Metal Pipe (n=0.025)



Source: USDA-NRCS

Figure SD-10 Typical Section of One-Zone Subsurface Drain
(Soils with Low Piping Potential)

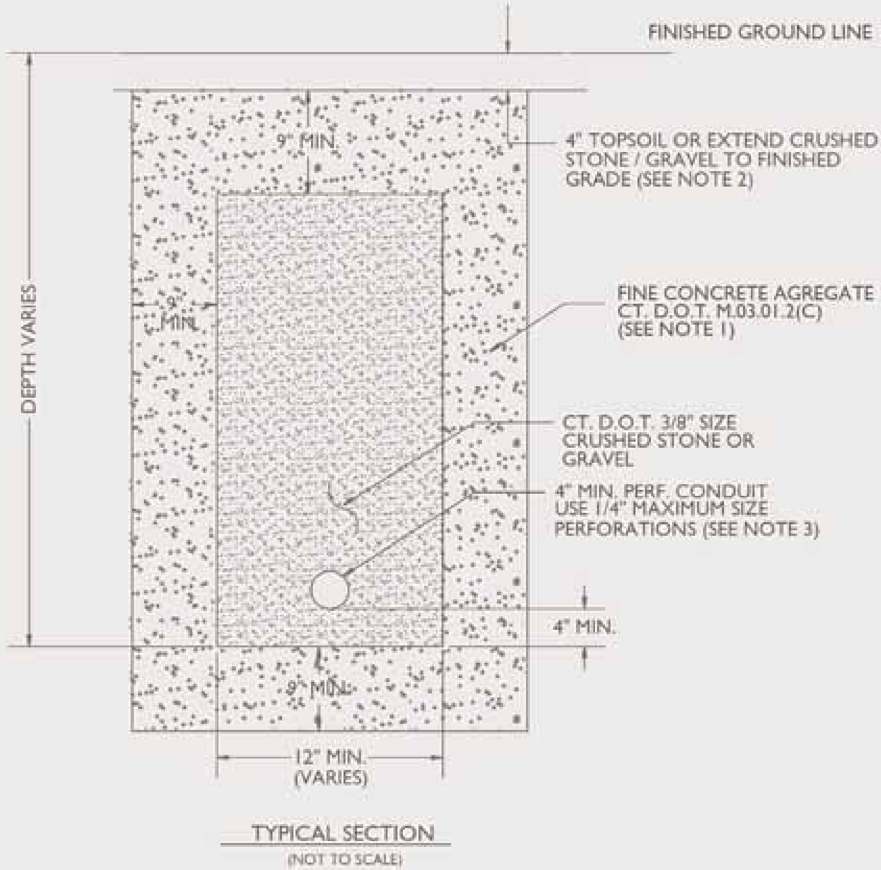


NOTES:

1. SEE NARRATIVE FOR GRADATION REQUIREMENTS OF ENVELOPE AND FILTER MATERIALS.
2. IF SURFACE WATER IS TO BE INTERCEPTED, EXTEND CRUSHED STONE OR GRAVEL TO THE GROUND SURFACE.
3. CONDUIT MAY BE HEAVY DUTY PERFORATED HIGH DENSITY POLYETHYLENE OR SPECIALLY DRILLED P.V.C.

Source: USDA-NRCS

Figure SD-11 Typical Section of Two-Zone Subsurface Drain
(Soils with Intermediate to High Piping Potential)

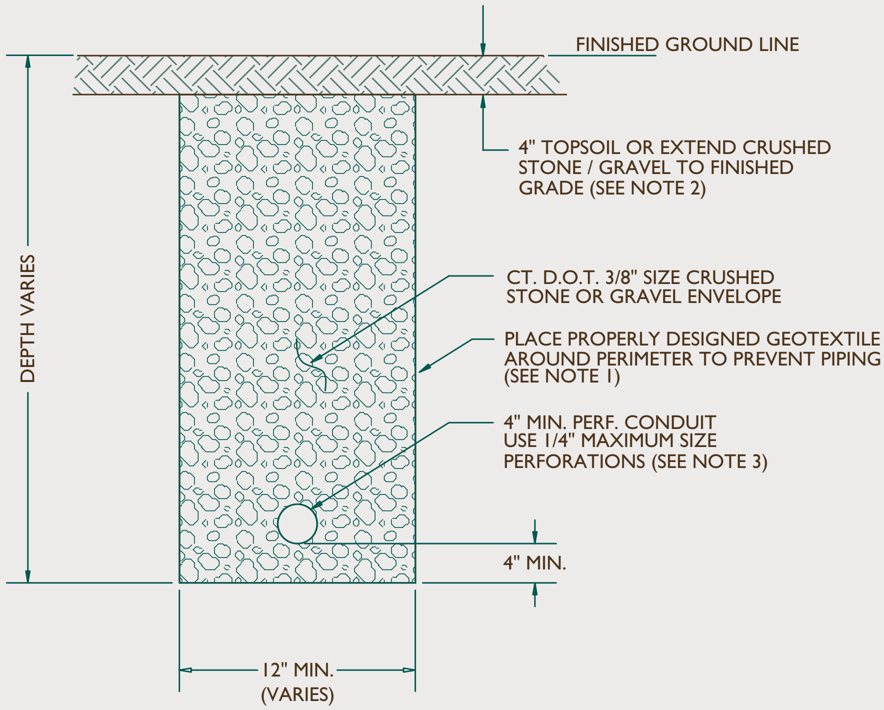


NOTES:

1. FINE CONCRETE AGGREGATE IS USED TO PREVENT PIPING OF ADJACENT SOILS INTO THE COARSE AGGREGATE.
2. IF SURFACE WATER IS TO BE INTERCEPTED, EXTEND FINE AGGREGATE TO THE GROUND SURFACE.
3. CONDUIT MAY BE HEAVY DUTY PERFORATED HIGH DENSITY POLYETHYLENE OR SPECIALLY DRILLED P.V.C.

Source: USDA-NRCS

Figure SD-12 Subsurface Drain with Geotextile
(Soils with Intermediate to High Piping Potential)



TYPICAL SECTION
(NOT TO SCALE)

NOTES:

1. THE SELECTED GEOTEXTILE SHALL BE DESIGNED SPECIFICALLY TO PREVENT PIPING OF ADJACENT SOILS INTO THE COARSE AGGREGATE.
2. IF SURFACE WATER IS TO BE INTERCEPTED, EXTEND COARSE AGGREGATE TO THE GROUND SURFACE.
3. CONDUIT MAY BE HEAVY DUTY PERFORATED HIGH DENSITY POLYETHYLENE OR SPECIALLY DRILLED P.V.C.

Source: USDA-NRCS

5-9 Detention Structures

Planning Considerations

The only measure included in this group is **Detention Basin**. See the measure for planning considerations.

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Detention Basin (DB)

Definition

An impoundment made by constructing a dam or an embankment (embankment detention basin), or by excavating a pit or dugout (excavated detention basin). Basins resulting from both excavation and embankment construction are classified as embankment detention basins where the depth of water impounded against the embankment at emergency spillway elevation is three feet or more.

Purpose

- To regulate the rate and amount of runoff from development sites during and after construction operations.
- To minimize the effects of downstream erosion and flooding.

Applicability

Where there is a need to control or prevent downstream erosion and flooding due to site development or from other land use changes.

Planning Considerations

Increased downstream erosion, sedimentation and flooding may be caused by increased runoff volume, increased peak discharge, reduced time of concentration, or reduced natural storage.

To minimize design and regulatory approval costs, design detention basins to avoid inland wetlands and watercourses and so that they are not subject to water diversion or dam safety regulation. A local or state inland wetlands permit will be required if a detention basin is proposed in a wetland area.

A state water diversion permit from the DEP's Inland Water Resources Division will be required if the contributing drainage area to the detention basin is greater than 100 acres. If the contributing drainage is less than 100 acres and no inland wetlands or watercourses are involved, then a diversion permit will not be required. However, if wetlands or watercourses are involved, a diversion permit may be required and a permit need determination should be sought from the DEP.

The DEP also regulates all dam construction within the state. Contact DEP Inland Water Resources Division early in the planning process to determine the need for a dam construction permit. Try to keep the effective height of the dam less than 15 feet and the product of the storage volume in acre-feet times the effective height of the dam less than 3,000 (see design criteria below). If these limitations are exceeded the design criteria for the embankments of the detention basin are raised to a higher standard.

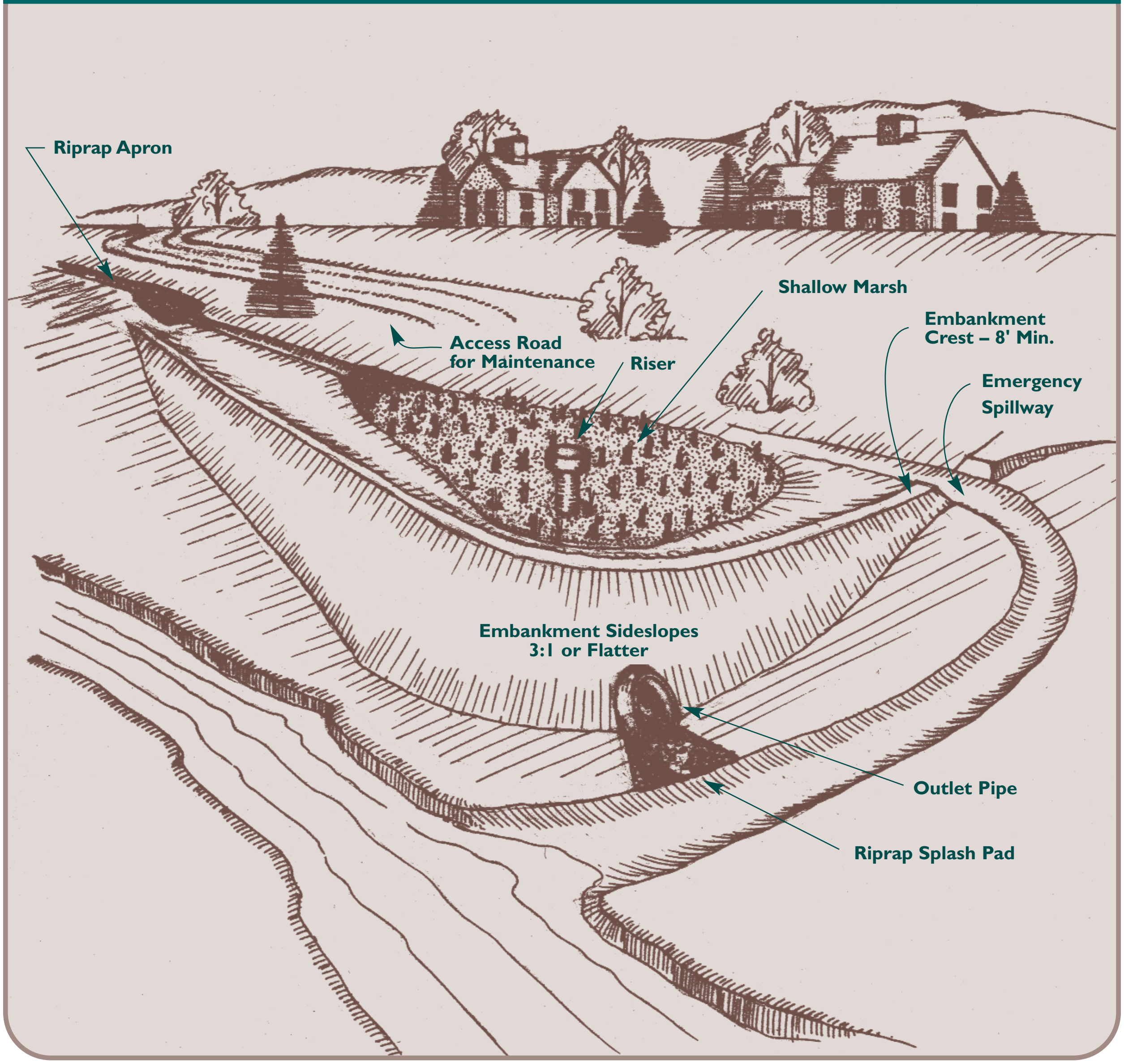
Carefully consider the visual design of detention basins in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of basins, excavated material and plantings are to relate visually to their surroundings and to their function. See **Figure DB-1** for a schematic of a detention basin.

In planning the detention basin consider safety features to protect the public. Design and locate any safety features so as not to interfere with the hydraulic operation of the structure.

For projects which include a temporary sediment basin, it is sometimes advantageous to locate the temporary sediment basin at the site of the detention basin. Sharing the same location may minimize site disturbance and cost. When this approach is used, the size requirements of both the detention and sediment basins must be determined and the larger of the two must be in place during the construction period. After construction, the minimum size shall be that of the detention basin. The construction should be phased so increases in runoff are controlled during the development of the project. One approach would be to construct the detention basin along with its berm and outlet works first, and expand the storage volume, if need be, to that required for the sediment basin.

The permanent outlet works may have to be temporarily modified during the construction period to provide the necessary wet and dry storage requirements for the temporary sediment basin and enhance the basin's ability to remove sediment. Upon stabilization of the contributing watershed, accumulated sediment is removed from the basin and any work, such as modifying the outlet works or installing permanent plantings, is done to complete the permanent detention basin.

Figure DB-1 Schematic of a Detention Basin



On-site detention may be undesirable when the site is located in the lower portions of a watershed before the confluence with a perennial watercourse. If detention is located in the lower reaches of a watershed, there is a risk, depending on the size and release rate of the basin, that the peak flows from the outlet control structure could combine with the peak flows from the upper reaches, thus increasing peak flows or sustaining peak flows over longer periods. These increases could result in prolonged flooding and channel erosion along and within the perennial stream course downstream of the site.

To avoid this problem a hydrologic analysis is required by an engineer. Locate the area downstream that is to be targeted for protection from additional runoff. A target area might be a flood prone road crossing, eroding stream bank or reach of stream where homes are currently endangered. Delineate the watershed to the targeted area. Determine where the proposed detention basin is located within that watershed. Conduct a hydrograph analysis to determine the timing of peak discharges. Use the Soil Conservation Service (NRCS) Technical Releases 20 or 55, U.S. Army Corps of Engineers HEC-I or other appropriate methods which produce hydrographs to evaluate existing and post-development conditions.

If the hydrograph analysis shows that detention is detrimental to the target area, but nearby downstream concerns are present, other methods to decrease peak flows from the site will need to be utilized.

Sequence and schedule the construction of a detention basin so that it is made functional before other site construction activities cause changes in infiltration rates that can result in increases in stormwater runoff.

Finally, the ownership and responsibility for operation and maintenance of the detention basin needs to be considered before the design process begins and should be determined by the completion of the local regulatory processes. The owner may be a homeowner, a homeowners association or a municipality.

Design Criteria[1]

Overall

Design the detention basin to be compatible with the floodplain management and stormwater management programs of the local jurisdiction and with local regulations for controlling sediment, erosion and runoff. The basin shall properly regulate storm discharges from the site to a safe, adequate outlet. Consider the duration of flow as well as the peak discharge. Provide adequate erosion control measures and other water-quality practices. Plan and design the basin to ensure minimal impact on visual quality and human enjoyment of the landscape. Blend structures and materials aesthetically with their surroundings.

Attempt to locate detention basins where:

- *Failure of the detention basin would not, within reasonable expectations, result in loss of life, damage all-weather roads, railroads, homes, commercial and industrial properties or interrupt the use or service of utilities. (Dams which might fail and endanger life or property are regulated by the Commissioner of the Department of Environmental Protection under the CGS §§22a-401 through 22a-411.*

- *the effective height of the dam for an embankment detention basin should be 15 feet or less. The effective height of the dam is defined as the difference in elevation in feet between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam.*

- *The product of the storage times the effective height of the dam should be less than 3,000. Storage is the volume in acre-feet in the reservoir below the elevation of the crest of the emergency spillway. The effective height of the dam is as defined above.*

Detention basins that exceed any one of the above conditions shall be designed to meet the criteria in Earth Dams and Reservoirs, Technical Release 60 (TR-60) by the USDA Soil Conservation Service (NRCS).

Design Storms

If the primary purpose of the detention basin is to minimize downstream erosion and subsequent sedimentation, the peak discharge from the 2-year, 10-year and 25-year storm frequency, 24-hour duration, Type III distribution storms shall be analyzed.

If the primary purpose of the detention basin is to minimize flooding, the peak discharge from the 2-year, 10-year, and 100-year frequency, 24-hour duration, Type III distribution storms shall be analyzed.

No increase in peak flow from the 2-year, 10-year and 25-year storms shall be allowed unless downstream increases are compatible with an overall floodplain management system. Check local requirements for additional criteria that may include larger storms. Some of the items to consider in determining if increased peak flows are compatible with an overall floodplain management system are:

- *the timing of peak flows from sub-watersheds;*
- *the increased duration of high flow rates;*
- *the stability of the downstream channels; and*
- *the distance downstream that the peak discharges are increased.*

See **Figure DB-6** and **Figure DB-7** for structure routing graphs.

Spillway Design

The outlets for the basin shall consist of a combination of an outlet control structure (sometimes referred to as a principal spillway) and an emergency spillway. These outlets shall pass the peak runoff from the contributing drainage area for the design flood. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the outlet control structure shall pass the entire routed peak runoff expected from the design storm. **However, an attempt to provide a separate emergency spillway shall always be made. An emergency spillway shall be provided on all detention basins with a contributing drainage area equal to or exceeding 20 acres. (Refer to Emergency Spillway subsection found on Page 5-9-11)**. Runoff computations shall be based upon the soil cover conditions which are expected to prevail during the life of the basin. Refer to standard engineering manuals and procedures for calculations of the peak rate of runoff. Notably, the flow through any dewatering orifice or pipe shall not be utilized when calculating the design elevations because of its potential to become clogged; therefore, available spillway storage shall begin at the first stage of the outlet control structure.

Outlet Control Structure

A structural spillway may be installed which combines the outflow requirements of a principal (primary) spillway and emergency (secondary) spillway. Another type of outlet control structure may consist of a riser pipe and barrel that controls the elevation of the water and the rate of discharge for the detention basin. The barrel and riser shall be hydraulically sized such that full pipe (barrel) flow is achieved when the water level is at or below the crest of the emergency spillway. For many applications outlet control structures consist of a vertical pipe or box of corrugated metal, plastic or reinforced concrete, with a minimum diameter of 15 inches, joined by a water

[1] For structures which are regulated under CGS §22a-401, the design criteria may be more stringent than that found in the **Detention Basin DesignCriteria.**

tight connection to a horizontal pipe (barrel) extending through the embankment and outletting beyond the downstream toe of the fill. The outlet control structure and amount of storage shall be sized to prevent the emergency spillway from overtopping for a 25-year design storm. If no emergency spillway is used, the outlet control structure shall be designed to pass the entire routed peak flow expected from the design storm.

Design Elevations: The crest of the outlet control structure shall be set at the elevation corresponding to the storage volume required. If severe sedimentation is expected, the design volume should include provisions for sediment volume.

Detention basins are individual in scope and design. The following freeboard requirements shall be used when no other design requirements exist. A minimum freeboard of 1.0 foot shall be provided between the routed water surface elevation for the design storm and the top of the embankment.

Anti-Vortex Device: An anti-vortex device and trash rack shall be attached to the top of a drop inlet control structure to improve the flow characteristics into the principal spillway and prevent blockage from floating debris. An example of an anti-vortex device is shown in **Figure DB-8**.

Trash Racks: To determine the dimensions of the trash rack, first determine the required cross-sectional area of the trash rack which will maintain a required maximum design velocity of 2 fps and then increase that area sufficiently to account for the obstruction caused by the bars.

The required cross-sectional area of the trash rack is estimated using the following formula:

$$A_{required} = \frac{Q}{V}$$

Where $A_{required}$ *is the required cross-sectional opening area of the trash rack,*
Q is the design flow for the outlet control structure, and
V is the design velocity which is required to be equal to or less than 2 fps.

Once $A_{required}$ is calculated, then it is proportionally increased to account for the obstruction of flow by the trash rack bars as follows:

$$A_{adjusted} = A_{required} \left(\frac{1}{1 - \%\text{ of area obstructed by trash rack bars}}\right)$$

Next a design for the trash rack is suggested. The area for the suggested trash rack design is then compared to $A_{adjusted}$. The suggested trash rack design is acceptable only when the suggested design area is greater than $A_{adjusted}$.

Design Examples 1 & 2 illustrate how to determine the minimum requirements for trash racks in a detention basin with a low and high stage outlets.

Detention Basin Trash Rack: Design Example 1

Figure DB-2 shows a sloped trash rack placed on the low stage outlet for the detention basin with suggested design dimensions. Given for this example is a design flow (Q) of 25 cfs for this outlet, the required maximum velocity (V) is 2 fps, and the trash rack bars obstruct 25% of the trash rack opening area.

$$A_{required} = \frac{Q}{V} = \frac{25\text{ cfs}}{2\text{ fps}} = 12.5\text{ ft}^2$$

Given that the bars obstruct 25% of cross-sectional opening area, increase the opening area as follows:

$$A_{adjusted} = A_{required} \left(\frac{1}{1 - 0.25}\right) = \frac{12.5}{0.75} = 16.7\text{ ft}^2$$

Adjusted required opening area is 16.7 ft^2.

A surface area of the trash rack is suggested by giving it dimensions of 3.5 ft. wide, 3.5 ft. high with its bars placed on 1:1 slope. Because the bars are sloped at a 1:1 slope, the actual length of the bars is (3.5 ft. x 1.41) or 4.94 ft. Therefore,

Suggested Surface Area of the Rack = (width) (length) = (3.5 ft.) (4.94 ft.) = 17.3 $ft.^2$

Since the suggested surface area of the sloping trash rack (17.3 $ft.^2$) is greater than the adjusted required opening area (16.7 $ft.^2$), then the suggested dimensions of 3.5 ft. wide by 3.5 ft high are acceptable.

Detention Basin Trash Rack: Design Example 2

Example #2 below calculates the minimum area on a box-shaped trash rack on the high stage outlet (see **Figure DB-3**) where the design flow (Q) for this outlet is 75.0 cfs, the acceptable velocity is set at 2 fps, and the trash rack bars obstruct 25% of the trash rack opening area. Given that the bars obstruct 25% of cross-sectional opening area, increase the opening area as follows:

$$A_{required} = \frac{Q}{V} = \frac{75 \text{ cfs}}{2 \text{ fps}} = 37.5 \text{ ft}^2$$

and

$$A_{adjusted} = A_{required} \left(\frac{1}{1 - 0.25}\right) = \frac{37.5}{0.75} = 50.0 \text{ ft}^2$$

Adjusted required opening area is 50.0 ft.^{2}.

Use the following formula to check the total available area of the trash rack using the suggested design dimension given in **Figure DB-3**.

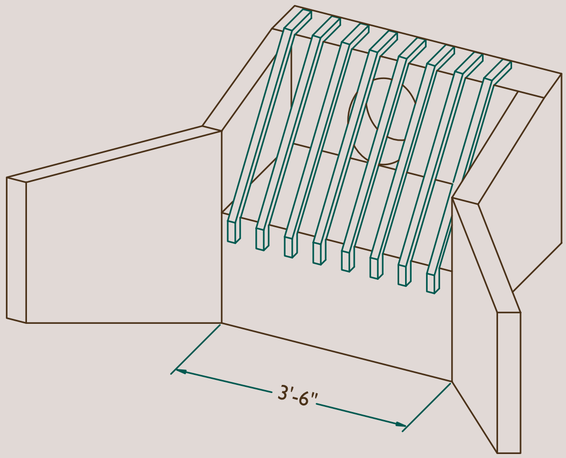
Area = [(side length) (2sides) + (front)] [(height) – (face of anti–vortex device)]

*Area=[*9.5 ft.*) (2) = (*4.0 ft.*)] [*2.5 ft.*) - [(*0.5 ft.*) (*2.5 ft. = 9.5 ft.*)]*

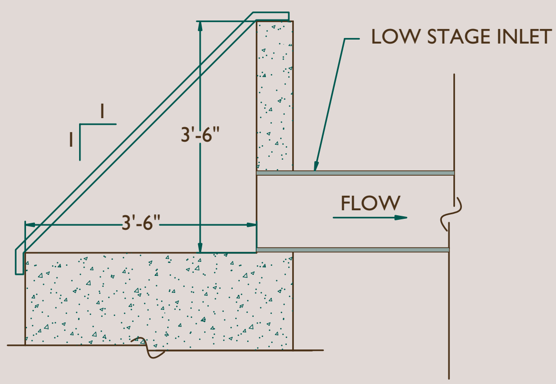
*Area = [*57.5 ft.^{2}*] - [*6.0 ft.^{2}*] =* 51.50 ft.^{2}

Since the designed surface area of the high stage trash rack (51.50 ft.^{2}) is greater than the adjusted required opening area (50.0 ft.^{2}), then the trash rack design is acceptable.

Figure DB-2 Low Stage Trash Rack for Design Example 1



ISOMETRIC
(Not To Scale)



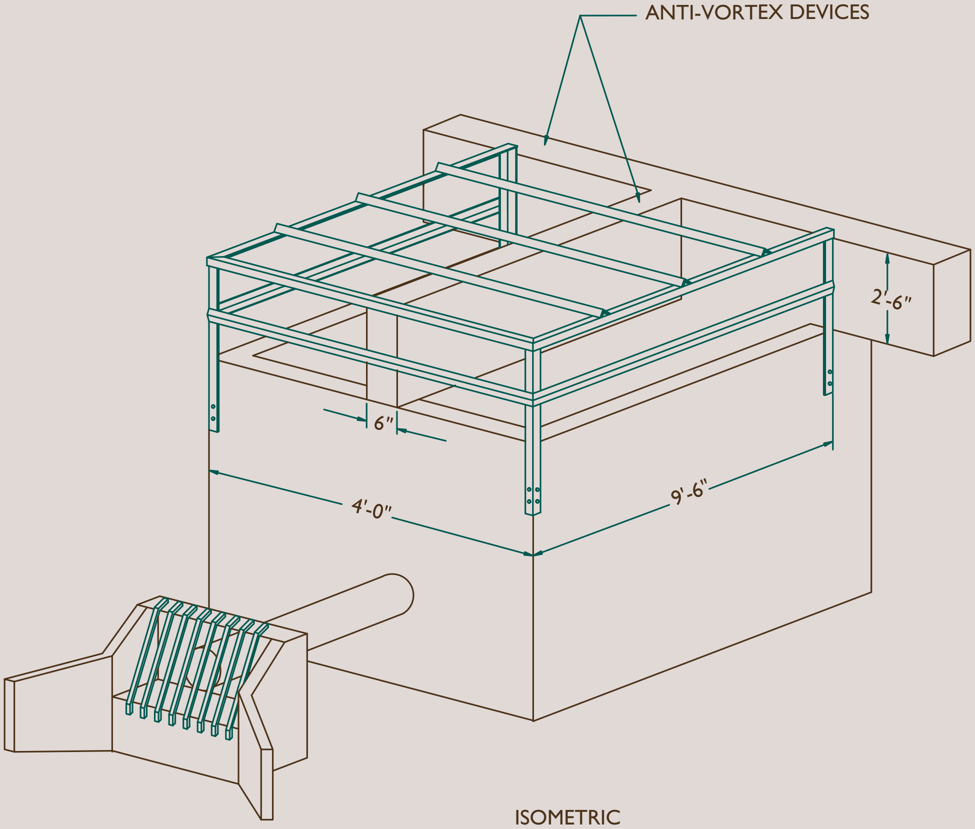
SIDE ELEVATION
(Not To Scale)

NOTES:
1. TRASH RACK SHALL BE FABRICATED OF STRUCTURAL STEEL IN CONFORMANCE WITH ASTM A-36.

2. ALL STRUCTURAL STEEL SHALL BE GALVANIZED IN ACCORDANCE WITH ASTM A-123.

Source: USDA-NRCS

Figure DB-3 High Stage Trash Rack for Design Example 2



ISOMETRIC
(Not To Scale)

NOTES:
1. TRASH RACK SHALL BE FABRICATED OF STRUCTURAL STEEL IN COMFORMANCE WITH ASTM A-36.

2. ALL STRUCTURAL STEEL SHALL BE GALVANIZED IN ACCORDANCE WITH ASTM A-123.

Source: USDA-NRCS

Drains: If the detention basin is intended to be dry during non-storm events, subsurface drains within the bottom of the basin which outlet into the spillway system may be incorporated as a means of dewatering the basin bottom.

Base: The base of the outlet control structure shall be designed to prevent its floatation. A minimum factor of safety of 1.25 shall be used (downward forces = 1.25 x upward forces).

Barrel: If used, the barrel of the outlet control structure, which extends through the embankment, shall be designed to carry the flow provided by the riser of the outlet control structure with the water level at the crest of the emergency spillway. The connection between the riser and the barrel shall be watertight. The area surrounding the outlet of the barrel shall be protected to prevent downstream erosion or scour. See **Outlet** section for more specifics.

Pipe Materials: The pipe shall be capable of withstanding the external loading without excessive yielding, buckling, or cracking. The following pipe materials are acceptable:

Corrugated Steel Pipe: Pipe gauge shall not be less than that indicated in **Figure DB-4**. The maximum outlet control structure barrel size shall be 48 inches. If larger sizes are used then a detailed analysis is required to demonstrate the structural integrity of the pipe and suitability for placement within a dam embankment. The pipe shall be helical (spiral) fabrication. The pipe shall be asphalt coated or aluminized. **Connections between pipe joints shall be watertight**. Flanges with gaskets or caulking may be used. Rod and lug coupling bands with gaskets or caulking may be used.

Corrugated Aluminum Pipe: Pipe gauge shall not be less than that shown in **Figure DB- 4**. The maximum outlet control structure barrel size shall be 36 inches. If larger sizes are used then a detailed analysis is required to demonstrate the structural integrity of the pipe and suitability for placement within a dam embankment. The pipe shall be helical (spiral) fabrication. Riveted pipe shall be close riveted. The embankment materials and water shall range between pH4 and pH9. Inlets, coupling bands and anti-seep collars shall be made of aluminum or other non-corrosive materials.

Fittings for aluminum pipe of metals other than aluminum or aluminized steel shall be separated from the aluminum pipe at all points by at least two layers of plastic tape having a total thickness of at least 24 mils, or by other permanent insulating material that effectively prevents galvanic corrosion. Bolts used to join aluminum and steel shall be galvanized, plastic coated, or otherwise protected to prevent galvanic corrosion. Bolts used to join aluminum to aluminum, other than aluminum alloy bolts, shall be galvanized, plastic coated, or otherwise protected to prevent galvanic corrosion.

Connections between pipe joints shall be watertight. Flanges with gasket or caulking may be used. Rod and lug coupling bands with gaskets or caulking may be used. Slip seam coupling bands with gaskets or caulking may be used.

Figure DB-4 Corrugated Steel & Aluminum Pipe Requirements

Corrugated Steel Pipe

Pipe Diameter (inches)	8 – 21	24	30	36	42	48	Risers Only		
							54	60	66
Min. Gauge (inches)	16	16	14	14	12	10	10	10	10

Corrugated Aluminum Pipe

Pipe Diameter	8 – 21	24	30	36	Risers Only		
					42	48	54
Gauge (inches)	16 (.06)	16 (.06)	14 (.075)	14 (.075)	12 (.105)	10 (.135)	10 (.135)

PVC Pipe: The PVC shall meet the requirements of **Figure DB-5**. **Connections between pipe joints and anti-seep collar connections to pipe shall be watertight**. Pipe joints shall be solvent welded, O-ring, or threaded. All fittings and couplings shall meet or exceed the same strength requirements as that of the pipe and be made of material that is recommended for use with the pipe. Connections of PVC pipe to less flexible pipe or structures shall be designed to avoid stress concentrations that could rupture the PVC. When using PVC pipe the maximum outlet control structure barrel size shall be 12 inch, except a larger PVC pipe may be used if the engineering design calculations justify the use of a larger pipe.

Figure DB–5 PVC Pipe*

Nominal Pipe Size (inches) Strength	Maximum	Depth of Fill Over Pipe (feet)
6, 8, 10, 12	Sched. 40	10
	Sched. 80	15
	SDR 26	10

*Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM D 1785 or ASTM D 2241

Smooth Steel: The minimum wall thickness shall be 3/16 inch. Previously used pipe may be used providing it is in good condition and does not have deep rust pits. The maximum outlet control structure barrel diameter shall be 48 inches. Pipe joints shall be threaded or welded by a competent welder. There are also several acceptable pre-engineered couplings available from pipe distributors.

Concrete Pipe With Rubber Gasket Joints: The pipe shall be designed with a concrete bedding. Connections between pipe joints and anti-seep collar connections to pipe shall be watertight and remain watertight after movement caused by foundation consolidation and embankment settlement.

Inlet: The inlet of the outlet control structure shall be structurally sound and made from materials compatible with the pipe. The inlet shall be designed to prevent floatation. The inlet shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. The inlet materials are subject to the same limitations and requirements as the pipe materials.

Hood Inlet: If the pipe is designed for pressure flow, the minimum available head between the top of the pipe and the crest of the emergency spillway shall be adequate to prime the pipe. This head shall be at least 1.4 times the pipe diameter. See **Figure DB-9** for hood inlet detail.

Drop Inlet: If the pipe is designed for pressure flow the weir length of the drop inlet shall be adequate to prime the pipe when the water surface is at or below the emergency spillway crest. For pipe barrels placed on critical slope or flatter, the drop inlet shall be at least 2D deep, where D is the barrel diameter. For pipe placed on steeper than critical slope, the drop inlet shall be at least 5D deep, where D is the barrel diameter.

Outlets: The outlet for the outlet control structure area shall be protected to prevent erosion. In addition, the outlet shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. Protection against scour at the discharge end of the spillway shall be provided. Measures may include an impact basin, outlet protection, riprap, excavated plunge pools or use of other generally accepted methods.

Pipes larger than 18 inches shall have an energy dissipator such as one of the following:

- *Saint Anthony Falls type outlet;*
- *impact basin;*
- *stilling basin or plunge pool; or*
- *outlet protection in accordance with the outlet protection measure*

Anti-Seep Collars: Since very little time is spent in determining potential phreatic water surfaces within detention basins, it is accepted practice to design anti-seep controls as if the basin were always full of water. Anti-seep collars shall be designed for installation on the barrel of the outlet control structure within the normal saturation zone of the embankment to increase the seepage length by at least 10%, if either of the following two conditions exist:

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

2. The embankment soils have less than 15% passing the #200 sieve and the barrel is greater than 10 inches in diameter.

The anti-seep collars shall be installed within the saturated zone The maximum spacing between collars shall be 14 times the projection of the collars above the barrel and in no case shall the spacing be greater than 25 feet. Collars shall not be closer than 2 feet from a pipe joint. Collars shall be placed sufficiently far apart to allow space for hauling and compacting equipment. Precautions should be taken to ensure 90%-95% standard proctor compaction is achieved around the collars. Connections between the collars and the barrel shall be watertight. See **Figure DB- 10** for details.

Alternatives to Anti-Seep Collars: Anti-seep collars are designed to control seepage and piping along the barrel by increasing the flow length and thus making any flow along the barrel travel a longer distance. However, due to the constraints that collars impose on embankment fill placement and compaction, collars may sometimes be ineffective if proper placement procedures are not followed precisely.

Alternative measures have been developed and are being incorporated into embankment designs. These measures include a structure known as a "filter diaphragm." A filter diaphragm consists of a layer of sand and fine gravel which runs through the dam embankment perpendicular to the barrel. The measure controls the transport of embankment fines, which is the major concern with piping and seepage. The diaphragm is designed to trap any embankment material being transported by seepage along the barrel. The flow is then conveyed out of the embankment via a pipe to the toe of the fill.

The critical design element for the filter diaphragm is the grain-size distribution of the filter material which is determined by the grain-size distribution of the embankment fill material. The use and design of filter diaphragms shall be based on site-specific geotechnical information and its construction should be supervised by a qualified professional.

Dewatering Pipe

A pipe with a suitable valve shall be provided to dewater the basin if the basin has a permanent pool. The outlet control structure may be used in conjunction with a dewatering pipe when so located to accomplish this function.

Emergency Spillway

An attempt to provide a separate emergency spillway shall always be made. However, there shall be an emergency spillway on all detention basins with a contributing drainage area equal to or exceeding 20 acres. The emergency spillway acts as a safety release for a detention basin, or any impoundment-type structure, by conveying the larger, less frequent storms through or around the basin without damage to the embankment.

The emergency spillway shall consist of an open channel (earthen and vegetated) constructed adjacent to the embankment over undisturbed material not within the embankment (not fill). The spillway shall have a control section at least 20 feet in length. The control section is a level portion of the spillway channel at the highest elevation in the spillway profile. Where conditions require the construction of an emergency spillway on the embankment, a spillway shall be constructed of a non-erodible material such as riprap. As an alternative, a structural spillway may be installed which combines the outflow requirements of a principal (primary) spillway and emergency (auxiliary) spillway.

The minimum capacity of a natural or constructed emergency spillway shall be that required to pass the peak flow expected from a design storm of 100-year frequency, 24-hour duration, Type III distribution less any reduction creditable to conduit discharge and detention storage. The capacity shall be calculated using the appropriate retardance and permissible velocities, as given in the **Vegetated Waterway** measure.

The emergency spillway shall safely pass either the peak inflow of the design storm runoff or the peak flow after routing.

Excavated Detention Basins: Excavated detention basins shall be designed with an outlet control structure constructed as described on **Page 5-9-4**. They can use the natural ground for the emergency spillway if the outlet slope is 5:1 or flatter and has existing vegetation or is immediately protected by sodding, riprap, asphalt lining, concrete lining, or other equally effective protection. The spillway shall meet the capacity requirement for embankment detention basins.

Embankment Detention Basins: Embankment detention basin spillways shall meet the following requirements:

Component Parts: Emergency spillways are open channels and consist of an inlet channel, control section and an exit channel. The emergency spillway should be as long as possible to provide protection from breaching. These emergency spillways should be constructed in natural ground whenever possible and have the discharge areas located at least 20 feet downstream of the embankment.

