Omaha Regional Stormwater Design Manual

Erosion and Sediment Control

Chapter 9

Revised June 2014

City of Omaha Environmental Quality Control Division
www.omahastormwater.org

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Acronyms & Abbreviations

AASHTO	American Associations of State Highway and Transportation Officials
ASTM	American Society for Testing Materials
ATB	asphalt treated base
BMP	Best Management Practice
CASQA	California Stormwater Quality Association
CFR	Code of Federal Regulations
cfs	cubic feet per second
CN	Curve Number
cu. yd.	cubic yard
e.g.	example
fps	feet per second
°F	Degrees Fahrenheit
ft	feet
H	Horizontal
hr	hour
in	inch
lbs	pounds
mm	millimeter
N/A	not applicable
NADM 88	North American Vertical Datum of 1988
NDEQ	Nebraska Department of Environmental Quality
NDOR	Nebraska Department of Roads
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
pH	potential hydrogen
ppm	parts per million
psi	pressure per square inch
PCWP	Papillion Creek Watershed Partnership
SCS	Soil Conservation Service
SMPG	Site Map Preparation Guide
sq. ft.	square feet
STA	Seal of Testing Assurance
SWPPP	Storm Water Pollution Prevention Plan
SWPPP-N	Storm Water Pollution Prevention Plan – Narrative
SWPPP-SM	Storm Water Pollution Prevention Plan – Site Map
USCC	U.S. Composting Council
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UV	ultra violet
V	vertical
W	width
yd	yard

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Chapter 9 Erosion and Sediment Control

9.1 Overview

9.1.1 Introduction

Uncontrolled stormwater runoff from construction sites carries soil particles and pollutants to downstream waterbodies and can negatively impact the surface water quality of rivers and lakes. Sediment deposited from construction site runoff can reduce the amount of sunlight reaching aquatic plants, clog fish gills, smother aquatic habitat and spawning areas, and impede navigation. The City of Omaha and surrounding cities formed the Papillion Creek Watershed Partnership (PCWP) to address issues related to surface water quality and quantity.

The PCWP was created in 2001 through an inter-local agreement to proactively deal with the demands on the Papillion Creek drainage area and to develop an implementation plan that addresses solutions to water quantity and quality problems. The PCWP is made up of the cities of Omaha, Bellevue, Boys Town, Gretna, La Vista, Papillion and Ralston; Sarpy County; and the Papio-Missouri River Natural Resources District. It is the mission of the PCWP to address issues related to surface water and stormwater quantity in the watershed by establishing goals and standards common to the region for development within the watershed through 2040. The PCWP standardized the construction site soil erosion and sediment control procedures and requirements in the Grading Permit Terms which can be found on the City's website at:

http://omahastormwater.org/

The PCWP Grading Permit Terms apply to projects required to obtain a general National Pollution Discharge Elimination System (NPDES) construction site stormwater permit for stormwater discharges associated with construction activity. The NPDES general permit applies to projects that cause land disturbance of equal to or greater than one ac. and less than one ac. if part of a larger common plan of development or sale. The PCWP permit terms require that a qualified preparer prepare a Storm Water Pollution Prevention Plan (SWPPP), the PCWP permit includes a list of qualified preparers. Generally, the SWPPP must:

1. Identify all potential sources of pollution which may reasonably be expected to affect the quality of stormwater discharges from the construction site;
2. Minimize erosion on disturbed areas and minimize the discharge of sediment and other pollutants in stormwater runoff;
3. Describe practices to be used to reduce pollutants in stormwater discharges from the construction site; and
4. Provide velocity dissipation devices at discharge locations and along the length of any outfall channel to provide a non-erosive flow velocity from the structure to a water course.

The intent of this chapter is to describe the fundamentals of erosion and sediment control, describe the process of developing a SWPPP, and provide proper selection, design, implementation and maintenance of erosion and sediment control best management practices (BMPs) for construction site runoff to meet requirements of PCWP Grading Permit Terms and those of the Nebraska Department of Environmental

Quality (NDEQ) General NPDES Permit. The guidelines contained within this chapter provide information on minimizing erosion and sediment problems on land undergoing urban development. The guidelines contained herein are intended to provide planning boards, governmental bodies, property owners, developers, contractors, consultants and others with information, options and design criteria for sound development of methods and plans which will address erosion and sedimentation. Feasible methods of minimizing erosion and sediment at an individual project level are varied and complex, and several alternative methods may be used to provide a solution. Final decisions on BMPs to be used are best made when implementing agencies, plan designers and contractors all provide input.

9.1.2 Best Management Practices Categories

BMPs suitable for controlling construction site runoff can be organized into three categories:

1. **Erosion Prevention BMPs–** Erosion prevention BMPs are the first line of defense in preventing erosion. This is accomplished by protecting the soil surface from raindrop impact and overland flow of runoff. The best way to protect the soil surface is to preserve the existing natural vegetation. Where land disturbance is necessary, temporary seeding or mulching should be used on areas which will be exposed for long periods of time. Erosion and sediment control plans should also include provisions for permanent stabilization of denuded areas and velocity dissipation at outfalls.

2. **Sediment Control BMPs –** Sediment control BMPs are structural practices, and are usually necessary since not all disturbed areas can be protected with erosion prevention measures. Sediment controls are designed to capture sediment before it leaves the site. It is important that sediment control BMPs be designed according to accepted standards. Improper use or inadequate installation can result in failure of the control and subsequent release of trapped sediment.

3. **Good Housekeeping BMPs –** Good housekeeping BMPs are practices focused on project planning, materials management, construction sequencing, staging, and maintenance activities which can be used to reduce the potential for stormwater runoff to mobilize construction site wastes and contaminate surface or ground water.

The selection of the proper BMP for a particular site begins with understanding the fundamentals of erosion and sediment control.

9.2 Fundamentals of Erosion and Sediment Control

9.2.1 The Erosion Process

Soil erosion is the process by which the land's surface is worn away by the action of wind, water, ice and gravity. Natural or geologic erosion has been occurring at a relatively slow rate since the earth was formed and is a tremendous factor in creating the earth as we know it today. Except for some cases of shoreline and stream erosion, natural erosion occurs at a very slow and uniform rate and remains a vital factor in maintaining environmental balance. Man's activities accelerate the erosion process by loosening and pulverizing soil, making it more susceptible to detachment by natural forces. Water generated erosion is unquestionably the most severe type of erosion, particularly in developing areas; it is, therefore, the type of erosion to which this manual is primarily addressed. Soil erosion by water involves the detachment of particles from the soil mass, transportation by surface runoff, and eventual deposition. Soil particles are detached by the impact of rainfall and the sheer force of runoff. Transportation of soil particles is primarily by channelized runoff, although raindrop splash causes some net down slope movement and increases the erosive capability of unchannelized overland flow. Runoff occurs when the rainfall intensity is greater than the soil infiltration rate. Once runoff begins, the quantity and size of material transported is a function of runoff velocity and turbulence.

Water generated erosion can be broken down into the following five types:

1. **Raindrop Erosion -**is the first effect of a rainstorm on the soil. Raindrop impact dislodges soil particles and splashes them into the air. These detached particles are then vulnerable to the next type of erosion.

2. **Sheet Erosion -**is the erosion caused by the shallow flow of water as it runs off the land. These very shallow moving sheets of water are seldom the detaching agent, 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 ft. on land surfaces before concentrating in surface irregularities.

3. **Rill Erosion -**is the erosion which develops as the shallow surface flow begins to concentrate in the low spots of the irregular contours of the surface. As the flow changes from the shallow sheet flow to deeper flow in these low areas, the velocity and turbulence of flow increase. The energy of this concentrated flow is able to both detach and transport soil materials. This action begins to cut small channels of its own. Rills are small but well-defined channels which are at most only a few in. in depth. They are easily obliterated by harrowing or other surface treatments.

4. **Gully Erosion -**occurs as the flow in rills comes together in larger and larger channels. The major difference between gully and rill erosion is a matter of magnitude. Gullies are too large to be repaired with conventional tillage equipment and usually require heavy equipment and special techniques for stabilization.

5. **Channel Erosion -**occurs as the volume and velocity of flow causes movement of the streambed and bank materials. Urban development typified by the removal of existing vegetation, by increasing the amount of impervious areas and by paving tributaries, drastically changes the volume and velocity of flow within a stream destroying the equilibrium of the stream and

causing channel erosion to begin. Common points where erosion occurs are at stream bends and at constrictions, such as those where bridges cross a stream. Erosion may also begin at the point where a storm drain or culvert discharges into a stream. Repair of eroded stream banks is difficult and costly.

Figure 9-1 illustrates the five stages of erosion described in the paragraph above.

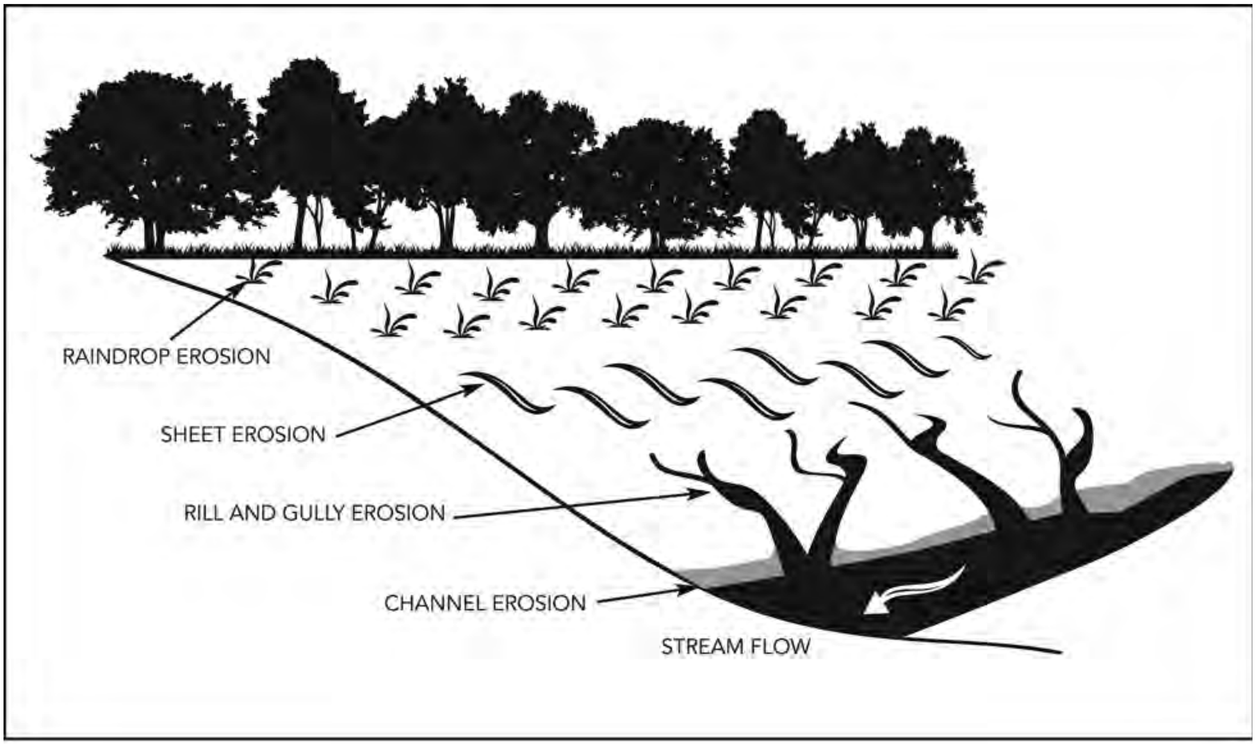


Figure 9-1 Types of Erosion

9.2.2 Factors Influencing Soil Erosion

The erosion potential of any area is determined by the characteristics of:

- Its soil
- Its vegetative cover
- Its topography
- Its climate

Although each of these factors is discussed separately herein, they are inter-related in determining soil erosion potential.

1. **Soil characteristics -**which influence the potential for erosion by rainfall and runoff are those properties which affect the infiltration capacity of a soil and those which affect the resistance of the soil to detachment and being carried away by falling or flowing water. The following four factors are important in determining soil erodibility:

a. Soil texture **-**refers to the sizes and proportions of the particles making up a particular soil. Sand, silt, and clay are the three major classes of soil particles. Soils high in sand content are said to be coarse-textured. Because water readily infiltrates into sandy soils, the runoff, and consequently the erosion potential, is relatively low. Soils with a high content of silts and clays are said to be fine-textured or heavy. Clay, because of its stickiness, binds soil particles together and makes a soil resistant to erosion. However, once the fine particles are eroded by heavy rain or fast flowing water, they will travel great distances before settling. Even with the sediment control measures described in this manual, it is extremely difficult to remove clay particles from flowing water. Typically, particles of clay and fine silt will settle in a large, calm water body, such as a bay, lake, or reservoir, at the bottom of a watershed. Thus, silty and clayey soils are frequently the worst water polluters. Soils that are high in silt and fine sand and low in clay and organic matter are generally the most erodible. Well-drained sandy and rocky soils are the least erodible.

b. Organic matter **-**consists of plant and animal litter in various stages of decomposition. Organic matter improves soil structure and increases permeability, water-holding capacity, and soil fertility. Organic matter in an undisturbed soil or in mulch covering a disturbed site reduces runoff and, consequently, erosion potential. Mulch on the surface also reduces the erosive impact of raindrops.

c. Soil structure **-**is the arrangement of soil particles into aggregates. A granular structure is the most desirable one. Soil structure affects the soil's ability to absorb water. When the soil surface is compacted or crusted, water tends to run off rather than infiltrate. Erosion potential increases with increased runoff. Loose, granular soils absorb and retain water, which reduces runoff and encourages plant growth.

d. Soil permeability **-**refers to the ability of the soil to allow air and water to move through the soil. Soil texture and structure and organic matter all contribute to permeability. Soils with high permeability produce less runoff at a lower rate than soils with low permeability, which minimizes erosion potential. The higher water content of a permeable soil is favorable for plant growth, although it may reduce slope stability in some situations.

2. **Vegetation -**plays an extremely important role in controlling erosion as it provides the following five benefits: (1) shields the soil surface from raindrop impact, (2) root systems hold soil particles in place, (3) maintains the soil's capacity to absorb water, (4) slows the velocity of runoff, and (5) removes subsurface water between rainfalls through the process of evapotranspiration. By limiting and staging the removal of existing vegetation and by decreasing the area and duration of exposure, soil erosion and sedimentation can be significantly reduced. Special consideration should be given to the maintenance of existing vegetative cover on areas of high erosion potential such as moderately to highly erodible soils, steep slopes, drainage ways, and the banks of streams.

3. **Topography -** 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. The shape of a slope also has a major bearing on erosion potential. The base of a slope is more susceptible to erosion than the top, because runoff has more momentum and is more concentrated as it approaches the base. Slope orientation can also be a factor in determining erosion potential. For example, a slope that faces south and contains

droughty soils may have such poor growing conditions that vegetative cover will be difficult to re-establish. Conversely, northern exposures tend to be cooler and moister, but they also receive less sun, which results in slower plant growth.

4. **Climate -** The frequency, intensity, and duration of rainfall are fundamental factors in determining the amounts of runoff produced in a given area. As both the volume and velocity of runoff increases, 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 changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year. When precipitation falls as snow, no erosion will take place. However, when the temperature rises, melting snow adds to runoff, and erosion potential is high. Because the ground is still partially frozen, its absorptive capacity is reduced. Frozen soils are relatively erosion resistant. However, soils with high moisture content are subject to uplift action and are usually very easily eroded upon thawing.