- ***Inlet Channel:*** *The inlet channel shall be level and straight for at least 20 feet upstream from the control section. Where site conditions do not allow a 20-foot long level section, armoring or sills may be utilized to prevent head cutting or breaching of the emergency spillway. Upstream from the level area the inlet channel may be graded back towards the basin to provide drainage. The alignment of the inlet channel may be curved upstream and flared out towards upstream from the straight portion.*

- ***Exit Channel:*** *The grade of the exit channel of an emergency spillway shall fall within the range established by discharge requirements and permissible velocities. For embankment dams the exit channel shall convey the design flow downstream to a point where the flow will not discharge to the toe of the embankment dam. Generally, the design flow should be contained in the exit channel without the use of dikes. If a dike is necessary, it shall have 2:1 or flatter side slopes, a top width minimum of 8 feet, and be high enough to contain the design flow plus one foot of freeboard.*

Velocity: The maximum permissible velocity in the exit channel shall be 4 feet per second for vegetated channels in soils with a plasticity index of 10 or less and 6 feet per second for vegetated channels in soils with a plasticity index greater than 10. For exit channels with erosion protection other than vegetation, the velocities shall be in the acceptable range for the type of protection used.

Cross Sections: Emergency spillways shall be trapezoidal and be located in undisturbed earth whenever practical. The side slopes shall be 2:1 or flatter. The minimum bottom width shall be 10 feet. The hydraulic requirements determine the elevation differences between the crest of the emergency spillway and the top of dam.

Structural Spillways Other Than Pipe

Structural spillways other than pipe shall be designed based on sound engineering data with acceptable soil and hydrostatic loadings as determined on an individual site basis.

When used as an outlet control structure, these structural spillways shall otherwise meet the flow requirements for outlet control structures and shall not be damaged by the emergency spillway design storm. When used as an emergency spillway, these structural spillways shall meet the capacity requirements for emergency spillways.

Earth Embankment

Freeboard: A minimum freeboard of 1.0 foot shall be provided between the routed water surface elevation for the design storm and the top of the embankment of the 100 year storm.

Top Width: The minimum top width of the embankment shall be 8 feet.

Side Slopes: For embankment stability the combined upstream and downstream side slopes of the settled embankment when added together shall not be less than 5:1 with neither slope steeper than 2:1. Slopes shall be designed to be stable in all cases.

Materials: The fill material for the embankment shall be taken from approved borrow areas. It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, oversized stones, rocks, or other organic or unsuitable material. The material selected shall have enough strength for the embankment to remain stable and be tight enough, when properly compacted, to prevent excessive seepage of water through the dam. Fill containing particles ranging from small gravel or coarse sand to fine sand and clay in desired proportions is appropriate. Embankment material should contain at least 15% passing the #200 sieve and not more than 50% passing the # 200 sieve.

No stones larger than 6 inches shall be allowed within the compacted embankment. Within two feet of any structure, the maximum size shall be 3 inches. Construction shall not take place during cold periods where temperatures are consistently lower than 40 degrees Fahrenheit. The soil intended for the embankment shall be laboratory tested with a written report by a professional engineer licensed to practice in Connecticut, experienced in the field of soil mechanics. The report shall carry the engineer's findings and suggested design parameters if at variance with those proposed in the design.

Compaction: Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material shall contain the proper amount of moisture to ensure that 90%-95% standard proctor compaction will be achieved. Fill material will be placed in 9-inch 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 transversed by at least one wheel or tread track of the equipment, or by using a compactor. Special care shall be taken in compacting around the anti-seep collars, conduits, and structures to avoid damage and achieve desired compaction.

Foundation Cutoff for Embankment Detention Basin: A foundation cutoff constructed with relatively impermeable materials shall be provided for all embankments. The minimum depth of the cutoff shall be 2 feet. The cutoff trench, as a minimum, shall extend up both abutments to the emergency spillway crest elevation. The minimum bottom width shall be 4 feet and wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for the embankment. The trench shall be kept free from standing water during the backfilling operations.

Seepage Control: Seepage control is to be included if seepage may create swamping downstream, if needed to ensure a stable embankment, or if special problems require drainage for a stable embankment. Seepage control may be accomplished by foundation, abutment or embankment drains, reservoir blanketing or a combination of these and other measures.

Foundation: The area on which an embankment is to be placed shall consist of material that has sufficient bearing strength to support the earthfill and structures without excessive consolidation. Any unsuitable materials shall be removed from the foundation area before construction.

Installation Requirements

Construct the detention basin in accordance with the engineered design.

Site Preparation

Clear, grub, and strip topsoil to remove trees, vegetation, roots, or other unsuitable material from areas under the embankment or any structural works related to the basin. Clear and grub the area of most frequent inundation (measured from the top of the outlet control structure) of all brush and trees to facilitate clean out and restoration.

Install Sediment Controls for Contributing Areas

Install sediment controls to trap sediment before it enters and leaves the detention basin construction site.

Stabilize the dam and emergency spillway in accordance with the engineered design, stabilize the spoil and borrow areas, and other disturbed areas in accordance with the **Temporary Seeding** or **Permanent Seeding measures**, whichever is applicable.

Safety

Install safety features and devices to protect humans and animals from such accidents as falling or drowning. Temporary fencing can be used until barrier plantings are established. Use protective measures such as guardrails and fences on spillways and impoundments as needed.

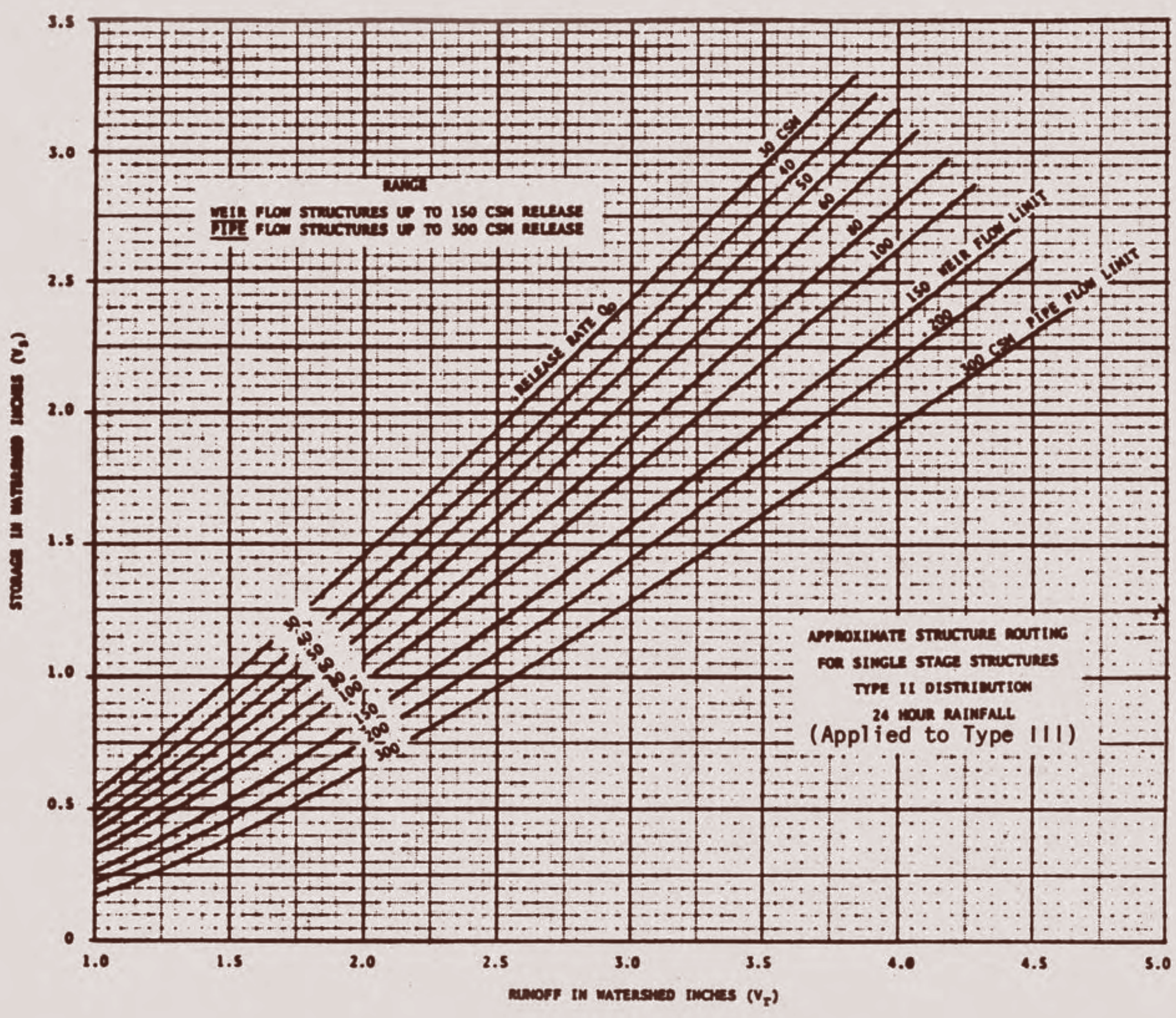
Operation and Maintenance

Ownership

The ownership and responsibility for operation and maintenance of the detention basins should have been determined by the completion of the local regulatory processes. The owner may be a homeowner, a homeowners association or a municipality.

There should be a legally binding and easily

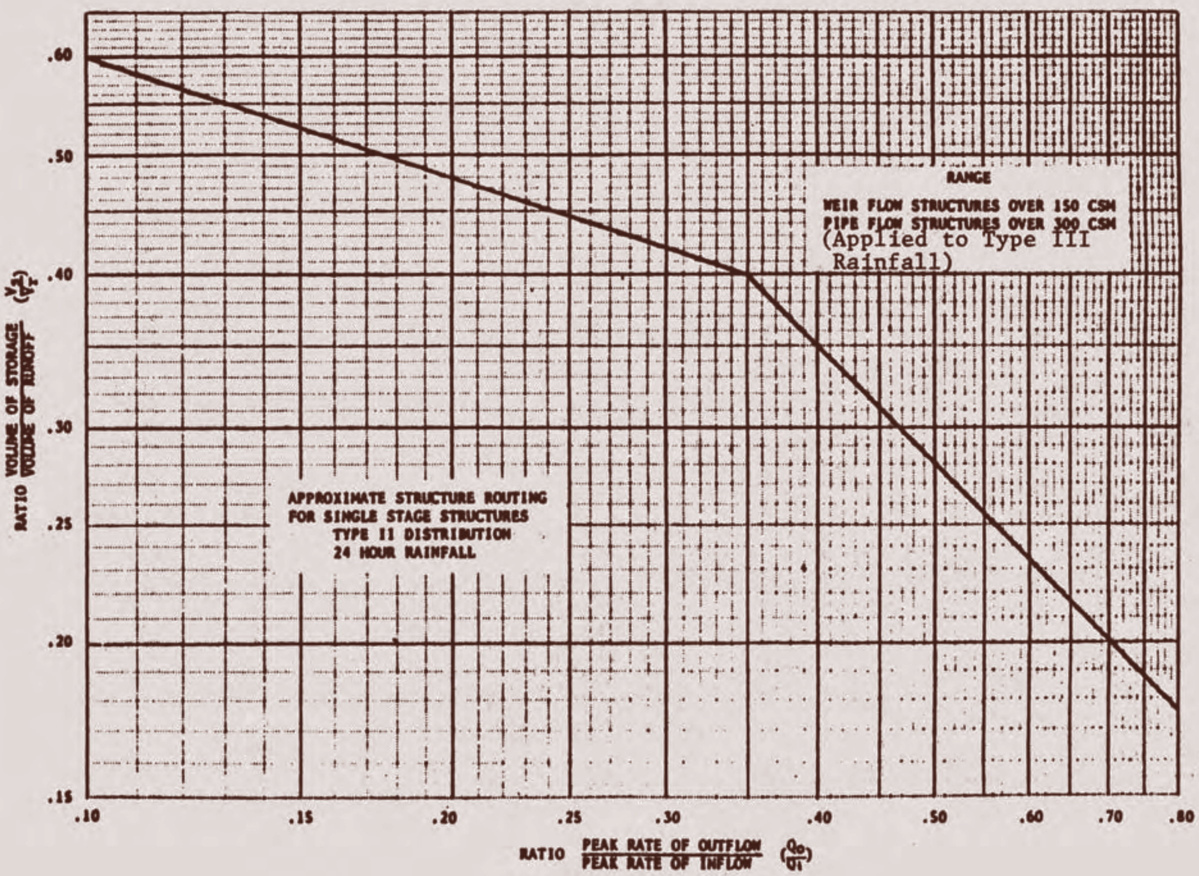
Figure DB-6 Structure Routing Graph



Source: USDA-NRCS

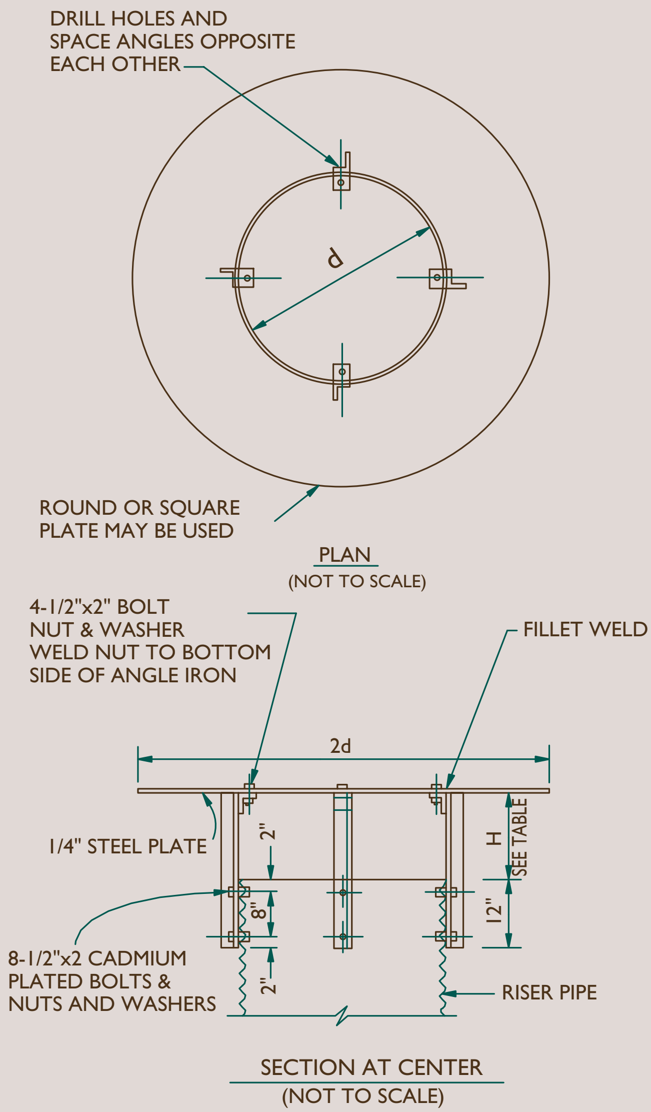
Detention Basin (DB)

Figure DB-7 Structure Routing Graph for Type III Distributions



Source: USDA-NRCS

Figure DB-8 Example of Anti-Vortex with Trash and Safety Guard Diagram



INLET d DIA. INCHES	BARREL DIA. INCHES	H INCHES
12	6	6
12	8	6
15	10	6
15	12	7
18	12	6
24	15	7 1/2
24	18	10
* 30	18	8 1/2
* 30	24	13 1/2
* 36	24	12

* USE ANGLE IRON STIFFENERS ON PLATE AS SPECIFIED.

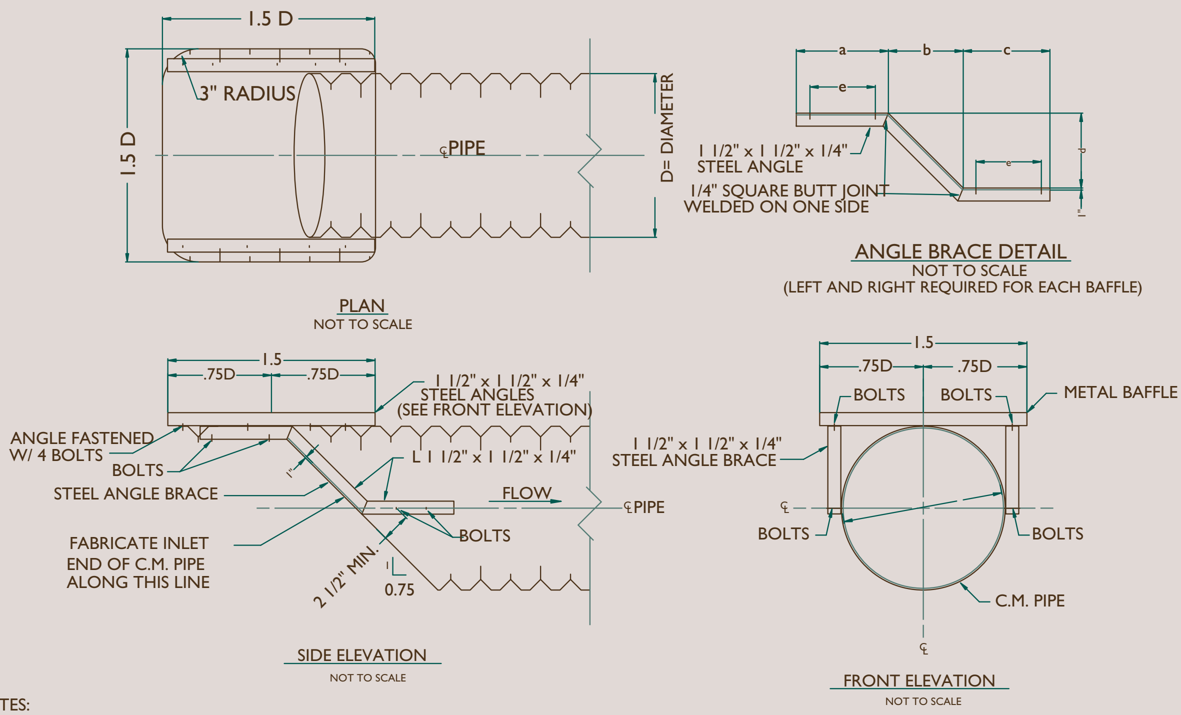
Source: USDA-NRCS

Figure DB-9 Hood Inlet Detail

TABLE OF QUANTITIES MATERIAL LIST & WEIGHTS FOR ANTI-VORTEX PLATE

PIPE DIA. INCHES	PLATE GAGE	PLATE SIZE INCHES	2" X 2" X 1/4" STEEL ANGLE BRACES (ONE RIGHT AND ONE LEFT) INCHES					REQ'D. NO.	2" X 2" X 1/4" STEEL ANGLE SUPPORT FEET AND INCHES	REQ'D. NO.	1/2" X 1 1/2" STEEL MACHINE BOLT WITH NUT AND WASHER NO. REQUIRED	TOTAL WEIGHT LBS.
			a	b	c	d	e					
15	16	22 1/2 x 22 1/2	8	7 7/8	8	6 3/8	5 1/3	2	1 - 11 1/2	1	12	30
18	16	27 x 27	10	9	9	7 7/8	5 1/3	2	2 - 4	1	13	39
21	16	31 1/2 x 31 1/2	10	11 7/8	9	9 1/2	5 1/3	2	2 - 8 1/2	1	14	47
24	14	36 x 36	13	13 3/4	12	11 1/4	8	2	3 - 1	1	15	65
30	14	45 x 45	13	17 3/8	12	13 7/8	8	2	3 - 10	1	16	88
36	12	54 x 54	13	21 1/8	12	17	8	2	4 - 7	2	31	163

METAL BAFFLE SHALL HAVE THE SAME COATING AS THE PIPE TO WHICH IT IS ATTACHED.
WHERE METAL BAFFLE IS FABRICATED OF MORE THAN ONE PIECE OF METAL,
THE SEPARATE PIECES SHALL BE SECURELY FASTENED TO EACH OTHER.
SHARP CORNERS SHALL BE REMOVED. METAL BAFFLE MAY BE MADE OF
CORRUGATED OR SMOOTH SHEET METAL AND SHAPED CIRCULAR, SQUARE OR AS SHOWN.

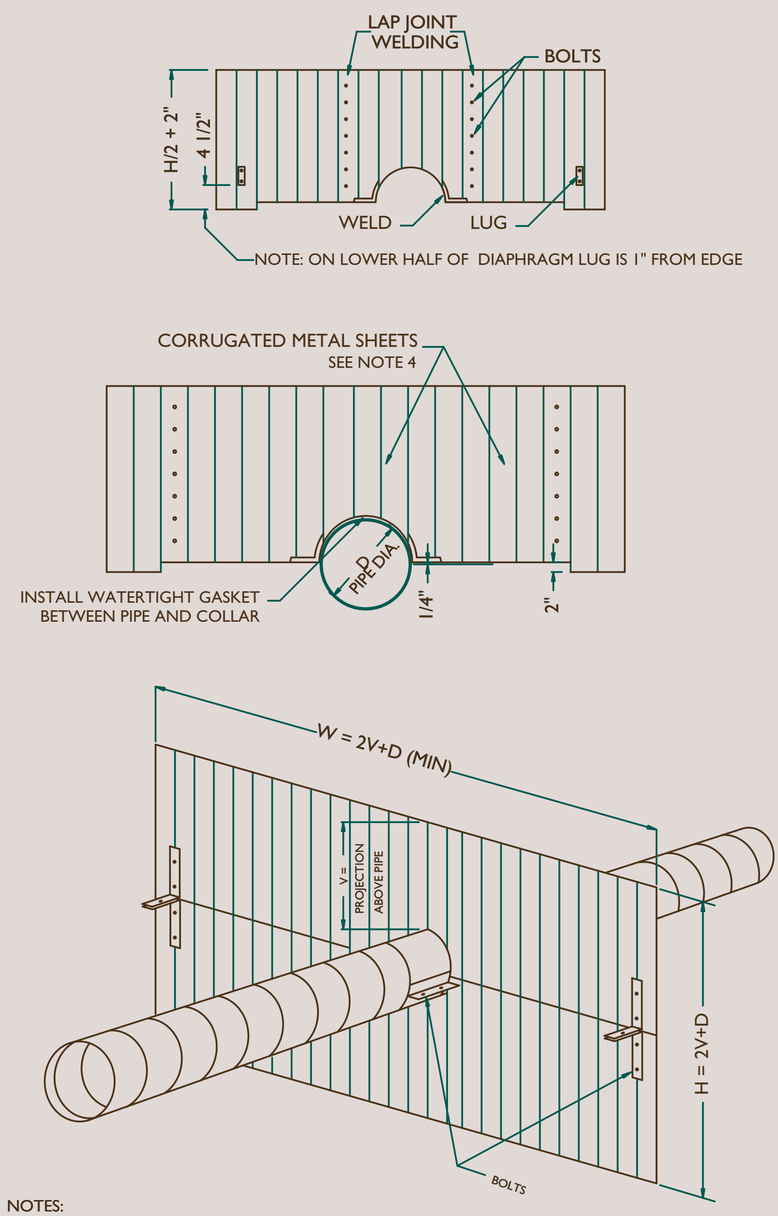


NOTES:

1. ALL BOLTS SHALL BE 3/8" X 1 1/2" WITH NUT AND SPLIT WASHERS.
2. ALL HOLES FOR BOLTS SHALL BE DRILLED 7/16" DIAMETER.
3. ALL NUTS, BOLTS AND WASHERS SHALL BE GALVANIZED, CADMIUM PLATED OR STAINLESS STEEL.
4. ALL CUTS SHALL BE SAW OR SHEAR CUTS.
5. HOLES IN THE ANGLE BRACE SHALL BE SPACED AND LOCATED TO MATCH CORRUGATIONS IN PIPE AND BAFFLE.
6. STEEL ANGLES SHALL BE GALVANIZED.
7. ALL GALVANIZING DAMAGED BY CUTTING, DRILLING OR WELDING SHALL BE REPAIRED BY PAINTING WITH TWO (2) COATS OF ZINC DUST – ZINC OXIDE PRIMER.

Source: USDA-NRCS

Figure DB-10 Anti-Seep Collar



NOTES:

1. ANTI-SEEP COLLARS TO BE FULLY BITUMINOUS COATED.
2. THE MAXIMUM SPACING OF ANTI-SEEP COLLARS ALONG THE CONDUIT SHALL BE NO GREATER THAN 14V, AND IN NO CASE GREATER THAN 25 FEET.
3. ANTI-SEEP COLLARS SHALL BE PLACED AT LEAST 2 FEET FROM PIPE JOINTS.
4. SEE FIGURE DB-4 FOR GAUGE.

Source: USDA-NRCS

5-10 Energy Dissipators

TO MAIN TOC

Planning Considerations

The energy dissipator measures are **Level Spreader, Outlet Protection** and **Stone Check Dam**. These measures serve the common function of dissipating the energy of runoff waters for the specific purpose of reducing erosion potential. They may be installed for either permanent or temporary use. While level spreaders and outlet protection are typically installed for permanent use, stone check dams are for temporary installations.

The **Level Spreader** measure includes a depression at the outfall for a channel or culvert with a broad stable discharge area used for the purpose of de-energizing and dispersing the runoff water to stable ground. It is commonly used with measures found in the Diversions Functional Group. When used at the outfall of a conduit, care should be given to insure that the exit velocities from the measure do not exceed the receiving area's capability to remain stable.

The **Outlet Protection** measure is also used at the outfall of a channel or culvert but uses structures or riprap to serve the multiple purpose of preventing scour and reducing runoff velocities to the receiving channels or watercourses.

The **Stone Check Dam** measure uses a dam constructed of stone across a drainageway to reduce the potential for channel erosion. Stone check dams are useful during the establishment of vegetative linings in channels. They can sometimes trap sediment particles by virtue of their ability to pond runoff, but are not a substitute for a **Temporary Sediment Trap** or **Temporary Sediment Basin**.

Level Spreader (LS)

Definition

An outlet for diversions and other water conveyances consisting of an excavated depression with a broad stable point of discharge constructed at zero grade across a slope.

Purpose

To reduce the depth and velocity of concentrated runoff and release it uniformly as sheet flow onto a stable area.

Applicability

- Where there is a need to carry storm water away from disturbed areas and to avoid stressing erosion control measures.
- Where sediment reduced runoff can be released in sheet flow over a stabilized slope without causing erosion.
- Where the spreader can be constructed on undisturbed soil.
- Where the area below the level spreader lip has a slope of 5% or flatter and is stabilized by vegetation.

Planning Considerations

The **Temporary Diversion** measure and the **Water Bar** measure each calls for a stable outlet for concentrated storm water flows. The level spreader is a relatively low-cost structure to release small volumes of concentrated flow where site conditions are suitable.

Check the proposed location of the level spreader to ensure it can be constructed on level, stable, and undisturbed ground. Any depressions in the outlet lip of the spreader could concentrate flow, and result in erosion. Check conditions downslope from the spreader to ensure the runoff water will not reconcentrate after release unless it occurs during interception by another measure (such as a permanent pond or detention basin) located below the level spreader.

For higher design flow conditions, a rigid outlet lip design is required to ensure the desired sheet flow conditions.

Special care should be taken when designing level spreaders on terrace escarpments located in the Connecticut River valley. These areas are very susceptible to erosion by the concentration flows. Consider using alternative methods to discharge runoff through the escarpment area.

Design Criteria

Slopes shall be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.

Criteria provided below are for flows from a 10-year frequency storm that is equal to or less than 20 cfs ($Q_{10} \leq 20$ cfs). For higher flows use other standard engineering practices that will result in a diffuse non-erosive discharge.

Spreader Dimensions

Determine the size of the level spreader by estimating the peak flow expected from a 10-year storm (Q_{10}).

Select the appropriate length, width and depth of the spreader from **Figure LS-1**.

Provide a 20-foot transition section in the diversion channel so that the width of the diversion will smoothly transition with the width of the spreader to ensure more uniform outflow.

Make the depth of the level spreader, as measured from the lip, at least 6 inches. The depth may be made greater to increase temporary storage capacity, improve trapping of debris and to enhance settling of any suspended solids.

Figure LS-1 Minimum Dimensions for Level Spreader

Design Flow, Q_{10} (cfs)	Depth (ft.)	Width of Lower Side Slope of Spreader (ft.)	Length (ft.)
0 – 10	0.5	6	10
10 – 20	0.6	6	20

Grade

The grade of the channel for the last 20 feet of the dike or diversion entering the level spreader shall be no steeper than 1%.

The grade of the level spreader channel shall be 0.0%.

Spreader Lip

The level lip of the spreader shall be of uniform height and zero grade over the length of the spreader with its discharge to an undisturbed well-vegetated area having a maximum slope of 5%. Slopes shall be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.

The level spreader lip may be stabilized by vegetation or may be of a rigid non-erodible material depending on the expected design flow.

A vegetated level lip shall be constructed with an erosion-resistant material, such as permanent turf reinforcement matting or temporary erosion control blankets, to inhibit erosion and allow vegetation to become established.

For higher design flows and permanent installations, a rigid lip of non-erodible material, such as pressure-treated timbers or concrete curbing, shall be used.

If a riprap apron is selected for a level spreader, **Figure LS-4** may be used for design of the measure.

Figure LS-2 Discharge Limitation

Spreader Lip	Design Flow (cfs)
Vegetated	0 – 4
Rigid	5 – 10

Installation Requirements (see **Figure LS-3**)

1. Construct the level spreader on undisturbed soil (not fill material).

2. Shape the entrance to the spreader in such a manner as to ensure that runoff enters directly onto the 0.0% channel.
3. Construct a 20-ft. long transition section from the diversion channel to blend smoothly to the width and depth of the spreader.

4. Construct the level lip at 0.0% grade to ensure uniform spreading of storm water runoff flow.

5. The protective covering for a vegetated lip shall be a minimum of 4 feet wide extending 6 inches over the lip and buried 6 inches deep in a vertical trench on the lower edge. Butt the upper edge smoothly cut sod, and securely hold in place with closely spaced heavy duty wire staples.

6. Entrench the rigid level lip at least 2 inches below existing ground and securely anchor to prevent displacement. Place an apron of DOT #3 stone or modified riprap at the top of the level lip and extended down slope at least 3 feet. Place the geotextile under stone and use galvanized wire mesh to hold stone securely in place.
7. Stabilize the disturbed area around the spreader immediately after its construction (see **Permanent Seed, Mulch for Seed** and/or **Stone Slope Protection** measures).

Maintenance

For temporary installations, inspect the level spreader at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater to determine maintenance needs.

For permanent installations, inspect after major rainstorms or once a year.

Maintain the level spreader lip at 0.0% slope to allow for proper functioning of the measure. Avoid the placement of any material on and prevent construction traffic across the structure. If the measure is damaged by construction traffic, repair it immediately.

Figure LS-3 Illustration of a Level Spreader with a Rigid Lip

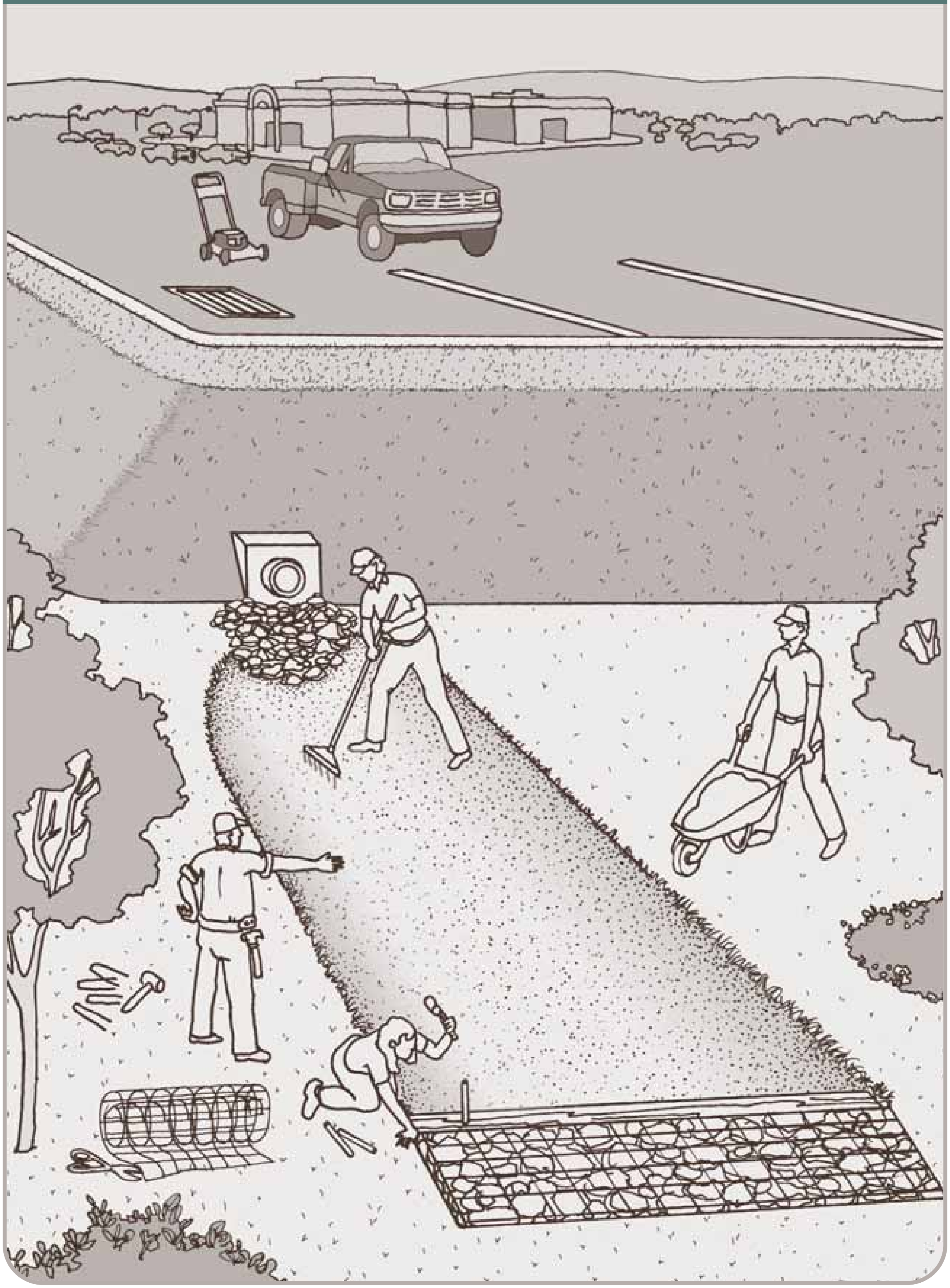
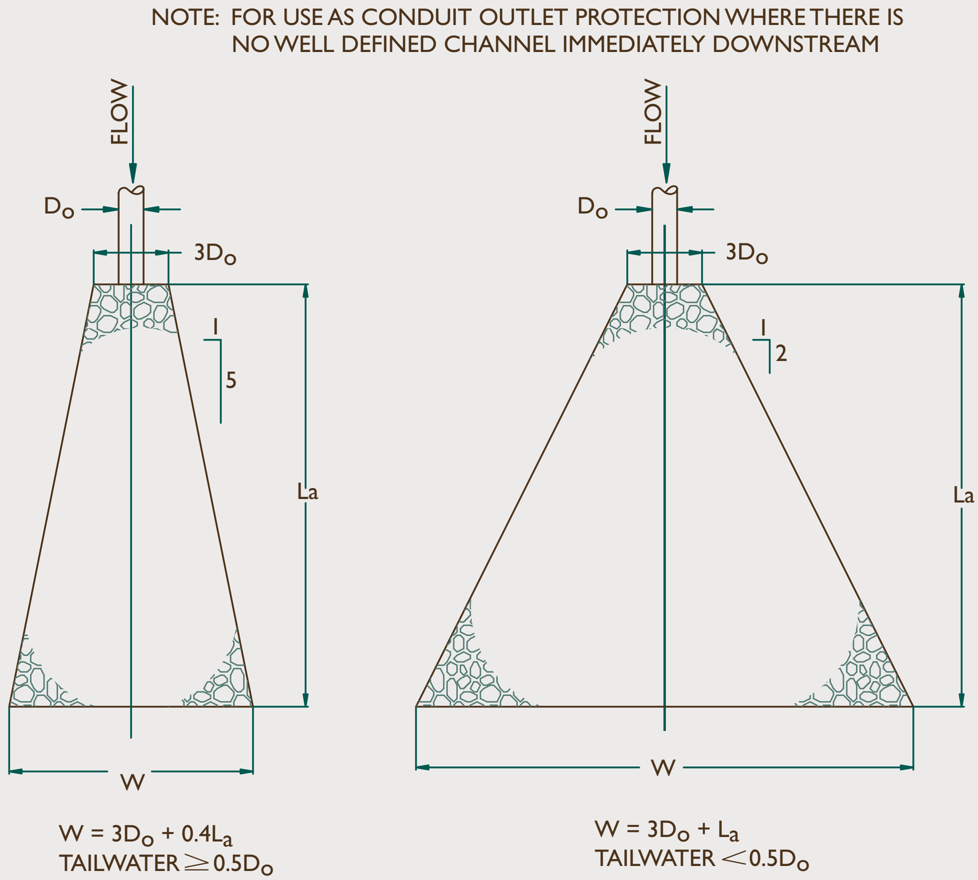


Figure LS-4 Conduit Level Spreader



Design Example

Given: D_O = 1.5 ft, Q = 14.5 cfs, TW = 0.7 ft.
Find: L_a, W, d_{50}

$$L_a = \frac{1.7Q}{D_o^{3/2}} + 8D_o = \frac{1.7(14.5\text{ cfs})}{1.5^{3/2}} + 8(1.5) = 25.4$$

$$L_a = 25.4\text{ ft.}$$

$$W = 3D_o + L_a = 3(1.5\text{ ft.}) + 25.4\text{ ft.} = 29.9\text{ ft. (Say 30 ft.)}$$

Median Stone Diameter:

$$d_{50} = \left(\frac{0.02}{TW}\right)\left(\frac{Q}{D_o}\right)^{4/3} = \left(\frac{0.02}{0.7}\right)\left(\frac{14.5}{1.5}\right)^{4/3} = 0.58 = 7\text{ inches}$$

Source: USDA-NRCS

Definition

Structurally lined aprons or other acceptable energy dissipating devices placed between the outlets of pipes or paved channel sections and a stable downstream channel.