9.2.3 Impacts from Erosion and Sedimentation

Erosion and sedimentation cause both environmental and economic impacts. Both are important, but it is often only the economic impact that spurs action from people. Environmental impacts are much harder to see, they tend to build slowly and not produce dramatic results for several years, often too late to correct the problem. Environmental impacts can be associated with the following four categories: (1) elimination of potential for future resource base and decreased biological diversity; (2) agricultural impacts including reduced crop production and higher input costs; (3) decreased water quality including damage to fish and wildlife resources, potability and water supply; and (4) decreased air quality.

Many economic impacts are hard to quantify. How does one set a value on loss of aquatic habitat or diminished water clarity? Other impacts may be readily quantified. For example, the cost of a silted-up reservoir may be the costs of dredging and disposing of the accumulated sediment. Economic impacts can include costs associated with: (1) low storage capacities in reservoirs, (2) dredging of navigable waterways, (3) maintenance of eroded sites, (4) correction of erosion problems, (5) removal and redistribution of sediment from structures, (6) diminished ecosystem health, and (7) diminished esthetics.

The principal effect land development activities have on the natural or geologic erosion process consists of exposing disturbed soils to precipitation and to surface storm runoff. Shaping of land for construction or development purposes alters the soil cover and the soil in many ways, often detrimentally affecting on-site drainage and storm runoff patterns and eventually the off-site stream and stream flow characteristics. Protective vegetation is reduced or removed, excavations are made, topography is altered and the removed soil material is stockpiled -often without protective cover. In effect, the physical properties of the soil itself are changed. The development process is such that many citizens of a locality may be adversely affected even by development of areas of only limited size. It has been shown that sediment loading rates for construction sites without erosion and sediment controls are 5 to 500 times greater than those from undeveloped land.

Potential hazards associated with development include:

1. A large increase in areas exposed to storm runoff and soil erosion.
2. Increased volumes of storm runoff, accelerated soil erosion and sediment yield and higher peak flows caused by:

a. Removal of existing protective vegetative cover.

b. Exposure of underlying soil or geologic formations which are less pervious and/or more erodible than the original soil surface.

c. Reduced capacity of exposed soils to absorb rainfall due to compaction caused by heavy equipment.

d. Enlarged drainage areas caused by grading operations, diversions, and street construction.

e. Prolonged exposure of unprotected disturbed areas due to scheduling problems and/or delayed construction.

f. Shortened times of concentration of surface runoff caused by altering steepness, distance and surface roughness and through installation of "improved" storm drainage facilities.

g. Increased impervious surfaces associated with the construction of streets, buildings, sidewalks and paved driveways and parking lots.

3. Alternation of the groundwater regime that may adversely affect drainage systems, slope stability and survival of existing and/or newly established vegetation.

4. Creation of south and west directional exposure of property which may hinder plant growth due to adverse temperature and moisture conditions.

5. Exposure of subsurface materials which are rocky, acidic, droughty or otherwise unfavorable to the establishment of vegetation.

6. Adverse alteration of surface runoff patterns by construction and development.

Increases in sedimentation yield higher levels of nutrients and toxicants. Sediment acts like a magnet to toxicants and trace metals. Additionally, the soil introduces nutrients into streams and groundwater, decreasing the oxygen available to support aquatic life. Even more startling is the apparent ability of sediment to act as long term storage media for toxicants.

9.2.4 Principles of Soil Erosion and Sediment Control

For an erosion and sediment control and stormwater management program to be effective, it is imperative that provisions for erosion and sediment control measures be made in the planning stages. These planned measures, when applied during construction, will result in orderly development, which minimizes environmental degradation. From the previous discussion about erosion and sediment processes and the factors affecting erosion, basic technical principles can be formulated to assist the project planner or designer in providing for effective soil erosion and sediment control. These principles should be used to the maximum extent possible on all projects.

1. **Plan the development to fit the particular topography, soils, drainage patterns, and natural vegetation of the site.** Detailed planning should be employed to assure that roadways, buildings, and other permanent features of the development conform to the natural characteristics of the site.

Large graded areas should be located on the most level portion of the site. Areas subject to flooding should be avoided, and floodplains should be kept free from filling and other development. Areas with steep slopes, erodible soils and soils with severe limitations for the intended uses should not be utilized without first overcoming the limitations through sound engineering practices. Erosion prevention and development and maintenance costs can be minimized by selecting a site suitable by its nature for a specific proposed activity, rather than by attempting to modify a site to conform to a proposed activity. This kind of planning can be more easily accomplished when a general land-use plan is developed based upon a comprehensive inventory of soils, water and other related resources.

2. **Minimize the extent of the area exposed at one time and duration of exposure**. When land disturbance is required and the natural vegetation is removed keep the area and the duration of exposure to a minimum. Plan the phases or stages of development so that only the areas which are actively being developed are exposed. All other areas should have a good cover of temporary or permanent vegetation or mulch. Grading should be completed as soon as possible after it is begun. Immediately after grading is completed, permanent vegetative cover should be established in the area. As cut slopes are made and as fill slopes are brought up to grade, these areas should be revegetated as the work progresses. This is known as staged seeding. Minimizing grading of large or critical areas during the seasons of maximum erosion potential, April through September, reduces the risk of erosion.

3. **Apply erosion prevention practices to prevent excessive on-site damage**. This third principle relates to using practices that prevent erosion on a site to prevent excessive sediment from being produced. Keep soil covered as much as possible with temporary or permanent vegetation or with various mulch materials. Special grading methods such as roughening a slope on the contour or tracking with a cleated dozer may be used. Other practices include diversion structures to divert surface runoff from exposed soils and grade stabilization structures to control surface water. "Gross" erosion in the form of gullies must be prevented by these water control devices. Lesser types of erosion such as sheet and rill erosion should be prevented but, often, scheduling or the large number of practices required makes this impractical. However, when erosion is not adequately controlled at the source, sediment control for the project as a whole is more difficult and expensive.

4. **Apply perimeter control practices to protect the disturbed area from off-site runoff and to prevent sedimentation damage to areas below the development site.** This principle relates to using practices that effectively isolate the development site from surrounding properties and especially to controlling sediment once it is produced and preventing its transport off-site. Diversions, dikes, sediment traps, vegetative filters and sediment basins are examples of practices which control sediment. Vegetative and structural sediment control measures can be classified as either temporary or permanent depending on whether or not they will remain in use after development is complete. Generally, sediment can be retained by two methods: (1) filtering runoff as it flows through an area, and (2) impounding the sediment-laden runoff for a period of time so that the soil particles settle out. Many practices are combinations of these two methods. The best way to control sediment; however, is to prevent erosion as discussed in the third principle.

5. **Keep runoff velocities low and retain runoff on the site.** The removal of existing vegetative cover and the resulting increase in impermeable surface area during development will increase both the volume and velocity of runoff. These increases must be taken into account when providing

for erosion prevention. Keeping slope lengths short and gradients low and preserving natural vegetative cover can keep stormwater velocities low and limit erosion hazards. Runoff from the development should be safely conveyed to a stable outlet using storm drains, diversions, stable waterways, rip-rapped channels or similar measures. Consideration should be given to the installation of stormwater retention or detention structures when there is a potential for flooding and damage to downstream facilities resulting from increased runoff from the site. Conveyance systems should be designed to withstand the velocities of projected peak discharges. These facilities should be operational as soon as possible after the start of construction.

6. **Stabilize disturbed areas immediately after final grade has been attained.** Permanent structures, temporary or permanent vegetation, and mulch, or a combination of these measures should be employed as quickly as possible after the land is disturbed. Temporary vegetation and mulches can be most effective where or when it is not practical to establish permanent vegetation. Such temporary measures should be employed immediately after rough grading is completed if a delay is anticipated in obtaining finished grade. The finished slope of a cut or fill should be stable, and ease of maintenance should be considered in the design. Stabilize roadways, parking areas, and paved areas with an aggregate sub-base whenever possible.

7. **Implement a thorough maintenance and follow-up program.** This last principle is vital to the success of the other six principles. A site cannot be effectively controlled without thorough, periodic checks of the erosion and sediment control practices. These practices must be maintained just as construction equipment must be maintained and materials checked and inventoried. This could be done by starting a routine “end of day check” to make sure all control practices are working properly. If they are not working, maintenance or improvement of the practices is needed. If necessary to achieve the planned results, alternative or supplemental practices should be selected and implemented.

Usually, these seven principles are integrated into a system of vegetative and structural measures along with management techniques to develop a plan to prevent erosion and control sediment. In most cases, a combination of limited grading, limited time of exposure, and a judicious selection of erosion prevention practices and sediment trapping facilities will prove to be the most practical method of controlling erosion and the associated production and transport of sediment. The following sections describe the selection and implementation of appropriate BMPs.

9.3 BMP Selection and Implementation Guidelines

There are many different erosion and sediment control BMPs available for selection by the designer. However, not all erosion and sediment control BMPs are applicable for all construction projects. In fact, a variety of site features within a single project site may dictate that different BMPs be used throughout the site. This section provides a process for identifying and selecting BMPs that are most effective during development to address erosion and sediment control needs. Section 9.4 provides additional detail on the specific information that is to be gathered and included in the SWPPP to meet the terms of the PCWP Grading Permit. Design criteria and construction guidelines for select BMPs are provided in Section 9.5.

The steps illustrated in Figure 9-2 provide a systematic approach for assessing sites and selecting the appropriate erosion prevention, sediment control, and good housekeeping BMPs during the construction process.

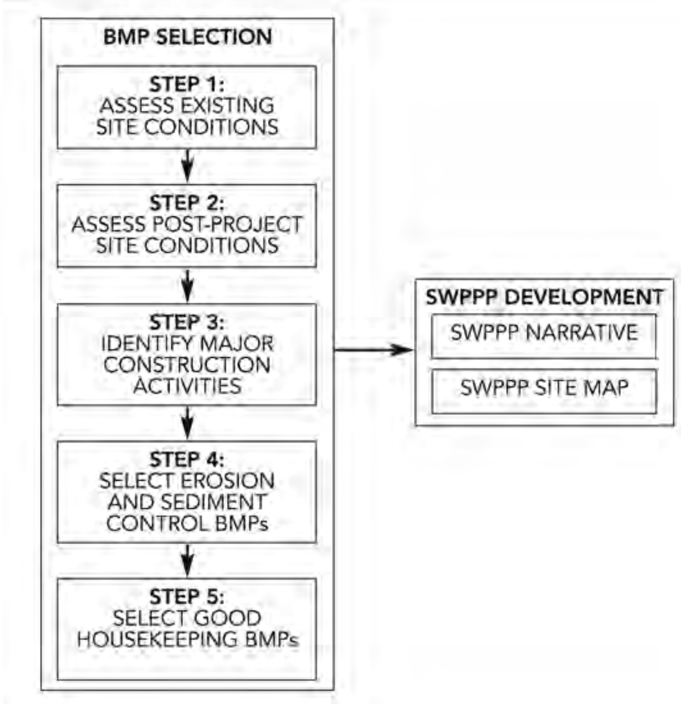


Figure 9-2 Steps for BMP Selection and SWPPP Development

Each step presented in Figure 9-2 is discussed in more detail in the following paragraphs.

9.3.1 Step 1: Assess Existing Site Conditions

The purpose of assessing the existing conditions of the site is to gather information that will help to identify site features where erosion prevention, sediment control, or good housekeeping BMPs may be needed. The following information should be assessed:

Topography – An appropriate scale topographic map of the site should be prepared to show the existing contours with elevations referenced to *North American Vertical Datum (NAVD) 1988*. Contours should be at intervals ranging from 1 to 5 ft. to determine the slope of the existing terrain. Previously published topographic maps may be a good starting point; however, the information shall be verified and confirmed by a field investigation.

The primary topographic considerations are slope steepness and slope length. Because of the effect of accumulated runoff, erosion potential is greater on long, steep slopes. As shown in Table 9-1, slope gradients can be grouped into three general ranges of soil erodibility: low erosion hazard (0 to 7 percent), moderate erosion hazard (7 to 15 percent), and high erosion hazard (greater than 15 percent). Within these slope gradient ranges, the erosion hazard becomes greater as the slope length increases. Therefore, in determining potential critical areas, the designer should be aware of excessively long slopes. As a general rule, the erosion hazard will become critical if the slope exceeds the following criteria: 300 ft. (0 to 7 percent), 150 ft. (7 to 15 percent), and 75 ft. (greater than 15 percent). All slopes with high and critical erosion hazards should be noted for protective measures.

Table 9-1 Erosion Hazard for Slope Gradients

Slope, Percent	Erosion Hazard	Maximum Slope Length[1], ft
0-7	Low	300
7-15	Moderate	150
> 15	High	75

[1]Erosion hazard becomes critical if maximum slopes are exceeded.

Drainage Patterns -All existing drainage swales and patterns on the site shall be located. Perennial or intermittent streams and wetlands shall be shown on the map.

One of the most important steps when analyzing existing site conditions is to understand the site's existing drainage patterns. The designer must determine: where concentrated and sheet flows will enter the site; how runoff, both concentrated and sheet flow, will travel across the site; where runoff will leave the site and whether it will be concentrated or sheet flow; and how much runoff will be generated. The designer shall delineate and measure the drainage boundaries of each drainage way through the site. If the drainage area is greater than 5 ac., it is recommended to subdivide it into smaller units because most BMPs discussed in this manual have a 5-ac. or less maximum drainage area.

Where possible, natural drainage ways shall be incorporated into the proposed site plan and protected in order to convey runoff through and off the site to minimize additional costs of constructing artificial drainage systems. Man-made ditches and waterways can become part of the erosion problem if they are not properly designed and constructed.

Soils - Major soil type(s) on the site should be determined and shown on the topographic map. Soils information can be obtained from a soil survey. Soil properties such as permeability, shrink-swell potential, texture, and erodibility should exert a strong influence on land development decisions. Highly erodible soils should be left undisturbed. If they must be disturbed, they shall be re-vegetated and mulched as soon as possible after grading is completed and exposed no longer than 14 days if the areas of the project are not being worked. If a soils report or survey gives particle size distribution, check what percent of the soil is composed of fine particles (typically 0.02 millimeter (mm.) or smaller). If a high percentage of the soil is smaller than 0.02 mm., much of the suspended sediment of this size will escape capture unless a sediment basin is constructed that takes holding times for the small particles into account. In some instances, chemically enhanced sand filtration may be necessary to filter out clay and silt particles.

In addition, areas with high infiltration potential should also be noted. Post-construction and construction site BMPs may be located in these areas to maximize infiltration of post-construction runoff volumes.

Ground Cover -The existing vegetation such as tree clusters, grassy areas, and unique and native vegetation should be shown on the map and protected during construction as required. In addition, existing denuded or exposed soil areas should be indicated. Preservation to the greatest extent possible of existing vegetated areas on the site is the single most effective form of erosion prevention. If the existing vegetation cannot be preserved, the designer should consider staging or phasing construction and using temporary seeding, temporary mulching or other temporary ground cover to minimize exposure of disturbed soil areas during the site development process.

Adjacent Areas -Off-site features such as streams, lakes, buildings, roads, etc. are particularly sensitive to erosion and sediment damage. These off site adjacent areas shall be accounted for during delineation of projected drainage areas to ensure the temporary controls are properly sized to protect these areas. An analysis of adjacent properties shall include both areas downslope and upslope from the project site. Concern for upslope of the project site should focus on the potential for concentrated runoff to enter the site (also known as run-on) and increase the potential for erosion. This also potentially increases the volume of runoff that needs to be managed and accounted for when sizing the controls. Upslope areas should be routed around the site whenever possible through the use of diversion dikes, bypasses and swales. If diversion is not possible, additional consideration will need to be given to prevent additional erosion from occurring due to the upslope areas passing through the site. Additionally, the design of any sediment trapping facilities will need to include the drainage area of the upslope areas to account for the additional volume of runoff and sediment that could be generated.

The potential for sediment pollution of watercourses downstream of the site should be considered as well as the potential for downstream channel erosion due to increased volume, velocity, and peak flow rate of stormwater runoff from the site. The potential for sediment deposition on adjacent properties due to sheet and rill erosion should also be analyzed so that appropriate sediment trapping measures can be planned and installed prior to any land disturbing activity.

9.3.2 Step 2: Assess Post-Project Site Conditions

After analyzing the existing conditions data and determining the site limitations, the designer can develop and design an appropriate site-specific plan. When designing the site plan, keep in mind that increases in runoff may require structural control measures or channel improvements. The SWPPP designer shall, minimize the increase in runoff or include runoff control measures in the initial design that minimize concentrating flow, promote sheet flow, divert non-project site flow from entering the project site. When feasible and where practical, incorporate erosion prevention BMPs as a first choice. In addition, the designer shall consider the following points when developing the site plan:

1. **Fit the development to the terrain -**The development of an area should be tailored to the existing site conditions. This will avoid unnecessary land disturbance, thereby minimizing erosion hazards. Where practical, soil should be balanced on the site to minimize cut and fill operations. Post-project slopes should be at a maximum of 2:1 to provide for final stabilization.

2. **Confine construction activities to the least critical areas -**Any land disturbance in the critically

erodible areas will necessitate the installation of more extensive control measures, require more frequent inspections, and possibly increased maintenance efforts.

3. **Cluster buildings together -**This minimizes the amount of disturbed area and therefore the potential for erosion as well as concentrates utility lines and connections in one area, and provides more open natural space.

4. **Minimize impervious areas -**Keep paved areas such as parking lots and roads to a minimum. This goes hand in hand with cluster development in eliminating the need for duplicating parking areas, access roads, etc. The more land that is kept in vegetative cover, the more water will infiltrate, thus reducing runoff and erosion.

5. **Utilize the natural drainage system -**If the natural drainage system of a site can be preserved instead of being replaced with storm sewers or man-made channels, the potential for downstream damages due to increased runoff can be minimized. Where feasible promote sheet flow drainage and minimize concentrating stormwater flows.

6. **Calculate runoff -**Runoff calculations must be done to determine the effect of the development on the existing hydrologic system. After the calculations have been done, make the necessary changes, and modifications to achieve compliance with the runoff requirements.

Once the majority of the site plan has been established, the proposed post-project conditions should be analyzed to assist in the selection of BMPs. The following post-project information shall be collected:

Topography -A small scale topographic map of the site showing post-project conditions should be prepared to show the proposed contours with elevations referenced to NAVD 88. Contours should be at intervals from 1 to 5 ft. to determine the slope of the proposed terrain.

Slopes of high and severe erosion potential as noted in Table 9-1 should be avoided in post-project grading plans. Look for areas where flow may be concentrated after the project is complete and provide energy dissipation measures to reduce erosion potential. Design of energy dissipation is discussed in Chapter 7 of the Omaha Regional Stormwater Design Manual.

Drainage Patterns – All proposed drainage swales and patterns on the site should be identified. Perennial or intermittent streams and wetlands should be shown on the map. Should proposed grading alter natural drainage boundaries, the designer shall map the drainage area boundaries that will exist after grading is complete. Designers should determine: where concentrated and sheet flows will enter the site; how runoff, both concentrated and sheet flow, will travel across the post-project site; where runoff will leave the site and whether it will be concentrated or sheet flow; and how much runoff will be generated after the project has been completed. Care should be taken to ensure that the increased runoff from the site will not erode or flood the existing natural drainage system. Possible sites for stormwater detention should be located at this time.

Where possible, natural drainage ways should be incorporated into the proposed site plan and protected in order to convey runoff through and off the site to minimize additional costs of constructing artificial drainage systems. Man-made ditches and waterways can become part of the erosion problem if they are not properly designed and constructed.

Soils – If a large amount of excavation is required for the project, soil properties at the finished grade may be different than those at the existing grade and should be evaluated for erosion potential.

Ground Cover – Post-project ground cover should be selected to minimize erosive forces and meet City landscaping codes and policies.

Adjacent Areas – If concentrated run-on is a concern under existing conditions, it may also be a concern under post-project conditions. Concentrated runoff should be conveyed through the site in such as way as to minimize erosion or routed around the site whenever possible through the use of diversion dikes, bypasses and swales.

9.3.3 Step 3: Identify Major Construction Activities

Once the existing and post-project conditions of the site have been identified and catalogued, the designer can begin to identify the major activities required during development. Identifying the major activities before selecting the appropriate BMPs is important because one BMP may be used at a specific location at the site during one activity (e.g. grading) while another BMP at the same location is more appropriate during a different activity (e.g. construction of buildings). Construction activities are specific to each project, however, some activities may include:

- Site Clearing and Grubbing
- Site Grading
- Construction of stormwater conveyance components
- Construction of streets, alleys, and other infrastructure
- Construction of buildings and parking areas
- Landscaping

Along with identifying the major activities, designers should also consider the duration of each activity. Temporary stabilization should be considered on areas of the site that are not impacted by on-going activities.

9.3.4 Step 4: Select Erosion and Sediment Control BMPs

Once Steps 1 through 3 have been completed, erosion and sediment control BMPs should be selected for implementation. The designer must select BMPs which will address all sedimentation and erosion prevention throughout the entire development process. First, measures must be considered to prevent erosion from occuring on a site. If erosion cannot be prevented then BMPs to control the resulting sedimentation should be installed. Finally, the overall site features should be evaluated for good housekeeping BMPs. When selecting BMPs apply the principles of erosion and sediment control as outlined in Section 9.2.4 and design and construction guidelines provided in Section 9.5 and Section 9.6.

9.3.4.1 Erosion Prevention BMPs

Erosion prevention shall be the primary line of defense in reducing the transport of sediment. Erosion prevention involves minimizing, to the maximum extent practical, runoff from interacting with disturbed or exposed soil. This can be accomplished by preserving existing vegetation, routing runoff from areas outside of the disturbed area around the site using diversion ditches or other methods, or forcing runoff to remain in a sheet flow condition without allowing the runoff to concentrate. BMPs that prevent erosion are listed in

Table 9-2. Table 9-2 can be used to help select erosion prevention BMPs for protection of exposed site features such as slopes and streambanks. In addition, erosion prevention BMPs are also used to control stormwater run-on. Refer to the appropriate section listed in Table 9-2 for design criteria and construction guidelines for each BMP.

Table 9-2 Erosion Prevention BMP Selection Matrix

Erosion Prevention BMP	Section	Protection for Slopes 0-7%	Protection for Slopes 7-15%	Protection for Slopes >15%	Controlling Run-On	Protection for Streambanks/ Channels
Diversion dikes	9.5.7				×	×
Temporary fill diversions	9.5.8				×	
Level spreader	9.5.10				×	×
Temporary slope drain	9.5.11	×	×	×	×	
Vegetative stream bank stabilization	9.5.17					×
Temporary seeding	9.5.19	×				
Permanent seeding	9.5.20	×				
Sodding	9.5.21	×	×	□		
Mulching	9.5.22	×	×	□		□
Soil stabilization blankets and matting	9.5.23	×	×	×		×
Preservation of natural vegetation	9.5.24	×	×	×	×	×
Compost blanket	9.5.28	×				
Live fascine rolls	9.5.30	×	□	□		×
Soil binders	9.5.32	×				

x = Designates where BMP is appropriate for use.
□ = Designates where BMP may be applied with careful consideration of design criteria.

Select erosion prevention BMPs can also be used as velocity dissipation devices along the length of outfall channels to provide non-erosive flow velocities. Erosion prevention BMPs referenced in this Chapter that may work well for this purpose include vegetative stream bank stabilization (Section 9.5.17), live fascine rolls (Section 9.5.30), and soil stabilization blankets and matting (Section 9.5.23).

Refer to Chapter 7: Energy Dissipators to select and size velocity dissipation devices at discharge locations from a structure to a water course. Velocity dissipators discussed in Chapter 7 include riprap apron, riprap basin, and impact basin.

9.3.4.2 Sediment Control BMPs

Sediment control shall be used to prevent sediment from leaving the site during development. Sediment control is used when the displacement of soil material is unavoidable, and capture is necessary. BMPs that provide sediment control are listed in Table 9-3. Table 9-3 can be used to help select sediment control BMPs based on slope length, drainage area, or site activity. Refer to the appropriate section listed in Table 9-3 for design criteria and construction guidelines for each BMP.

Table 9-3 Sediment Control Selection Matrix

Sediment Control BMP	Section	Slope Length		Drainage Area		Site Activity	
		< 100 ft	> 100 ft	< 5 acres	> 5 acres	Construction Traffic	Enhance Settling
Stabilized construction entrance	9.5.2					×	
Construction road stabilization	9.5.3					×	
Silt fence	9.5.4	×					
Storm drain inlet protection	9.5.5			×			
Culvert inlet protection	9.5.6			×			
Check dam	9.5.9		×	×			
Temporary vehicular crossing	9.5.12					×	
Turbidity curtain	9.5.13			×	×		
Temporary sediment trap	9.5.14		×	×			×
Temporary sediment basin	9.5.15		×	×	×		×
Wattle	9.5.25	×		×			
Compost sock	9.5.26	×		×			
Compost berm	9.5.27	×		×			
Wheel wash	9.5.29					×	
Chemically enhanced sand filtration	9.5.31						×

x = Designates where BMP is appropriate for use.

9.3.5 Step 5: Select Good Housekeeping BMPs

Good housekeeping BMPs are intended to work in conjunction with erosion and sediment control BMPs to reduce the discharge of construction material waste and other pollutants from the construction site. The good housekeeping BMPs that are discussed in Section 9.6 include:

- Construction Scheduling and Sequencing (Section 9.6.1),
- Sanitary Waste Management (Section 9.6.2),
- Solid Waste Management (Section 9.6.3),
- Material Delivery and Storage (Section 9.6.4),
- Street Cleaning / Sweeping (Section 9.6.5),
- Vehicle and Equipment Fueling (Section 9.6.6),
- SWPPP Notification Sign (Section 9.6.7), and
- Concrete Washout (Section 9.6.8).

9.3.6 BMP Selection Considerations

Each of the BMP categories described may be implemented in different areas of a development site during different activities of site development. For example, erosion prevention diversion dikes could be used to route off-site runoff around a disturbed area in one portion of the site and temporary seeding could be used to minimize the amount of time disturbed soil is exposed to erosive forces in another area, while a temporary sediment basin could be used to capture sediment laden runoff from both areas.

The designer shall view the three BMP types as a continuum and recognize that the highest levels of control will be accomplished when all methods are used in series or parallel depending on site conditions and current construction activity. Additional considerations for BMP selection include:

1. **Acceptance -**Look at environmental compatibility, institutional acceptance and visual impact.
2. **Cost -**Consider material cost, add-ons, installation, and inspection costs.
3. **Effectiveness -**Compare effectiveness of different BMPs. Use manufacturer specifications and design recommendations to compare engineering properties.
4. **Site Design** – Design considerations shall include temporary BMP orientation, location and temporary BMP restoration guidance. Temporary BMP designs should also include appropriate sampling/monitoring access locations as required.
5. **Installation -**Consider ease of installation and durability once installed. Designers should also gain recommendations from the contractor to determine the best phasing for installation.
6. **Vegetation -**Consider compatibility of BMP to foster vegetation.
7. **Public Safety** – Consider public safety and use safety fences (Section 9.5.1) around appropriate measures.
8. **Inspection, Operations and Maintenance -**Consider inspection and maintenance requirements for the various BMPs, proper ingress and egress for performing maintenance, and any irrigation or fertility requirements necessary for vegetation.

9.3.7 BMPs for Sites Less Than One Ac. and Part of a Larger Common Plan of Development

Development sites that are less than one ac. and part of a larger common plan of development, such as single family residential sites, are required to implement and maintain lot-level controls. Typically the BMP for a single residential lot includes an aggregate construction entrance, sediment control in the form of silt fence at the location where water leaves the site, and a topsoil stockpile upstream of sediment control measures. Sediment controls should also be implemented to protect adjacent waterways and storm drains.

Good housekeeping measures appropriate for single-lot construction include:

- Clean up any sediment tracked off the construction site in a thorough and timely manner.
- Dispose of construction waste in a dumpster or containment device.
- Stake portable toilet and anchor away from storm drain inlets.

9.4 Storm Water Pollution Prevention Plan

Simply stated, a SWPPP contains documents describing the potential for construction project pollutants to enter waterways. The SWPPP also explains and illustrates the measures which are to be taken to control those pollutants. Storm Water Pollution Prevention Planning should begin early as part of the site planning process, not as an afterthought. Minimizing the potential for soil erosion during construction and siting of post-construction BMPs should be a significant consideration when deciding upon the layout of buildings, parking lots, roads and other facilities. Costly pollutant, erosion, and sediment control measures can be minimized if the site design can be adapted to existing site conditions and good conservation principles are used.

9.4.1 SWPPP General Guidelines

The SWPPP has a written portion known as the SWPPP-Narrative (SWPPP-N) and an illustrative portion, which is the SWPPP-Site Map (SWPPP-SM). The Narrative is a written report which explains the pollutant, erosion, and sediment control decisions made for a particular project and the justification for those decisions. The Narrative is especially important to the City's review staff because it contains concise information concerning existing site conditions, construction schedules, and other pertinent items which are not apparent in a typical site plan. The Narrative is also important to the construction superintendent and inspectors who are responsible for seeing that the plan is implemented properly. It provides them with a single report which describes where and when the various pollutant, erosion, and sediment control practices should be installed.

The Site Map is an illustrative map that graphically depicts topographic and design information related to construction site pollution prevention activities. The Site Map can be an independent entity from the working or construction drawings of the project or included as part of the construction documents. The Site Map is important to review staff, inspectors and contractors because it shows the location of erosion prevention and sediment control measures and includes maintenance schedules and phasing information all on one document.

A SWPPP Narrative and Site Map must contain sufficient information to satisfy the City that the issues and challenges associated with erosion and sedimentation have been adequately addressed for a proposed project. The length and complexity of the SWPPP should be commensurate with the size and capacity of the project, the severity of the site conditions, and the potential for off-site issues or concerns. Obviously, a SWPPP for constructing a house on a single subdivision lot does not need to be as complex as a SWPPP for a shopping center development. Also, SWPPPs for projects undertaken on flat terrain will generally be less complicated than plans for projects constructed on steeper slopes where erosion potential is greater. The greatest level of planning and detail should be evident in SWPPPs for projects which are directly adjacent to flowing streams, dense population centers, or high value properties where damage may be particularly costly or detrimental to the environment.

The primary guidelines for determining the information to include in the SWPPP Narrative are found in the PCWP Storm Water Pollution Prevention Plan Narrative which is located on the City's stormwater website at http://omahastormwater.org/forms. Guidelines to determine the information to include in the SWPPP Site Map are in the PCWP SWPPP – Site Map Preparation Guide which is also located on the City's website. Each of the minimum standards for the Site Map must be satisfied to meet requirements of the PCWP permit.