Purpose

To prevent scour at storm drain, culvert or drainageway outlets and to minimize the potential for downstream erosion by reducing the velocity of concentrated storm water flows.

Applicability

At the outfall of all storm drain outlets, road culverts, paved channel outlets, new channels constructed as outlets for culverts and conduits, etc. discharging into natural or constructed channels, which in turn discharge into existing streams or drainage systems.

Planning Considerations

Analysis and appropriate treatment shall be done along the entire length of the flow path from the end of the conduit, channel or structure to the point of entry into an existing stream or publicly maintained drainage system. Where flow is excessive for the economical use of an apron, excavated stilling basins may be used. Acceptable designs for stilling basins may be found in the following sources:

- *Hydraulic Design of Energy Dissipators for Culverts and Channels, Hydraulic Engineering Circular No. 14, U.S. Department of Transportation, Federal Highway Administration. December 1975.*
- *Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, U.S. Department of the Interior, Bureau of Reclamation.*
- *Scour at Cantilevered Pipe Outlets – Plunge Pool Energy Dissipator Design Criteria, Agricultural Service Research Publication ARS-76, 1989.*

(All of the above are available from the U.S. Government Printing Office.)

- *Plunge Pool Design at Submerged Pipe Spillway Outlets, American Society of Agricultural Engineers, Volume 37(4):1167-1173, 1994.*

Design Criteria

Determination of Needs

The need for conduit outlet protection shall be determined by comparing the allowable velocity which the soil will withstand to the exit velocity of the flow from the conduit. The allowable velocity for water over the soil shall be that given in **Figure OP-1**. The exit velocity of the water in the conduit shall be calculated using the greater of the conduit design storm or the 25-year frequency storm. When the exit velocity of the water in the conduit exceeds the allowable velocity for the soil, outlet protection is required. Outlet protection is also required if the conduit outfall is set above the receiving channel (i.e., cantilevered) causing the water to drop at the outlet end of the culvert.

Figure OP-1 Allowable Velocities for Various Soils

Soil Texture	Allowable Velocity (ft./sec.)
Sand and sandy loam	2.5
Silt Loam	3.0
Sandy clay loam	3.5
Clay loam	4.0
Clay, fine gravel, graded loam to gravel	5.0
Cobbles	5.5
Shale	6.0

Source: USDA-NRCS

Riprap Aprons

Design Limitations: No bends or curves at the intersection of the conduit and the apron protection will be permitted.

There shall be no vertical drop from the end of the apron to the receiving channel.

Apron Dimensions: If an apron is used for energy dissipation, the following criteria apply:

1. The length of the apron, L_a, shall be determined from the formula:

$$L_a = \frac{1.7Q}{D_o^{3/2}} + 8D_o$$

   where:

   D_o is the maximum inside culvert width in feet, and
   Q is the pipe discharge in cubic feet per second (cfs) for the conduit design storm or the 25-year storm, whichever is greater.

2. The width of the apron, W, shall be determined as follows:

- *Where there is a well-defined channel downstream of the apron, the bottom width of the apron shall be at least equal to the bottom width of the channel. The structural lining shall extend at least one foot above the tailwater elevation but no lower than two-thirds of the vertical conduit dimension above the conduit invert.*

- *Where there is no well defined channel immediately downstream of the apron, the width, W, of the outlet end of the apron shall be as follows:*

   For tailwater elevation greater than or equal to the elevation of the center of the pipe, $W = 3\ D_o + 0.4\ L_a$
   For tailwater elevation less than the elevation of the center of the pipe, $W = 3\ D_o + L_a$

   where:

   L_a is the length of the apron determined from the length formula and
   D_o is the culvert width.

   The width of the apron at the culvert outlet shall be at least three times the culvert width.

3. The side slopes shall be 2:1 or flatter.

4. The bottom grade shall be 0.0% (level).

5. There shall be no vertical drop at the end of the apron or at the end of the culvert.

Riprap Requirements

1. The median stone diameter, d_{50} in feet is determined using the formula for d_{50} found in the Outlet Protection Design Example Problem on page 5-10-8 where:
   Q and D_o are as defined under apron dimensions and
   TW is tailwater depth above the invert of the culvert in feet.

2. At least 50% by weight of the riprap mixture shall be larger than the median size stone designated as d_{50}. The largest stone size in the mixture shall be 1.5 times the d_{50} size. The riprap shall be reasonably well graded.

3. The thickness of riprap lining, filter and quality shall meet the requirements in the riprap standard.

4. Concrete paving may be substituted for riprap. However, this method may not provide for energy dissipation.

5. Gabions or precast cellular blocks may be substituted for riprap if the d_{50} size calculated above is less than or equal to the thickness of the gabions or concrete revetment blocks.

See Example Design Problem on next page.

Other Outlet Protections

Standard engineering practices allow for many different types of outlet protection which provide energy dissipation. Common outlet protections include the use of a riprap apron (see **Figure OP-2**) and a riprap stilling basin (see **Figure OP-3**). Also see **Figure LS-4** in **Level Spreader** measure which combines a level spreader with outlet protection.

Installation Requirements

Install in accordance with the requirements of the engineered design.

Maintenance

Inspect the completed structure annually and after each major rainfall for damage and deterioration. Repair damages immediately.

Outlet Protection Design Example Problem

Given: D_o = 1.5 ft, Q = 14.5 cfs, TW = 0.7 ft.
Find: L_a, W, d_{50}
Solution:

For L_a (length of apron):

$$L_a = \frac{1.7Q}{D_o^{3/2}} + 8D_o = \frac{1.7(14.5\text{ cfs})}{1.5^{3/2}} + 8(1.5) = 25.4$$

Answer: L_a = 25.4 ft.

For W (apron width):

$$W = 3D_o + L_a = 3(1.5) + 29.9\text{ ft.}$$

Answer: W = 30 ft.

For d_{50} (median stone diameter):

$$d_{50} = \left(\frac{0.02}{TW}\right)\left(\frac{Q}{D_o}\right)^{4/3} = \left(\frac{0.02}{0.7}\right)\left(\frac{14.5}{1.5}\right)^{4/3} = 0.58\text{ ft.}$$

Answer: d_{50} = 0.58 ft. or 7 inches

Figure OP-2 Outlet Protection Utilizing Riprap Apron

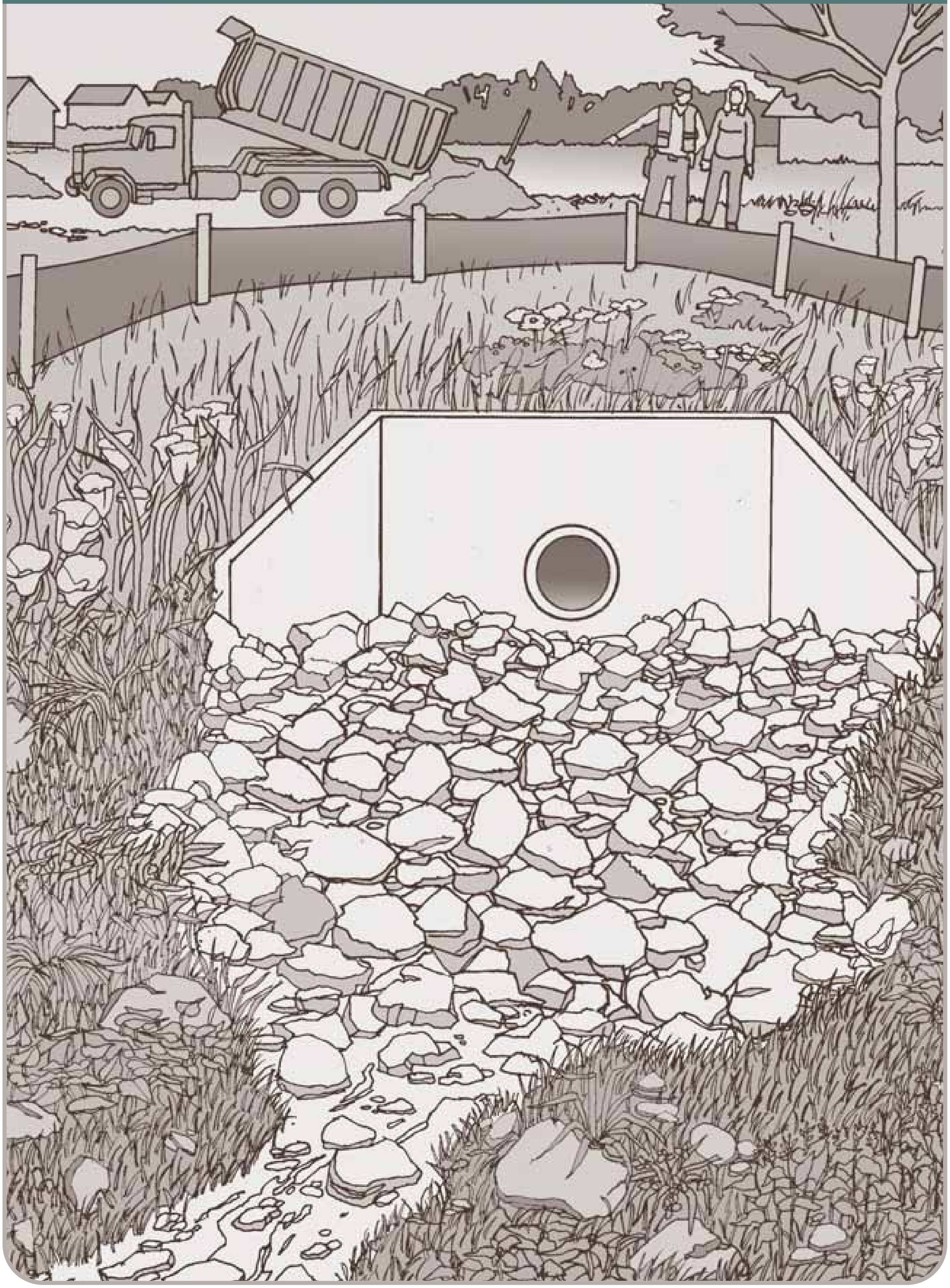
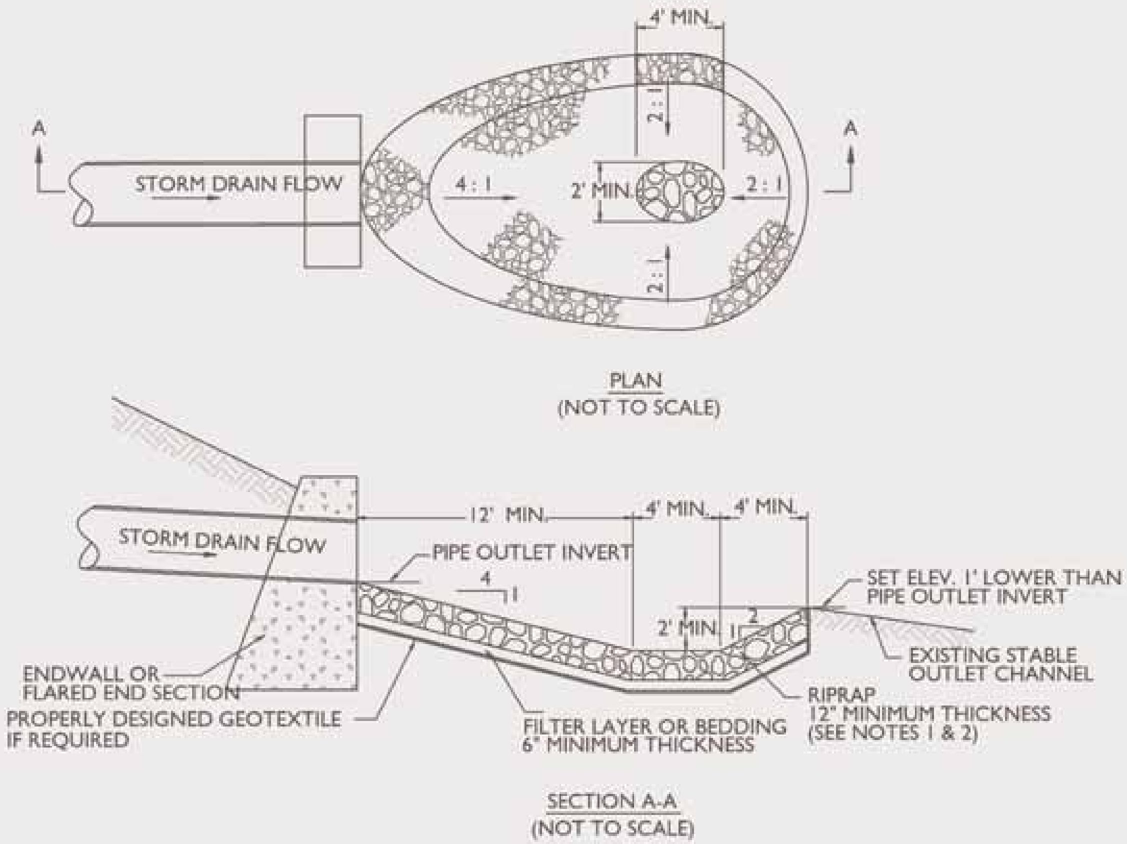


Figure OP-3 Configuration of Outlet Protection using a Riprap Stilling Basin



NOTES:

1. RIPRAP SIZE AND THICKNESS SHALL BE ADJUSTED UPWARD AS THE STORM DRAIN SIZE AND OUTLET VELOCITY INCREASE. SEE PLANNING CONSIDERATIONS SECTION FOR DESIGN REFERENCES.
2. CONSIDER THE APPLICATION OF CEMENTIOUS GROUT IN THE RIPRAP TO PREVENT VANDALISM AND FACILITATE SEDIMENT AND DEBRIS CLEANOUT.

Source: USDA-NRCS

10-Energy Dissipators

Stone Check Dam (SCD)

Definition

A temporary stone dam placed across a drainageway.

Purpose

- To reduce the velocity of concentrated storm water flows, thereby reducing erosion of the drainageway.
- To temporarily pond storm water runoff to allow sediments to settle out.

Applicability

- Where concentrated flows are expected to cause erosion.
- For temporary drainageways which, because of their short length of service, will not receive a non-erodible lining but still need protection to reduce erosion.
- For permanent drainageways which, for some reason, will not receive a permanent non-erodible lining for an extended period of time.
- For temporary or permanent drainageways which need protection during the establishment of vegetative linings. This measure is not a substitute for a **Temporary Sediment Trap** or a **Temporary Sediment Basin**, however, stone check dams may be used in conjunction with those measures.

Planning Considerations

A stone check dam is considered to be temporary if it is used less than 1 year. It is considered to be permanent if it is used more than 1 year. Its length of use and the size of the watershed determine if an engineered design is required (see **Figure SCD-1**).

When planning the location of the stone check dam(s) consider the tailwater effects, duration of ponding, stone size, the contributing watershed and, if placed in a watercourse, the effects on fish habitat and fish passage. Also assess if the final use of the area will require the stone check dam(s) to be removed. Give consideration to mowing requirements and aesthetics. For stone check dams to be located in a vernal, intermittent or permanent watercourse, check with regulatory authorities regarding permits.

Figure SCD-1 Design Requirements

Design Requirements	Drainage Area	Length of Use
no engineered design	† 2 acres	<6 months
2-yr frequency storm	>2 acres	>6 months, <1 year
25-yr frequency storm	any drainage size	>1 year

Design Criteria

No engineered design is required for a stone check dam if the contributing drainage area is 2 acres or less and its intended use is shorter than 6 months.

If the contributing drainage area is greater than 2 acres or its intended use is longer than 6 months, design the stone check dam according to generally accepted engineering standards (e.g. National Engineering Handbook – Part 650, DOT Drainage Manual). Additionally, the design shall contain construction standards and specifications required for implementation and maintenance of the measure.

For use of a stone check dam less than 1 year, design the stone check dam to safely pass the peak flow expected from a 2-year frequency storm without structural failure and adverse tailwater effects.

For use of a stone check dam exceeding 1 year, design the stone check dam to safely pass the peak flow expected from a 25-year frequency storm without structural failure of the check dam and adverse tailwater effects.

Specifications

For engineered stone check dams, construct the stone check dam in accordance with the design standards and specifications. For all non-engineered stone check dams, comply with the following specifications.

Materials

Stone: Shall meet the requirements of DOT Standard Specifications Section M.01.01, #3 aggregate. The stone shall be sound, tough, durable, angular, not subject to disintegration on exposure to water or weathering, be chemically stable, and shall be suitable in all other respects for the purpose intended.

Application

Place the stone by hand or machine, making side slopes no steeper than 1:1 (i.e., the angle of repose) with a maximum height of 3 feet at the center of the check dam. A geotextile may be used under the stone to provide a stable foundation and to facilitate removal of the stone.

In Drainageways: The minimum height of the check dam shall be the flow depth of the drainageway but it shall not exceed 3 feet in height at the center. Extend the stone check dam to the full width of the drainageway, plus 18 inches on each side leaving the height of the center of the stone check dam approximately 6 inches lower than the height of the outer edges (see **Figure SCD-2**).

The maximum spacing between check dams shall be such that the toe of the upstream check dam is at the same elevation as the top of the center of the downstream check dam (see **Figure SCD-2**).

Catch Basins in Drainageways on Slopes and at Culvert Inlets: Where catch basins in drainageways are located on slopes or at culvert inlets, locate the check dam across the drainageway no farther than 20 feet above the catch basin or culvert. For culvert inlets, locate the check dam at least 6 feet from the inlet (see **Figure SCD-3**).

Catch Basins in Depressions or low spots (yard drains): Encircle the entire catch basin with a stone check dam not to exceed 18 inches in height and 3 feet out from the outside edge of the top of the frame (see **Figure SCD-4**).

Culvert Inlets: Locate the stone check dam approximately 6 feet from the culvert in the direction of the incoming flow (see **Figure SCD-5**).

Special Case Combinations for Added Filtration & Frozen Ground Conditions: These are non-engineered stone check dams modified for use in critical watersheds (e.g. public water supply, cold water fisheries) when the drainage area is 2 acres or less or when a sediment barrier needs to be installed during frozen ground conditions.

*Stone Check Dam/Geotextile (***Figure SCD-6***)*: Stone check dams that are installed with an internal core of geotextile. The geotextile encourages ponding while the stone check dam provides stability. The geotextile must meet the minimum standards set forth in **Geotextile Silt Fence** measure. Partially construct the stone check dam to at least half its height. Place the geotextile over the partially built dam with sufficient material on the upstream side to allow for it to make complete contact with the ground. Complete the placement of stone by burying the geotextile within the check dam. Useful life of the measure is limited by the life of the geotextile used and maintenance.

*Stone Check Dam/Hay Bales (***Figure SCD-6***):* Stone check dams that are installed with a core of hay bales. The hay bales provide filtering capacity while the stone check dam provides stability. The hay bales must meet the minimum standards set forth in **Hay Bale Barrier** measure. At the location of the stone check dam first lay a loose bed of hay several inches thick along the entire length of the check dam alignment. Place hay bales with the ends of adjacent bales tightly abutting one another. Wedge any gaps with loose hay. Bury hay bales with stone and complete the construction of the stone check dam as indicated in the Application paragraphs above. Useful life of the measure is limited by the life of the hay bales and maintenance.

Maintenance

For permanent stone check dams, inspect and maintain the stone check dam in accordance with the standards and specifications provided in the design.

For temporary stone check dams, inspect stone check dams at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater to determine maintenance needs.

Remove the sediment deposits when deposits reach approximately half the height of the check dam.

Replace or repair the check dam within 24 hours of observed failure. Failure of the check dam has occurred when sediment fails to be retained because:

- *stone has moved,*
- *soil has eroded around or under the check dam reducing its functional capacity, or*
- *trapped sediments are overtopping the check dam.*

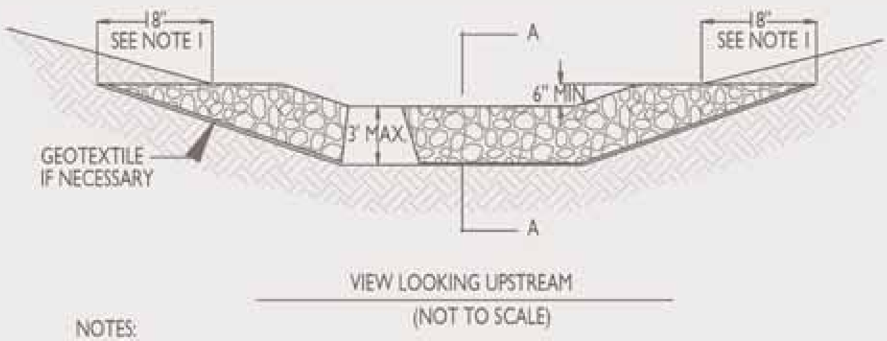
When repetitive failures occur at the same location, review conditions and limitations for use and determine if additional controls (e.g. temporary stabilization of contributing area, diversions, stone check dams) are needed to reduce failure rate.

Maintain the stone check dam until the contributing area is stabilized.

After the contributing area is stabilized, remove accumulated sediment. Stone check dams may be removed or graded into the flow line of the channel over the area left disturbed by sediment removal. Grade so there are no obstructions to water flow. If stone check dams are used in grass-lined channels which will be mowed, remove all the stone or carefully grade out the stone to ensure it does not interfere with mowing.

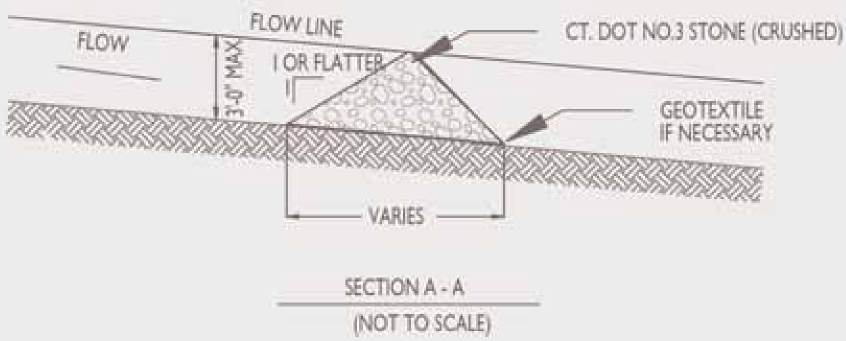
Stabilize any disturbed soil that remains from check dam removal operations.

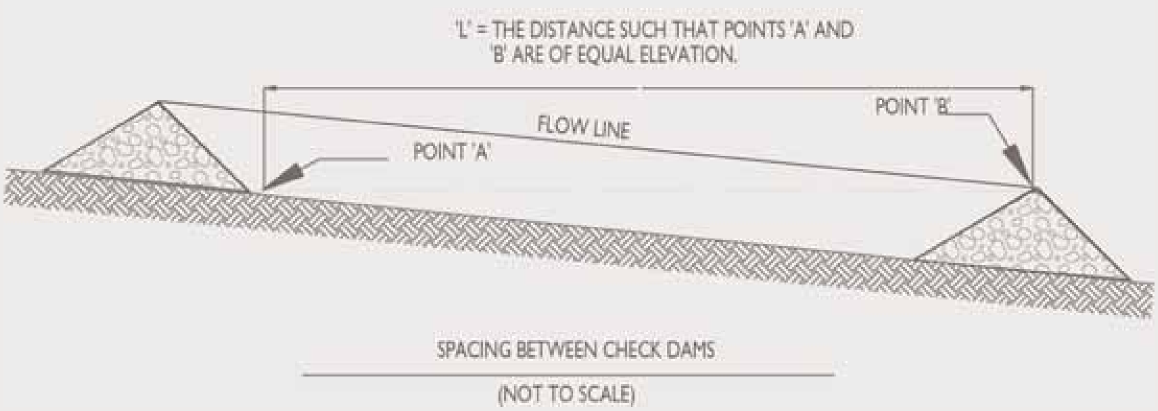
Figure SCD-2 Stone Check Dam Installation in Drainageways



NOTES:

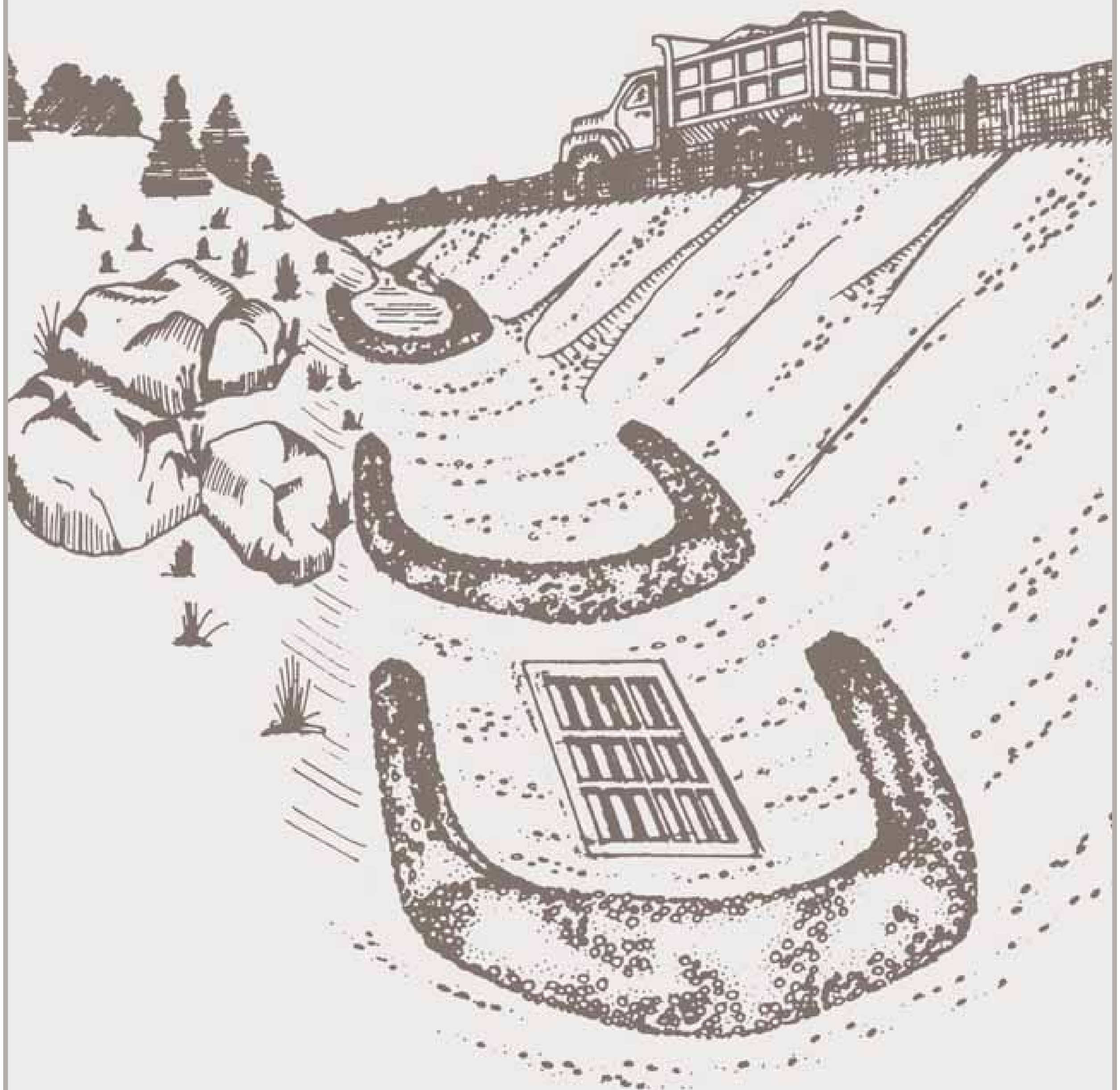
1. KEY STONE INTO THE DITCH BANKS AND EXTEND INTO THE ABUTMENTS A MINIMUM OF 18" TO PREVENT FLOW FROM FLANKING THE CHECK DAM.
2. THE MINIMUM DESIGN CAPACITY SHALL CONVEY A 2 YEAR - 24 HOUR PEAK FLOW.





Source: USDA-NRCS

Figure SCD-3 Stone Check Dam Above Catch Basin in Drainageway on Slope



Stone Check Dam (SCD)

Figure SCD-4 Stone Check Dam at Catch Basin in Depression

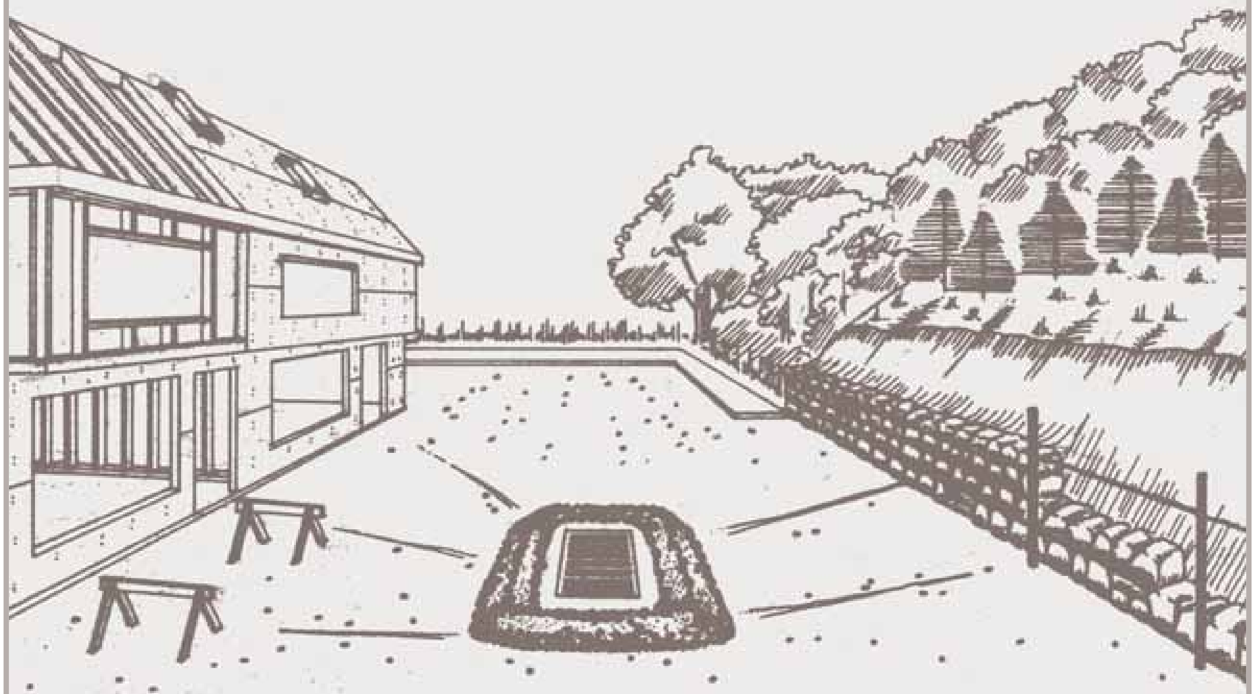


Figure SCD-5 Stone Check Dam at Culvert Inlet on Slope

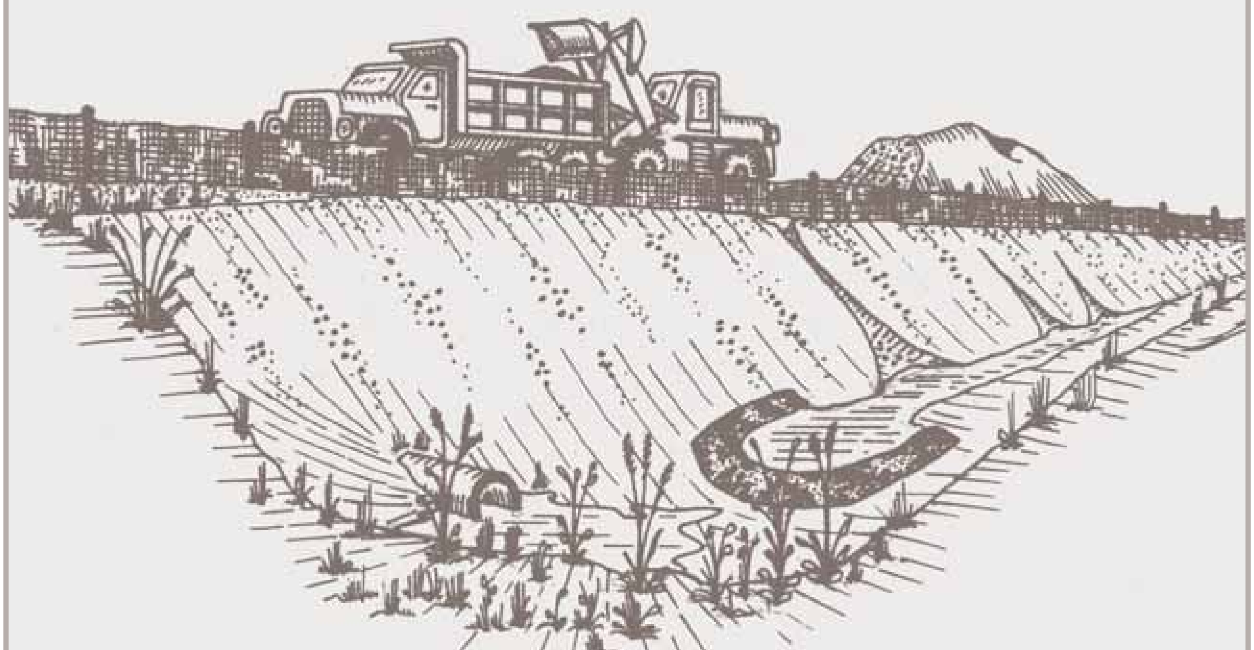
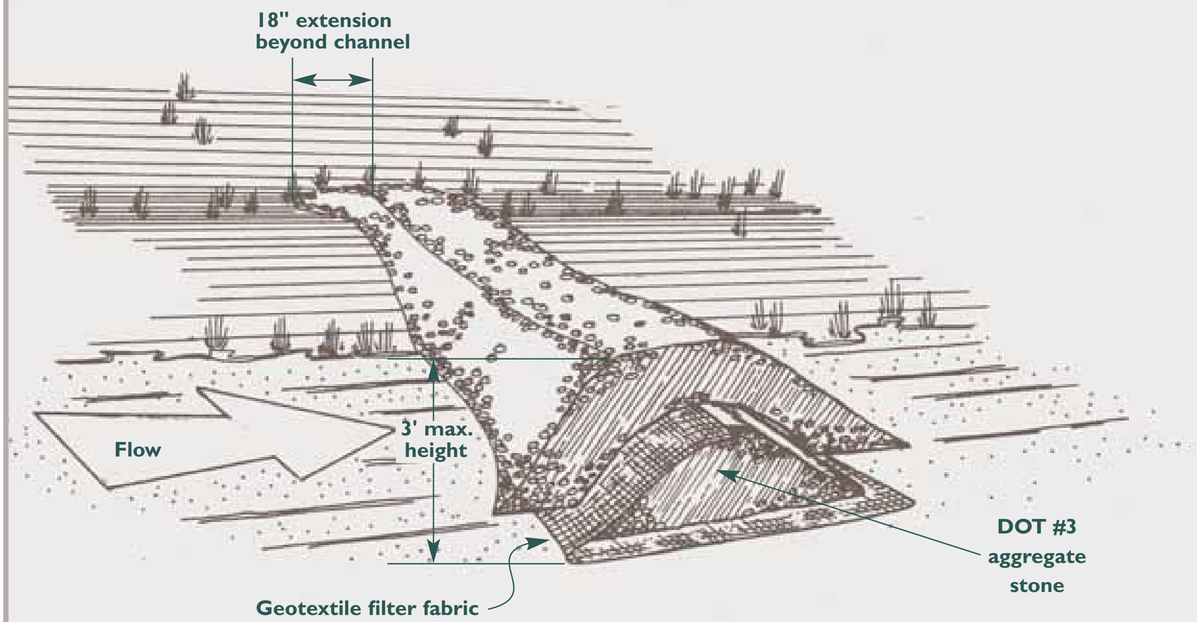
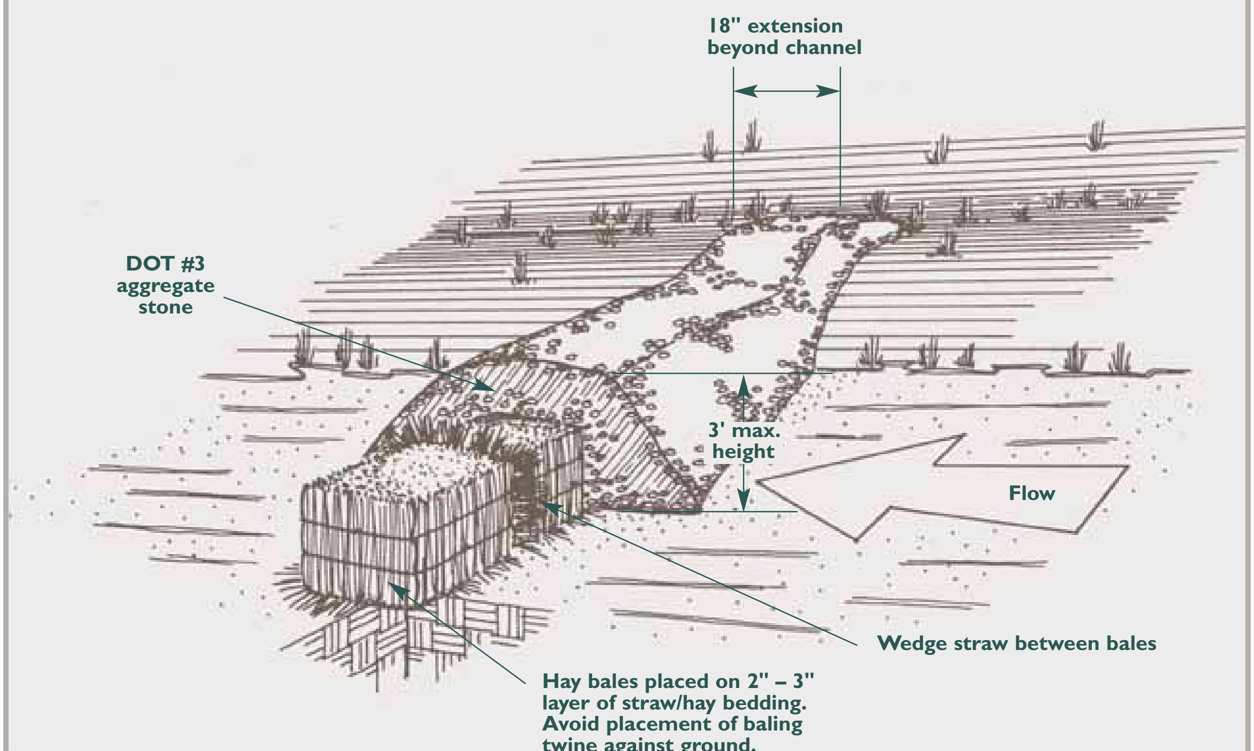


Figure SCD-6 Special Case Combination Stone Check Dams





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Planning Considerations

The measures included in the sediment impoundments and barriers functional group include **Temporary Sediment Basin, Temporary Sediment Trap, Hay Bale Barrier, Geotextile Silt Fence, Turbidity Curtain** and **Vegetated Filter**. The primary function of these measures is to slow the velocity of sediment laden waters enough to allow suspended sediments to drop out of solution. Secondary functions can include the filtering of sediment laden waters and the creation of a physical barrier that prevents the sediment laden water from mixing with clean waters.

Sediment impoundments (**Temporary Sediment Basin and Temporary Sediment Trap**) are excavated and/or diked areas which impound water long enough to allow sediment to settle out of the water column. They are intended to provide 75%–90% trap efficiency[1] for a 10 year 2 hour return frequency storm.

[1] Temporary sediment basins and traps are not intended for use as post-construction storm water management controls. Post-construction storm water management controls may require a design that is based upon a target settling efficiency rather than a trap efficiency.

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These measures are different from each other by their design requirements. Temporary sediment basins:

- *require an engineered design,*
- *are limited to a maximum of 100 acres contributing drainage area,*
- *can be used for more than 2 years, but not for post construction stormwater management,*
- *have an outlet control structure that includes an emergency spillway and*
- *have an initial minimum storage of 134 cubic yards per acre of contributing drainage area (which may be adjusted based on the engineering analysis).*

Temporary sediment traps:

- *do not require an engineered design,*
- *are limited to a maximum of 5 acres contributing drainage area,*
- *used only where the intended use is less than 2 years,*
- *have an above ground outlet and*
- *have a minimum storage of 134 cubic yards per acre of contributing drainage area without adjustment.*

Sediment barriers (**Hay Bale Barrier**, **Geotextile Silt Fence**, and **Turbidity Curtain**) are temporary barriers consisting of either natural or man made materials installed and maintained within or at the edge of disturbed areas to control the movement of sediments. Additionally, hay bale barriers may be used to redirect small volumes of water away from sensitive areas or highly erodible slopes.

The design criteria for sediment barriers are not based upon any specific storm. As a rule, their installation is limited to 1 acre or less of contributing drainage area. Both hay bale barriers and geotextile silt fences are useful in toe-of-slope and catch basin protection as well as in some pumping settling basins. In channels, only geotextile silt fences may be used to a limited extent. However, a geotextile silt fence and hay bales may be used in a channel within a non-engineered stone check dam (see next page).

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On land, hay bale barriers and geotextile silt fences may be used separately or in combination with each other, such as for catch basin protection, culvert inlet protection and dewatering facilities. Hay Bales or geotextiles can be used in combination with stone when added protection is needed for work in critical watersheds (e.g. public water supply, nearby cold water fisheries) or when the ground is frozen. This special application is described in the **Stone Check Dam** measure found in the Energy Dissipators Functional Group.

More than one sediment barrier measure may be used for the same situation. However, each measure has performance characteristics that tend to make its application more appropriate. In choosing which type to use, it is important to consider both the length of time that the barrier must remain effective and the sediment retention capacity needed.

Historically, stone check dams were included as a sediment barrier. The stone check dam measure has been revised and placed in the Energy Dissipators Functional Group.

In tidal waters or water deeper than 2 feet, a **Turbidity Curtain** is used as a sediment barrier. Its design and installation is determined by water fluctuation, depth, velocity, wave conditions and manufacturer's recommendations.

In non-tidal water less than 2 feet deep geotextile silt fences, hay bale barriers, or other similar barriers, such as sandbags, may be used to isolate construction waters from non-construction waters.

When locating a sediment impoundment or barrier, anticipate the possible need to have equipment access the area for the removal of accumulated sediments.

Only one measure is identified as a filter (**Vegetated Filter**) and is more limited in its application than any other measure in this group. A vegetated filter can only be used where slopes of both the contributing area and filtering area are less than 10%, where the contributing area is less than one acre and there is a sufficient length of flow through the filter to meet filtering needs. Frequently, a vegetated filter can not be used either due to the steepness of slope or the failure to have a wide enough filtering area to meet the minimum flow lengths through the filter.

Figure SB&F-1 identifies the limitations for each sediment barrier and filter measure. Stone check dams (non-engineered) are included only for reference when they are combined with hay bales or geotextile silt fencing.

Figure SB&F-1 Sediment Barrier and Filter Limitations

Limitation	Hay Bale	Geotextile Silt Fence	Turbidity Cutain	Vegetated Filter	Stone Check (non-engineered)
site conditions	on land	on land or standing water < 2 ft. deep	in water > 2 ft. deep	on land	on land
max. slope gradient	50% (2:1)	50% (2:1)	NA	10% (10:1)	50% (2:1)
max. slope length					
toe of slope application	100 ft.	100 ft.	NA	NA	NA
swale application	NA	depends on contributing slope gradient	NA	NA	depends on contributing slope gradient
max. drainage area	1 acre	1 acre	NA	1 acre	2 acres
expected life of control	≤ 3 months	1-3 years	per manufacturers specifications	until silted in	1 year
time of year to install	before ground freezes[1]		non-frozen water conditions	must be established before initial use	year round
location on landscape	not on pavement, bedrock or other hard surface that prevents proper entrenching or anchoring		in water > 2 ft. depth	slope in filter area not steeper than 10%	on land
in still water < 2 ft. deep	no	by special design only	no	no	no
in water > 2 ft. deep	no	no	yes	no	no
sheet flows - toe of slope	on the contour 5-10 away from toe of slope	on the contour 0-10 away from toe of slope	NA	only where vegetation is adequate to filter runoff water	not advised
drainageways	not advised	"U" shaped across drainageway	NA	NA	across drainageway
catch basins in hollows	ring basin		NA	NA	ring basin
on slopes	twin "U" shaped up- and down-slope of basin		NA	NA	twin barriers, one up- and down-slope of basin
culver inlets	no	"U" shaped at least 6 ft. from inlet	yes	no	"U" shaped at least 6 ft. from inlet
culvert outlets	no	"U" shaped at least 6 ft. from outlet	yes	no	"U" shaped at least 6 ft. from outlet

[1] special case – see stone barrier measure when stone barrier and hay bale barrier are combined during frozen ground conditions

Temporary Sediment Basin (SB)

Definition

A temporary dam, excavated pit or dugout pond constructed across a waterway or at other suitable locations with a controlled outlet(s) such that a combination of wet and dry storage areas are created. A basin that is created by the construction of a dam is classified as an *embankment sediment basin* and a basin that is constructed by excavation is an *excavated sediment basin.* A basin that is created by a combination of dam construction and excavation is classified as an *embankment sediment* basin when the depth of water impounded against the embankment at emergency spillway elevation is three feet or more.

Purpose

- To intercept and retain sediment during construction.
- To reduce or abate water pollution.
- To prevent undesirable deposition of sediment in wetlands, on bottom lands and developed areas.
- To preserve the capacity of reservoirs, ditches, canals, diversions, storm sewers, waterways and streams.

Applicability

- Below disturbed areas with a contributing drainage areas less than 100 acres. For drainage areas less than five acres, a **Temporary Sediment Trap** may be used.
- Only for locations where failure of the temporary sediment basin will not, within reasonable expectations, result in loss of life or damage to buildings, roads, railroads or utilities.
- Not for use as a post-construction stormwater renovation system.

Planning Considerations

The preferred method of sediment control is to prevent erosion and control it near the source, rather than constructing sediment basins which only trap a portion of the sediments. However, where physical conditions, land ownership or construction operations preclude the treatment of the sediment source by the installation of erosion control measures to keep soil and other material in place, a temporary sediment basin may offer the most practical solution to the problem.

Consider sequencing construction so that the basin is located in an area that won't be developed until after the contributing watershed is stabilized. Also, sequence construction activities and locate the basin to minimize interference with other construction activities and construction of utilities.

Locate the basin outside of wetlands and try to locate it in such a way that maximum storage benefit is obtained from the existing surrounding terrain to minimize disturbance from the construction of the dam.

Regardless of the construction sequence and location, plan to provide and maintain construction equipment access for the removal of accumulated sediment.

To minimize the size of the temporary sediment basin, plan to divert clean waters around the basin and intercept only runoff from disturbed areas.

For projects which include a permanent detention basin, it is sometimes advantageous to locate the temporary sediment basin at the site of the detention basin. Sharing the same location may minimize site disturbance and cost. When this approach is used, the size requirements of both the detention and sediment basins must be determined and the larger of the two must be in place during the construction period. After construction, the minimum size shall be that of the detention basin. One approach would be to construct the detention basin along with its berm and outlet works first, and expand the storage volume, if need be, to that required for the sediment basin. The permanent outlet works are modified during the construction period to provide the necessary wet and dry storage requirements and enhance the basin's ability to remove sediment. Upon stabilization of the contributing watershed, accumulated sediment is removed from the basin and any work, such as modifying the outlet works or installing permanent plantings, is done to complete the permanent detention basin.

Finally, the E&S plan should identify the sediment removal threshold(s), the method(s) of disposing of the sediment removed from the basin, the method of basin removal and final stabilization of the sediment basin after the contributing drainage area is stabilized.

Contact DEP Inland Water Resources Division early in the planning process to determine the potential need for a dam construction permit and/or water diversion permit. A local or state inland wetlands permit will be required if the temporary sediment basin is proposed in a wetland and/or watercourse area. Additional local permits may be required for work within floodplain and wetlands buffer areas. Check local ordinances and regulations regarding health and safety, as sediment basins may attract children and can be dangerous.

Design Criteria

Overall

Design the sediment basin to be compatible with the floodplain management and storm water management programs of the local jurisdiction and with local regulations for controlling sediment, erosion and runoff.

Attempt to locate sediment basins where:

1. Failure of the sediment basin would not, within reasonable expectations, result in loss of life, damage roads, railroads, homes, commercial and industrial properties or interrupt the use or service of utilities. (Dams which might fail and endanger life or property are regulated by the Commissioner of the Department of Environmental Protection under the CGS §§22a-401 through 22a-411.);

2. The effective height of the dam for an embankment sediment basin should be 15 feet or less. The effective height of the dam is defined as the difference in elevation in feet between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam becomes the upper limit;

3. The product of the storage times the effective height of the dam should be less than 3,000. Storage is the volume in acre-feet in the reservoir below the elevation of the crest of the emergency spillway. The effective height of the dam is as defined above.

Sediment basins that exceed any one of the above conditions shall be designed to meet the criteria in Earth Dams and Reservoirs, Technical Release 60 (TR-60)

Drainage Area

The maximum allowable drainage area into a sediment basin shall be 100 acres. An emergency spillway shall be provided on all embankment sediment basins with a contributing drainage area equal to or greater than 20 acres.

Basin Capacity

The volume in the sediment basin below the crest elevation of the emergency spillway shall be at least that required for *wet storage* (which includes *sediment storage*) plus that required for *residence storage*.

Residence Storage Time and Volume: Residence time is defined as the volume weighted average time that an amount of flow will reside in a reservoir.

The sediment basin shall provide, in addition to sediment storage volume and wet storage volume, adequate volume to provide a minimum 10 hours residence time for a 10-year frequency, 24-hour duration, Type III distribution storm.

Flood routing is required to determine residence storage time. **Figure SB-13**, along with flood routing using the approximate methods in the **Detention Basin** measure, TR-55, or other generally accepted flood routing methods, will provide the minimum required residence storage volume and the maximum allowable principal spillway discharge.

Sediment Storage Volume: At least 1 year of predicted sediment load must be provided regardless of the planned frequency of sediment removal. Where it is determined that periodic removal of sediment is practical, the sediment storage volume may be proportionately reduced.

For the purpose of determining the sediment storage volume, use 80% trap efficiency. Sediment Storage Requirements for Reservoirs Technical Release No. 12 by the USDA, NRCS may be used to provide a more refined estimate of the actual trap efficiency[1] of specific sediment basin.

Sediment volume is calculated from the following formula:

$$V = \frac{(DA)(A)(DR)(TE)(2{,}000\text{lbs./ton})}{(\gamma)(43{,}560\text{sq.ft./ac})}$$

where:

V = the volume of sediment trapped in ac. ft./yr.
DA = the total drainage area in acres
A = the average annual erosion in tons per acre per year using either values from the Universal Soil Loss Equation, the Revised Universal Soil Loss Equation or the values in **Figure SB-1** for the listed land use.
DR = the delivery ratio determined from **Figure SB-12**.
TE = the trap efficiency as given above. (Use 0.8)
γ = the estimated sediment density in the sediment basin in lbs/cu. ft. (from **Figure SB-2**).

Wet Storage Volume: The volume of the wet storage shall be at least twice the volume of the sediment storage volume (see above) and shall be designed to a minimum depth of 2 feet.

Wet storage volume is the volume in the basin that is located below the invert of the lowest outlet structure for the basin. The wet storage may not provide permanent ponding of water depending on site conditions but will create a permanent pool for settling suspended sediment during a runoff event. The wet storage is intended to minimize the re-suspension of existing trapped sediments during a runoff event. To reduce sediment removal frequency, increase the volume of wet storage which will increase the sediment storage volume.

Basin Shape and Depth

The length, width, and depth of the basin are measured from the emergency spillway crest elevation.

[1] Trap efficiency is the amount (expressed as a percent) or the total sediment delivered to the basin that will remain in the sediment basin. It is a function of residence time, characteristics of the sediment, nature and properties of inflow, and other factors.

Depth: The average depth shall be 4 feet or greater.

Width: The minimum width shall be:

$W = 10\sqrt{Q_5}$

where: W = width in feet
Q_5 = peak discharge from a 5-year frequency storm in cfs.

When the downstream area is highly sensitive to sediment impacts, the minimum width shall be:

$W = 10\sqrt{Q_{25}}$

where: W = width in feet
Q_{25} = peak discharge from a 25-year frequency storm in cfs.

Figure SB-1 Determining Erosion Rates

Land Use	Ave. Annual Erosion
Wooded area	0.2 ton/ac/yr
Developed urban areas, grassed areas, pastures, hay fields, abandoned fields with good cover	1.0 ton/ac/yr
Clean tilled cropland (corn, vegetables, etc.)	10 ton/ac/yr
Construction Areas	50 ton/ac/yr

Source: USDA-SCS

Figure SB-2 Estimated Sediment Density

Soil Texture *	γ_s Submerged (lbs/cu. ft.)
Clay	40-60
Silt	55-75
Clay-silt mixtures (equal parts)	40-65
Sand-silt mixtures (equal parts)	75-95
Clay-silt-sand mixtures (equal parts)	50-80
Sand	85-100
Gravel	85-125
Poorly sorted sand and gravel	95-130

* Use USDA soil data from county soil surveys or sieve analysis to determine soil texture.

Source: USDA-NRCS.

Length: The effective flow length shall be equal to at least two times the effective flow width. When site constraints prohibit the design of an adequate length, baffles are required to provide for the creation of an adequate flow length. (see **Figure SB-7**)

Spillway Design

The outlets for the basin shall consist of a combination of principal and emergency spillways. These outlets must pass the peak runoff from the contributing drainage area for the design storm (see **Figure SB-5**). If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the design storm. However, an attempt to provide a separate emergency spillway should always be made (refer to “Emergency Spillway”, **Figure SB-10**). Runoff computations shall be based upon the soil cover conditions which are expected to prevail during the life of the basin. Refer to standard engineering practices for calculations of the peak rate of runoff. Notably, the flow through the dewatering orifice cannot be utilized when calculating the design storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway crest.

The spillways designed by the procedures contained in this manual will not necessarily result in any reduction in the peak rate of runoff. If a reduction in peak runoff is desired, the appropriate hydrographs and storm routings shall be generated to choose the basin and spillway sizes.

Principal Spillway

For maximum effectiveness, the principal spillway should consist of a vertical pipe or box of corrugated metal or reinforced concrete, with a minimum diameter of 15 inches, joined by a water tight connection to a horizontal pipe (barrel) extending through the embankment and outletting beyond the downstream toe of the fill. If the principal spillway is used in conjunction with a separate emergency spillway, then the principal spillway shall be designed to pass at least the peak flow expected from a 2-year storm. If no emergency spillway is used, the principal spillway shall be designed to pass the entire peak flow expected from the design storm.

Design Elevations: The crest of the principal spillway shall be set at the elevation corresponding to the storage volume required. If a principal spillway is used in conjunction with an emergency spillway, the principal spillway crest shall be a minimum of 1.0 foot below the crest of the emergency spillway. In addition, a minimum freeboard of 1.0 foot shall be provided between the design high water elevation (design depth through the emergency spillway) and the top of the embankment. If no emergency spillway is used, the crest of the principal spillway shall be a minimum of 3 feet below the top of the embankment; in addition, a minimum freeboard of 2.0 feet shall be provided between the design high water and the top of the embankment.

Anti-Vortex Device and Trash Rack: If a riser-type principal spillway is used, an anti-vortex device and trash rack shall be attached to the top of the riser to improve the flow characteristics and prevent blockage due to floating debris. (See **Figure SB-8** and **Figure SB-9** for examples of the anti-vortex device and trash rack.)

Base: The base of the principal spillway shall be firmly anchored to prevent floatation. If the riser height of the spillway is greater than 10 feet, computations shall be made to determine the anchoring requirements. A minimum factor of safety of 1.25 shall be used (downward forces = 1.25 x upward forces).

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

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

2. A square steel plate securely attached or welded to the base of the riser, a minimum of 0.25 inch thick and having a width equal to twice the diameter of the riser shall be used; it shall be covered with stone, gravel, or compacted soil to prevent flotation.

Note: *If a steel base is used, special attention should be given to compaction so that 95% standard proctor compaction is achieved over the plate. Also, added precautions should be taken to ensure that material over the plate is not removed accidently during removal of sediment from the basin.*

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 shall be watertight. The outlet of the barrel shall be protected to prevent erosion or scour of downstream areas.

Seepage Control Along Principal Spillway Barrels:
Anti-Seep Collars: Anti-seep collars are designed to control seepage and piping along the barrel by increasing the flow length and thus making any flow along the barrel travel a longer distance.

Anti-seep collars shall be used along 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.

2. The embankment has a low silt-clay content (Unified Soil Classes SM or GM based on sieve analysis. See Appendix H for classification specifications) and the barrel is greater than 10 inches in diameter.

Anti-seep collars shall be installed within the saturated zone The maximum spacing between collars shall be 14 times the projection of the collars above the barrel and in no case shall exceed 25 feet. Collars shall not be closer than 2 feet from a pipe joint. Collars should be placed sufficiently far apart to allow space for hauling and compacting equipment. Precautions should be taken to ensure 95% standard proctor compaction is achieved around the collars. Connections between the collars and the barrel shall be watertight.

Filter Diaphragms: Due to the constraints that collars impose on embankment fill placement and compaction, collars may sometimes be ineffective or actually result in a increase in seepage and piping.

Alternative measures to anti-seep collars have been developed and are being incorporated into embankment designs. These measures include a structure known as a "filter or drainage diaphragm." A filter diaphragm consists of a layer of sand and fine gravel which runs through the dam embankment perpendicular to the barrel. Typically, the structure is 4 to 5 inches in width, approximately 1 foot in height, and is located at the barrel elevation at its intersection with the upper bounds of the seepage zone. The measure controls the transport of embankment fines, which is the major concern with piping and seepage. The diaphragm channels any undesirable flow through the fine-graded material, which traps any embankment material being transported. The flow is then conveyed out of the embankment through a drain.

The critical design element of the filter diaphragm is the grain-size distribution (gradation) of the filter material which is determined by the gradation of the adjacent embankment fill material. The use and design of these measures shall be based on site-specific geotechnical information and be supervised by a qualified professional.

Principal Spillway - Construction Specifications: 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 firmly compacted soil foundation. The base of the riser shall be firmly anchored according to design criteria to prevent its floating. With the exception of filter diaphragms, pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the barrel or anti-seep collars (compact by hand if necessary). Fill material shall be placed around the pipe in 6-inch layers and compacted until 95% standard proctor compaction is achieved. A minimum of two feet of fill shall be hand-compacted over the barrel before crossing it with construction equipment.

Pipe conduits for embankment sediment basins shall meet the following requirements:

Pipe Materials: The pipe shall be capable of withstanding external loading without yielding, buckling, or cracking. The following pipe materials are acceptable:

1. **Corrugated Steel Pipe:** Pipe gauge is not to be less than that indicated in **Figure SB-3.** The maximum principal spillway barrel size shall be 48 inches. The pipe shall be helical fabrication. Flanges with gaskets or caulking may be used. Rod and lug coupling bands with gaskets or caulking may be used.

2. **Corrugated Aluminum Pipe:** Minimum pipe gauge is shown in **Figure SB-3**. The maximum principal spillway barrel size shall be 36 inches. The pipe shall be riveted fabrication. The embankment and water shall range between pH 4 and pH 9. Inlets, coupling bands and anti-seep collars must be made of aluminum.

Fittings for aluminum pipe fabricated of metals other than aluminum or aluminized steel must be separated from the aluminum pipe at all points by at least two layers of plastic tape having a total thickness of at least 24 mils, or by other permanent insulating material that effectively prevents galvanic corrosion.

Bolts used to join aluminum and steel must be galvanized, plastic coated, or otherwise protected to prevent galvanic corrosion. Bolts used to join aluminum to aluminum, other than aluminum alloy bolts, must be galvanized, plastic coated, or otherwise protected to prevent galvanic corrosion.

Connections between pipe joints must be watertight. Flanges with gaskets or caulking may be used. Rod and lug coupling bands with gaskets or caulking may be used. Slip seam coupling bands with gaskets or caulking may be used.

3. **Plastic Pipe:** PVC pipe shall meet the requirements of **Figure SB-4**. Connections between pipe joints and anti-seep collar connections to the pipe must be watertight. Pipe joints shall be solvent welded, O-ring, or threaded. All fittings and couplings shall meet or exceed the same strength requirements as that of the pipe and be made of material that is recommended for use with the pipe. Connections of plastic pipe to less flexible pipe or structures shall be designed to avoid stress concentrations that could rupture the plastic. The maximum principal spillway barrel size shall be 12 inches.

Figure SB-4 PVC* Pipe Requirements

Nominal Pipe Size (Inches)	Strength	Maximum Depth of Fill Over Pipe (Feet)
6, 8, 10, 12	Sched. 40	10
	Sched. 80	15
	SDR 26	10

*Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM D 1785 or ASTM D 2241

Source: Adapted from Standards for Soil Erosion and Sediment Control in New Jersey, New Jersey State Conservation Committee.

4. **Smooth Steel:** The minimum wall thickness shall be 3/16 inch. Used pipe shall be in good condition and not have deep rust pits. The maximum principal spillway barrel shall be 48 inch. Pipe joints shall be threaded or welded by a competent welder.

5. **Concrete, With Rubber Gasket Joints:** The pipe shall be laid in concrete bedding. Connections between pipe joints and anti-seep collar connections to pipe shall be watertight and remain watertight after movement caused by foundation consolidation and embankment settlement.

Inlets for Pipe Conduits: The inlet shall be structurally sound and made from materials compatible with the pipe. The inlet shall be designed to prevent floatation.

Figure SB-3 Corrugated Steel and Aluminum Pipe Requirement

Corrugated Steel Pipe

							Risers Only		
Pipe Diameter	8 to 21	24	30	36	42	48	54	60	66
Minimum Gauge	16	16	14	14	12	10	10	10	10

Corrugated Aluminum Pipe

					Risers Only		
Pipe Diameter	8 to 21	24	30	36	42	48	54
Gauge (inches)	16 (.06)	14 (0.75)	14 (0.75)	14 (0.75)	12 (.105)	10 (.135)	10 (.135)

Source: Standards for Soil Erosion and Sediment Control in New Jersey. New Jersey State Soil Conservation Committee.

The inlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. The inlet materials shall be subject to the same limitations and requirements as pipe conduits.

1. **Watertight Riser:** Risers shall be completely watertight except for the inlet.

2. **Pipe Drop Inlet:** Pipe drop inlets, where designed for pressure flow, shall meet the following conditions:
   (a) The weir length shall be adequate to prime the pipe below the emergency spillway elevation.
   (b) For pipe on less than critical slope, the height of the drop inlet shall be at least 2 times the conduit diameter.
   (c) For pipe on a critical slope or steeper, the height of the drop inlet shall be at least 5 times the conduit diameter.

Anti-vortex Devices: Sediment basins with the principal spillway designed for pressure flow shall have adequate anti-vortex devices. See **Figure SB-8** and **Figure SB-9**.

Trash and Safety Guards: An appropriate guard shall be installed at the inlet. The guard shall prevent clogging of the pipe by trash and reduce the safety hazard to people. The guard shall be a type that will not plug with leaves, grass or other debris. See **Figure SB- 9** and **Figure SB-9**.

Outlets for Pipe Conduits: The outlets shall be structurally sound and made from materials compatible with the pipe. The outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. Protection against scour at the discharge end of the spillway shall be provided. Measures may include impact basins, Saint Anthony Falls outlets, riprap, excavated plunge pools or other generally accepted energy dissipators.

Anti-seep Collars: Pipe conduits for embankment sediment basins shall be provided with anti-seep collars or filter diaphragms. The minimum number of anti-seep collars shall be determined by the size of the collars and the length of that part of the conduit lying in the saturated zone of earth embankment. Anti-seep collars are not required for excavated sediment basins.

The size and number of anti-seep collars is determined such that the ratio of the length of the line of seepage ($L + 2\ n\ V$) to L is to be not less than 1.15 where

V = projection of the anti-seep collar in feet
L = length in feet of the conduit within the zone of saturation, measured from the downstream side of the riser to the toe drain or point where the phreatic line intercepts the conduit, whichever is shorter
n = number of anti-seep collars

Anti-seep collars should be equally spaced along that part of the barrel within the saturated zone at distances of not more than 25 feet. See page 5-11-8 for other criteria on seepage control which may conflict.

The anti-seep collars and their connections to the pipe shall be watertight. The collar material shall be compatible with pipe materials.

Emergency Spillway

An attempt to provide a separate emergency spillway shall always be made. However, there shall be an emergency spillway on all temporary sediment basins with a contributing drainage equal to or exceeding 20 acres. The emergency spillway acts as a safety release for a sediment basin, or any impoundment-type structure, by conveying the larger, less frequent storms through or around the basin without damage to the embankment. The emergency spillway shall consist of an open channel (earthen and vegetated) constructed adjacent to the embankment over undisturbed material (not fill).

Where conditions will not allow the construction of an emergency spillway on undisturbed material, a spillway may be constructed of a non-erodible material such as riprap. The spillway shall have a control section at least 20 feet in length. The control section is a level portion of the spillway channel at the highest elevation in the channel profile.

Where conditions require the construction of an emergency spillway on the embankment, a spillway shall be constructed of a non-erodible material such as riprap. As an alternative, a structural spillway may be installed which combines the outflow requirements of a principal (primary) spillway and emergency (auxiliary) spillway.

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

Emergency Spillways for Excavated Sediment Basins: If the downstream slope is 5:1 or flatter and has existing vegetation or is immediately protected by sodding, riprap, asphalt lining, concrete lining, or other equally effective protection, then excavated sediment basins may utilize the natural ground for the emergency spillway. Otherwise, the spillway shall meet the capacity requirement for embankment sediment basins given below.

Emergency Spillway for Embankment Sediment Basins: Emergency spillways for embankment sediment basins shall meet the following requirements:

Capacity: The minimum capacity of the emergency spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in **Figure SB-5** less any reduction creditable to principal spillway discharge and detention storage.

If routed, the flood routing shall be done using the approximate methods outlined in the **Detention Basin** measure, TR-55, or other generally accepted methods of emergency spillway flood routing. When discharge of conduit-type principal spillway system is considered in calculating outflow through the emergency spillway, the crest elevation of the inlet shall be such that full pipe flow will be generated in the conduit before there is discharge through the emergency spillway.

Figure SB-5 Design Data		
Drainage Area (acres)	Frequency (years)	Minimum Duration (hours)
Less than 50	25	24
50-100	100	24

Source: USDA-NRCS

Design Elevations: The design storm elevation through the emergency spillway shall be at least 1.0 feet below the top of the embankment. The crest of the emergency spillway channel shall be at least 1.0 feet above the crest of the principal spillway.

Location: The emergency spillway channel shall be located so that it will not be constructed over fill material. The channel shall be located so as to avoid sharp turns or bends. The channel shall return the flow of water to a defined channel downstream from the embankment.

Spillway variables (see **Figure SB-10** and **Figure SB-11**): Emergency spillways are to provide for passage of the design flow at a safe velocity to a point downstream where the embankment will not be endangered. The maximum permissible velocity in the exit channel shall be 4 feet per second for vegetated channels in soils with a plasticity index of 10 or less and 6 feet per second for vegetated channels in soils with a plasticity index greater than 10 (based on laboratory analysis). For exit channels with erosion protection other than vegetation, the velocities shall be non-erosive for the type of protection used.

The emergency spillway channel shall return the flow to the receiving channel at a non- eroding velocity.

Cross Sections: Emergency spillways shall be trapezoidal and be located in undisturbed earth. The side slopes shall be 2:1 or flatter. The bottom width shall be a minimum of 8 feet. The embankment requirements shall determine elevation differences between the crest of the emergency spillway and the settled top of dam.

Component Parts: Emergency spillways are open channels and consist of an inlet channel, control section and an exit channel. The emergency spillway shall be sufficiently long to provide protection from breaching.

Inlet Channel: The inlet channel shall be level and straight for at least 20 feet upstream of the control section. Upstream from this level area it may be graded back towards the basin to provide drainage. The alignment of the inlet channel may be curved upstream from the straight portion.

Exit Channel: The grade of the exit channel of a constructed spillway shall fall within the range established by discharge requirements and permissible velocities. The exit channel shall carry the design flow downstream to a point where the flow will not discharge onto the toe of the embankment. The design flow should be contained in the exit channel without the use of dikes. However, if a dike is necessary, it shall have 2:1 or flatter side slopes, a minimum top width of 8 feet, and be high enough to contain the design flow plus 1 foot of freeboard.

Emergency Spillway - Construction Specifications: Do not construct vegetative emergency spillways over fill material. Design elevations, widths, entrance and exit channel slopes are critical to the successful operation of the spillway and should be adhered to closely during construction.

Structural Spillways Other Than Pipe

Structural spillways other than pipe systems will have structural designs based on sound engineering data with acceptable soil and hydrostatic loadings as determined on an individual site basis.

When used as a principal spillway, structural spillways shall meet the flow requirements for principal spillways and shall not be damaged by the emergency spillway design storm. When used as a combination principal emergency spillway, it shall pass the storm runoff from the appropriate storm in **Figure SB-5**.

Embankment Design

Height: The effective height of the dam for an embankment detention basin is 15 feet or less. The effective height of the dam is defined as the difference in elevation in feet between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam becomes the upper limit. Additional design guidance can be found in the NRCS Practice Standard 378, August 1982. Sediment basins that exceed the above conditions shall be designed to meet the criteria in Earth Dams and Reservoirs Technical Release 60 (TR-60).

Embankment Cross-Section: For embankments of less than 10 feet, the embankment must have a minimum top width of 6 feet, and the side slopes shall be 2:1 or flatter. For embankments 10 to 14 feet in height, the minimum top width shall be 8 feet and the side slopes shall be 2-1/2:1 or flatter. For 15 foot high embankments (maximum allowed under this practice), the minimum top width shall be 10 feet with 2-1/2:1 side slopes or flatter.

Site Preparation: Areas under the embankment and any structural works related to the basin shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other unsuitable material. In order to facilitate cleanout and restoration, the area of most frequent inundation (measured from the top of the principal spillway) will be cleared of all brush and trees.

Foundation Cutoff: A foundation cutoff, constructed with relatively impermeable materials, shall be provided for all embankments. The cutoff trench shall be excavated along the centerline of the dam. The trench must extend at least 2 feet into undisturbed foundation soils. The cutoff trench shall extend up both abutments to the emergency spillway crest elevation. The width shall be wide enough to permit operation of compaction equipment (4 feet minimum). 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 kept free from standing water during the backfilling operations.

Seepage Control: Seepage control is to be included if seepage may create swamping downstream, if needed to ensure a stable embankment, or if special problems require drainage for a stable embankment. Seepage control may be accomplished by foundation, abutment or embankment drains, reservoir blanketing or a combination of these and other measures.

Foundation: The area on which an embankment is to be placed shall consist of material that has sufficient bearing strength to support the embankment without excessive consolidation.

Earth Embankment Design

Freeboard: The minimum elevation of the top of the settled embankment shall be 1.0 foot above the water surface in the reservoir with the emergency spillway flowing at design depth.

Materials: The fill material for the embankment shall be from approved borrow areas. It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, oversized stones, rocks, man made materials, or other perishable or unsuitable material. The material selected must have enough strength for the dam to remain stable and be impervious enough, when properly compacted, to prevent excessive seepage through the dam. Impervious portions of the embankment shall consist of at least 15% clay or silt. Using the Unified Soil Classification System (See **Appendix H**), SC (clayey sand), GC (clayey gravel) and CL ("low liquid limit" clay) are among the preferred types of embankment soils. SM, ML and GM type soils may also be used. Fill material should be selected based on laboratory analysis.

Allowance for Settlement: The design height of the embankment shall be increased by the amount needed to ensure that, after all settlement and consolidation has taken place, the height of the dam will equal or exceed the design height. This increase shall not be less than 10% when compaction is by hauling equipment or 5% if controlled compaction is used, except where detailed soil testing and laboratory analysis shows that a lesser amount is adequate.

Compaction: Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material shall contain the proper amount of moisture to ensure that at least 90% – 95% standard proctor compaction will be achieved. Fill material will be placed in 9-inch 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 one wheel or tread track of the equipment, or by using a compactor. Special care shall be taken in compacting around the anti- seep collars and principal spillway system to avoid damage and achieve desired compaction (compact by hand, if necessary).

Provisions for Maintenance Sediment Removal

Sediment basin designs shall include provisions for the periodic removal of accumulated sediments, including adequate access for excavating and hauling equipment, dewatering and the threshold of sediment deposition that triggers the sediment removal operation. Additionally, disposal sites for the removed sediments shall be planned. See measures found in the Dewatering Functional Group and the discussion in Chapter 4, Special Treatments (stockpiling).

Sediment Storage Markers

Detail the location and installation requirements for sediment storage stakes or other means of showing the threshold elevation for sediment cleanout.

Stabilization of Disturbed Areas

The embankment, emergency spillway, spoil and borrow areas, and other disturbed areas above normal water level shall be vegetatively stabilized in accordance with the **Permanent Seeding** or **Sodding** measures or otherwise provided with a non-erodible surface.

Construction Specifications

Construction specifications shall to be included either on the plans or contained in a supplemental document referenced by and accompanying the plans. The construction specifications identify all material and operational specifications that are required by the design. The construction specifications must include but are not limited to design requirements for site preparation, foundation cutoff, seepage control, foundation construction, materials for principal and emergency spillways, vegetation establishment and sediment storage markers.

Installation Requirements

Construct in accordance with the design plans and construction specifications.

Site Preparation

Clear, grub and strip topsoil to remove trees, vegetation, roots, or other unsuitable material from areas under the embankment or any structural works related to the basin. Clear and grub the area of most frequent inundation (measured from the top of the outlet control structure) of all brush and trees to facilitate clean out and restoration.

Install Sediment Controls for Contributing Areas

Install sediment controls to trap sediment before it enters and leaves the detention basin construction site.

Stabilize the dam and emergency spillway in accordance with the engineered design, stabilize the spoil and borrow areas, and other disturbed areas in accordance with the **Temporary Seeding** or **Permanent Seeding** measures, whichever is applicable.

Safety

Install safety features and devices to protect humans and animals from such accidents as falling or drowning. Temporary fencing can be used until barrier plantings are established. Use protective measures such as guardrails and fences on spillways and impoundments as needed.

Maintenance

Inspect the temporary sediment basin at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater to determine conditions in the basin. Clean the sediment basin of sediments when sediment accumulation exceeds one half of the wet storage capacity of the basin or when the depth of available pool is reduced to 18 inches, whichever is achieved first. Sediment levels shall be marked within the sediment storage area by stakes or other means showing the threshold elevation for sediment cleanout.

Prior to the removal of sediments, dewater the basin through pumping or other means to the expose previously submerged sediments. Use measures found in the Dewatering Functional Group and Chapter 4, Special Treatments (Stockpiling). Do not allow accumulated sediment to flush into the stream or drainageway. Stockpile the sediment in such a manner that it will not erode from the site or into a wetland, watercourse or other sensitive area.

Sediment removal, transportation and disposal shall occur as shown on the plans as limited by the design criteria.