Section 9.5 of this manual contains minimum design criteria for erosion and sediment control BMPs. Wherever any of these practices are to be employed on a site, the specific title and number of the practice should be clearly marked and defined within the SWPPP. By referencing the manual properly, the SWPPP designer can minimize the need for lengthy descriptions of the practices in the SWPPP. Designers are urged to use the standard numbering and coding system for BMPs contained in this manual. Use of this coding system will result in increased uniformity of SWPPPs and thus increase their readability to SWPPP reviewers, job superintendents, and inspectors. Section 9.5 of this manual also contains a BMP matrix which lists each erosion and sediment control BMP with a description and chapter to reference for design guidance.

The owner of the land being developed has the responsibility for SWPPP preparation and submission. The owner may designate someone to prepare the SWPPP; however, the owner retains the ultimate responsibility. In addition, the SWPPP is intended to be a dynamic document and shall evolve with the project. The temporary controls shall reflect the evolution of the project from the initial phase of the project to final stabilization. The SWPPP is also considered to be an auditable document by the United States Environmental Protection Agency (US EPA) and shall be revised and kept up-to-date throughout the course of the project.

9.4.2 SWPPP Usage

The SWPPP documents, both Site Map and Narrative, are living auditable documents and should be updated as changes are made as to how stormwater pollution at the construction site is managed. Changes in design, construction, operation, or maintenance at the construction site that has or could have a significant effect on the discharge of pollutants to waters of the state constitute an amendment to the corresponding SWPPP documents.

Inspection results including a delay in the replacement or maintenance of non-functional BMPs should also be documented in the SWPPP along with details to explain the cause of the delay. If it is determined during inspection that the SWPPP is ineffective, it must be updated to include additional or modified BMPs that meet the objectives of the PCWP permit. Revisions to the SWPPP must be completed within the timeframe outlined in the permit. Implementation of the SWPPP revisions must also be accomplished according to permit deadlines.

SWPPP documents must be available at the construction site or other location easily accessible during normal business hrs. Information as to where the SWPPP is located and who to contact for viewing must be posted at an accessible location at the construction site.

9.5 Erosion and Sediment Control BMPs

Section 9.5 provides design criteria and construction guidelines for the BMPs noted in Section 9.3. These guidelines will set the minimum requirements for BMPs used in the SWPPP. Use of the BMP guidelines in conjunction with the minimum standards outlined in Section 9.4 will allow the designer of the Site Map greater flexibility in selection of BMPs, while complying with the requirements necessary for approval of a SWPPP.

The following Table 9-4 provides a summary of the BMPs included in Section 9.5 and symbols for use in noting application of the practices on the SWPPP Site Map.

Table 9-4 Erosion and Sediment Control BMP Matrix

Benefit Codes:

A - Access Prevention
B - Perimeter Control
C - Slope Protection
D - Sediment Trapping
E - Drainage and Streambank Protection
F - Temporary Stabilization
G - Permanent Stabilization
H - Stormwater Management

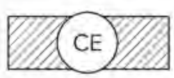
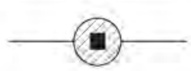
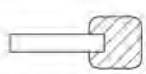
Section	Title	Symbol	Description	Benefits
9.5.1	Safety Fence	SAF—SAF—SAF	A protective barrier installed to prevent access to an erosion prevention measure.	A
9.5.2	Construction Entrance		A stabilized aggregate pad with a filter fabric underliner located at any point where vehicular traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area.	B,F
9.5.3	Construction Road Stabilization		The temporary stabilization of access roads, subdivision roads, parking areas and other on-site vehicle transportation routes with aggregate immediately after grading.	F
9.5.4	Silt Fence	SF——SF——SF	A temporary sediment barrier consisting of synthetic filter fabric stretched across and attached to supporting posts and entrenched.	B, D, E
9.5.5	Storm Drain Inlet Protection		A sediment filter or an excavated impounding area around a storm drain drop inlet or curb inlet.	D
9.5.6	Culvert Inlet Protection		A sediment filter located at the inlet to storm sewer culverts.	D
9.5.7	Temporary Diversion Dike		A temporary ridge of compacted soil constructed at the top or base of a sloping disturbed area.	B, C
9.5.8	Temporary Fill Diversion		A channel with a supporting ridge of soil on the lower side, constructed along the top of an active earth fill.	C

Table 9-4 Erosion and Sediment Control BMP Matrix (Continued)

Benefit Codes:

A - Access Prevention
B - Perimeter Control
C - Slope Protection
D - Sediment Trapping
E - Drainage and Streambank Protection
F - Temporary Stabilization
G - Permanent Stabilization
H - Stormwater Management

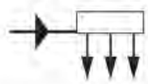
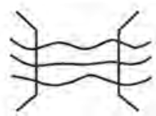
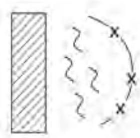
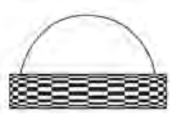
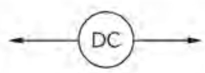
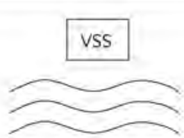
Section	Title	Symbol	Description	Benefits
9.5.9	Check Dams		Small temporary aggregate dams constructed across a swale or drainage ditch.	E, F
9.5.10	Level Spreader		An outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.	B, F
9.5.11	Temporary Slope Drain		A flexible tubing or conduit extending from the top to the bottom of a cut or fill slope.	C, F
9.5.12	Temporary Vehicular Stream Crossing		A temporary structural span installed across a flowing watercourse for use by construction traffic. Structures may include bridges, round pipes, pipe arches, or oval pipes.	E
9.5.13	Turbidity Curtain		A floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water.	B
9.5.14	Temporary Sediment Trap		A temporary ponding area formed by constructing an earthen embankment with an aggregate outlet.	B, D, H
9.5.15	Temporary Sediment Basin		A temporary barrier or dam with a controlled stormwater release structure formed by constructing an embankment of compacted soil across a drainageway.	B, D, H
9.5.16	Dust Control		Reducing surface and air movement of dust during land disturbing, demolition and construction activities.	F
9.5.17	Vegetative Stream Bank Stabilization		The use of vegetation in stabilizing streambanks.	E, G

Table 9-4 Erosion and Sediment Control BMP Matrix (Continued)

Benefit Codes:

A - Access Prevention
B - Perimeter Control
C - Slope Protection
D - Sediment Trapping
E - Drainage and Streambank Protection
F - Temporary Stabilization
G - Permanent Stabilization
H - Stormwater Management

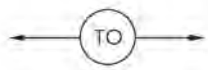
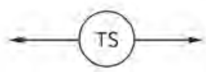
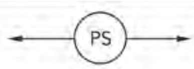
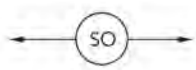
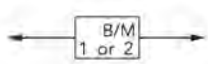
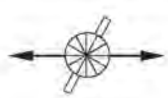
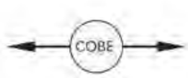
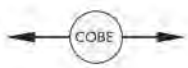
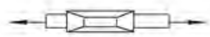
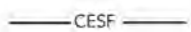
Section	Title	Symbol	Description	Benefits
9.5.18	Topsoiling		Methods of preserving and using the surface layer of undisturbed soil often enriched in organic matter, in order to obtain a more desirable planting and growth medium. Purpose: To provide a suitable growth medium for final site stabilization with vegetation.	G
9.5.19	Temporary Seeding		The establishment of temporary vegetative cover on disturbed areas by seeding with appropriate rapidly growing annual plants.	F
9.5.20	Permanent Seeding		The establishment of perennial cover on disturbed areas by planting seed.	G
9.5.21	Sodding		Stabilizing fine-graded disturbed areas by establishing permanent grass stands with sod.	C, D, E, G
9.5.22	Mulching		Application of plant residues or other suitable materials to the soil surface.	F
9.5.23	Soil Stabilization Blankets and Matting		The installation of a protective covering (blanket) or a soil stabilization mat on a prepared planting area of a steep slope, channel or shoreline.	F, G
9.5.24	Preserving Natural Vegetation		The practice of identifying and preserving well-established existing vegetation by prohibiting land disturbing activity.	G, H
9.5.25	Wattle		Tube-shaped erosion prevention devices filled with straw, flax, rice, coconut fiber, or compost material that help slow, filter, and spread overland flows to reduce erosion and minimize rill and gully development.	D
9.5.26	Compost Sock		A mesh tube filled with composted material which is placed perpendicular to sheet flow runoff to prevent erosion and retain sediment in disturbed areas.	D
9.5.27	Compost Berm		A dike composed of compost. The compost berm is trapezoidal in cross section and placed perpendicular to sheet flow runoff to prevent erosion and retain sediment in disturbed areas.	D

Table 9-4 Erosion and Sediment Control BMP Matrix (Continued)

Benefit Codes:

A - Access Prevention
B - Perimeter Control
C - Slope Protection
D - Sediment Trapping
E - Drainage and Streambank Protection
F - Temporary Stabilization
G - Permanent Stabilization
H - Stormwater Management

Section	Title	Symbol	Description	Benefits
9.5.28	Compost Blanket		A layer of loosely applied compost or composted material placed on disturbed areas to prevent erosion and retain sediment.	C, F
9.5.29	Wheel Wash Area		Designated area to wash wheels to prevent the transfer of mud, dust or contaminants from leaving the construction site.	B, D
9.5.30	Live Fascine Rolls		Bound, cylindrical shaped rolls of live branch cuttings which are placed into shallow trenches along a streambank to provide slope stability or prevent erosion.	C, D, E
9.5.31	Chemically Enhanced Sand Filtration		Uses a chemical additive to promote settling of clay and silt particles along with a sand filtration system.	D
9.5.32	Soil Binders		Emulsion materials applied to exposed surfaces to stabilize soil particles.	C, F

9.5.1 Safety Fence

Symbol:

SAF—SAF—SAF

BMP Guideline

Definition: A protective barrier installed to prevent access to an erosion prevention measure.

Purpose: To prohibit the undesirable use of an erosion prevention measure by the public.

Conditions Where Practice Applies:

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

Design Criteria:

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

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

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

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

5. Plastic fence may be used as safety fencing primarily in situations where the need is for a temporary barrier. Plastic fence shall meet the following requirements:

Physical Property	Test	Requirements
Color	N/A	International Orange
Tensile yield	ASTM D638	Avg. 2000 lbs. Per 4-ft. width
Ultimate tensile strength	ASTM D638	Avg. 2900 lbs. Per 4-ft. width
Elongation at break	ASTM D638	Greater than 1000%.

6. Metal fence should be used when a potentially dangerous control measure will remain permanently, such as a stormwater detention basin. However, it may also be used for measures which only serve a temporary function, at the discretion of those responsible for project safety. Metal fence shall meet the material requirements of the City of Omaha Department of Public Works Standard Specifications.

Construction Guidelines:

Safety fences must be installed prior to the erosion and sediment control measure becoming accessible.

The web of the plastic fence shall be secured to a conventional metal “T” or “U” post driven into the ground to a minimum depth of 18 in.; posts should be spaced on 6 ft. centers.

Metal fence shall be installed as required by City of Omaha Department of Public Works Standard Specifications.

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

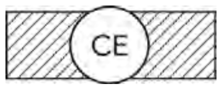
Inspection and Maintenance:

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

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

9.5.2 Construction Entrance

Symbol:



BMP Guideline

Definition: A construction entrance consists of a stabilized aggregate pad with a filter fabric underliner located at any point where vehicular traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area.

Purpose: The purpose of a construction entrance is to reduce or eliminate the tracking of sediment onto public rights-of-way or streets.

Conditions Where Practice Applies:

A stabilized construction entrance is required any place traffic will be leaving a construction site and move directly onto a public road or other paved area.

Design Criteria: (Figure 9-3)

1. Road material should consist of 2-in. aggregate or a reclaimed or recycled concrete equivalent. Aggregate depth shall be not less than 6 in. for light duty entrances and 12 in. for heavy duty entrances. Other materials which can be used to create a construction entrance include articulated blocks, mats and steel plates, with prior approval from the City.

2. The entrance should be a 12-ft. minimum width and must extend the full width of the vehicular ingress and egress area. Increase to a 24-ft. minimum width if there is only one access to the site. The length shall be a minimum of 70 ft.

3. If conditions on the site are such that the majority of the mud is not removed by the vehicles traveling over the construction entrance, then the tires of the vehicles must be washed before entering the public road. Refer to Section 9.5.29 Wheel Wash Area if washing of tires is required by the City.

4. Filter fabric should be placed on the entire area to be covered with aggregate. The filter fabric shall be woven or non-woven fabric, inert to commonly encountered chemicals, hydro-carbons, mildew, rot-resistant, and conform to the following fabric properties as listed in Table 9-5.

Table 9-5 Fabric Properties for Construction Entrances

Fabric Properties[1]	Light Duty Entrance	Heavy Duty Entrance	Test Method
Grab tensile strength (lbs.)	180	250	ASTM D4632
Elongation @ Failure (%)	50	60	ASTM D4632
Mullen Burst Strength (psi)	250	380	ASTM D3786
Puncture Strength (lbs.)	90	125	ASTM D4833
Apparent Opening Size (mm)	0.20	0.20	ASTM D4751

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

Construction Guidelines:

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

2. Following the installation of the filter cloth, the aggregate shall be placed to the specified dimensions. If a wheel wash area is deemed necessary refer to Section 9.5.29 for construction guidelines.

3. All surface water flowing or diverted towards construction entrances shall be piped across the entrance. If piping is impractical, a mountable berm with 5:1 slopes will be permitted.

Inspection and Maintenance:

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

2. Inspect roads adjacent to site daily. Remove sediment deposits from streets within 24 hrs.

3. Inspect construction entrance for any sediments and aggregates which could be transferred to local roads, weekly during rainy periods and at two-week intervals during dry periods.