Figure SB-6 Sediment Basin Schematic Elevations

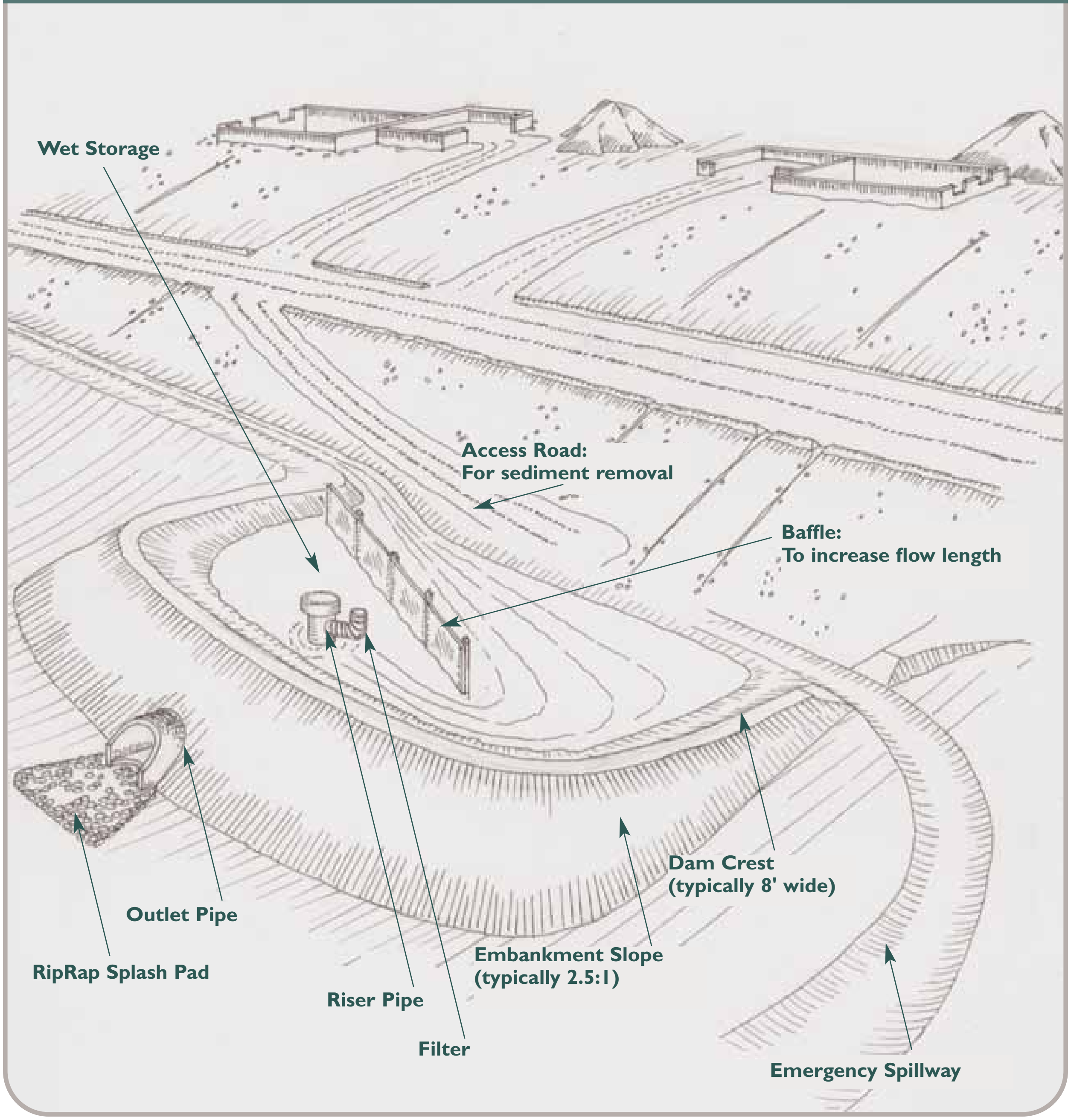
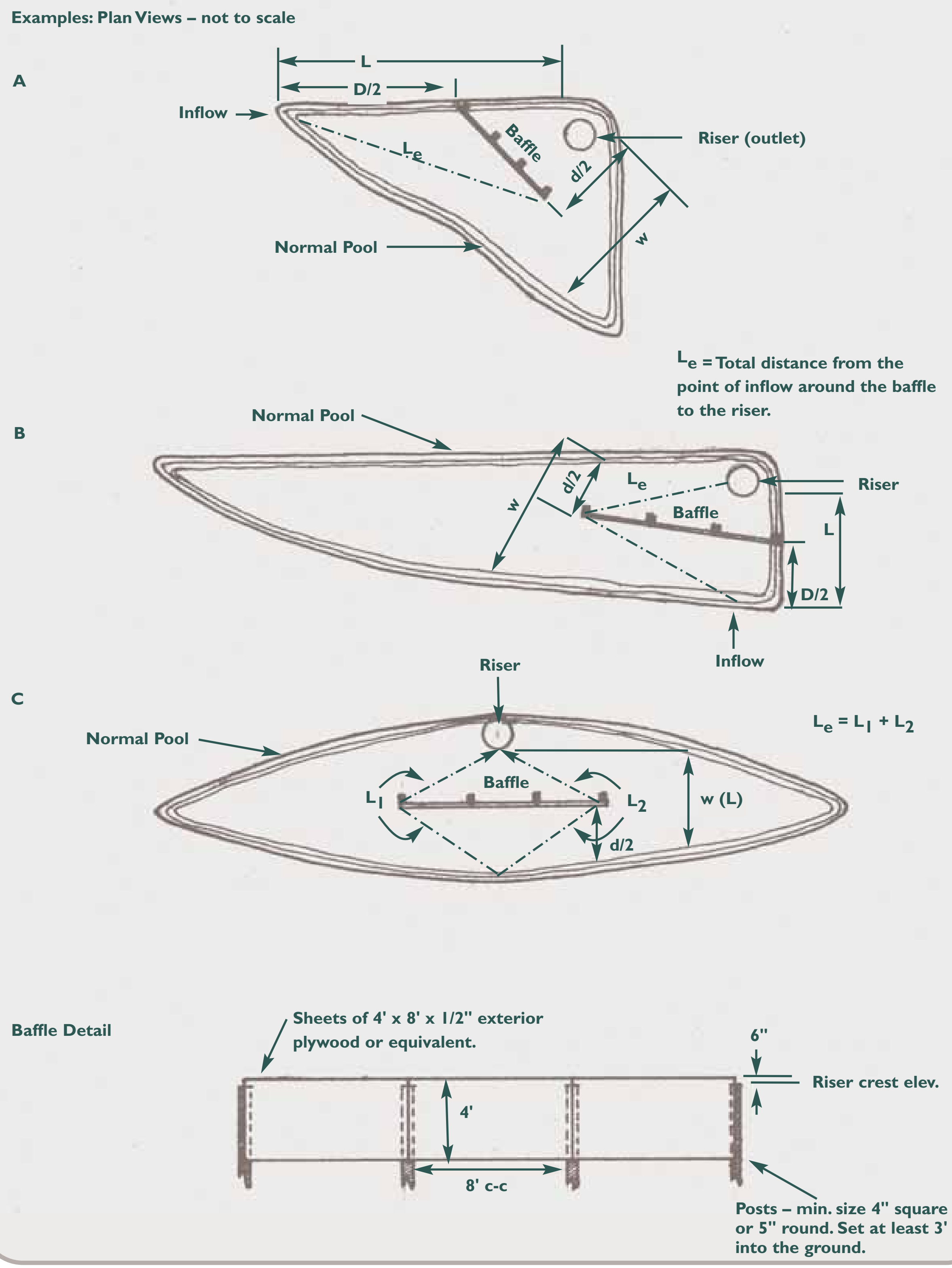
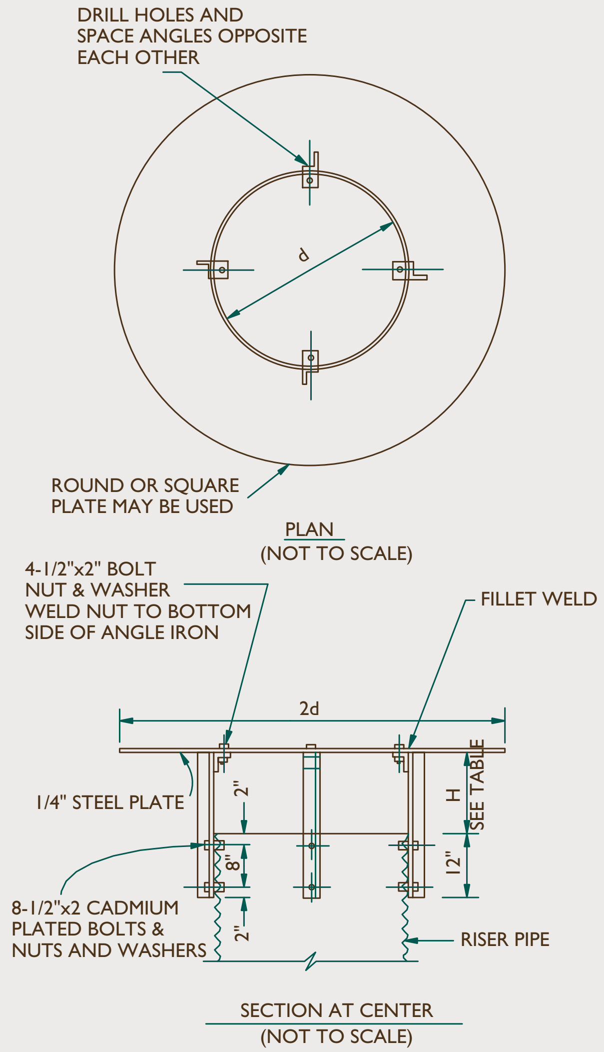


Figure SB-7 Sediment Basin Baffle Details



Source: USDA-NRCS

Figure SB-8 Anti-Vortex - Trash and Safety Guard Diagram

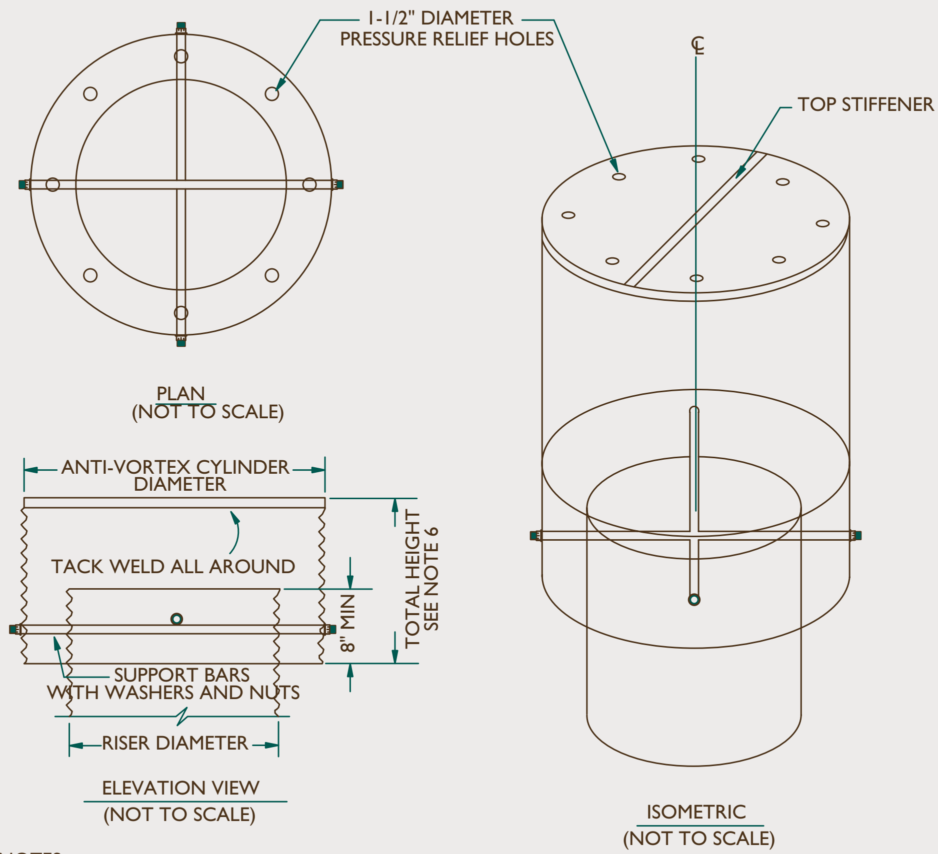


INLET d DIA. INCHES	BARREL DIA. INCHES	H INCHES
12	6	6
12	8	6
15	10	6
15	12	7
18	12	6
24	15	7 1/2
24	18	10
* 30	18	8 1/2
* 30	24	13 1/2
* 36	24	12

* USE ANGLE IRON STIFFENERS ON PLATE AS SPECIFIED.

Source: USDA-NRCS

Figure SB-9 Concentric Trash Rack and Anti-Vortex Device



NOTES:

1. TOP STIFFENER (IF REQUIRED) IS 2" X 2" X 1/4" ANGLE WELDED TO TOP AND ORIENTED PERPENDICULAR TO CORRUGATIONS.
2. TOP IS 12 GAGE CORRUGATED METAL OR 1/8" STEEL PLATE. PRESSURE RELIEF HOLES MAY BE OMITTED IF ENDS OF CORRUGATIONS ARE LEFT FULLY OPEN WHEN CORRUGATED TOP IS WELDED TO CYLINDER.
3. CYLINDER IS 12 GAGE CORRUGATED METAL PIPE OR FABRICATED FROM STEEL PIPE WITH A MINIMUM 1/8" WALL THICKNESS.
4. SUPPORT BARS ARE 1/2" DIAM. (MIN).
5. TRASH RACK DIAMETER SHALL BE SIZED SO THE VELOCITY THROUGH THE BOTTOM OF THE RACK IS LESS THAN 2.5 FEET/SECOND.
6. THE TOP OF THE CONCENTRIC TRASH RACK SHALL BE SET AT OR ABOVE THE ELEVATION AT WHICH THE PRINCIPAL SPILLWAY BARREL FLOWS FULL (PRIMES).

Source: USDA-NRCS

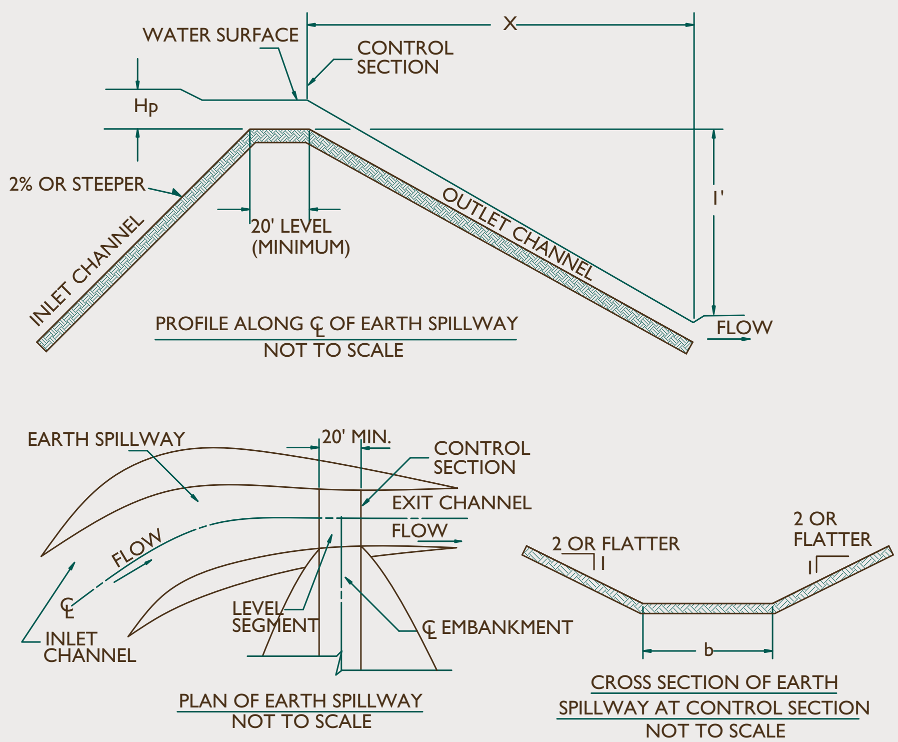
Figure SB-10 Design Data for Earth Spillways

LEGEND

n = MANNING'S COEFFICIENT OF ROUGHNESS.
Hp = DIFFERENCE IN ELEVATION BETWEEN CREST OF EARTH SPILLWAY AT THE CONTROL SECTION | AND WATER SURFACE IN RESERVOIR, IN FEET.
b = BOTTOM WIDTH OF EARTH SPILLWAY AT THE CONTROL SECTION, IN FEET.
Q = TOTAL DISCHARGE, IN C.F.S.
V = VELOCITY, IN FEET PER SECOND, THAT WILL EXIST IN CHANNEL BELOW CONTROL SECTION, AT DESIGN Q, IF CONSTRUCTED TO SLOPE (S) THAT IS SHOWN.
S = FLATTEST SLOPE (S), IN % ALLOWABLE FOR CHANNEL BELOW CONTROL SECTION.
X = MINIMUM LENGTH OF CHANNEL BELOW CONTROL SECTION, IN FEET.
z = SIDE SLOPE RATIO (2:1).

NOTES:

1. FOR A GIVEN Hp A DECREASE IN THE EXIT SLOPE FROM S AS GIVEN IN THE TABLE DECREASES SPILLWAY DISCHARGE, BUT INCREASING THE EXIT SLOPE FROM S DOES NOT INCREASE DISCHARGE. IF AN EXIT SLOPE (Se) STEEPER THAN S IS USED, THEN THE VELOCITY (Ve) IN THE EXIT CHANNEL WILL INCREASE ACCORDING TO THE FOLLOWING RELATIONSHIP:
$$Ve = V\left(\frac{Se}{S}\right)^{0.3}$$
2. DATA TO RIGHT OF HEAVY VERTICAL ON FIGURE SB-11 SHOULD BE USED WITH CAUTION, AS THE RESULTING SECTIONS WILL BE EITHER POORLY PROPORTIONED OR HAVE VELOCITIES IN EXCESS OF 6 FT/SEC.



PROFILE ALONG ℄ OF EARTH SPILLWAY
NOT TO SCALE

PLAN OF EARTH SPILLWAY
NOT TO SCALE

CROSS SECTION OF EARTH SPILLWAY AT CONTROL SECTION
NOT TO SCALE

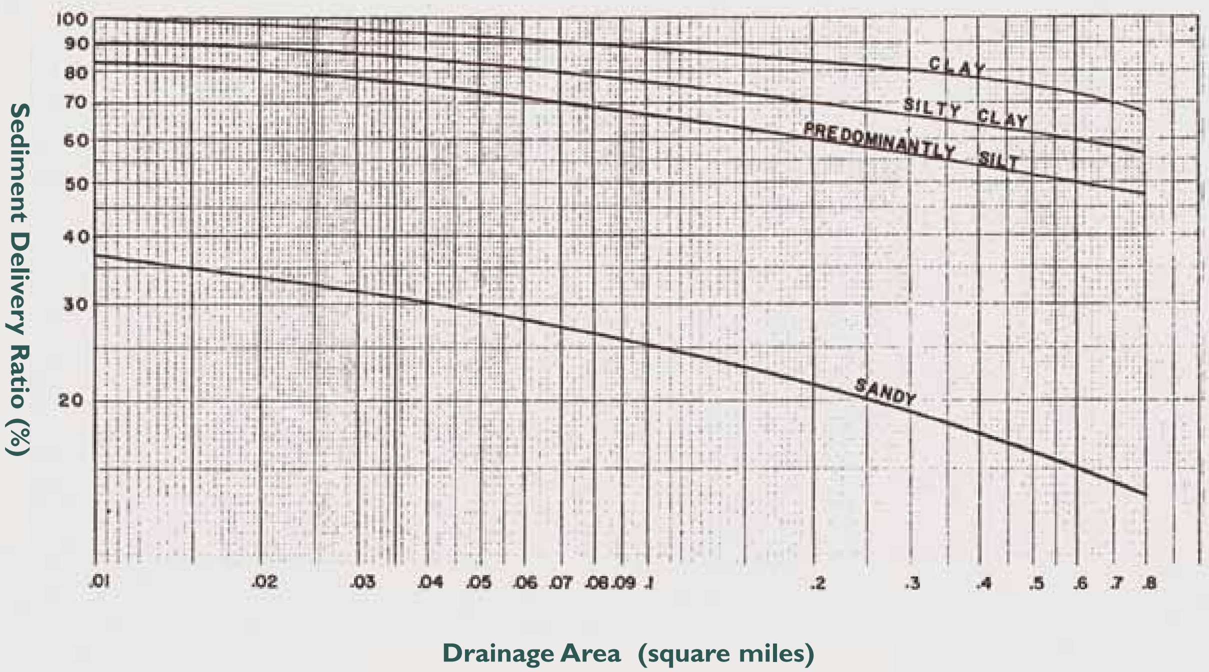
Source: USDA-NRCS

Figure SB-11 Table Containing Design Data for Earth Spillways When Used as Emergency Spillway

STAGE (Hp) IN FEET	SPILLWAY VARIABLES	BOTTOM WIDTH (b) IN FEET																
		8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
0.5	Q	6	7	8	10	11	13	14	15	17	18	20	21	22	24	25	27	28
	V	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	S	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	X	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
0.6	Q	8	10	12	14	16	18	20	22	24	26	28	30	32	34	35	37	39
	V	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	S	3.7	3.7	3.7	3.7	3.6	3.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	X	36	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37
0.7	Q	11	13	16	18	20	23	25	28	30	33	35	38	41	43	44	46	48
	V	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	S	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	X	39	40	40	40	41	41	41	41	41	41	41	41	41	41	41	41	41
0.8	Q	13	16	19	22	26	29	32	35	38	42	45	46	48	51	54	57	60
	V	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	S	3.3	3.3	3.3	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	X	44	44	44	44	45	45	45	45	45	45	45	45	45	45	45	45	45
0.9	Q	17	20	24	28	32	35	39	43	47	51	53	57	60	64	68	71	75
	V	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	S	3.2	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
	X	47	47	48	48	48	48	48	48	48	48	49	49	49	49	49	49	49
1.0	Q	20	24	29	33	38	42	47	51	56	61	63	68	72	77	81	86	90
	V	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	S	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3-0
	X	51	51	51	51	52	52	52	52	52	52	52	52	52	52	52	52	52
1.1	Q	23	28	34	39	44	49	54	60	65	70	74	79	84	89	95	100	105
	V	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	S	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	55	55	55	55	55	55	55	56	56	56	56	56	56	56	56	56	56
1.2	Q	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
	V	4.4	44	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	S	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	58	58	59	59	59	59	59	59	60	60	60	60	60	60	60	60	60
1.3	Q	32	38	46	53	58	65	73	80	86	91	99	106	112	119	125	133	140
	V	4.5	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	S	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	X	62	62	62	63	63	63	63	63	63	63	63	64	64	64	64	64	64
1.4	Q	37	44	51	59	66	74	82	90	96	103	111	119	127	134	142	150	158
	V	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	4.9	4.9	49	4.9
	S	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	X	65	66	66	66	66	67	67	67	67	67	67	68	68	68	68	68	69
1.5	Q	41	50	58	66	75	85	92	101	108	116	125	133	142	150	160	169	178
	V	4.8	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.1	5.1
	S	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5
	X	69	69	70	70	71	71	71	71	71	71	71	72	72	72	72	72	72
1.6	Q	46	56	65	75	84	94	104	112	122	132	142	149	158	168	178	187	197
	V	5.0	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	S	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	72	74	74	75	75	76	76	76	76	76	76	76	76	76	76	76	76
1.7	Q	52	62	72	83	94	105	115	126	135	145	156	167	175	187	196	206	217
	V	5.2	5.2	5.2	5.3	5.3	53	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	S	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	76	78	79	80	80	80	80	80	80	80	80	80	80	80	80	80	80
1.8	Q	58	69	81	93	104	116	127	138	150	160	171	182	194	204	214	226	233
	V	5.3	5.4	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.6	5.6	56	5.6	5.6	5.6
	S	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	80	82	83	84	84	84	84	84	84	84	84	84	84	84	84	84	84
1.9	Q	64	76	88	102	114	127	140	152	164	175	188	201	213	225	235	248	260
	V	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	S	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	84	85	86	87	88	88	88	88	88	88	88	88	88	88	88	88	88
2.0	Q	71	83	97	111	125	138	153	164	178	193	204	218	232	245	256	269	283
	V	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9
	S	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	88	90	91	91	91	91	92	92	92	92	92	92	92	92	92	92	92
2.1	Q	77	91	107	122	135	149	162	177	192	207	220	234	250	267	276	291	305
	V	5.7	5.8	5.9	5.9	5.9	59	59	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	S	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	92	93	95	95	95	95	95	95	95	96	96	96	96	96	96	96	96
2.2	Q	84	100	116	131	146	163	177	194	210	224	238	253	269	288	301	314	330
	V	5.9	5.9	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2
	S	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	96	98	99	99	99	99	99	100	100	100	100	100	100	100	100	100	100
2.3	Q	90	108	124	140	158	175	193	208	226	243	258	275	292	306	323	341	354
	V	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
	S	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	100	102	102	103	103	103	104	104	104	105	105	105	105	105	105	105	105
2.4	Q	99	116	136	152	170	189	206	224	241	260	275	294	312	327	346	364	378
	V	6.1	6.2	62	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
	S	2.3	2.3	23	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	105	105	106	107	107	108	108	108	108	109	109	109	109	109	109	109	109

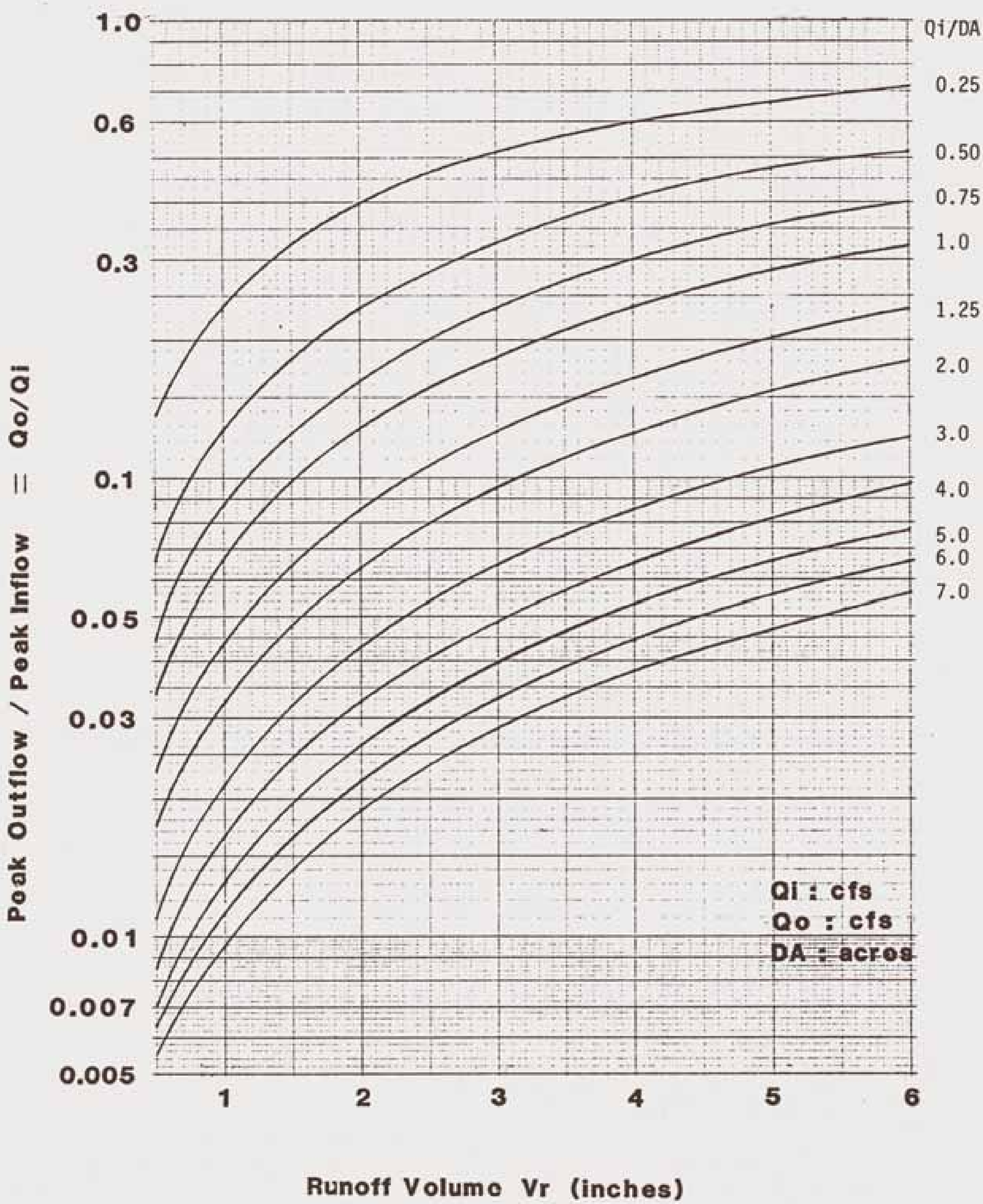
Source: USDA-NRCS

Figure SB-12 Sediment Delivery Ratio Vs. Drainage Area Graph



Source: USDA-NRCS

Figure SB-13 Maximum Peak Outflow for Detention Time Graph



Source: USDA-NRCS

Temporary Sediment Basin: Design Example 1

Determining Volume in a Sediment Basin to Meet Sediment Storage Volume and Detention Storage Volume Requirements

One-hundred acres drain into a planned sediment basin. Failure of the sediment basin at the planned site will not result in loss of life or damage to buildings, roads, railroads or utilities. Ten acres are to be cleared and developed into houses. Ninety acres are in woods and will not be disturbed during the life of the sediment basin. It is estimated it will take 18 months to develop the site. The sediment basin will be installed as the first item of construction and removed as the last item of construction. The owner estimates that the ten acres to be developed will be bare for 12 months and under roofs, pavement, and sod for the last six months of construction. The soils are Agawam fine sandy loam on a flat slope. The sediment pool will be normally dry. The 10-year, 24-hour rainfall is 5.0 inches.

Determine sediment storage volume using the following method:
Determine, *DA* - Drainage Area and *A* - Average Annual Erosion

1st year
Woods
(DA) (A) = 90 ac x 0.2 tons/ac/yr = 18 tons/yr

Construction Area
(DA) (A) = 10 ac x 50 tons = 500 tons/yr
(DA) (A) = 518 tons for the 1st year.

2nd year
Woods
(DA) (A) = 90 ac x 0.2 tons/ac/yr = 18 tons/yr
Urban Area
(DA) (A) = 10 ac x 1.0 tons/ac/yr = 10 tons/yr
(DA) (A) = (18 + 10) = 14 tons for 2nd year for six month life
(DA) (A) = 518 + 14 = 532 tons for the life of the basin.

Determine *DR* - delivery ratio
100/640 = 0.16 sq mi from **Figure SB-12** for a sandy soil, *DR* = 24%.

Determine γ - density of the sediment. From **Figure SB-1** the density of submerged sand is 85-100 lbs/cu. ft., Use γ = 90 lbs/cu. ft.

Determine *TE* trap efficiency. The *TE* is 80 % from the sediment storage volume section of the Sediment Basin measure.

Determine *V* - minimum volume for sediment storage for the planned life of the structure using the formula:

$$V = \frac{(DA)(A)(DR)(TE)(2{,}000\,lbs./ton)}{(\gamma)(43{,}560\,sq.ft./ac)}$$

V = (532) (0.24) (0.80) (1/90) (2,000) (1/43,560)
V = 0.052 Ac. ft. for sediment storage.
Determine detention storage volume.

Given that:
Q_{10} = 30 cfs and
V_r = 1.30 inches

Then:
Q_i = 30 cfs $\qquad$ V_r = 1.3

$$\frac{Q_{10}}{DA} = \frac{30}{100} = 0.30$$

From **Figure SB-13**

$$\frac{Q_o}{Q_i} = 0.27$$

(continued on next page)

Design Example I *(continued)*

Q_o = 8.1 cfs = maximum allowable principal spillway discharge.

$$Q_o = (0.27)(Q_i) = (0.27)(30) = 8.1 \text{ cfs}$$

$$\text{Release rate} = \frac{(8.1 \text{ cfs})(640 \text{ Ac./sq. mi.})}{(100 \text{ Ac.})} = 51.8 \text{ csm}$$

V_r = 1.3 inches

From the figures in the Detention Basin measure for single stage structures with release rates less than 300 csm, the minimum storage required, Vs, is 0.67 inches.

$$V_s = 0.67 \text{ inches} = \frac{(0.67 \text{ in.})(100 \text{ Ac.})}{(12 \text{ in./ft.})} = 5.58 \text{ Ac. ft.}$$

V_s = 5.58 Ac. ft. for detention storage volume.

The minimum volume required below the crest of the emergency spillway is 0.052 Ac. ft. plus 5.58 Ac. ft. or 5.63 Ac. ft.

Temporary Sediment Basin: Design Example 2

Same as Design Example 1 except the soil is Hollis fine sandy loam on a steep slope.

Determine sediment storage volume using method given in Example No. 1.

(DA) (A) same as in Design Example 1

(DA) (A) = 518 tons for the 1st year

(DA) (A) = 14 tons for the 2nd year

Determine, DR - delivery ratio.

The Hollis soil is a fine sandy loam. Using the Soil Survey Report, this soil would be approximately 60% sand and 40% silt. Using **Figure SB-12** with 0.16 sq. mi. drainage area and a value between the sandy and silty curves, the delivery ratio is 45%.

Determine, γ - density of sediment. γ = 95 lbs/cu.ft., using **Figure SB-1** with sand-silt mixture.

The trap efficiency is the same as Design Example No. 1 and is 80%.

Determine minimum volume for sediment storage for the planned life structure using the formula:

$$V = \frac{(DA)(A)(DR)(TE)(2{,}000\,lbs./ton)}{(\gamma)(43{,}560\,sq.ft./ac)}$$

V = (518 + 14) (0.45) (0.80) (1/95) (2,000) (1/43,560)

V = 0.093 Ac. ft. for sediment storage

Determine detention storage volume.

Given that:

$Q_i = Q_{10}$ = 285 cfs

V_r = 2.89 inches and

DA = 100 acres

Then:

$$\frac{Q_i}{DA} = \frac{285}{100} = 2.89 \text{ inches}$$

From **Figure SB-13**

$$\frac{Q_o}{Q_i} = 0.066$$

Qo = (0.066) (Q_i) = (0.066) (285)

Q_o = 18.8 cfs (the maximum allowable principal spillway discharge rate)

Q_o = (relative to drainage area) $= \frac{18.8\text{cfs}}{100\text{ acres}} \; \frac{(640\text{ acres})}{(1\text{ sq. mile})}$

= 120.3 csm

From **Detention Basin** measure **Figure DB-6,**
when V_r = 2.89 inches V_5 is 1.65 inches

$$V_s = 1.65 \text{ inches} = \frac{(1.65\text{ in.})(100\text{ Ac.})}{(12\text{ in./ft.})} = 13.75 \text{ Ac. ft.}$$

V_s = 13.75 Ac. ft. for detention storage volume

The minimum volume required below the crest of the emergency spillway is 0.093 Ac. ft. for sediment storage volume plus 13.75 Ac. ft. for detention storage volume or 13.84 Ac. ft.

Conclusions From Design Examples

To have a reasonable size sediment basin that is effective, two components are critical. The total drainage area must be small. The volume of runoff must be low. To accomplish this requires good vegetative cover and soils with high infiltration rates.

Temporary Sediment Trap (TST)

Definition
A temporary ponding area with a stone outlet formed by excavation and/or constructing an earthen embankment.

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

Applicability
- Below disturbed areas where the contributing drainage area is 5 acres or less. For drainage areas greater than 5 acres use **Temporary Sediment Basin** measure.
- Where the intended use is 2 years or less. For uses greater than 2 years use **Temporary Sediment Basin** measure.
- When diverting sediment-laden water with temporary diversions that meet the above limitations for use.

Planning Considerations
Sequence the construction of temporary sediment traps, along with other perimeter erosion and sediment controls so that they are constructed and made functional before land disturbance in the contributing drainage area takes place.

The temporary sediment trap has two storage requirements: one for wet storage and one for dry storage. Commonly, the wet storage is created by excavation within a drainage way and the dry storage created by the construction of a pervious stone dike across the drainage way. Sometimes the trap is formed, at least in part, by the construction of an embankment. Such an embankment constitutes a dam and is therefore limited to a height of no greater than 5 feet and requires care in its construction.

E&S plans should identify the size of the contributing drainage area, wet and dry storage requirements as well as the volume of sediment accumulation that will trigger trap cleaning. Sediment is required to be removed from the trap when the sediment accumulation exceeds half of the wet storage volume of the trap. The plans should also guarantee that access is provided for sediment removal and detail how excavated sediment will be disposed (such as by use in fill areas on-site or removal to an approved off-site location).

Variations in temporary sediment trap design may be considered, but plan reviewers should ensure the minimum storage requirements and structural requirements noted below are maintained.

Specifications

Location
Locate temporary sediment traps so that they can be installed prior to conducting any grading activities in the contributing watershed. Do not locate traps in close proximity to existing or proposed building foundations if there is any concern regarding seepage of water from the temporary sediment trap into the foundations or foundation excavation area. Locate traps to obtain maximum storage benefit from the terrain, for ease of clean out and disposal of the trapped sediment.

Trap Capacity
The temporary sediment trap shall have an initial storage volume of 134 cubic yards per acre of drainage area, half of which shall be in the form of wet storage to provide a stable settling medium. The remaining storage volume shall be in the form of a drawdown (dry storage) which will provide extended settling time during less frequent, larger storm events. **Figure TST-1** contains the formulas for calculating the wet storage volume and the dry storage volume.The volume of wet storage shall be measured from the low point of the excavated area to the base of the stone outlet structure (see **Figure TST-2**). The volume of the dry storage shall be measured from the base of the stone outlet to the top of the stone outlet (overflow mechanism).

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

Figure TST-1 Formula for Figuring Temporary Sediment Trap Storage Requirements

Wet storage volume may be approximated as follows:

$$V_w = 0.85 \times A_w \times D_w$$

where,

V_w = the wet storage volume in cubic feet

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

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

Dry storage volume may be approximated as follows:

$$V_d = \frac{(A_w + A_d)}{2} \times D_d$$

where,

V_d = the dry storage volume

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

A_d = the surface area of the flooded area at the top of the stone outlet (over flow mechanism), in square feet

D_d = the depth in feet, measured from the base of the stone outlet to the top of the stone outlet

Note: Conversion between cubic feet and cubic yards is: cubic feet x 0.037 = cubic yards.

Slope Limitations

All cut and fill slopes shall be 2:1 or flatter except for the excavated wet storage area where slopes shall not exceed 1.5:1. The maximum depth of excavation within the wet storage area should not exceed 3 feet to facilitate clean-out and for site safety considerations.

Inlet / Outlet Configuration

The outlet shall be located at the most distant hydraulic point from the inlet. In cases where a long narrow site runs perpendicular to the direction of flow, baffles consisting of stone dikes or other structurally sufficient barriers should be added along the long axis of the trap to increase travel distance through the trap (see **Figure TST-3**).

Outlet

Plan the outlet in such a manner that the minimum wet storage and dry storage volumes are created (see Trap Capacity section above) and 1 foot of free board between the top of the outlet and the crest of the embankment is established. The outlet consists of a pervious stone dike with a core of modified riprap and faced on the upstream side with DOT #3 stone. Temporary sediment traps must outlet onto stabilized (preferably undisturbed) ground, into a watercourse, stabilized channel, or into a storm drain system. **Figure TST-4** shows an example of an outlet for a temporary sediment trap.

Embankment

The maximum height of a temporary sediment trap embankment is limited to 5 feet as measured vertically from the crest of the embankment to the down slope base of the embankment or toe of the stone dike, whichever is lower. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in **Figure TST-2**. Side slopes of the embankment shall be 2:1 or flatter.

Materials

Modified Riprap: shall meet the requirements of DOT Standard Specifications Section M.12.02.

DOT #3 Stone: shall meet the requirements of DOT Standard Specifications Section M.01.01 for #3 Aggregate.

Construction

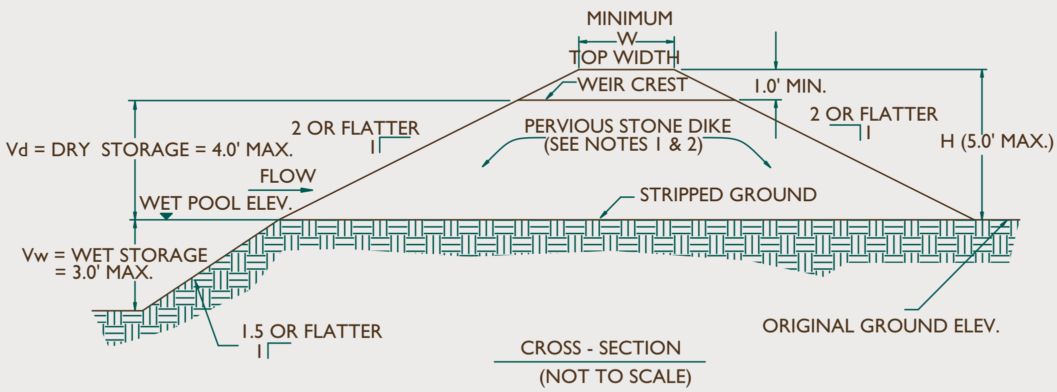
Clear, grub and strip any vegetation and root mat from any proposed embankment and outlet area. Remove stones and rocks whose diameter is greater than 3 inches and other debris.

Excavate wet storage and construct the embankment and/or outlet as needed to attain the necessary storage requirements. Use only fill material for the embankment that is free from excessive organics, debris, large rocks (over 6 inches) or other unsuitable materials. Compact the embankment in 9-inch layers by traversing with equipment while it is being constructed.

Stabilize the earthen embankment using any of the following measures: **Temporary Seeding**, **Permanent Seeding**, or **Stone Slope Protection** immediately after installation.

Carry out construction operations in such a manner that erosion and water pollution are minimized.

Figure TST-2 Minimum Top Width (w) Required for Temporary Sediment Trap Embankments According to Height of Embankment (feet)



1. PERVIOUS STONE DIKE SHALL BE CONSTRUCTED OF CT DOT MODIFIED RIPRAP WITH #3 STONE ON FACE.
2. NON-OVERFLOW PORTIONS AND ABUTMENTS OF TEMPORARY SEDIMENT TRAPS MAY BE CONSTRUCTED OF COMPACTED EARTHFILL.

TOP WIDTH VS. HEIGHT

H = HEIGHT OF EMBANKMENT
W = TOP WIDTH OF EMBANKMENT

H (ft)	W(ft)
1.5	2.0
2.0	2.0
2.5	2.5
3.0	2.5
3.5	3.0
4.0	3.0
4.5	4.0
5.0	4.5

Source: USDA-NRCS

Maintenance

Inspect the temporary sediment trap at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater. Check the outlet to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should maintained at least 1 foot below the crest of the embankment. Also check for sediment accumulation and filtration performance.

When sediments have accumulated to one half the minimum required volume of the wet storage, dewater the trap as needed, remove sediments and restore the trap to its original dimensions. Dispose of the sediment removed from the basin in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

The temporary sediment trap may be removed after the contributing drainage area is stabilized. If it is to be removed, then the plans should show how the site of the temporary sediment trap is to be graded and stabilized after removal.

Figure TST-3 Example plan Views of Baffles in Temporary Sediment Traps

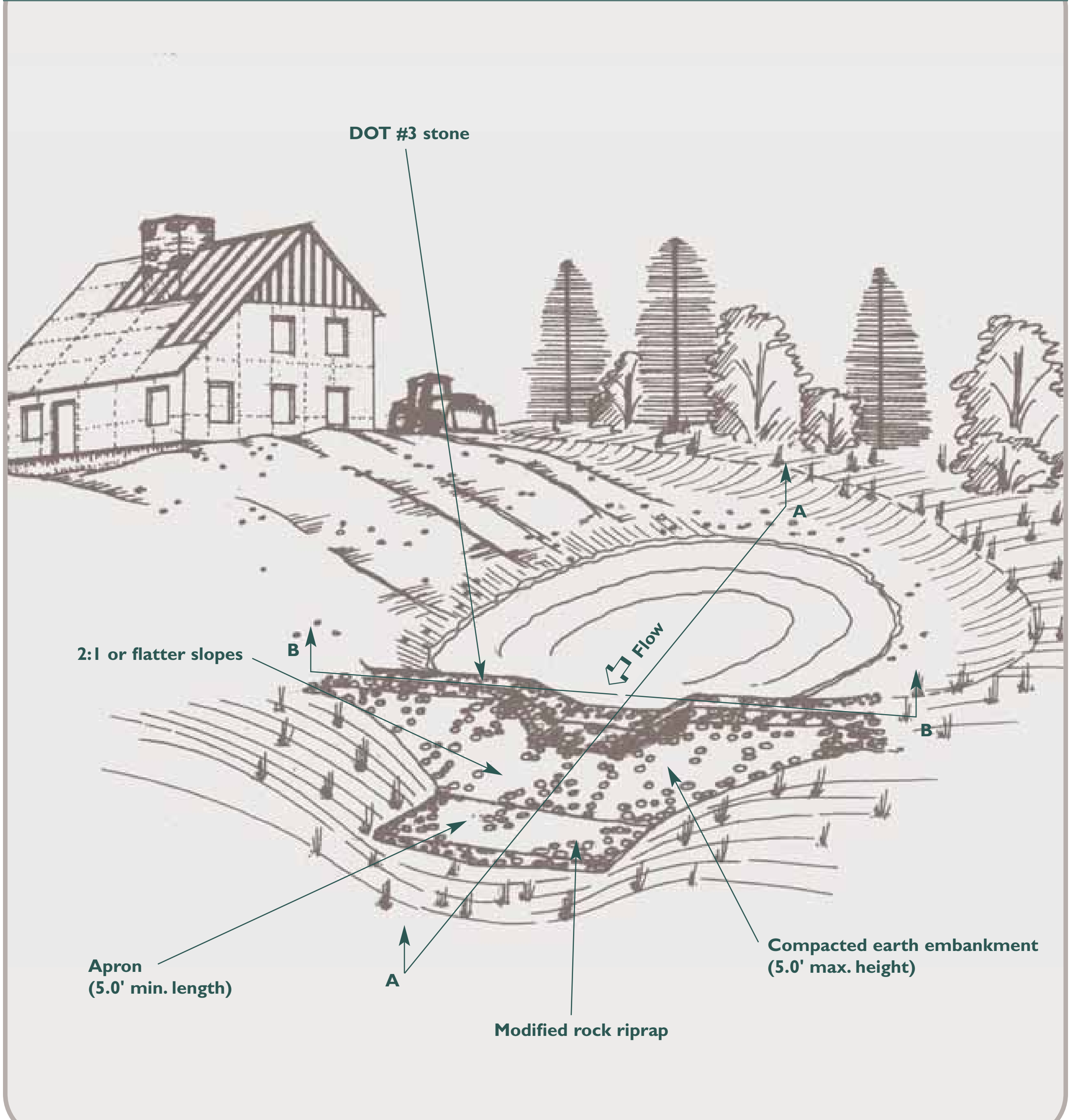
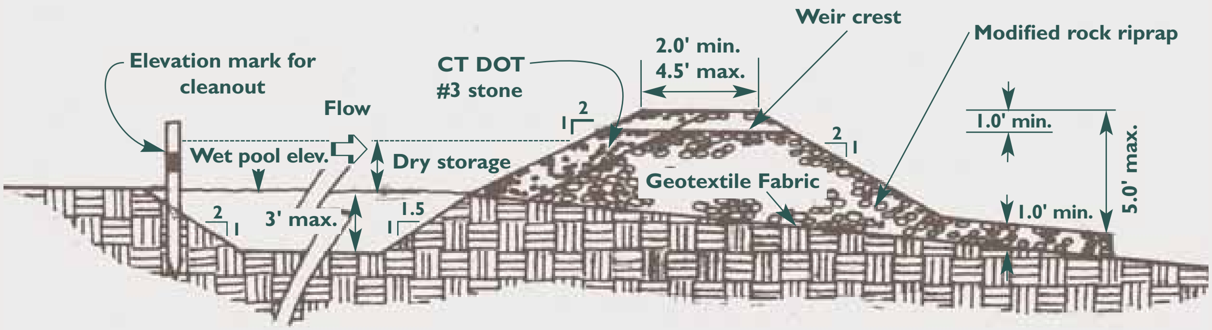
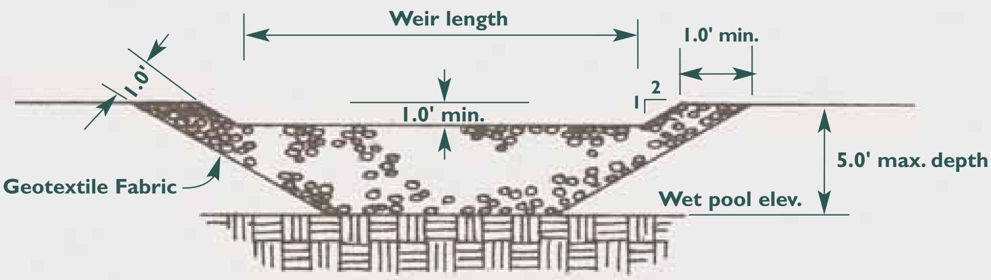


Figure TST-4 Views of a Temporary Sediment Trap Outlet



X – Section A-A
(not to scale)



X – Section B-B
(not to scale)

Temporary Sediment Trap (TST)

Hay Bale Barrier (HB)

Definition

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

Purpose

- To intercept and detain small amounts of sediment from small disturbed areas.
- To decrease the velocity of sheet flows.
- To redirect small volumes of water away from erodible soils.
- To settle and assist in filtering waters discharged from pumping operations (see **Pumping Settling Basin** measure, Type I and Type II).

Applicability

- Below small disturbed areas where the drainage area (disturbed and undisturbed) is less than 1 acre in size.
- Above disturbed slopes to direct surface water away from erodible areas where the drainage area (disturbed and undisturbed) is less than 1acre in size.
- Where protection and effectiveness is required for less than 3 months.
- Where sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas, watercourses and other sensitive areas.
- Not for use in drainageways, except in special cases where it is applied with other measures (see **Geotextile Silt Fence** and **Stone Check Dams** Special Cases).
- Not intended for use in streams.

Planning Considerations

See Planning Considerations for Sediment Impoundments, Barriers and Filters Function Group.

Specifications

Materials

Hay Bales: shall be made of hay or straw with 40 pounds minimum weight and 120 pounds maximum weight held together by twine or wire.

Stakes for Anchoring Hay Bales: shall be a minimum of 36 inches long and made of either hardwood with dimensions of at least 1.5 inches square or steel posts with a minimum weight of 0.5 pound per linear foot.

Placement on the Landscape

Contributing drainage area is no greater than 1 acre. Maximum slope length is as shown in **Figure HB-1**.

Toe of Slope: Locate 5-10 feet down gradient from the toe of slope (see **Figure HB-2**), generally on the contour. When the contour can not be followed, stagger the bale installation and install perpendicular wings spaced as shown in **Figure HB-1** to break the velocity of water flowing behind the bales. The barrier should be located with sufficient distance from the toe of the slope to allow access by equipment for removal of accumulated sediments

Swales: Not recommended. See **Geotextile Silt Fence** or **Stone Check Dam** measures.

Catch Basins in Swales on Slopes: Not recommended. See **Geotextile Silt Fence** or **Stone Check Dam** measures.

Catch Basins in Depressions or Low Spots (yard drains): Encircle catchbasin (see **Figure HB-3**).

Culvert Inlets: Not recommended. See **Geotextile Silt Fence** measure.

Culvert Outlets: Not recommended. Use **Temporary Sediment Trap** and/or **Stone Check Dam** measures.

Pumping Settling Basin: See **Pumping Settling Basin** measure.

Installation (see Figure HB-2)

Trench excavation: Excavate a trench as wide as the bales and at least 4 inches deep. Each end of the trench should be winged upslope so that the bottom of the last bale is higher than the top of the lowest hay bale in the barrier.

Figure HB-1 Hay Bale Design Slope/ Length Limitations	
Slope Steepness[1]	Slope Length and Wing Spacing
5:1 or shallower	100 feet
3:1 to 5:1	75 feet
2:1 to 3:1	50 feet

[1] Where the gradient changes through the drainage area the steepest slope section shall be used.

Hay Bale Placement: Place bales in a single row in the trench, lengthwise, with ends of adjacent bales tightly abutting one another and the bindings oriented around the sides rather than along the tops and bottoms of the bales (to avoid premature rotting of the bindings).

Staking Hay Bales: Anchor each bale with at least 2 stakes, driving the first stake in each bale toward the previously laid bale to force the bales together. Stakes must be driven a minimum of 18 inches into the ground.

Fill any gaps between the bales with hay or straw to prevent water from escaping between the bales.

Backfill & Tamped: Backfill the bales with the excavated trench material to a minimum depth of 4 inches on the uphill side of the bales Tamp by hand or machine and compact the soil. Loose hay or straw scattered over the disturbed area immediately uphill from the hay bale barrier tends to increase barrier efficiency.

Substitute Measures

Geotextile Silt Fence may be used as a substitute. When frozen or other similar ground conditions prevent the proper trenching or anchoring of hay bales, a sediment barrier consisting of a stone check dam with a hay bale core may be substituted for the hay bale barrier. See **Stone Check Dam** measure, "Special Case Combinations for Added Filtration & Frozen Ground Conditions" for details.

Maintenance

Inspect the hay bale barrier at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater to determine maintenance needs. For dewatering operations, inspect frequently before, during, and after pumping operations.

Remove the sediment deposits or install a secondary barrier upslope from the existing barrier when sediment deposits reach approximately one half the height of the barrier (see **Figure HB-4**).

Replace or repair the barrier within 24 hours of observed failure. Failure of the barrier has occurred when sediment fails to be retained by the barrier because:

(a) the barrier has been overtopped, undercut or bypassed by runoff water,
(b) the barrier has been moved out of position, or
(c) the hay bales have deteriorated or been damaged.

When repetitive failures occur at the same location, review conditions and limitations for use and determine if additional controls (e.g. temporary stabilization of contributing area, diversions, stone barriers) are needed to reduce failure rate or replace hay bale barrier. See **Figure HB-5** for trouble shooting failures.

Maintain the hay bale barrier until the contributing area is stabilized.

After the upslope areas have been permanently stabilized, pull the stakes out of the hay bales. Unless otherwise required, no removal or regrading of accumulated sediment is necessary. The hay bales may then be left in place or broken up for ground cover.

Figure HB-2 Placement and Construction of a Hay Bale Barrier

Place hay bales on contour and wing last hay bales upslope so that top of last several hay bales are higher then line of hay bales

1 Excavate trench 4" and place fill up-slope of trench.
2 Place hay bale and stake first stake at angle towards first bale. Stakes are 18" min. into ground.
3 Wedge loose hay between bales.
4 Backfill & compact excavated fill along hay bale

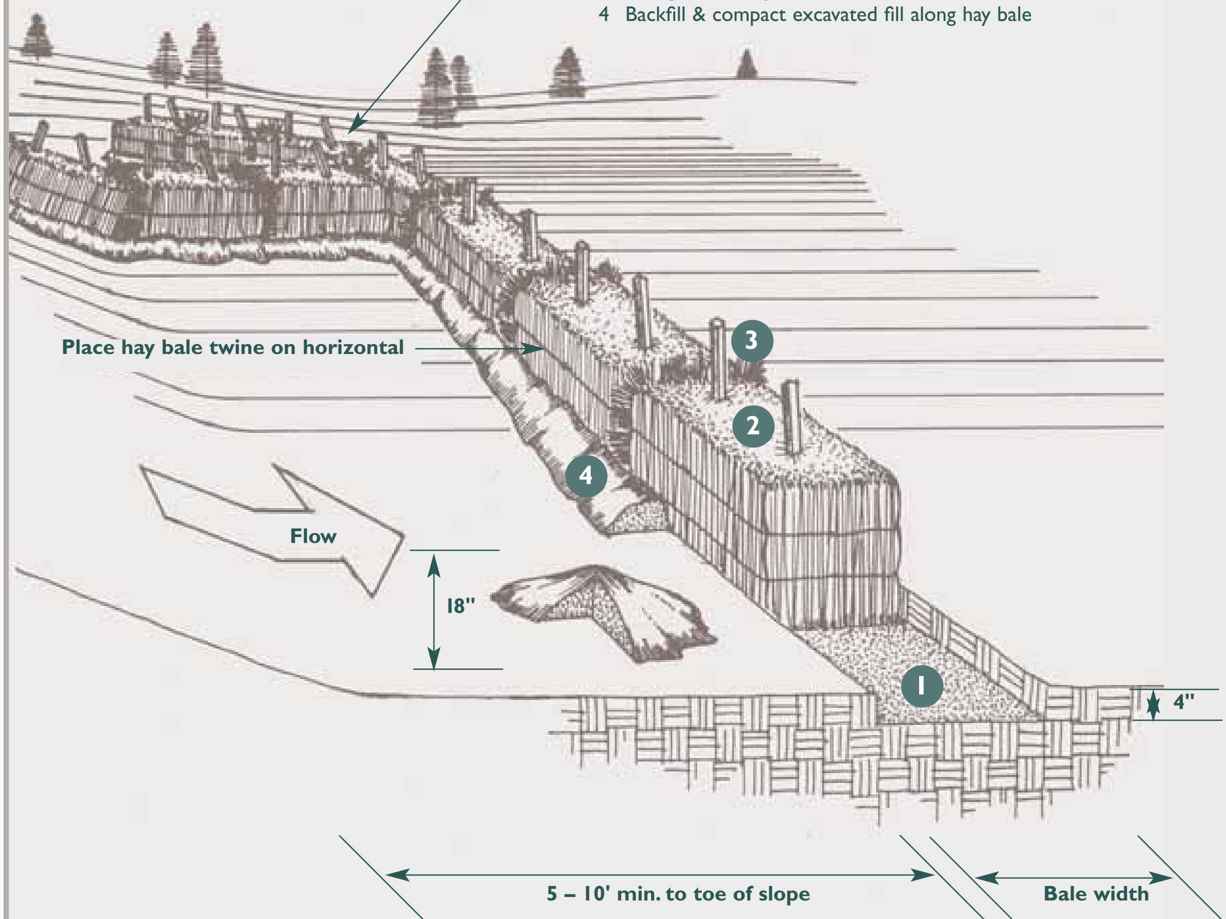


Figure HB-3 Hay Bale Barrier at Catchbasin in Hollow

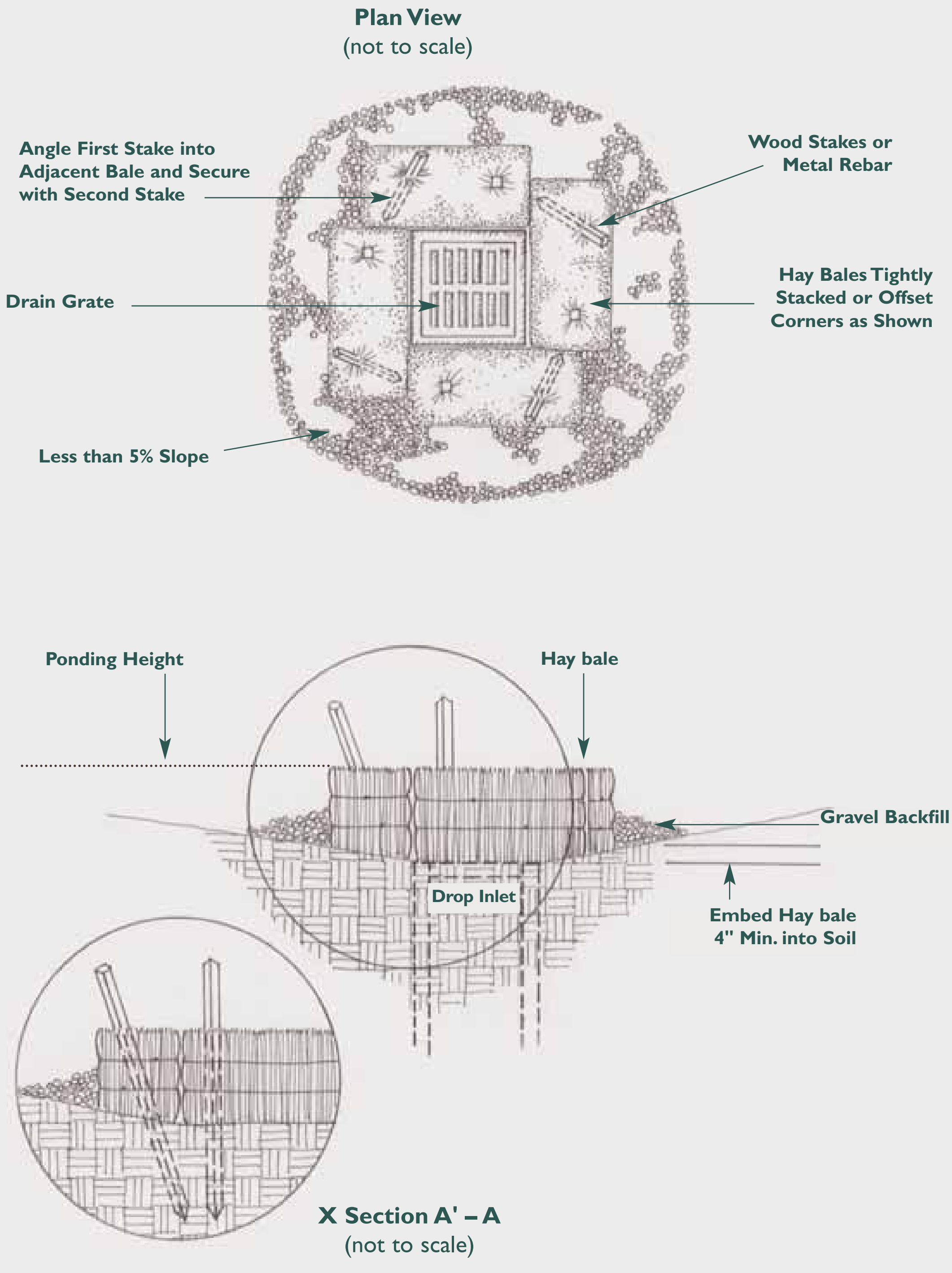


Figure HB-4 Adding Backup Hay Bale Barrier

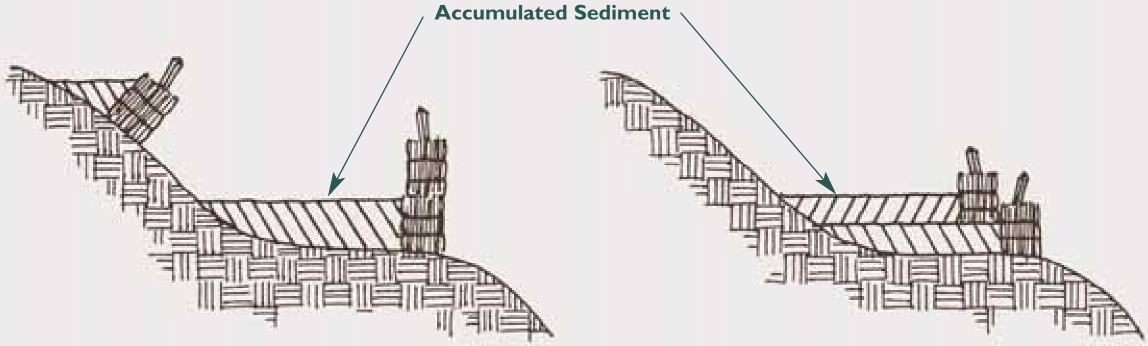


Figure HB-5 Hay Bale Barrier Trouble Shooting Guide

Problem	Cause	Fix
undercutting	inadequate trenching	reset bales properly or for small failure backfill downslope rills, fill & compact under failing bale, fill joints with hay, backfill up slope side of bale with 4" wedge of wood chips or compacted soil
	spaces between bales	
	barrier not on the contour, runoff flowing along upslope side of barrier	same as above, and install perpendicular wings to break flow line such that bottom end of wing is higher than top of barrier
rilling around end	not extending end of hay bale barrier far enough upslope	extend hay bale barrier far enough upslope so that bottom of last bale is higher than top of lowest bale
hay bales moved	watershed too large	change to stone barrier
	flows too concentrated	change to geotextile silt fence or stone barrier
	inadequately staked	fill and compact any rills at hay bale barrier, reinstall bale, fill joints, backfill and compact, increase staking depths

Geotextile Silt Fence (GSF)

Definition

A temporary sediment barrier consisting of a geotextile fabric pulled taut and attached to supporting posts and entrenched.

Purpose

- To intercept and retain sediment from disturbed areas.
- To decrease the velocity of sheet flows and low volume concentrated flows.

Applicability

- Below small disturbed areas where the contributing drainage area (disturbed and undisturbed) is less than 1 acre in size.
- At storm water drainage inlets and catch basins where sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas, water-courses and other sensitive areas.
- Not for use in areas where rock, frozen ground or other hard surface prevents proper installation of the barrier (see Special Case Combinations in **Stone Check Dam** measure).
- Prohibited from use in drainageways whose flow is supported by ground water discharge.

Planning Considerations

See Planning Considerations for Sediment Impoundments, Barriers and Filters Functional Group. When used at a culvert outlet, plan to install the geotextile silt fence before the start of construction and complete the installation of the required outlet protection before the culvert is made functional. It is preferable to control sediment at the inlets rather than at the outlet. Use at outlets should be limited to situations where inlet controls are not possible or to act as a backup to inlet controls.

Specifications

Materials

Geotextile fabric: shall be a pervious sheet of polypropylene, nylon, polyester, ethylene or similar filaments and shall be certified by the manufacturer or supplier as conforming to the requirements shown in **Figure GSF-1**. The geotextile shall be non-rotting, acid and alkali resistant and have sufficient strength and permeability for the purpose intended, including handling and backfilling operations. Filaments in the geotextile shall be resistant to absorption. The filament network must be dimensionally stable and resistant to de-lamination. The geotextile shall be free of any chemical treatment or coating that will reduce its permeability. The geotextile shall also be free of any flaws or defects which will alter its physical properties. Torn or punctured geotextiles shall not be used.

Supporting posts: shall be at least 42 inches long made of either 1.5 inch square hardwood stakes or steel posts with projections for fastening the geotextile possessing a minimum strength of 0.5 pound per linear foot.

Placement on the Landscape

Contributing drainage area 1 acre or less. Maximum slope length is as shown in **Figure GSF-2**.

For toe of slope (**Figure GSF-3**): Locate 5-10 feet down gradient from the toe of slope, generally on the contour with maintenance and sediment removal requirements in mind. When the contour can not be followed install the fence such that perpendicular wings are created to break the velocity of water flowing along the fence. See **Figure GSF-2** for spacing requirements.

Swales (see **Figure GSF-4**): Locate "U" shape across swale such that the bottom of both ends of the fence are higher than the top of the lowest section of the fence.

Catch Basins in Swale on Slopes: Locate 2 "U" shapes across swale as above: one immediately up slope from the catch basin and the other immediately down slope from the catch basin.

Catch Basins in Depressions: Encircle catch basin.

Culvert Inlets: Locate in a "U" shape approximately 6 feet from the culvert in the direction of the incoming flow.

Figure GSF-1 Geotextile Silt Fencing Minimum Requirements		
Physical Property	**Test Method**	**Minimum Requirement**
filtering efficiency	ASTM 5141	75% (min)
grab tensile strength (lbs.)	ASTM D4632	100 lbs
elongation @ failure	ASTM D4632	15 %
Mullen burst strength	ASTM D3786	250 psi
puncture strength	ASTM 4833	50 lbs
apparent opening size	ASTM D4751	no greater than 0.90 mm and no less than 0.60 mm
flow rate	ASTM D4491	0.2 gal/ft2/min
permativity	ASTM D4491	0.05 sec. -1 (min)
ultraviolet radiation stability %	ASTM-D4355	70% after 500 hours of exposure (min)

Culvert Outlets: Locate across the swale at least 6 feet from the culvert outlet.

Figure GSF-2 Geotextile Silt Fence Slope/ Length Limitations	
Slope Steepness[1]	**Slope Length and Wing Spacing**
5:1 or flatter	100 feet
3:1 to 5:1	75 feet
2:1 to 3:1	50 feet

[1] Where the gradient changes through the drainage area the steepest slope section shall be used.

Installation (see **Figure GSF-3**)

Trench excavation: Excavate a trench a minimum of 6 inches deep and 6 inches wide on the up slope side of the fence location. For slope and swale installations, extend the ends of the trench sufficiently up slope such that bottom end of the fence will be higher than the top of the lowest portion of the fence.

When the fence is not to be installed on the contour, excavate wing trenches spaced at the intervals given in **Figure GSF-2.**

When trench excavation is obstructed by an occasional stone or tree root, provide a smooth transition between the trench bottom and the obstruction.

Support Posts: Drive support posts on the down slope side of the trench to a depth of at least 12 inches into original ground.

Never install support posts more than 10 feet apart. Install support posts closer than 10 feet apart when concentrated flows are anticipated or when steep contributing slopes and soil conditions are expected to generate larger volumes of sediment. For catch basins in hollows, drive posts at each corner of the catch basin. Whenever the geotextile filter fabric that is used exceeds the minimum material specifications contained in this measure, the spacing of the stakes shall be per manufacturer's recommendations.

Geotextile Filter Fabric: Staple or secure the geotextile to the support posts per manufacturer's instruction such that at least 6 inches of geotextile lies within the trench, the height of the fence does not exceed 30 inches[2] and the geotextile is taut between the posts. When the trench is obstructed by stones, tree roots, etc. allow the geotextile to lay over the obstruction such that the bottom of the geotextile points up slope.

In the absence of manufacturer's instructions, space wire staples on wooden stakes at a maximum of 4 inches apart and alternate their position from parallel to the axis of the stake to perpendicular.

Do not staple the geotextile to living trees.

Provide reinforcement for the fence when it can be exposed to high winds.

When joints in the geotextile fabric are necessary, splice together only at a support posts, and securely seal (see manufacturer's recommendations).

Backfill & Compaction: Backfill the trench with tamped soil or aggregate over the geotextile (see **Figure GSF-3**). When the trench is obstructed by a stone, tree root, etc. make sure the bottom of the geotextile lies horizontal on the ground with the resulting flap on the up slope side of the geotextile and bury the flap 6 inches of tamped soil, or aggregate.

Maintenance

Inspect the silt fence at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater to determine maintenance needs. When used for dewatering operations, inspect frequently before, during and after pumping operations.

[2] higher barriers may impound volumes of water sufficient to push over the support posts

Remove the sediment deposits or, if room allows, install a secondary silt fence up slope of the existing fence when sediment deposits reach approximately one half the height of the existing fence.

Replace or repair the fence within 24 hours of observed failure. Failure of the fence has occurred when sediment fails to be retained by the fence because:

(a) the fence has been overtopped, undercut or bypassed by runoff water,
(b) the fence has been moved out of position (knocked over), or
(c) the geotextile has decomposed or been damaged.

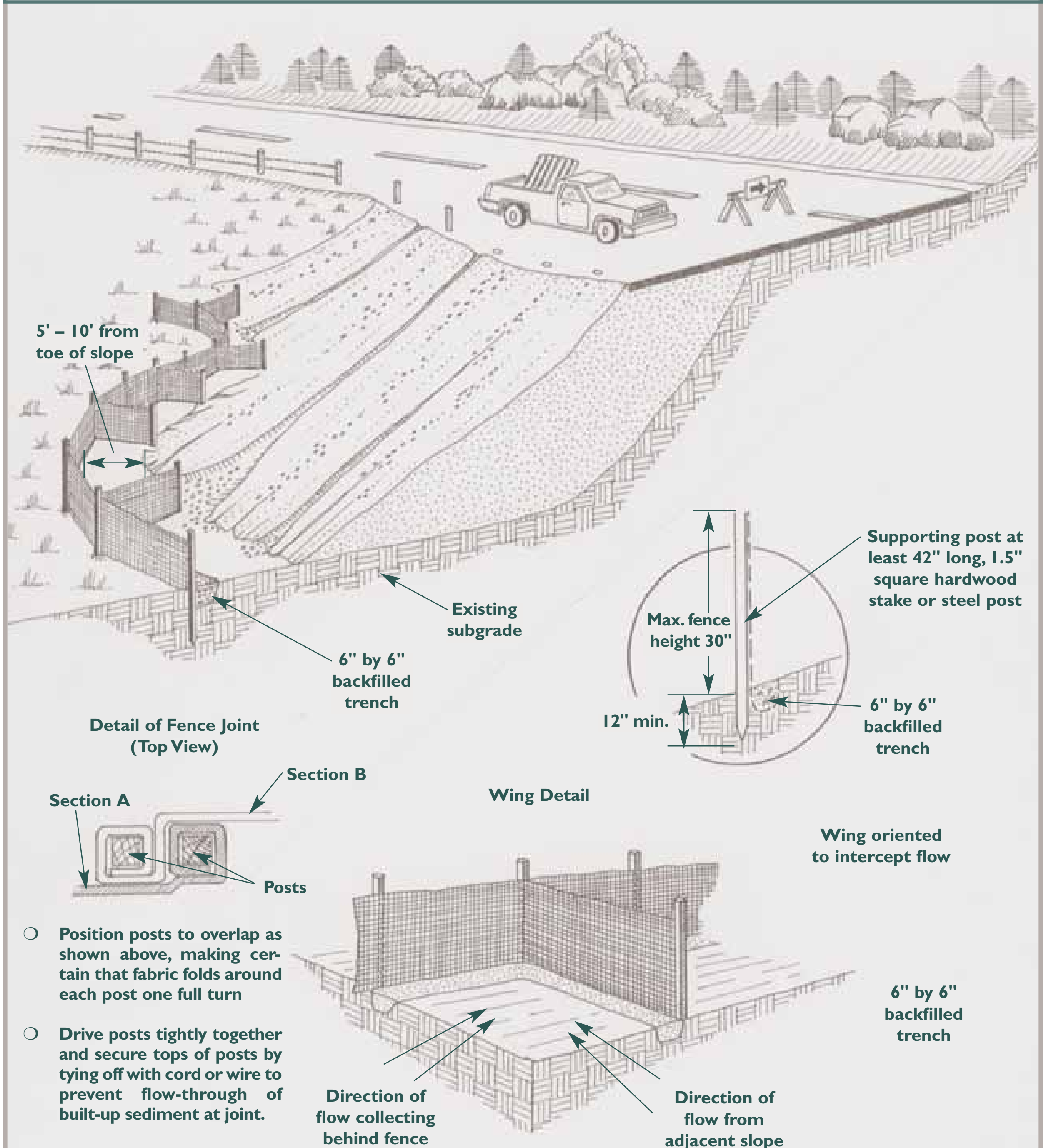
When repetitive failures occur at the same location, review conditions and limitations for use and determine if additional controls (e.g. temporary stabilization of contributing area, diversions, stone barriers) are needed to reduce failure rate or replace fence. See **Figure GSF-5** for trouble shooting failures.

Maintain the fence until the contributing area is stabilized.

After the contributing area is stabilized determine if sediment contained by the fence requires removal or regrading and stabilization. If the depth is greater than or equal to 6 inches, regrading or removal of the accumulated sediment is required. No removal or regrading is required if sediment depth is less than 6 inches.

Remove the fence by pulling up the support posts and cutting the geotextile at ground level. Regrade or remove sediment as needed, and stabilize disturbed soils.