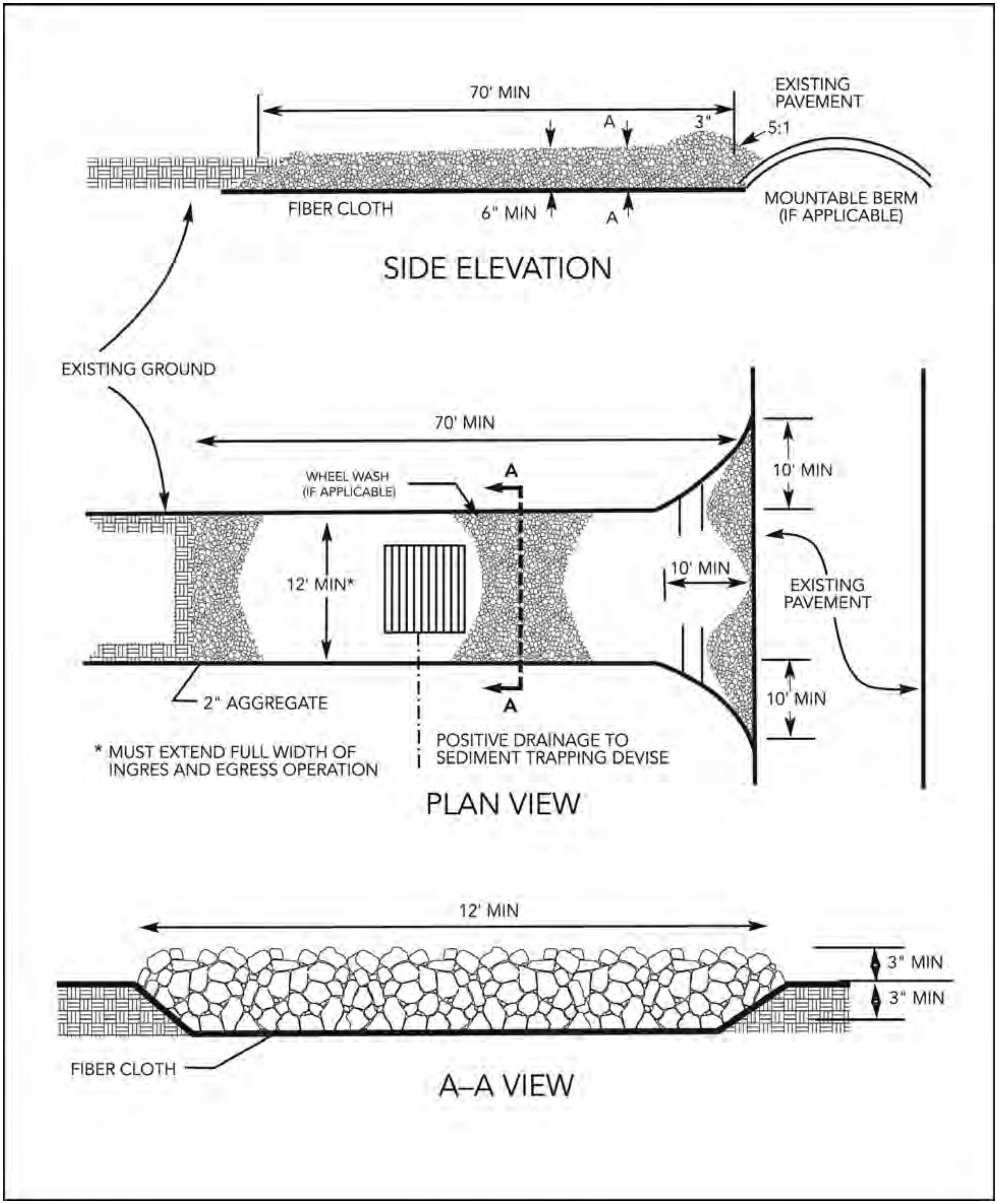
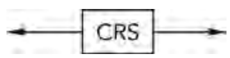


Figure 9-3 Aggregate Construction Entrance

9.5.3 Construction Road Stabilization

Symbol:



BMP Guideline

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

Purpose: To reduce the erosion of temporary roadbeds by construction traffic during wet weather, and to reduce the erosion and subsequent regrading of permanent roadbeds between the time of initial grading and final stabilization.

Conditions Where Practice Applies:

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

Construction Guidelines:

1. Clear and strip roadbed and parking areas of all vegetation, roots, and other objectionable materials.
2. Temporary roads shall follow the contour of the natural terrain to the extent possible. Slopes shall not exceed 10 percent.
3. Temporary parking areas shall be located on naturally flat areas to minimize grading. Grades shall be sufficient to provide drainage but should not exceed 4 percent.
4. Provide surface drainage and divert excess runoff to stabilized areas.
5. Maintain cut and fill slopes to 2:1 or flatter and stabilize with vegetation as soon as grading is accomplished.
6. Roadbeds shall be a minimum of 14 ft. wide for one-way traffic and a minimum of 24 ft. wide for two-way traffic.
7. Drainage ditches shall be provided as needed.
8. A 6-in. course of crushed rock for base course, conforming to the requirement of City of Omaha Standard Specifications, shall be applied immediately after grading or the completion of utility installation within the right-of-way. Filter fabric may be applied to the roadbed for additional stability. Design criteria for filter fabric can be found in Section 9.5.2 Construction Entrance. In heavy duty traffic situations, aggregate should be placed at an 8- to 10-in. depth to avoid excessive dissipation or maintenance needs.
9. Provide appropriate sediment control measures to prevent off-site sedimentation.

Inspection and Maintenance:

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

9.5.4 Silt Fence

Symbol:

SF——SF——SF

BMP Guideline

Definition: A silt fence is an entrenched, temporary sediment barrier consisting of synthetic filter fabric stretched across and attached to supporting posts. A silt fence may have wood or steel posts and may be supported by additional wire fencing.

Purpose: The purpose of a silt fence is to decrease the velocity of sheet flows and intercept and detain small amounts of sediment from disturbed areas in order to prevent sediment from leaving a construction site.

Conditions Where Practice Applies:

1. Below disturbed areas subject to sheet and rill erosion.
2. Where the size of the drainage area is no greater than one-fourth of an ac. per 100 ft. of silt fence length, the maximum slope length behind the barrier is 100 ft., and the maximum slope gradient behind the barrier is 50 percent (2:1). Multiple lines of silt fence spaced 100 ft. apart may be used.
3. In areas where rock or other hard surface would not prevent the full and uniform depth anchoring of the barrier.
4. Silt fences shall not be used as ditch checks. Refer to Section 9.5.25 Wattle and Section 9.5.9 Check Dams.
5. Areas where standing water created by the silt fence will not cause a problem.

Construction Guidelines:

Table 9-6 Temporary Silt Fence Property Requirements

Property	Test Methods	Supported Silt Fence[1]	Unsupported Silt Fence	
			Geotextile Elongation >=50%[2]	Geotextile Elongation <50%[2]
Maximum Post Spacing	-	1.2 m or 4 ft	1.2 m or 4 ft	2 m or 6.5 ft
Grab Strength	ASTM D 4632			
Machine Direction		400 N or 90 lb	550 N or 125 lb	
X-Machine Direction		400 N or 90 lb	450 N or 100 lb	
Permittivity	ASTM D 4491	0.05 sec^{-1}	0.05 sec^{-1}	
Apparent Opening Size	ASTM D 4751	0.60 mm max or US sieve #30	0.60 mm max or US sieve #30	
Ultraviolet Stability (retained strength)	ASTM D 4355	70% after 500 hours of exposure	70% after 500 hours of exposure	

Notes:
[1]Silt fence support shall consist of 14-gauge steel wire with a mesh spacing of 150 mm by 150 mm or prefabricated mesh of equivalent strength.

[2]As measured per ASTM D 4632.

1. Synthetic filter fabric shall conform to the property requirements found in Table 9-6.:
2. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0 – 120° Fahrenheit.
3. Wood or steel fence posts shall be a minimum length of 4 ft. Steel posts will be standard "T" or "U" posts weighing not less than 1.33 pounds per lineal ft..
4. Wire fencing support shall be at least 2.5 ft. high and minimum 14.5 gauge with a maximum 6 in. mesh opening.

Installation:

1. The height of a silt fence shall be a minimum of 24 in. above the original ground surface and shall not exceed 30 in. above ground elevation. Minimum embedment depth shall be 6 in. as shown in Figure 9-4 and Figure 9-5.
2. The filter fabric shall be used as a continuous roll cut to the length of barrier needed to minimize the use of joints.
3. Install the ends of silt fence runs with a gradual upslope to prevent end runs and loss of sediment.
4. Maximum post spacing shall be based on the fabric support. Supported silt fence shall have a maximum post spacing of 4 ft. Unsupported silt fence shall have a maximum post spacing of 6.5 ft.
5. Trench or Soil Slicing Construction
    a. Trench Construction: A trench shall be excavated approximately 4 in. wide and 6 in. deep on the upslope side of the silt fence. The bottom of the silt fence fabric shall be buried in a "J" configuration to the minimum depth of 6 in.. Backfill the trench and compact the soil so that the compacted soil completely fills the trench.
    b. Soil Slicing Construction: Soil slicing construction involves using a specialized machine to create a slit into the ground, inserting the fabric into the silt and compacting the slice closed. The filter fabric shall be inserted into the ground 8 to 12 in. deep so that no flow can pass under the fabric.
6. When joints are unavoidable, filter cloth shall be spliced together only at a support post, with a minimum overlap of at least two posts.
7. Place the posts at required spacing. Drive posts or place a minimum of 1.65 ft. into the ground. Minimum depth of 2 ft. is required on a slope of 3:1 or greater.
8. Steel "T" posts should be installed so that the flat portion (top of the "T") is against the fabric to extend the life of the fabric.
9. When wire support is used, the wire mesh must be fastened securely to the upslope side of the posts using heavy duty wire staples at least one in. long, tie wires, or hog rings. The wire shall extend from the ground surface to the height of the fabric. Fabric shall be stapled or wired to the wire support, and 6 in. of the fabric shall be extended into the trench. The fabric shall not be

stapled to existing trees.

10. When wire support is not used, the fabric must be fastened securely to the upslope side of the posts using heavy duty wire staples at least one in. long or tie wires. The fabric shall not be stapled to existing trees.

11. When installing silt fence on-site, compaction prior to installing posts is recommended. Compact the soil immediately next to the fabric starting with the upstream side first then the downstream side.

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

Inspection and Maintenance:

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

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

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

4. Sediment deposits must be removed when the level of deposition reaches approximately one-half the height of the barrier.

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

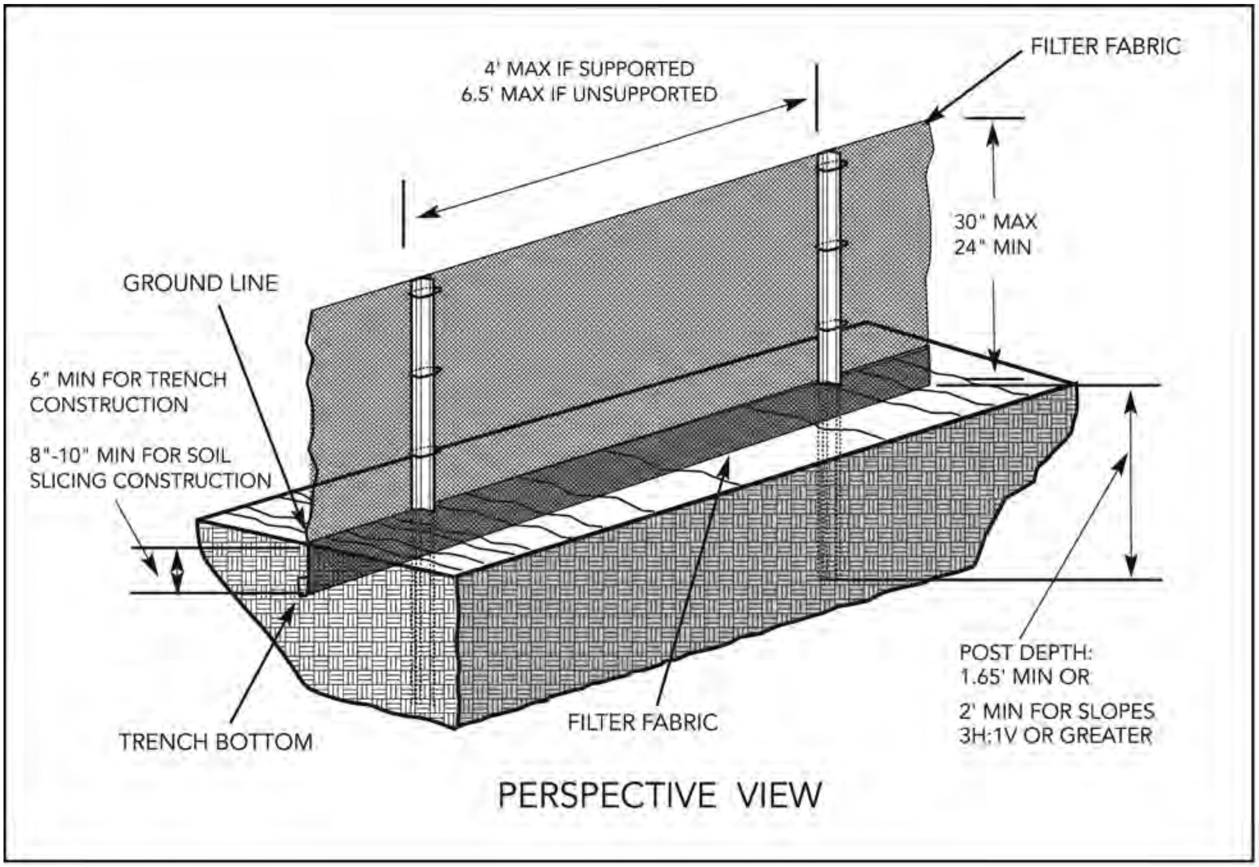


Figure 9-4 Silt Fence Installation

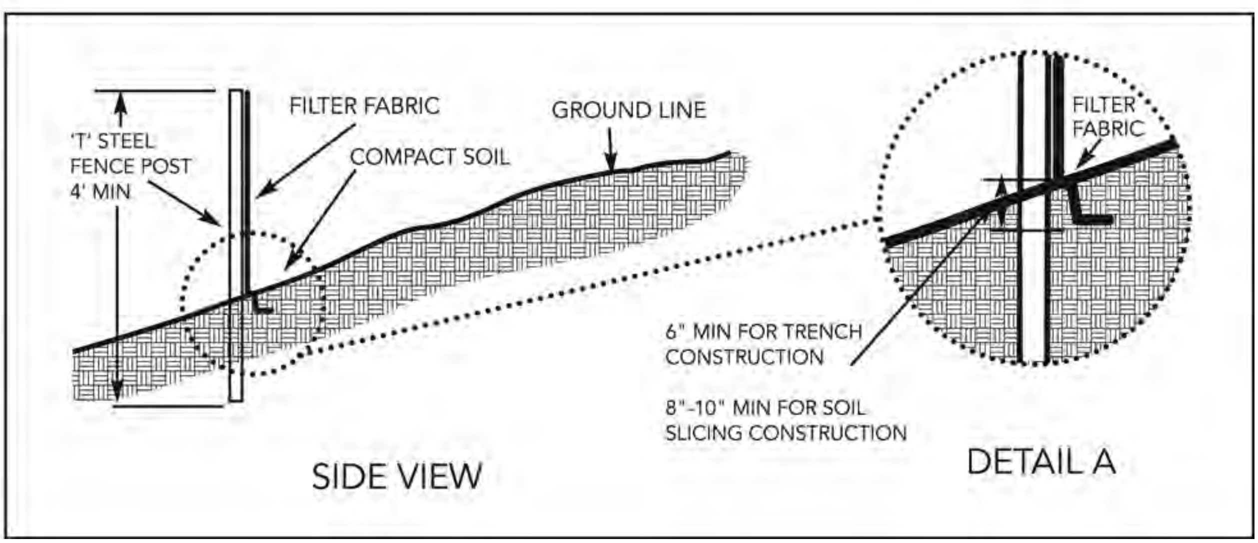
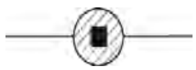


Figure 9-5 Typical Section of Silt Fence Installation

9.5.5 Storm Drain Inlet Protection

Symbol:



BMP Guideline

Definition: Storm drain inlet protection involves installing a sediment filter or an excavated impounding area around a storm drain drop inlet or curb inlet.