Figure GSF-3 Toe of Slope Installations with Wings



- Position posts to overlap as shown above, making certain that fabric folds around each post one full turn
- Drive posts tightly together and secure tops of posts by tying off with cord or wire to prevent flow-through of built-up sediment at joint.

Figure GSF-4 Swale and Catch Basin Installations

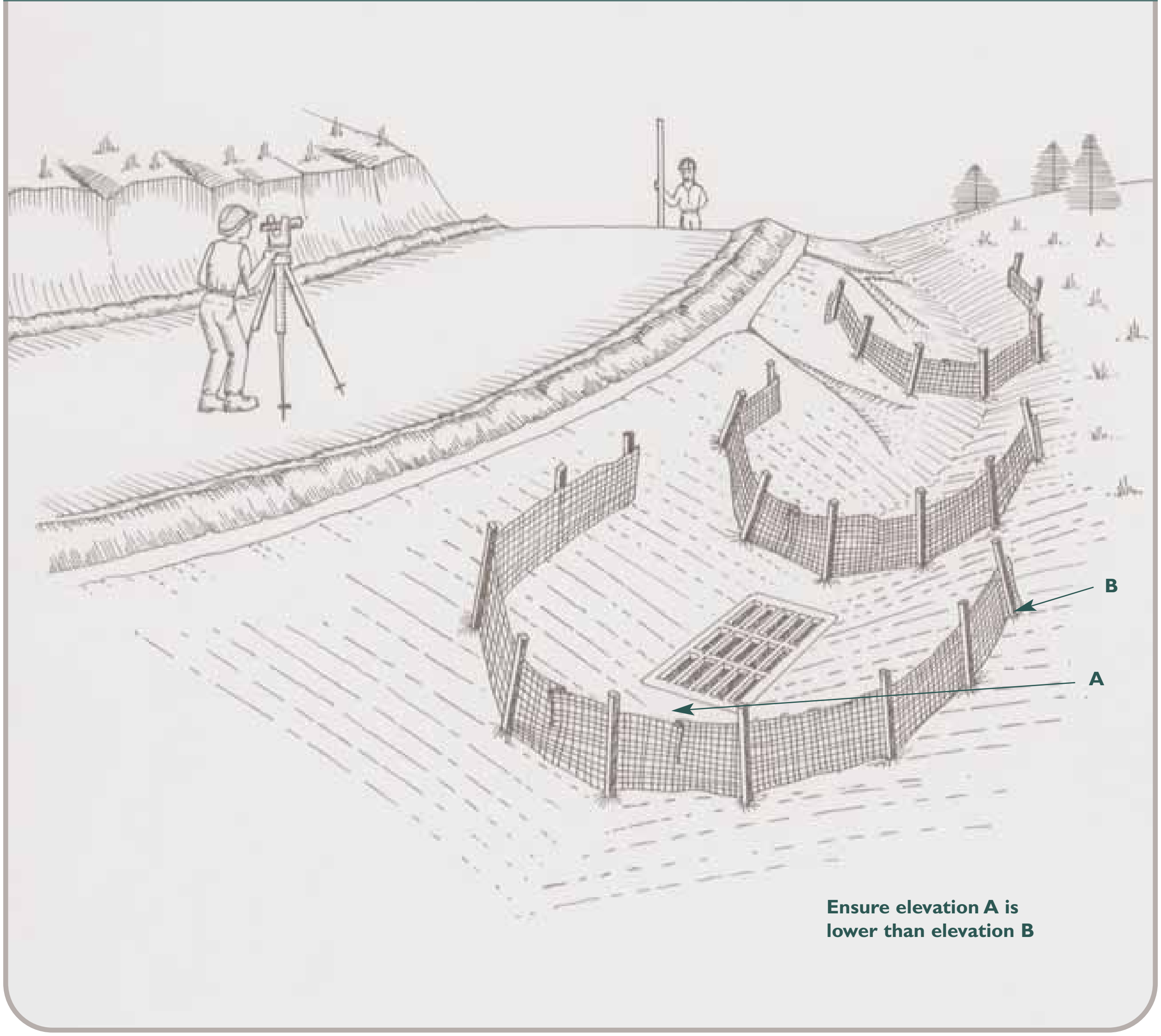


Figure GSF-5 Silt Fence Trouble Shooting Guide

Problem	Cause	Fix
fence fallen over or stakes broken from pressure of water	too large drainage area	Change to stone check dams or add additional controls up slope to reduce velocities and sediment loading (see measure matrix, Chapter 4 for other measures available).
	flows too concentrated	Repair or replace fence, increase staking frequency, angle stake up slope, consider installing hay bale barrier on the down slope side of fence in area of concentration or adding guy wire for support.
	stake not driven deep enough geotextile not properly attached to stakes	Repair or replace fence, increase stake depth. Recheck manufacturer's instructions on attachment and re-attach.
undercutting, toe failure	poor trenching or inadequate compaction, not enough geotextile buried	Install new fence properly or retrench, fill & compact rills at fence failure, drive stakes deeper as necessary to bury enough geotextile, fill & compact trench and down slope rills to provide support. For repeated failures consider installing hay bale barrier on the down slope side at the failure site after repair work is done.
	fence not on the contour, runoff eroding up slope side of barrier	Retrench, fill & compact rills at fence failure, and install perpendicular wings to break flow line such that bottom end of wing is higher than top of fence at wing joint **OR** install stone barriers on up slope side of fence to reduce runoff velocities. For repeated failures consider installing hay bale barrier on the down slope side at the failure site after
	poor transition from trench to obstruction at grade	Fill failed area to make smooth transition from trench to obstruction and re-bury flap of geotextile with 6 inches of tamped soil or aggregate. For repeated failures consider installing hay bale barrier on the down slope side at the failure site after repair work is done.
water running around ends	not extending end of fencing far enough up slope	Extend fence far enough up slope so that bottom of fence end is higher than top of lowest portion of fence, overlap joints at least 6 inches.

Turbidity Curtain (TC)

Definition
A temporary, impervious barrier installed in a stream, river, lake or tidal area which will retain silts, sediment, and turbidity within the construction area.

Purpose
- To promote the settling of suspended solids in water.
- To protect water quality and aquatic habitat in streams, rivers, lakes and tidal areas.

Applicability
- Where construction activities will take place immediately adjacent to or within tidal and non- tidal watercourses and sediment movement into the water is unavoidable.
- Where other sediment barriers will not be effective in preventing the movement of sediment in the water.
- Where water velocity in the area needing control will not exceed 5 feet per second (or a current of approximately 3 knots). For situations where there are greater flow velocities or currents, a qualified engineer and product manufacturer must be consulted.

Planning Considerations
Turbidity curtains are designed to deflect and contain sediment laden water within a limited area and/or provide enough residence time so that soil particles will fall out of suspension and not travel to other areas. **Turbidity curtains should not be used as an alternative to land based erosion and sediment control measures.** However, when proximity to a watercourse or waterbody precludes the use of other types of erosion control measures, the use of a turbidity curtain during land disturbance is essential. An engineer should be consulted in determining which type of turbidity curtain should be used and when consultation with the manufacture is needed.

If waters are in the U.S. Coast Guard jurisdiction be sure to check with their local marine safety officer to be sure the curtain is not in the boat channel and if boom lights are required.

One of the most important considerations, when contemplating the use of turbidity curtains, is how the removal of the curtain and any contained sediments will impact the water quality and aquatic habitat. Determine if sediment removal will be needed and provide for the necessary disposal. In some cases, more environmental damage could be caused by sediment removal than if the curtain were not installed in the first place.

Channel Flow Applications
Considerations must 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 significant volumes of water. They are designed and installed to isolate construction waters from clean water and trap sediments within a confinement area, without halting the movement of non construction waters. Turbidity curtains shall not be extended across channel flows.

Tidal and /or High Wind and Wave Applications
In tidal or wind and wave action situations, the curtain should never touch bottom. A minimum 1-foot gap should be maintained between the curtain and the bottom. It is also seldom practical to extend a turbidity curtain deeper than 10 to 12 feet. Curtains installed deeper will be subject to very large loads which will strain the material and mooring systems.

Specifications

Turbidity Curtain Types
There are four turbidity curtain types. The type used must be based on the flow conditions within the water body (i.e., a flowing channel, lake, pond or a tidal watercourse) at the proposed site of installation:

(a) **Type I (flatwater):** An area that is **calm and protected** with no current, such as small lakes, ponds, canals and protected non-tidal shoreline areas. In these areas the curtain may extend to the bottom of the installation area. If the curtain is deeper than the installation area and lies freely on the bottom, it may load with silt, causing problems in curtain removal.

(b) **Type II (lightweight):** An area that is **semi-protected with current up to 2 feet/second** such as moderate sized lakes, canals and shoreline areas. Two feet/second is the velocity at which fine silts and clays can be expected to erode. In a Type II situation the curtain may extend to within one foot or less off the bottom. This allows minimal currents in the area to pass under the curtain at a very low velocity. Keeping the velocity of current to a minimum will serve to minimize the spread of silt.

(c) **Type III (middleweight):** An area that is **exposed with currents up to 5 feet/second**, such as rivers, streams, large lakes and exposed shorelines with current in one direction. In these areas the curtain should extend to 1 foot or less off the bottom. Moderate currents will cause the curtain to lift away from the bottom allowing the current to pass. It may be necessary to reduce the depth of the curtain and/or install the curtain at an angle to the current to keep the velocity as low as possible.

(d) **Type IV (heavyweight):** An area that is **exposed and subjected to current, wind and tides** such as harbors, and shorelines exposed to large expanses of water. In this situation the curtain should extend to the bottom of the installation area of high tide. The fluctuation of the tides will keep the buildup of silt on the curtain to a minimum.

Materials

Turbidity curtains shall be fabricated from tightly woven geosynthetic or impervious reinforced thermoplastic material, brightly colored, which is stable when subjected to ultraviolet light. Woven geosynthetic material shall be of sufficient tightness such that turbidity levels are maintained at levels less than 5 NTUs over ambient conditions in waters being protected immediately adjacent to the turbidity curtain. An upper hem shall be installed to enclose a flexible flotation material. A lower hem shall be installed to contain a flexible ballast so that the curtain will hang vertically in the water. Each end or section of curtain shall be furnished with anchoring devises.

When Type I is used, external anchors of wooden or metal stakes (2x4 inch or 2.5 inch minimum diameter wood or 1.33 lbs/linear foot steel) may be used.

Anchoring Equipment

All types of turbidity curtains require anchors. The use of proper anchoring systems is important to holding booms in their desired location.

Usually an anchoring system consists of the following components:

- Anchor
- Anchor Chain
- Anchor Line
- Anchor Buoy
- Hardware to connect components

Anchor selection is based on anticipated loads (type of boom, current and winds) and bottom conditions. For example, a Danforth type anchor is good for sandy bottoms. The associated components, i.e., anchor chain, etc., would generally be determined by anchor size and depth of water.

The anchor line or rode should generally be 3 to 4 times the water depth to ensure the anchor will set and hold properly.

The anchor buoy placed between the anchor line and boom should be sufficiently buoyant to prevent the boom from being pulled under water.

Usually 6 to 8 feet of anchor chain attached to the anchor stock is enough to ensure the anchor "sets" properly.

Winds, currents and boom size will determine the number, and sizes of anchors required for a particular application. In tidal areas, the booms must be anchored from both sides to keep the boom in its desired location. Smaller anchors may be substituted for larger anchors by increasing the number of anchors used and at what interval they are attached to the boom.

Sizing

When sizing the length of the curtain, avoid excessive joints. A minimum of 50 feet and a maximum of 100 feet between joints is recommended.

Installation Requirements

Each turbidity curtain installation is unique because of individual site conditions and individual settings. In general, the following information is appropriate for most applications. See **Figure TC-1** for an illustration of a turbidity curtain in tidal waters.

Set appropriate anchors around the perimeter of the installation. For best performance, use Danforth type anchors for sandy bottoms, or kedge type or mushroom anchors for mud bottoms. An anchor buoy should be used between the curtain and the anchor rope when working in currents. Alternative methods of anchoring might include fabricated heavy concrete weights or driven pilings. Shore anchor points are usually posts or pilings tied back to an anchor.

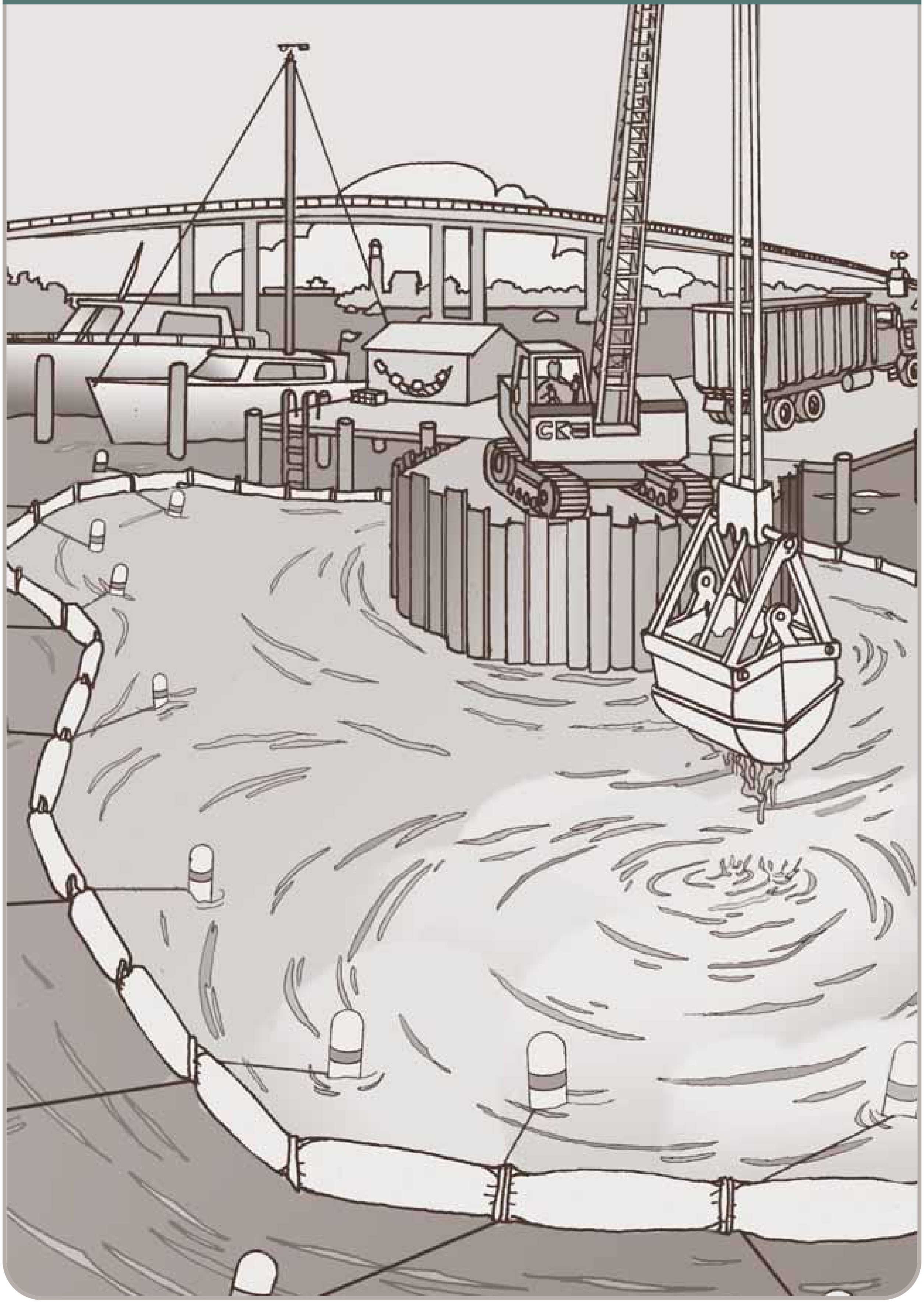
Note: *Always attach anchor lines to the floatation device, not to the bottom of the curtain.*

Remove the outside bundling ropes for each section. Lay the curtain out in an orderly fashion near the point of entry into the water. Inspect load line to ensure that it is not twisted around the float. If multiple lengths of curtains are involved, lay out remaining curtains and untie the furling ties nearest the section ends. Connect sections and re-tie the furling ties.

Tie one end of the curtain to the shore anchor point. Tow the curtain into position slowly either by hand or with the aid of a boat. A worker should be on shore to assist the curtain into the water. Once the curtain is in position, return and tie off the curtain at intermediate anchor points.

After the installation is complete and the curtain is properly anchored, return along the curtain and cut all the furling ties to lower the curtain skirt.

Figure TC-1 Illustration of a Turbidity Curtain in Tidal Waters



Maintenance & Removal

Inspect daily for damage. Depending on the duration and nature of the project, sediment shall be removed when its accumulation interferes with the function of the turbidity curtain. Material may be removed with construction equipment such as backhoes, draglines, mud sucking pumps or hydraulic dredges. If mud sucking pumps or hydraulic dredges are being used, then see **Dewatering of Earth Materials** measure. When required, removal and disposal of sediments shall be in an environmentally sound manner.

When there has been a significant change from the original depth of the watercourse due to sediment accumulation or when otherwise required, remove sediment prior to the removal of the turbidity curtain. Also remove accumulated sediment when the function of the watercourse is impaired or when the accumulated sediments can be expected to be reintroduced into the water column by water flow once the turbidity curtain is removed. When sediment accumulation does not meet the conditions above, sediment may still be removed. However, its removal should be restricted to those situations where the removal will not create worse environmental conditions than if the sediment remained in place. Removal may have to be accomplished in stages since disturbance of the trapped material during removal will cause re-suspension.

Maintain the curtain for the duration of the project or for as long as the contributing area is capable of loading sediments to the body of water. Prior to the removal of the turbidity curtain, allow soil particles to settle out of the water column for a minimum of 6 to 12 hours depending on the clarity of the water and engineer's recommendation.

Vegetated Filter (VF)

Definition
A maintained area of well established herbaceous or woody vegetation through which small volumes of sediment-laden water pass and are filtered.

Purpose
- To intercept and detain small amounts of sediment from small disturbed areas by filtering runoff waters.
- To decrease the velocity of sheet flows and allow for sediment deposition to occur before reaching sensitive areas.

Applicability
- For contributing drainage areas of 1 acre or less in size.
- For contributing slopes are no steeper than 10%.
- Where slopes in the vegetated filter area are no steeper than 10%.
- For use only when existing vegetation is in an adequate condition to provide filtering of runoff water. If vegetated filters are to be established from permanent seedings, use is prohibited until after the grass has reached 6 inches in height, has been mowed twice and survived one full growing season.
- Not for use where flows concentrate or at the outlet of diversions, drainageways, and waterways except in special cases where other measures are applied in conjunction with a vegetated filter, such as a **Level Spreader**, **Geotextile Silt Fence** or **Hay Bale Barrier**.

Planning Considerations
Vegetated filters are located in non-wetland areas and outside of riparian buffer areas. The vegetation in the filter must be sediment tolerant. The minimum flow length through the vegetated filter is determined by the steepness of the contributing slope, the soil texture of the contributing slope, the condition of vegetation within the filter and level of human activity above the filter area. A 90% total suspended solids (TSS) removal efficiency rate can be expected in areas where low levels of human disturbance above the filter area occur, variations in the vegetation are minimal and flow velocity conditions are uniform throughout the filter. A 50% TSS removal rate can be expected over a period of time if design conditions of the filter deteriorate.

When planning to use existing vegetation it must be healthy, have a vigorous growth habit and be protected from damage by construction equipment.

When planning to establish a herbaceous vegetated filter use either **Sodding** or **Permanent Seeding** measures. Sodding is a convenient method for establishing a vegetated filter that may be used immediately after installation. Sodding around a catch basin and accompanied by geotextile silt fencing or haybale barriers during contributing slope stabilization creates a vegetated filter that is very effective in reducing sediment loading to the storm drain system. Seeding may be done to establish a vegetated filter, however the area cannot be used until after the first growing season and grass growth has become well established.

Due to problems with sediment accumulation, this measure is not recommended for use greater than 1 year.

Specifications

Size and Slope Requirements
Determine the minimum flow length through a vegetated filter based upon the slope and soil texture of the contributing drainage area, vegetative condition of the filter, and level of human activity above the filter. Use **Figure VF-1** to determine filter length.

Slopes to and within the vegetated filter shall not exceed 10%.

Condition of Vegetation in Filter Area
Herbaceous vegetation shall be a dense formed sod of fine stemmed, healthy plants. Woody vegetation shall be well established and healthy with an undisturbed layer of leaf litter or duff. Protect vegetation by prohibiting the use of construction equipment in the area.

Maintenance

Inspect the vegetated filter at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater to determine maintenance needs. Maintenance is required when sediment fails to be retained by the filter due to rilling, excessive deposition of sediment, vegetation failure or other causes.

If the vegetated filter area failed due to rilling, install additional measures immediately below the filter to prevent sediment from leaving the filter area, such as a **Geotextile Silt Fence** or **Stone Check Dam**. Rills shall then be regraded, re-seeded or sodded.

Additionally, if the vegetated filter failed due to excessive sediment loading causing the vegetation to become buried, inspect the contributing area and install additional measures to control sediment before runoff enters the filter area. If further use of the vegetated filter is planned, consider manually removing the accumulated sediment that has buried the vegetation. Otherwise, seed or otherwise stabilize the accumulated sediments in the filter area.

Figure VF-1 Determining Vegetative Filter Lengths

Slope of contributing area	Soil Texture Class I[1]	Soil Texture Class II[1]	Soil Texture Class III[1]
High Density and Low Disturbance Potential (in feet)[2]			
0	50	110	150
1	54	119	162
2	58	128	174
3	62	136	186
4	66	145	198
5	70	154	210
6	74	163	370
7	78	172	390
8	82	180	410
9	86	189	430
10	90	198	450
Medium Density or High Disturbance Potential (in feet)[3]			
0	150	330	735
1	162	356	794
2	174	383	853
3	186	409	911
4	198	436	970
5	210	462	1029
6	370	814	1813
7	390	858	1911
8	410	902	2009
9	430	946	2107
10	450	990	2205

[1] Texture Class I - sands and loamy sands; Soil Texture Class II - sandy clay loams and sandy loams; Soil Texture Class III - all other soil textural classes (see Appendix H, Soil Classification Systems).

[2] Vegetation must be grass, transition forest or forest and thick enough that 80% or more of the filter area no bare ground can be seen through the grass or surface matter. These areas experience low levels of human disturbance by foot traffic.

[3] Vegetation density and/or surface litter is less than 80% of the ground or filter area will experience a high level of disturbance by foot traffic.

Source: Riparian Buffer Strategies for Urban Watersheds, Metro Washington Council of Government publication, p.44. 1995.

5-12 Tire Tracked Soils

TO MAIN TOC

Planning Considerations

The only measure in this group is **Construction Entrance**.

The **Construction Entrance** measure consists primarily of a stone pad and is used where construction traffic gains access to paved surfaces. While it is an integral part of a construction access road, it is also used for projects too small to require a construction access road. Commonly it is required to prevent unsafe roadway conditions caused by soil deposited onto paved surfaces. It reduces the potential of sediment transport from these paved surfaces during storm events as well as preventing dust clouds and slippery pavement.

Construction Entrance (CE)

Definition

A stone stabilized pad sometimes associated with a mud rack, automotive spray, or other measures located at points of vehicular ingress and egress on a construction site.

Purpose

To reduce the tracking of sediment off site onto paved surfaces.

Applicability

At points of construction vehicle ingress and egress where sediment may be tracked onto adjoining paved surfaces by vehicles.

Planning Considerations

The construction entrance is intended to cause sediment to drop off of vehicle tires and prevent it from being tracked onto adjoining paved areas. Its design and maintenance requirements are dependent upon how intensely the entrance is used and the nature of the sediments that can be tracked. Consider the texture of the sediments to be retained by the construction entrance. The minimum construction entrance is 50 feet, but where the soils subject to tracking contain less than 80% sand, then the minimum length of the construction entrance is 100 feet (see textural triangle in Appendix H). For sites containing clay or silty soils consider developing a construction access road with a gravel base. (See Chapter 4, Special Treatments, Construction Access Roads). The length of the construction entrance may be reduced by the establishment of an access road with a stable surface that is not subject to soil tracking.

If the construction entrance drains to a paved surface and its grade exceeds 2%, then plan on installing a water bar within the construction entrance to divert water away from the paved surface. For access roads that slope down to the construction entrance, consider installing a water bar and associated sediment barrier to protect the construction entrance from unnecessary siltation during storm events.

Placing a geotextile beneath the stone pad of the construction entrance can reduce the pumping of subsoil into the stone by construction traffic and reduce maintenance costs.

Select the site of the construction entrance to avoid poorly drained soils where possible. Where lateral flows of water must be maintained through the construction entrance, consider having an engineer design subsurface drainage or other drainage facilities to eliminate the obstruction to flow.

Consider requiring the installation of construction access fencing to restrict construction traffic to the construction entrance.

When the construction entrance is installed to the minimum standards and is properly maintained, but is still unable to prevent the majority of sediments from being tracked off site, the entrance must either be extended or a washing rack installed. If a washing rack or similar device is to be used to wash sediment from tires, make provisions to intercept the wash water and trap the sediment before it is carried off-site. Determine the sizing requirements for the sediment trapping facility so that it will hold the maximum volume of water that would be used over a 2-hour period. (See **Pumping Settling Basin** measure for formula on pumping rate and storage requirements).

The use of a construction entrance may not eliminate the need for periodic street sweeping, but if properly maintain it should significantly reduce the need.

Specifications

Materials

Stone: Use angular stone sized according to the standards set by ASTM C-33, size No. 2 or 3, or DOT Standard Specifications section M.01.01, size #3. See **Figure SP-1 on page 5-4-14** for stone sizing requirements.

Geotextile: Fibers used in the geotextile shall consist of synthetic polymers composed of at least 85% by weight polypropylenes, polyesters, polyamides, polyethylene, polyolefins or polyvinylidene-chlorides. The fibers shall be formed into a stable network of filaments or yarns retaining dimensional stability relative to each other. The geotextile used shall be specifically intended for "road stabilization" applications and shall be consistent with the manufacturer's recommendations for the intended use.

Location

Locate the entrance to provide maximum utilization by construction vehicles. Avoid poorly drained soils, where possible.

Construction Entrance Dimensions (see **Figure CE-2**)

Stone Thickness: not less than 6 inches.

Width: A 12-foot minimum with points of ingress or egress flared sufficiently to accommodate the turning radius of the construction vehicles used.

Length: A 50-foot minimum except where the tracked sediments contain less than 80% sand, a 100-foot minimum is required. If the traveled length is less than the minimum, then the construction entrance shall be the traveled length. On a site specific basis increase lengths as needed to prevent the tracking of sediment onto paved surfaces.

Construction

Clear the area of the entrance of all vegetation, roots, and other objectionable material. At poorly drained locations install subsurface drainage insuring the outlet to the drains are free flowing.

If using a geotextile in place of free draining material, unroll the geotexile in a direction parallel to the roadway centerline in a loose manner permitting it to conform to the surface irregularities when the stone is placed. Unless otherwise specified by the manufacturer, the minimum overlap of geotextile panels joined without sewing according to the manufacturer's recommendations. The geotextile may be temporarily secured with pins recommended or provided by the manufacturer but they shall be removed prior to placement of the stone.

Place the stone to the specified dimensions. Keep additional stone available or stockpile for future use. If the grade of the construction entrance drains to the paved surface and it exceeds 2%, construct a water bar within the construction entrance at least 15 feet from its entrance on the paved surface diverting runoff water to a settling or filtering area.

Construct any drainage and settling facilities needed for washing operations. If wash racks are used, install according to the manufacturer's specifications.

Washing

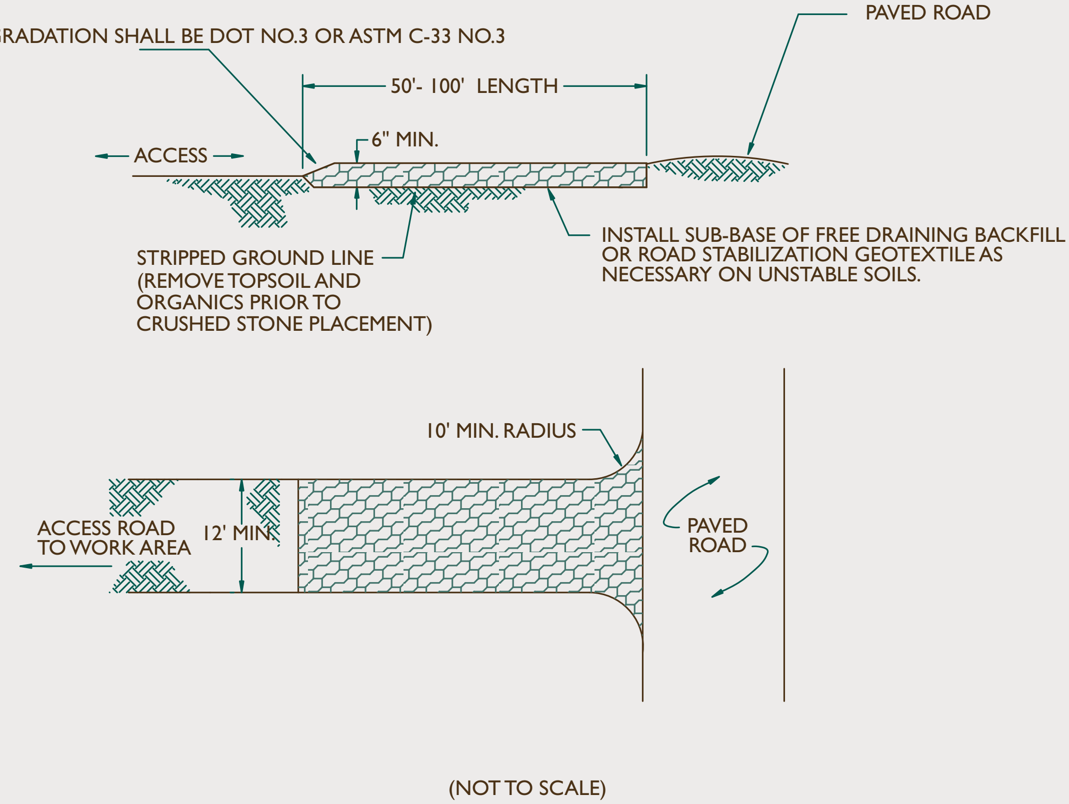
If most of the sediment is not removed by travel over the stone, wash tires before vehicles enter a public road. Divert wash water away from the entrance to a settling area to remove sediment. Size settling area to hold the volume of water used during any 2-hour period. Using a wash rack may make washing more convenient and effective.

Maintenance

Maintain the entrance in a condition which will prevent tracking and washing of sediment onto paved surfaces. Provide periodic top dressing with additional stone or additional length as conditions demand. Repair any measures used to trap sediment as needed. Immediately remove all sediment spilled, dropped, washed or tracked onto paved surfaces. Roads adjacent to a construction site shall be left clean at the end of each day.

If the construction entrance is being properly maintained and the action of a vehicle traveling over the stone pad is not sufficient to remove the majority of the sediment, then either (1) increase the length of the construction entrance, (2) modify the construction access road surface, or (3) install washing racks and associated settling area or similar devices before the vehicle enters a paved surface.

Figure CE-2 Diagram of Typical Construction Entrance



Source: USDA-NRCS

Construction Entrance (CE)

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Planning Considerations

The dewatering measures are **Pump Intake and Outlet Protection, Pumping Settling Basin, Portable Sediment Tank** and **Dewatering of Earth Materials**. The function of these measures is to handle and treat water that is generated during dewatering operations. Dewatering may involve either the use of pumps or the draining of excavated and dredged soils that are too wet to transport without leakage.

The **Pump Intake and Outlet Protection** measure uses structures or other protective devises, such as barrels, boards, stones, strainers and floats, which are attached to intake and discharge hoses to prevent the excessive pumping of sediments at the intake and the erosion at the point of discharge.

The **Pumping Settling Basin** measure utilizes an enclosed sediment barrier or excavated pit constructed with stable sides, an inlet and an outlet for the purpose of settling and/or filtering turbid water that is being pumped at a construction site. This measure is not needed if the pumped water is clear and sufficiently de-energized at the point of discharge. Similarly, a basin may not be needed if the volume of water is small and sufficient stable vegetative cover exists at the point of discharge to adequately treat the discharged water before draining into a wetland, watercourse, storm drain system or public road. In this case, the discharge area must be sufficiently stable so that it resists scouring and can filter the wastewater.

The **Portable Sediment Tank** measure uses a tank or other similar container to temporarily store and retain sediment before the water is discharged or transported to an approved location for further treatment when a pumping settling basin is impractical.

The **Dewatering of Earth Materials** measure uses an excavation and dike with a spillway to hold excavated or dredged soils that are too wet to be regraded or transported. The purpose of this measure is to provide a containment area large enough to allow for sufficient water to drain from the soil so that it may be regraded or transported.

The use of these measures is dependent upon specific site conditions, the contractor's method of operations, and contractor's dewatering equipment. Innovative techniques for dewatering structures other than those shown are encouraged, and should be evaluated on a case-by-case basis by the approving authority.

Dewatering needs should be identified in the erosion and sediment control plan and at least a general description of dewatering operations given. However, it should be recognized that any dewatering plan typically needs to be modified due to unforseen onsite conditions or alternate methods available to the contractor.

continued on next page

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For complex projects the E & S plan shall, at a minimum, identify dewatering needs and possible dewatering discharge locations. If a detailed dewatering plan is not contained within the overall E & S plan, it shall be forwarded to the approving agency for review and approval prior to the start of dewatering activities. It is not uncommon that once a construction contractor is selected and prior to actual dewatering, the contractor's detailed dewatering plan is submitted to the reviewing agency for review and approval.

Regardless of when a detailed dewatering plan is submitted, the plan shall identify the specific methods, devices and schedules to be used including, but not limited to:

- *details on protection at the inlet and outlet of pumps, method for floating the pump intake, or other methods to minimize and retain the sediment;*
- *details on any containment berm construction when dewatering earth materials; and*
- *identification of a contingency plan for emergency operations should the dewatering operation prove inadequate to meet the dewatering need or is found to be causing unacceptable turbidity problems (e.g., alternative discharge locations or use of a portable sediment tank).*

If turbidity or siltation problems are not adequately controlled by the continency plan , then the operation shall be ceased and a revised dewatering plan submitted for approval prior to further implementation.

To minimize the amount of sediment transport from dewatering operations:

- *Divert surface waters[1] away from areas needing dewatering; use* ***Diversions*** *and* ***Land Grading*** *measures;*
- *Consider if well points and sumps can be used to lower the groundwater table[1] reducing the need for settling facilities;*
- *For sites that don't require continuous pumping, pump work areas before construction activities begin each work day;*
- *Provide filtration near the suction intake;*
- *Locate pumps, intake sumps, and other intake structures in areas which will not require constant moving, when possible;*
- *Locate pump discharge facilities (portable, permanent, or bio-filtering structures) such that aminimum disturbance of existing wetlands and watercourses is incurred; and.*
- *Provide protection at outlets from pumping operations to dissipate pumping surges and prevent erosion at the point of discharge.*

[1] Diverting surface waters or pumping ground water waters may require a DEP water diversion permit or a local inland wetlands permit (see Appendix F, Regulatory Matrix).

Pump Intake And Outlet Protection (PuP)

Definition
Structures or other protective devices into which or on which intake and discharge hoses are placed during pumping operations.

Purpose
- To reduce the amount of sediments taken up by a pump during dewatering operations.
- To prevent soil erosion due to scouring and the resuspension of detained sediments at the point of pump discharge.

Applicability
Wherever dewatering is required by means of pumping such as cofferdams, building foundations, utility line installation (or repair) and pond construction or rehabilitation.

Planning Considerations
There is no specific design for this measure. The pump intake protection shown in **Figure PuP-1** and **Figure PuP-2** illustrate basic design concepts which when implemented during dewatering operations reduce sediment uptake.

Typically, pump intakes are installed in sumps that have been excavated below the grade such that water drains away from the active construction area. The location and size of sumps are dependent upon the field conditions found at the time of construction and dewatering operations. The expected conditions and potential sump needs should be noted on the plans. The sumps may require relocation as work progresses.

The pump outlet protection shown in **Figure PuP-3** illustrate basic design concepts which when implemented during dewatering operations reduces soil erosion and resuspension of sediments.

Specifications

Sizing Pumping Sumps
Determine the size of the pumping sump based upon the volume of water required to be pumped and the size of the pump. When using portable sediment storage tanks, the sump shall be capable of storing the amount of water that enters the dewatering site during time that it takes to switch portable sediment storage tanks.

For dewatering trenches, cofferdams and foundation excavations the sump is typically excavated 2 feet or more below the grade of the proposed work.

For pond rehabilitation the sump shall be a minimum of 2 feet below the pond bottom, depending upon the dewatering needs of material to be removed from the pond. Size of the sump is dependent upon conditions in the pond.

Installation
1. Determine if a sump is needed and the appropriate method of pump intake and outlet protection.

2. Where standing water is encountered in the area of a proposed sump, begin dewatering the site by floating the pump intake at the water's surface. Carefully monitor water levels to prevent the uptake of bottom sediments.

3. Excavate the sump within or adjacent to the area to be dewatered. Install pump intake and outlet protection before pumping begins.

4. Installation of the pump intake protection should conform to pumping rates and the general design concepts. **Figure PuP-1** shows a typical sump and intake constructed of stone imbedded with a perforated stand pipe. It is generally used where there is no need to frequently move the pumping sump or where the stone can be used on site for bedding material. In some instances the prefiltration of discharge waters may be enough to reduce or eliminate the need for a dewatering basin or portable sediment tank. **Figure PuP-2** shows a typical sump and intake that calls for lining (rather than filling) the pumping

sump with stone and attaching a strainer to the suction hose so that the hose is suspended off the bottom of the pumping sump and is protected against pumping bottom sediments. This design is useful when frequent relocation of the pumping sump is anticipated. However, it does not reduce the need for a dewatering basin.

5. The pump outlet protection shall adequately dissipate the energy of the discharge so as to prevent erosion and the resuspension of sediments at the point of discharge. **Figure PuP-3** illustrates an example of pump outlet protection. Pump outlet protection is required even if the discharge is to a pumping settling basin.

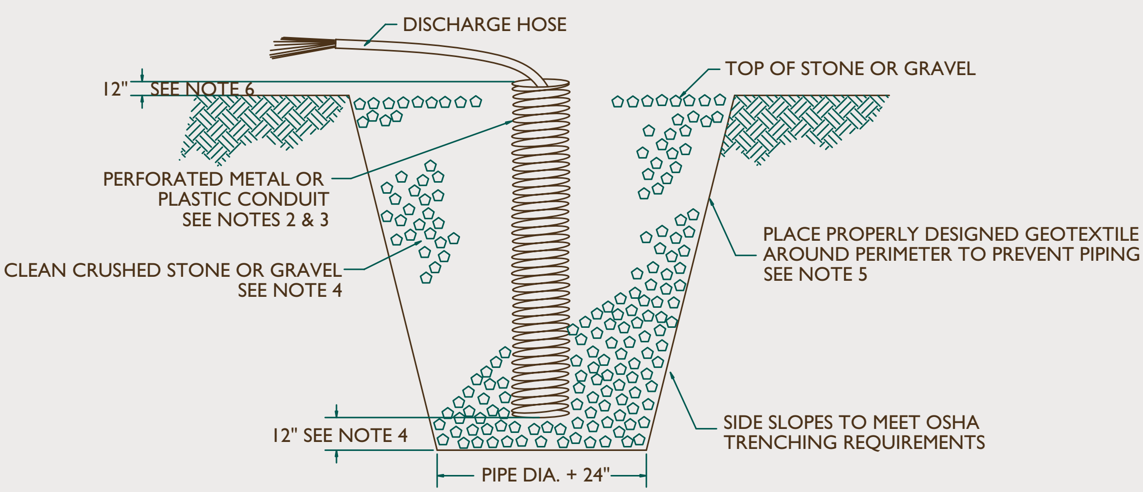
Operation

Monitor pumping operations and adjust pumping rates as needed to keep the construction area dewatered, and minimize pumping sediment.

Maintenance

Inspect the pumping sump, pump intake protection and pump discharge conditions frequently during dewatering operations for proper functioning of equipment.

Figure PuP-1 Pump Intake Protection Using Stone Filled Sump with Standpipe



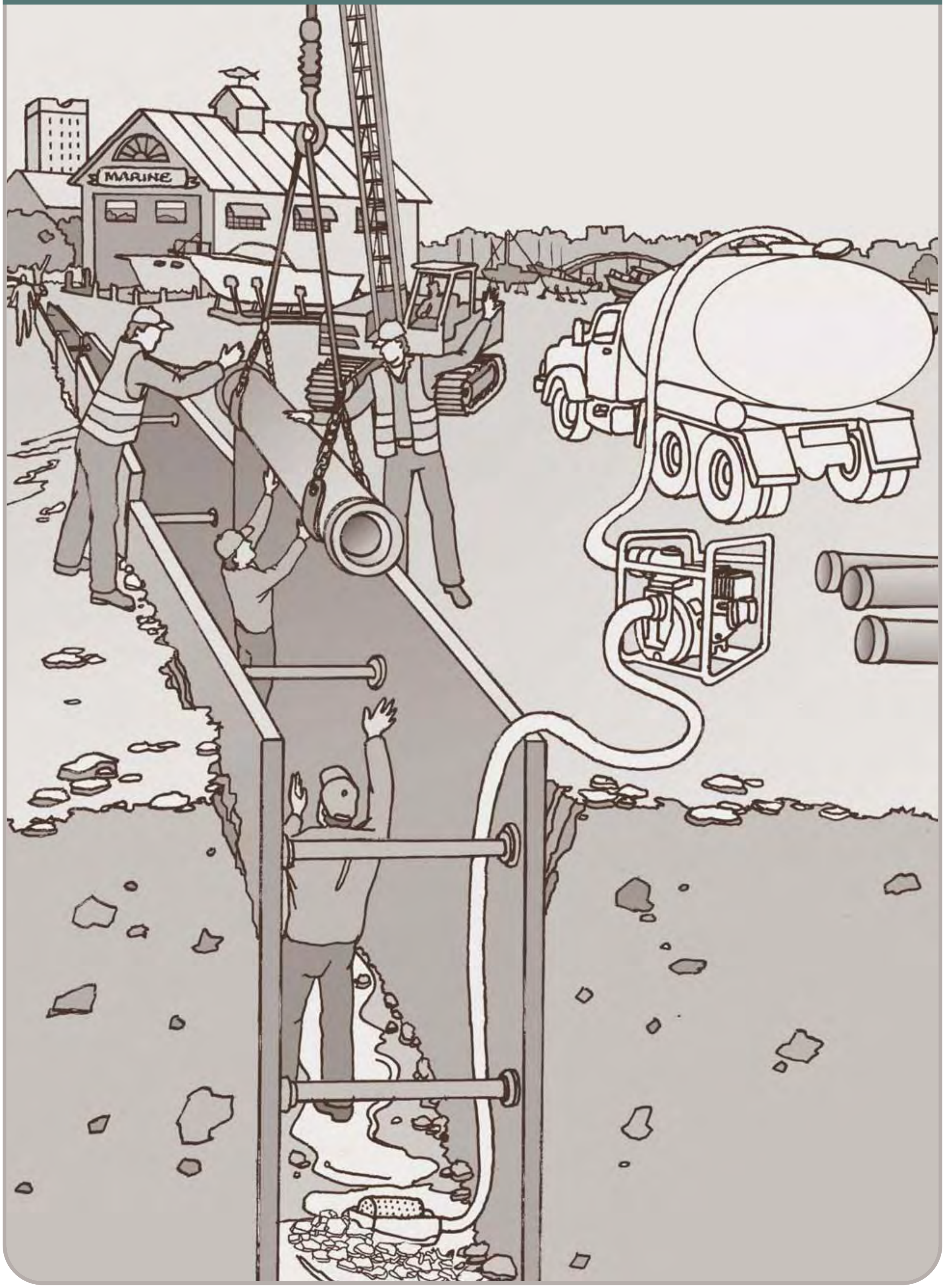
TYPICAL SECTION OF SUMP PIT

NOT TO SCALE

1. OVERALL SUMP PIT DIMENSIONS SHALL BE COMPATIBLE WITH ANTICIPATED SEEPAGE RATES AND PUMP SIZE TO BE USED.
2. THE STANDPIPE DIAMETER AND NUMBER OF PERFORATIONS SHALL BE COMPATIBLE WITH THE PUMP SIZE BEING USED.
3. PERFORATIONS IN THE STANDPIPE SHALL BE EITHER CIRCULAR OR SLOTS. PERFORATION SIZE SHALL NOT EXCEED 1/2" IN DIAMETER.
4. CRUSHED STONE OR GRAVEL SHALL BE NO SMALLER THAN CT DOT #67 SIZE NOR LARGER THAN CT DOT #3 SIZE. CRUSHED STONE SHALL EXTEND A MINIMUM OF 12" BELOW THE BOTTOM OF THE STANDPIPE.
5. IF EXCESSIVE MOVEMENT OF FINE SOIL PARTICLES FROM THE SURROUNDING EXISTING SOILS IS ANTICIPATED, A PROPERLY DESIGNED GEOTEXTILE SHALL BE PLACED BETWEEN THE EXISTING SOILS AND THE CRUSHED STONE OR GRAVEL BACKFILL.
6. THE STANDPIPE SHALL EXTEND A MINIMUM OF 12" ABOVE THE SURROUNDING GROUND.

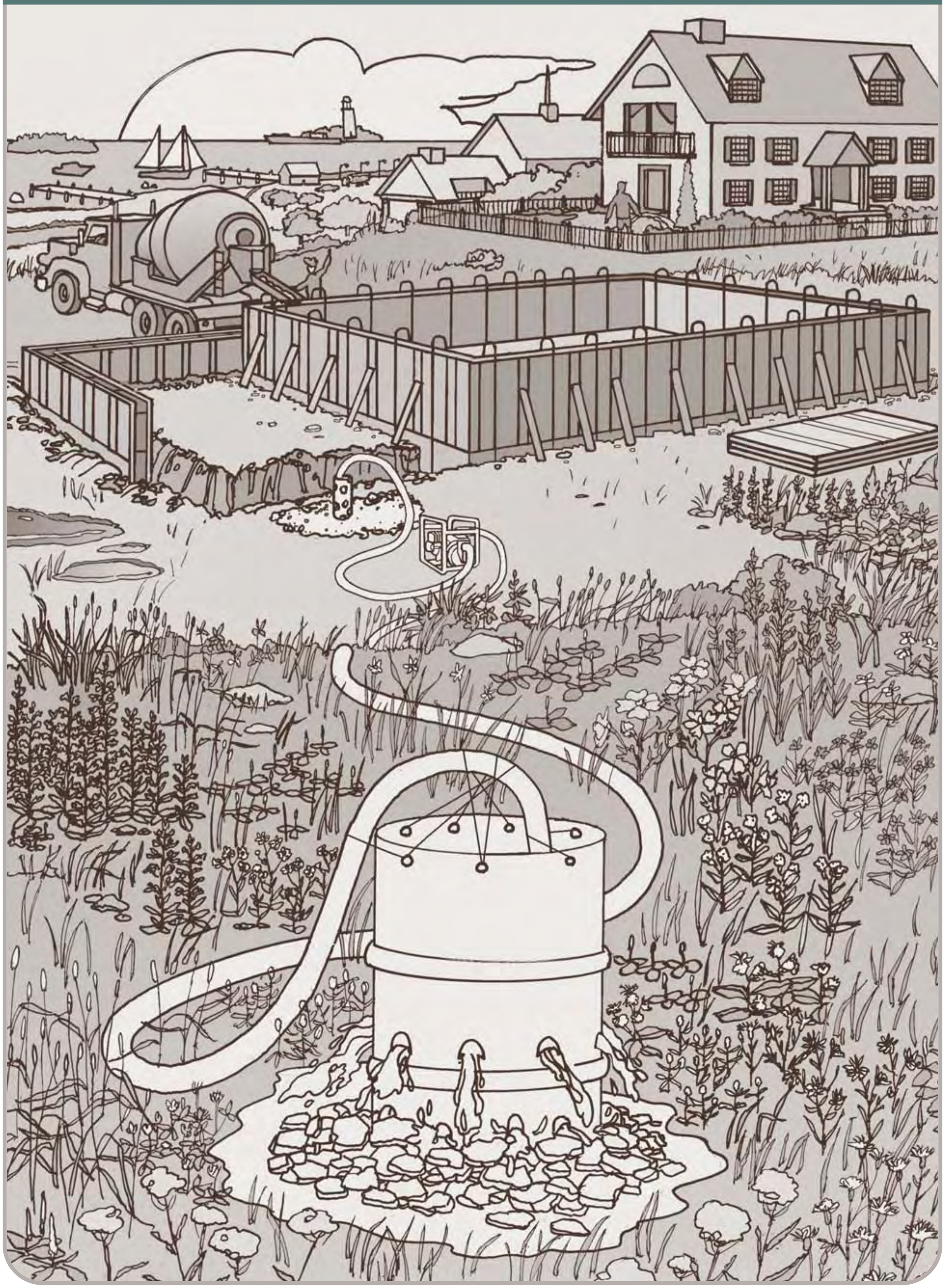
Source: USDA-NRCS

Figure PuP-2 Pump Intake Protection Using Sump with Strainer



Pump Intake and Outlet Protection (PuP)

Figure PuP-3 Examples of Pump Outlet Protection



Pumping Settling Basin (PSB)

Definition
An enclosed sediment barrier or excavated pit constructed with a stable inlet and outlet such that sediment laden water from pumping operations is de-energized and temporarily stored, allowing sediments to be settled and/or filtered out before being released from the construction site.

Purpose
To allow for the settlement of sediment from pumping operations prior to the water being discharged.

Applicability
- When a pump discharge from a construction area is sediment laden.
- Not for use with hydraulic dredging operations in open waters. (See **Dewatering of Earth Materials** measure).

Specifications

Materials
Whenever used in this measure:

- *hay bale barriers shall meet those required in the* ***Hay Bale Barrier*** *measure.*
- *geotextile shall meet that required in the* ***Geotextile Silt Fence*** *measure, and*
- *pump surge energy dissipators shall be provided and capable of sufficiently de-energizing pump discharges to prevent scour and remain in place (See* ***Pump Intake and Outlet Protection*** *measure).*

Sizing
Pumping settling basins are sized to have a minimum retention time of 2 hours. Use the following formula to determine the storage volume required:

Cubic feet of storage required = *Pump Discharge Rate (g.p.m.) x 16*

For sites where available storage is insufficient at the planned pumping rate, the maximum pumping rate is determined from the following formula:

$$\text{Pump Discharge Rate (g.p.m.)} = \frac{\text{Cubic feet of storage available}}{16}$$

In calculating the capacity, include the volume available from the floor of the basin to the crest of the outlet control.

Pumping Settling Basin (PSB)

Location

Locate the pumping settling basin on the site such that surface water is directed away from the pumping settling basin (See **Temporary Water Diversion** measure).

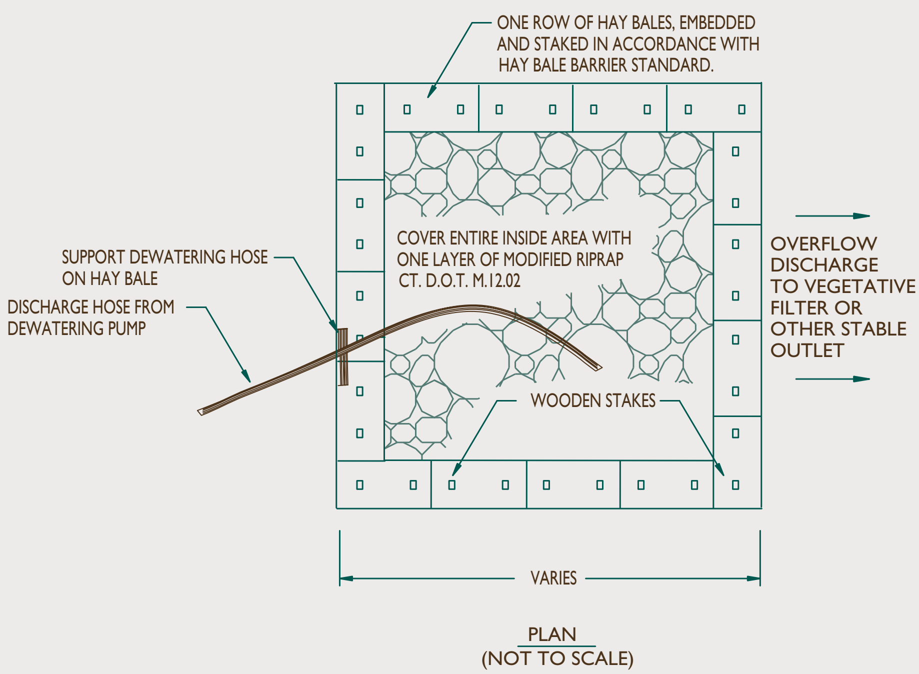
Installation

All dewatering basins, regardless of type, contain a water/sediment storage area, an energy dissipator for pump discharges entering the basin (See **Pump Intake and Outlet Protection** measure and an emergence overflow that provides for a stable filtration surface through which water may leave the basin. Pump discharge is located at a point in the dewatering basin that is farthest from the basin outlet.

Depending upon existing soil conditions and side slopes of excavated pumping settling basin, soil stabilization may be required. The excavation may be lined with geotextile or stone to help reduce scour and to prevent the erosion of soil from within the structure.

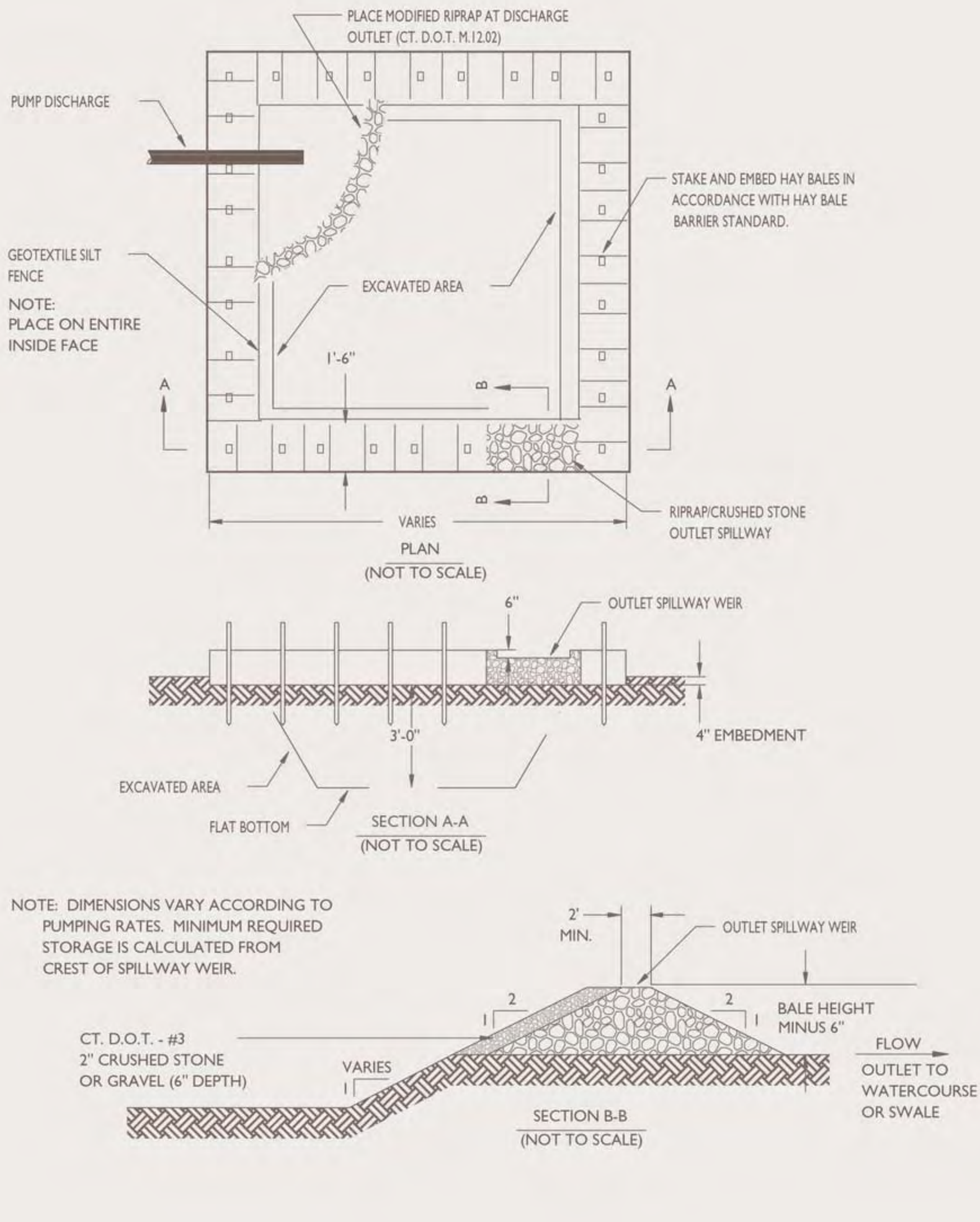
Type I - Small Volumes: Consist of an above ground enclosure created by a **Hay Bale Barrier**. See **Hay Bale Barrier** measure for material specifications and general installation requirements. This type of basin is located only on flat grades and is limited for use by its storage volume where the anticipated sediment delivery would not require cleaning and the expected use is for a very short duration. For calculating storage use the top of the lowest hay bale on the perimeter to the crest of the outlet control. An example of use for this type of basin would be a dewatering operation for a trench where no adequate vegetated filter exists (See **Vegetated Filter** measure) before the discharge enter into critical area such as a wetland, watercourse, street

Figure PSB-1 Example of Type I Pumping Settling Basin



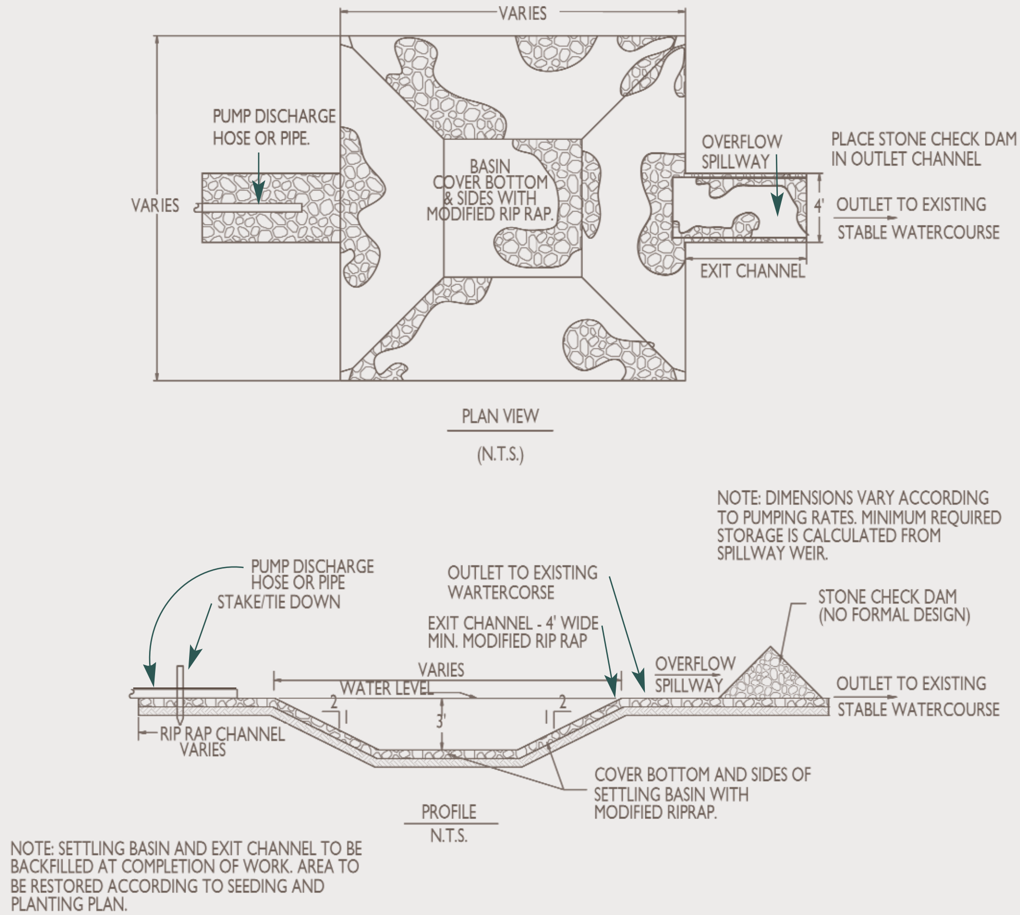
Source: USDA-NRCS

Figure PSB-2 Example of Type II Dewatering Settling Basin



Source: USDA-NRCS

Figure PSB-3 Example of Type III Pumping Settling Basin



Source: USDA-NRCS

Portable Sediment Tank (PST)

Definition

A tank or container into which sediment laden water is pumped in order to trap and retain the sediment before discharging the water or to transport the sediment laden water to an approved location for further treatment.

Purpose

To trap and retain sediment.

Applicability

- When a pump discharge from a construction area is sediment laden and space limitations prevent the use of a pumping settling basin.
- For sites with severe space limitations, a portable sediment tank may be used to transport the sediment laden water to an approved location.

Planning Considerations

Typically used with cofferdam dewatering associated with bridge repair work, utility work or in the redevelopment of urban areas.

When pumping requirements are expected to exceed the two hour storage capacity of the sediment tank and pumping cannot be discontinued for the length of time needed to drain the tank properly at the pumping site, consider using two or more portable sediment tanks that may be alternately filled, moved and drained at an acceptable location. Former milk trucks or water trucks have been used for this purpose where off-site disposal has allowed for off-site dewatering basins or adequate filtration by vegetative buffers. Do not use a tank that was formerly used for contaminated or hazardous materials.

When a portable dewatering tank is to be used next to a cofferdam, the weight of the tank and maximum volume of water and associated structures must be considered when constructing the cofferdam to ensure the structural stability of the cofferdam. Alternately, if the cofferdam has already been built, before placing any tank adjacent to the cofferdam, consider the cofferdam's ability to remain structurally stable when the tank is full.

Specifications

Materials

The tank is a structure constructed of steel, sturdy wood or other material suitable for handling the pressure exerted by the volume of water to be stored. The pump discharge into the tank shall be located at a point in the portable sediment tank that is farthest from the tank outlet. The outlet of the tank shall be equipped with an energy dissipator.

Location

Locate non-portable sediment tanks for ease of clean-out and disposal of the trapped sediment, and to minimize the interference with construction activities and pedestrian traffic.

Tank Sizing for On-Site Discharges

For discharging the portable sediment tank directly, size the tank to have a minimum retention time of at least 2 hours. Use the following formula to determine the storage volume required:

Cubic feet of storage required = *Pump Discharge Rate (g.p.m.) x 16*

Portable Sediment Tank (PST)

When the tank size available is insufficient at the planned pumping rate, maximum pumping rate is determined from the following formula:

$$\text{Pump Discharge Rate (g.p.m.)} = \frac{\text{Cubic feet of storage available}}{16}$$

An example of a typical sediment tank is shown on **Figure PST-1**. Other container designs may be used if the storage volume is adequate and is approved by the regulating agency.

When the tank size available cannot meet the 2-hour storage requirement and reduced pumping rates are not practical, then several tanks may be alternately filled and drained with pumping rates restricted to meet tank transport, draining and return times.

Operation

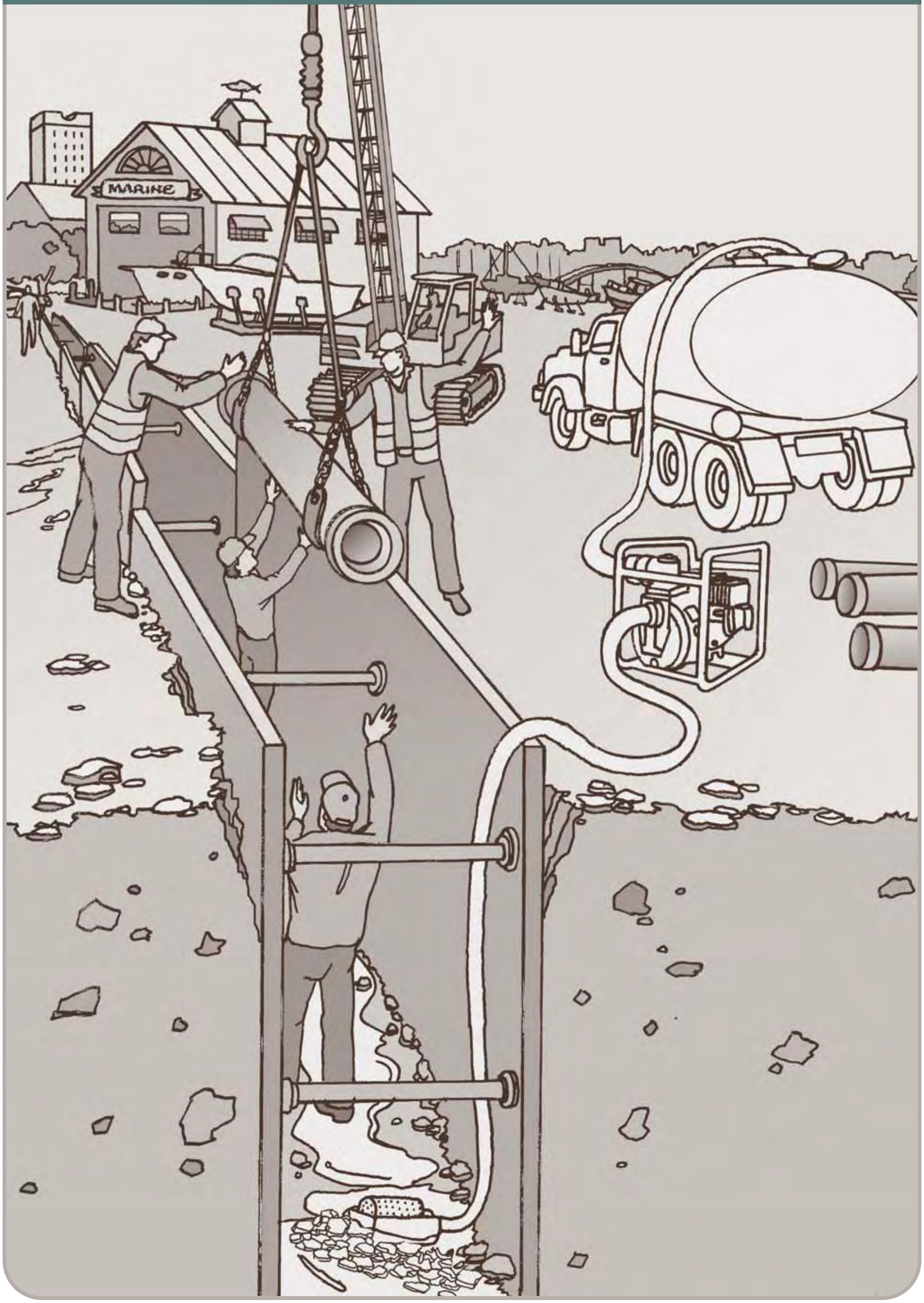
Once the water level nears the top of the tank, either shut off the pump while the tank drains and additional capacity is made available, or transport the tank to an appropriate disposal site.

Maintenance

Inspect the sediment tank continuously during use. For a tank that is discharging water while the pumping operation is ongoing and when the wet storage area has lost one half of its volume to sediment build up, discontinue pumping and remove accumulated sediments or replace the tank. For a tank that is used to transport the pumped water to a location distant from the pumping operation, discontinue pumping long enough to change the tank.

Any transported discharge of water and cleaning of the tank shall be done in such a manner as to prevent sediment laden water from reaching a wetland, watercourse or paved travelway.

Figure PST-1 Portable Sediment Tank In Operation



Dewatering of Earth Materials (DWM)

Definition
A procedure that uses a perimeter earthen berm and excavation to create a containment area where excessively wet soil is placed to allow for the draining of water or evaporation of excessive moisture.

Purpose
To dry soil sufficiently so that it may be regraded or transported.

Applicability
- When excavating saturated soils that are too wet to transport or to be contained with geotextile silt fence or hay bales.
- Not for dewatering contaminated soils. Handling of contaminated soils shall comply with the directives of the regulating agency (e.g. DEP and EPA).

Planning Considerations
Select a containment site that will be large enough to contain the anticipated volume of material to be dewatered and any perimeter berm. Locate the containment area so that the material being dewatered does not interfere with other construction activities and can be left for the time necessary for dewatering. Avoid wetlands, watercourses, drainageways and wooded areas. Sandy and gravelly material will generally dewater quicker than fine silts and clays, particularly if the containment area is gently sloping. The containment area can be divided into cells to allow for alternating use of the cells.

Design Criteria
An engineered design is required if (1) the berm for the containment area exceeds 3 feet in height above stripped, natural or original ground, or (2) the volume of materials needing dewatering exceeds 200 cubic yards at any one time. Use standard engineering practices.

Sizing
Size the containment area by the volume and type of material to be dewatered and the length of time that the material will remain stockpiled. Design the containment berm to withstand any anticipated loads.

Site Selection
Select a site where the slope is 8% or flatter. Do not locate on previously filled ground. Give preference to sites with well drained soils. An underdrain may be needed to improve the dewatering function of a containment area located on poorly drained soils.

Specifications

1. Strip and stockpile the topsoil from the containment area.

2. Divert surface water away from containment area as necessary (See **Temporary Diversion** Measure).

3. Construct the berm around the containment area with suitable soils. Certain types of soils are subject to instability upon saturation or loading and must be avoided. Examples of these soils include fine sands, silt loams, clay, peat and mucks. Sites containing such soils may require the borrowing of more suitable material from off site for berm construction.

4. Install a geotextile silt fence to filter the discharge from the disturbed area if an inadequate vegetated filter exists between the disturbed containment area and any wetland, watercourse or storm drain inlet. (See **Vegetated Filter** measure).

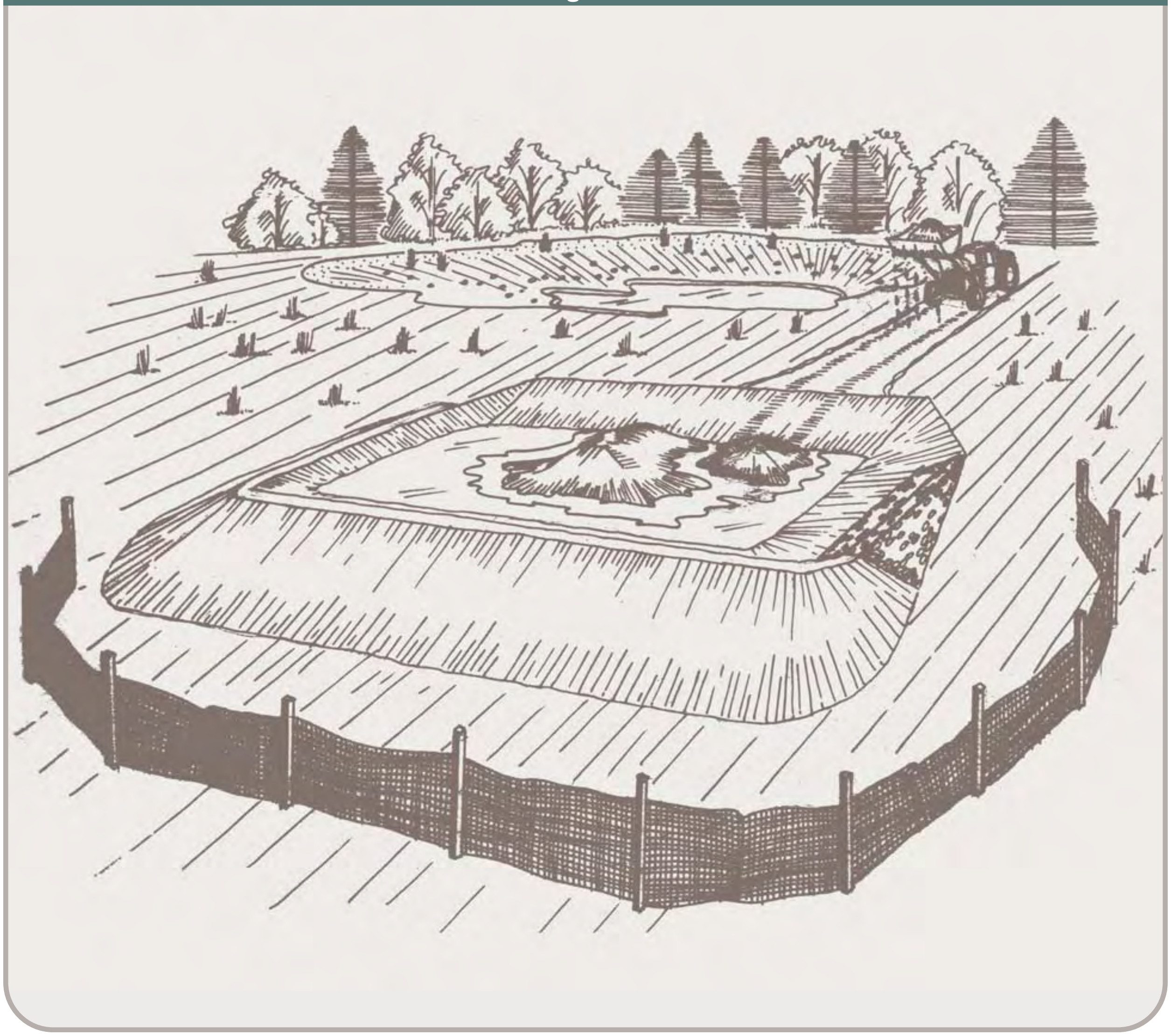
5. Place the saturated soil within the containment area such that drainage can occur.

Maintenance
Inspect containment area and associated sediment controls on a daily basis while dewatering operations are active. When dewatering operations are not active, inspect weekly or immediately after 0.5 inch of rain within a 24 hour period.

If the containment berm fails, determine the cause of the failure. If the berm failed due to overtopping, repair the berm and any damage caused by the berm failure and reduce usage of the containment area such that overtopping is prevented. If the berm experienced an internal structural failure, cease using the containment area, add additional controls to contain eroded sediments, repair the damage caused by the berm failure, and before repairing the berm have the dewatering operation reviewed by an engineer for repair requirements. Repair and clean out perimeter erosion and sediment controls as needed.

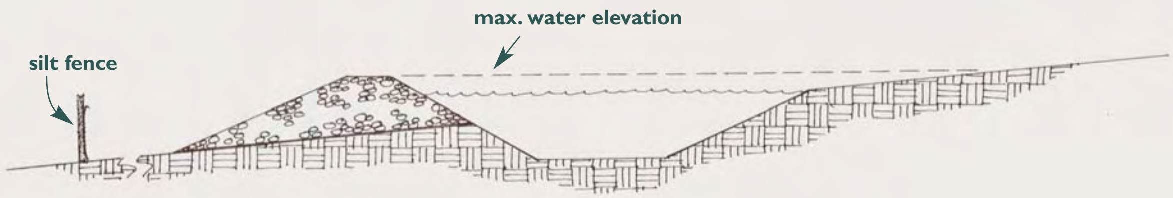
After dewatering operations are completed, regrade the containment area to a finished grade and stabilize in accordance with the planned use of the area .

Figure DW-1 Example of Non-Engineered Dewatering Containment Area for Dewatering Earth Materials



Dewatering of Earth Materials (DWM)

Figure DW-1A Cross Section – Example of Non–Engineered Dewatering Containment Area for Dewatering Earth Materials



cross section through emergency spillway