Purpose: The purpose of storm drain inlet protection is to prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

Conditions Where Practice Applies:

This practice shall be used where the drainage area to an inlet is disturbed, it is not possible to temporarily divert the storm drain outfall into a trapping device and watertight blocking of the inlets is not advisable. It is not to be used in place of sediment trapping devices. This may be used in conjunction with storm drain diversion to help prevent siltation of pipes installed with low slope angle. There are nine specific types of storm drain inlet protection practices that vary according to their function, location, drainage area and availability of materials:

1. Excavated Drop Inlet Sediment Trap
2. Silt Fence Drop Inlet Protection
3. Block and Aggregate Drop Inlet Sediment Filter
4. Block and Aggregate Curb Inlet Sediment Filter
5. Filter Sock Curb Inlet Sediment Filter

Design Criteria: (Figure 9-6, Figure 9-7, Figure 9-8, Figure 9-9 and Figure 9-10)

1. The drainage area shall be no greater than 1 ac.
2. The inlet protection device shall be constructed in a manner that will facilitate cleanout and disposal of trapped sediment and minimize interference with construction activities.
3. The inlet protection device shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.
4. Design criteria more specific to each particular inlet protection device will be found within this guideline.
5. For the inlet protection devices which utilize aggregate as the chief ponding/filtering medium, a range of aggregate sizes is offered; 0.75 in. to 1.5 in. clean aggregate can be used. The designer should attempt to get the greatest amount of filtering action possible (by using smaller size aggregate), while not creating significant ponding problems.
6. In all designs which utilize aggregate with a wire mesh support as a filtering mechanism, the aggregate can be completely wrapped with the wire mesh to improve stability and provide easier cleaning.

7. Filter fabric may be added to any of the devices which utilize coarse aggregate to significantly enhance sediment removal. The fabric, which must meet the physical requirements found in Section 9.5.4, Silt Fence, should be secured between the aggregate and the inlet (on wire mesh if present). As a result of the significant increase in filter efficiency provided by the fabric, a larger size of aggregate (1.5 in. to 2.5 in.), may be utilized with such a configuration. The larger aggregate will help keep larger sediment masses from clogging the fabric. Notably, significant ponding may occur at the inlet if the filter cloth is utilized in this manner.

Construction Guidelines:

1. Excavated Drop Inlet Sediment Trap

    a. The excavated trap shall be sized to provide a minimum storage capacity calculated at the rate of 900 cu. ft. per ac. of drainage area. The trap shall be no less than one ft. nor more than two ft. deep measured from the top of the inlet structure. Side slopes shall be no steeper than 2:1.

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

    c. Weep holes protected by fabric and aggregate shall be provided for draining the temporary pool.

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

2. Silt Fence Drop Inlet Protection

    a. Fabric shall conform to the construction guidelines found in Section 9.5.4, Silt Fence and shall be cut from a continuous roll to avoid joints.

    b. Stakes shall be 2 in. x 4 in. wood or equivalent metal with a minimum length of three ft. Stakes shall be spaced evenly around the perimeter of the inlet a maximum of three ft. apart and securely driven into the ground a minimum of 18 in. deep.

    c. To provide needed stability to the installation, frame with 2 in. x 4 in. wood strips around the crest of the overflow area at a maximum of 1.5 ft. above the drop inlet crest.

    d. Place the bottom 12 in. of the fabric in a trench and backfill the trench with 12 in. of compacted soil.

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

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

Remove sediment from the pool area as necessary or when it reaches half the height of the fabric, with care not to undercut or damage the fabric.

3. Block and Aggregate Drop Inlet Sediment Filter

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

    b. Wire mesh shall be placed over the outside vertical face of the concrete blocks and across top opening to prevent aggregate from being washed through the holes in the blocks. Wire mesh with 0.5 in. openings shall be used.

    c. Aggregate shall be piled against the wire to the top of the block barrier.

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

4. Block and Aggregate Curb Inlet Sediment Filter

    a. Two concrete blocks shall be placed on their sides abutting the curb at either side of the inlet opening. A 2 in. x 4 in. stud shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.

    b. Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks.

    c. Wire mesh with 0.5 in. openings shall be placed over the outside vertical face of the concrete blocks and extend across the top opening to prevent aggregate from being washed through the holes in the blocks or over the top of the blocks.

    d. Coarse aggregate shall be piled against the wire to the top of the barrier.

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

5. Filter Sock Curb Inlet Sediment Filter

    a. Filter socks or bags shall be fabricated from porous organic or synthetic filter fabric.

    b. Filter socks or bags shall be selected and sized appropriately for the inlet(s) to be protected.

    c. The fabricated filter socks or bags shall be filled with porous aggregate or synthetic media to effectively filter sediment without unduly “choking” or plugging the inlet(s) to be protected. Sock should not be filled with material which can produce a pollutant into the storm sewer. (i.e. compost, nutrient rich material)

d. Filter sock or bag installations shall be designed to provide bypass or overflow openings to allow the inlet to receive stormwater and avoid flooding of adjacent buildings during intense runoff events.

e. Trapped sediment shall be removed after each runoff event.

f. When the porosity of filter socks or bags and filter media is restricted by filtered sediment, filter socks and media shall be replaced or cleaned to restore the original installation function.

Inspection and Maintenance:

1. Structures shall be inspected after each rain and repairs made as necessary.
2. Structures shall be removed and the area stabilized when the remaining drainage area has been properly stabilized.

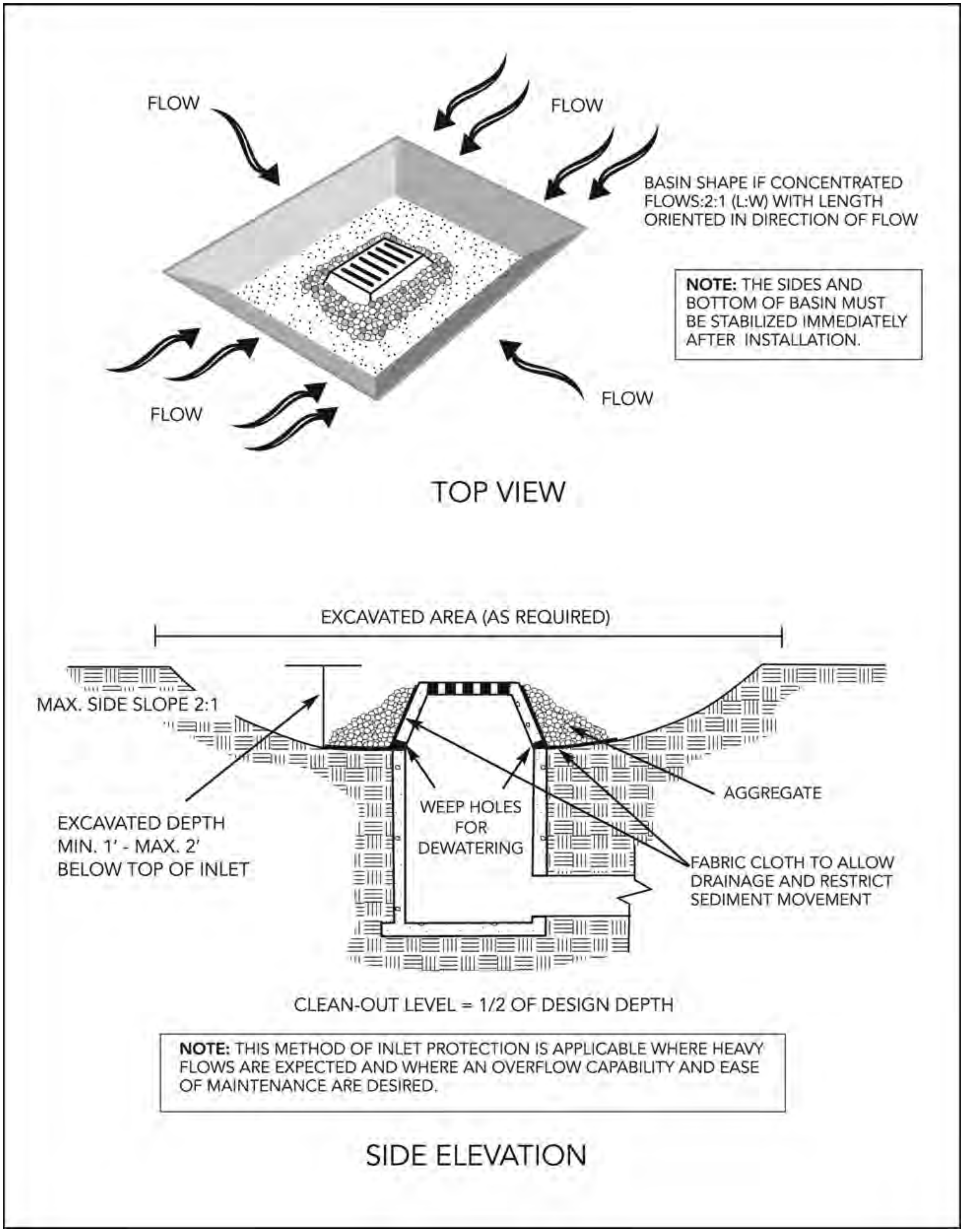
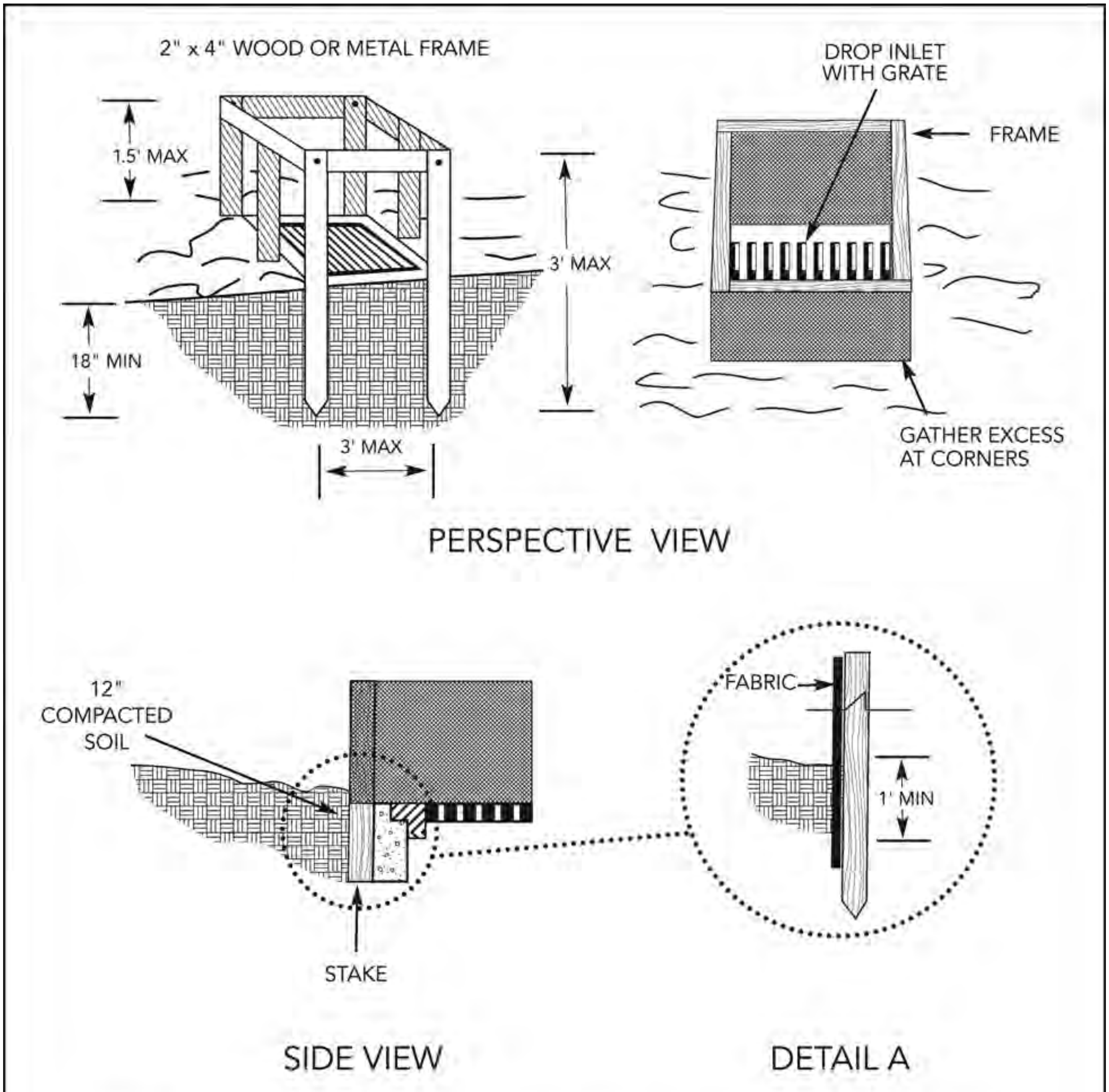
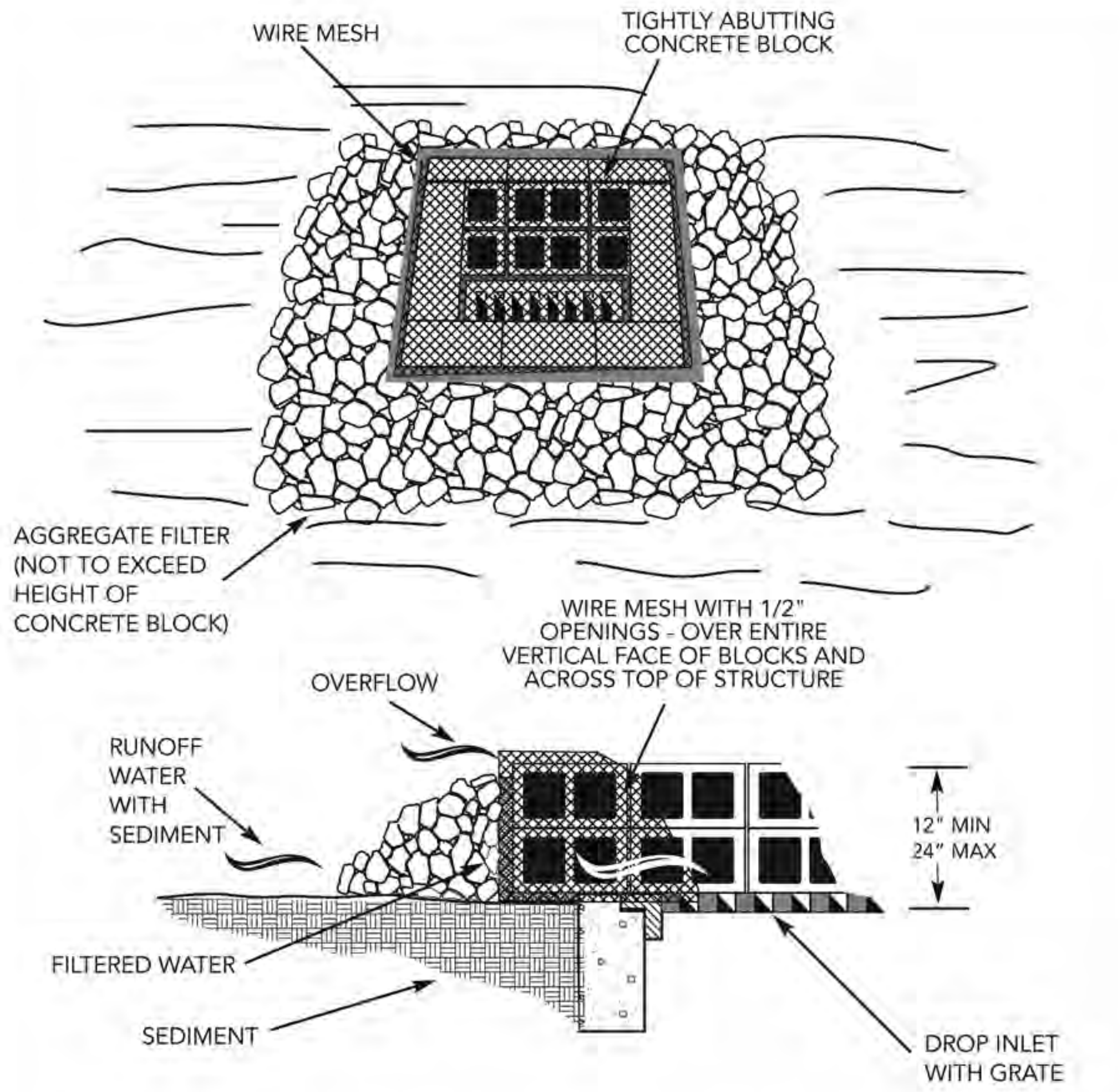


Figure 9-6 Excavation Drop Inlet Sediment Trap



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

Figure 9-7 Silt Fence Drop Inlet Protection



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

Figure 9-8 Block and Aggregate Drop Inlet Sediment Filter

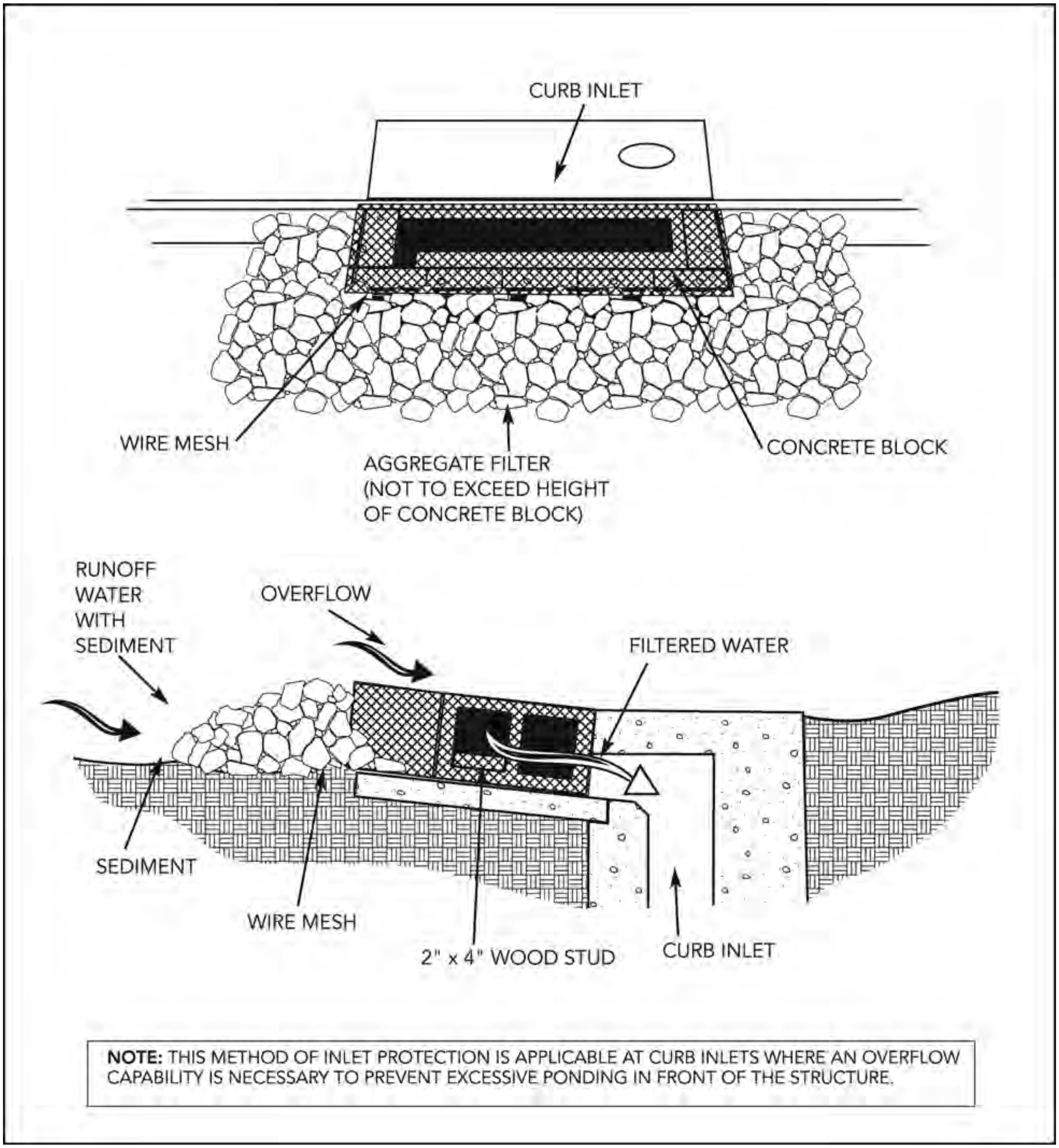


Figure 9-9 Block and Aggregate Curb Inlet Sediment Filter

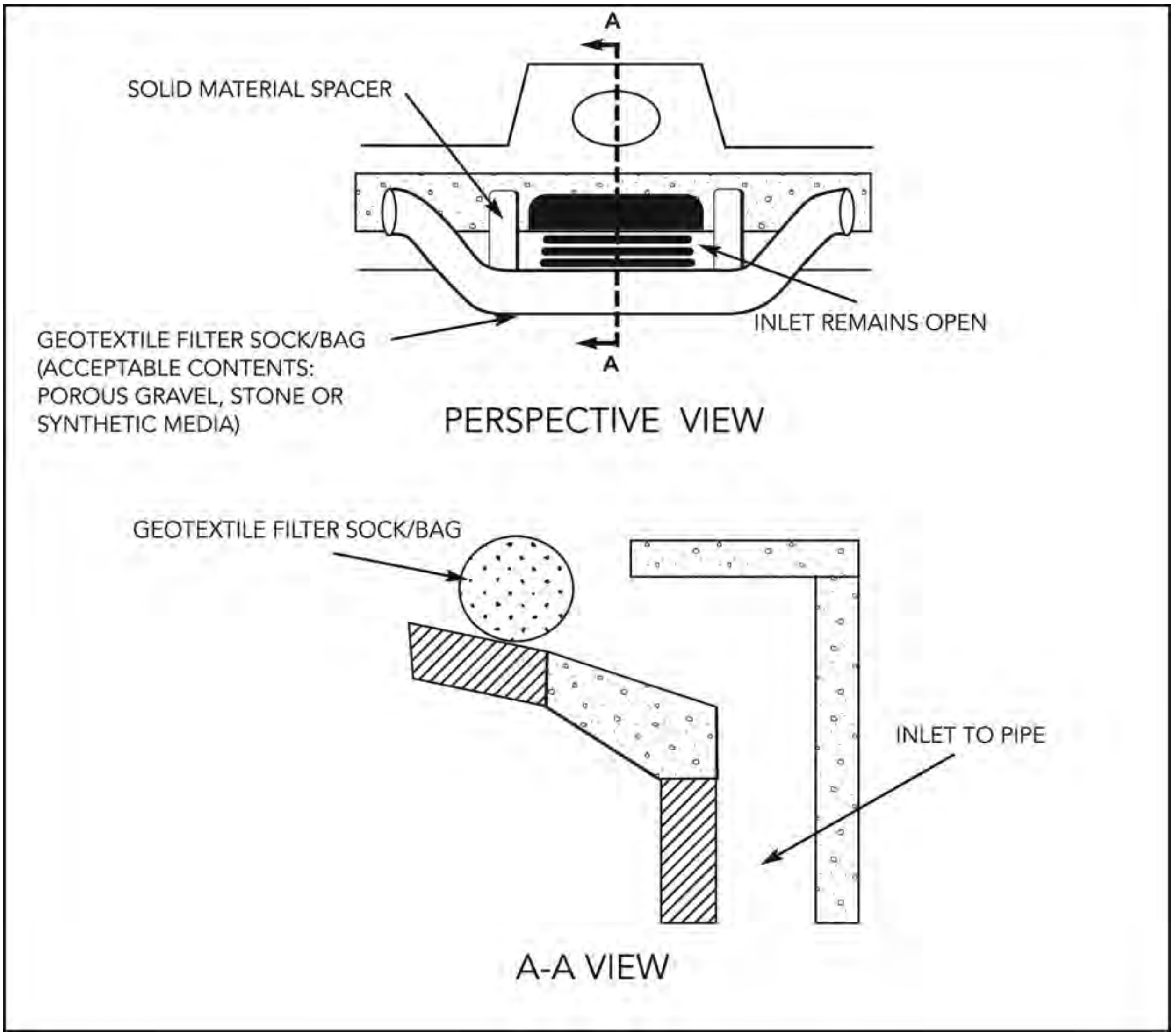
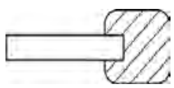


Figure 9-10 Curb Inlet Protection With Filter Sock

9.5.6 Culvert Inlet Protection

Symbol:



BMP Guideline

Definition: Culvert inlet protection is provided by constructing a sediment filter located at the inlet to storm sewer culverts.

Purpose: The purpose of culvert inlet protection is to prevent sediment from entering, accumulating in and being transferred by a culvert and associated drainage system prior to permanent stabilization and to prevent erosion at culvert inlets during the phase of a project where elevation and drainage patterns change, causing original control measures to be ineffective or in need of removal.

Conditions Where Practice Applies:

Where culvert and associated drainage system is to be made operational prior to permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different conditions.

Design Criteria:

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

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

Construction Guidelines:

1. Silt Fence Culvert Inlet Protection (Figure 9-11)

   a. The maximum area draining to this practice shall not exceed one ac.

   b. The construction guidelines and installation requirements as noted in Section 9.5.4, Silt Fence will apply to this practice unless otherwise noted below.

   c. The height of the silt fence shall be a minimum of 24 in. and shall not exceed 30 in., with support post spacing not to exceed 3 ft.

   d. Placement of the barrier shall be a minimum of 6 ft. from the culvert in the direction of the incoming flow, creating a horseshoe shape.

   e. If silt fence cannot be installed properly or the flow and/or velocity of flow to the culvert protection is excessive and may breach the structure, a culvert inlet sediment trap should be used. (Figure 9-12)

2. Culvert Inlet Sediment Trap

   a. The maximum area draining to this practice shall not exceed three ac.

   b. Geometry of the design will be a horseshoe shape around the culvert inlet.

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

d. All other construction guidelines found within Section 9.5.14, Temporary Sediment Trap also apply to this practice.

e. Runoff storage requirements shall be in accordance with information outlined in Section 9.5.14, Temporary Sediment Trap.

f. The proper installation of the culvert inlet sediment trap is a viable substitute for the installation of the Temporary Sediment Trap.

Inspection and Maintenance:

1. The structure shall be inspected after each rain and repairs made as needed.
2. Aggregate shall be replaced or cleaned when inspection reveals that clogged voids are causing ponding problems which interfere with the proper functioning of the structure.
3. Sediment shall be removed and the impoundment restored to its original dimensions when sediment has accumulated to half the design depth. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.
4. Temporary structures shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

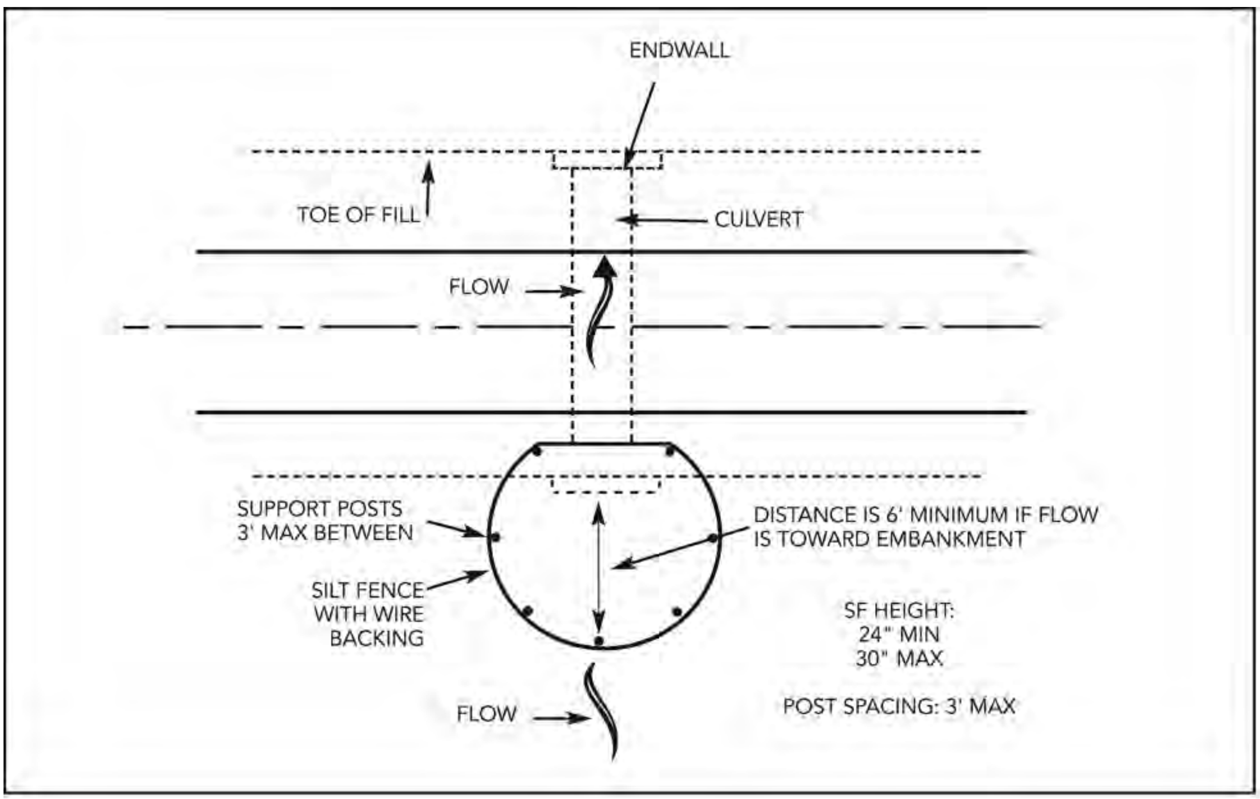


Figure 9-11 Silt Fence Culvert Inlet Protection

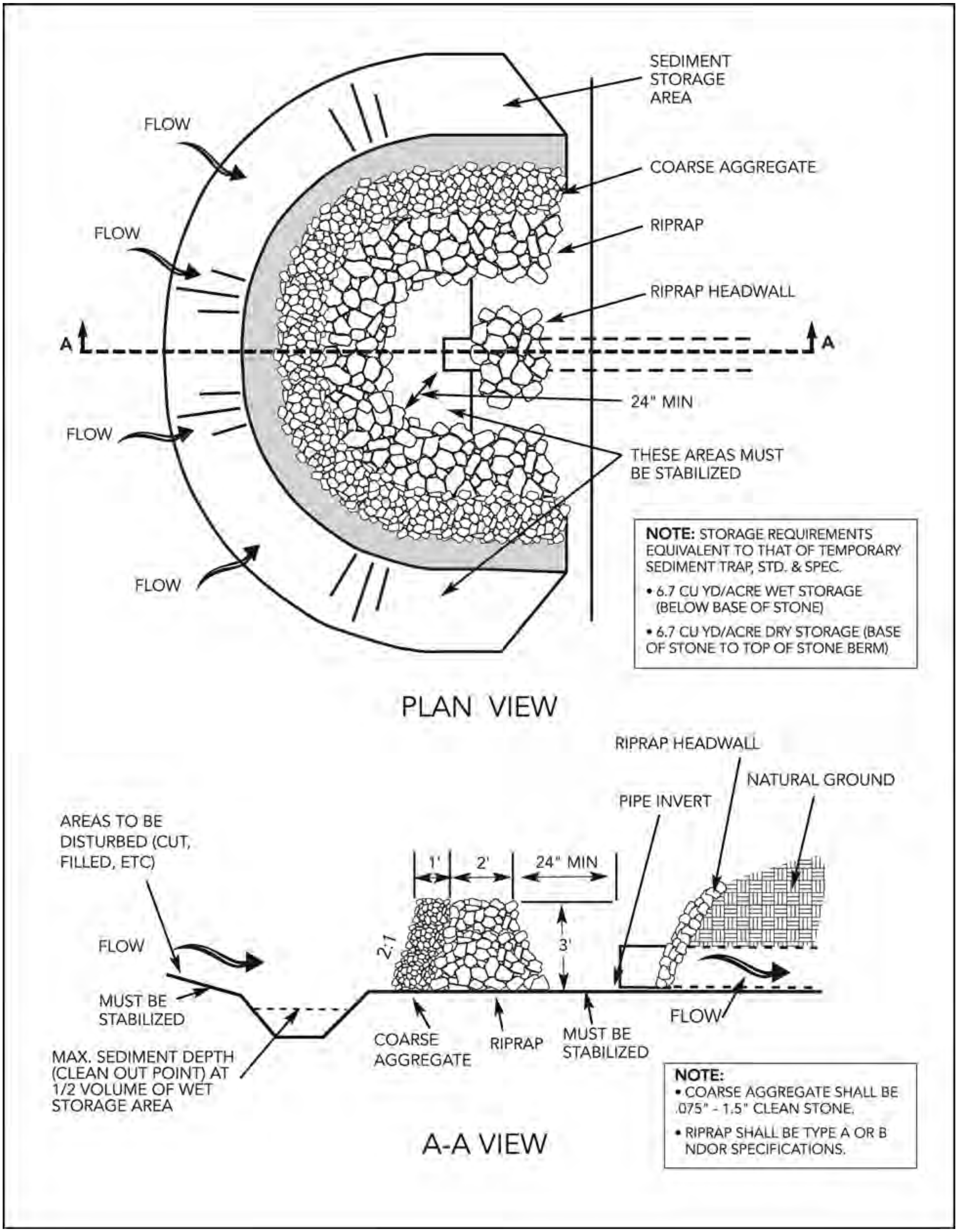


Figure 9-12 Culvert Inlet Sediment Trap

9.5.7 Temporary Diversion Dike

Symbol:

BMP Guideline

Definition: A temporary diversion dike is a temporary ridge of compacted soil constructed at the top or base of a sloping disturbed area.

Purpose: The purpose of a temporary diversion dike is to divert storm runoff from upslope drainage areas away from unprotected disturbed areas and slopes to a stabilized outlet or to divert sediment laden runoff from a disturbed area to a sediment trapping facility such as a sediment trap or sediment basin.

Conditions Where Practice Applies:

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

Design Criteria: (Figure 9-13)

1. The maximum allowable drainage area is five ac.
2. The minimum allowable height measured from the upslope side of the dike is 18 in.
3. Side slopes shall be 1.5:1 or flatter, along with a minimum base width of 4.5 ft.
5. The channel behind the dike shall have a positive grade to a stabilized outlet.
5. The diverted runoff, if free of sediment, must be released through a stabilized outlet or channel.
6. Sediment laden runoff must be diverted and released through a sediment trapping facility such as a Temporary Sediment Trap (Section 9.5.14) or Temporary Sediment Basin (Section 9.5.15).

Construction Guidelines:

1. Temporary diversion dikes must be installed as a first step in the land disturbing activity and must be functional prior to upslope land disturbance.
2. The dike shall be adequately compacted to prevent failure.
3. Temporary or permanent seeding and mulch shall be applied to the dike immediately following its installation.
4. The dike should be located to minimize damages by construction operations and traffic.

Inspection and Maintenance:

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

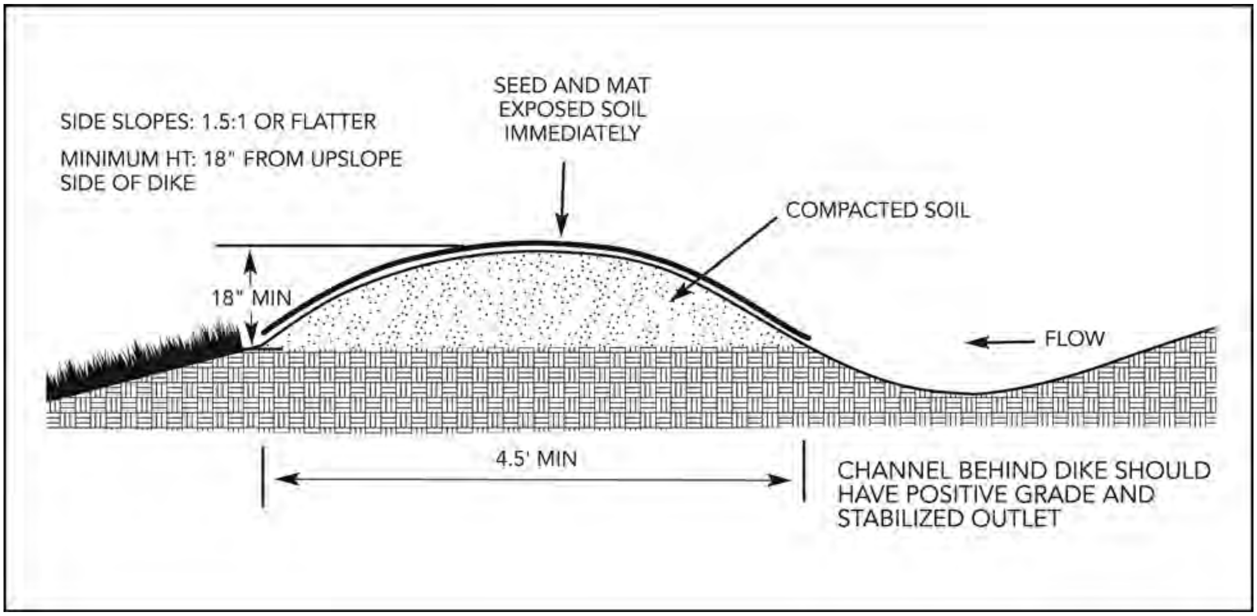


Figure 9-13 Temporary Fill Diversion

9.5.8 Temporary Fill Diversion

Symbol:

BMP Guideline

Definition: Temporary fill diversion is a channel with a supporting ridge of soil on the lower side, constructed along the top of an active earth fill.

Purpose: The purpose of a temporary fill diversion is to divert storm runoff away from the unprotected slope of the fill to a stabilized outlet or sediment trapping facility.

Conditions Where Practice Applies:

Whenever the drainage area at the top of an active earth fill slopes toward the exposed slope this temporary structure should remain in place for less than one week.

Design Criteria: (Figure 9-14)

1. The maximum allowable drainage area is five ac.
2. The minimum allowable height of the supporting ridge shall be 9 in.
3. The channel shall have a positive grade to a stabilized outlet.
4. The diverted runoff must be released through a stabilized outlet, slope drain or sediment trapping measure.

Construction Guidelines:

1. The diversion shall be constructed at the top of the fill at the end of each work day as needed.
2. The diversion shall be located at least 2 ft. inside the top edge of the fill.
3. The supporting ridge shall be constructed with a uniform height along its entire length. Without uniform height, the fill diversion may be susceptible to breaching.

Inspection and Maintenance:

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

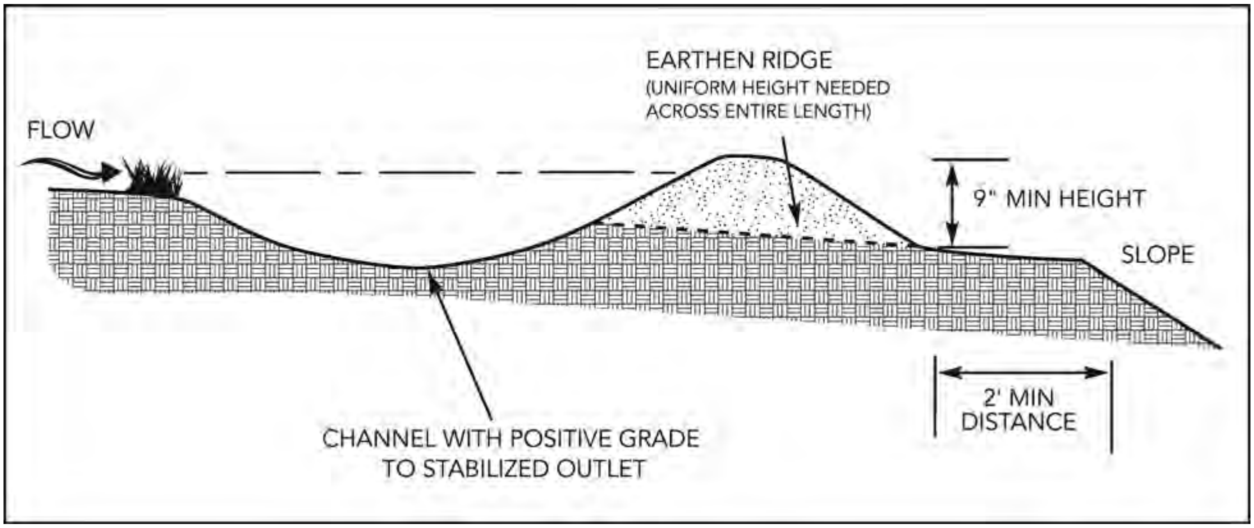
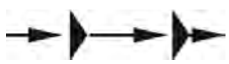


Figure 9-14 Temporary Fill Diversion

9.5.9 Check Dams

Symbol:



BMP Guideline

Definition: Check dams are small temporary aggregate dams constructed across a swale or drainage ditch.

Purpose: The purpose of check dams is to reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. This practice also traps sediment generated from adjacent areas or the ditch itself, mainly by ponding of the stormwater runoff. Field experience has shown it to perform more effectively than silt fence in the effort to stabilize wet-weather ditches.

Conditions Where Practice Applies:

This practice, utilizing a combination of aggregate sizes, is limited to use in small open channels which drain 10 ac. or less. It should not be used in a perennial or intermittent stream as the objective or regulated waterbody. Some specific applications include:

1. Temporary ditches or swales which, because of their short length of service, cannot receive a non-erodible lining but still need protection to reduce erosion.
2. Temporary ditches or swales which need protection during the establishment of grass linings.
3. An aid in the sediment trapping strategy for a construction site. This practice is not a substitute for major perimeter trapping measures such as a Sediment Trap or a Sediment Basin.

Construction Guidelines: (Figure 9-15 and Figure 9-16)

1. The drainage area of the ditch or swale being protected shall not exceed two ac. when 2 in. coarse aggregate is used alone and shall not exceed 10 ac. when a combination of Type A or B riprap and 2 in. coarse aggregate is used. Refer to the accompanying detail for orientation of aggregate and cross-sectional view of the measure.
2. An effort should be made to extend the aggregate to the top of channel banks; however, the maximum height of the dam shall be 3.0 ft.
3. The center of the check dam must be at least 6 in. lower than the outer edges to create a weir effect.
4. For added stability, the base of the check dam shall be keyed into the soil approximately 6 in.
5. The maximum spacing between the dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam. (Figure 9-17)
6. Aggregate should be placed according to the configuration shown on the accompanying detail. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.
7. Filter cloth should be used under the aggregate to provide a stable foundation and to facilitate the removal of the aggregate.

8. Check dams must be removed when their useful life has been completed. In temporary ditches and swales, check dams should be removed and the ditch filled in when they are no longer needed. In the case of grass-lined ditches, check dams should be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams should be seeded and mulched immediately after they are removed. The use of filter cloth underneath the aggregate will make the removal of the aggregate easier.

Inspection and Maintenance:

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

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

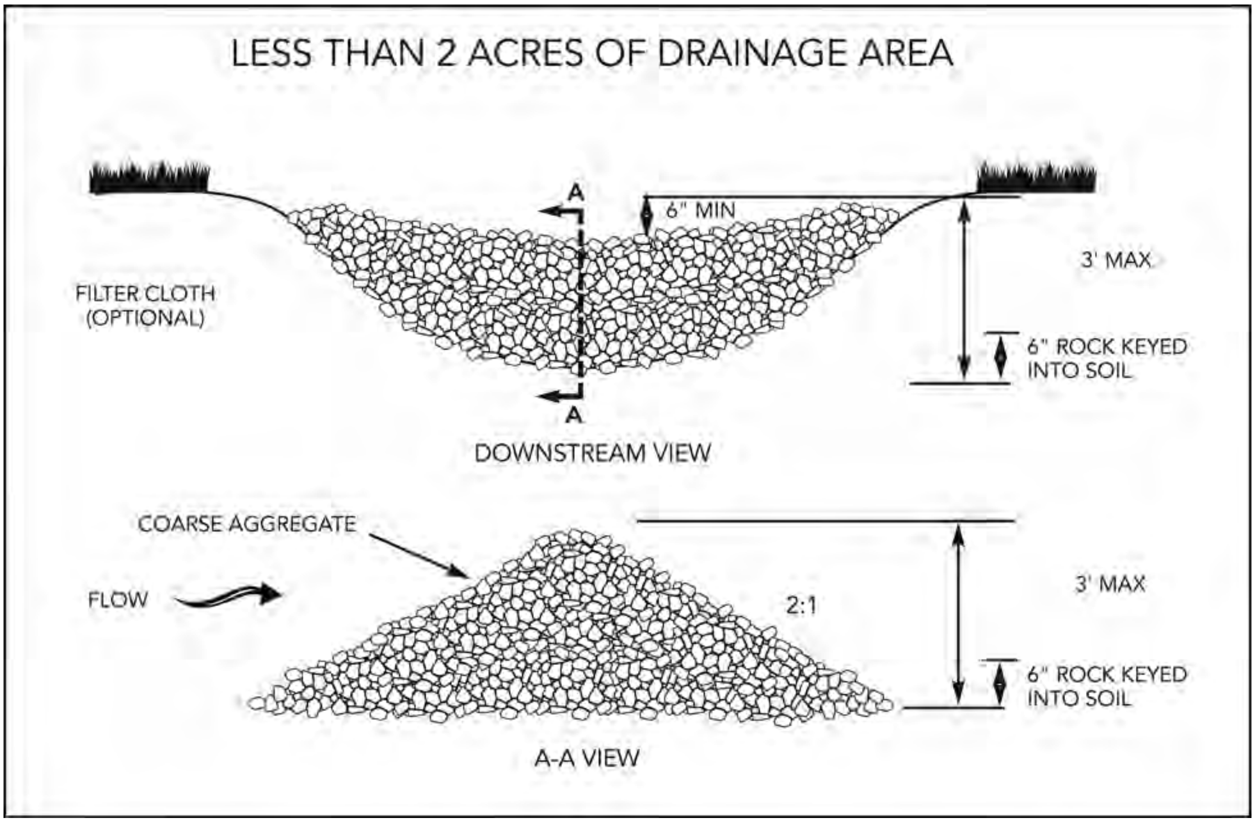


Figure 9-15 Rock Check Dam – Less Than 2 Ac.

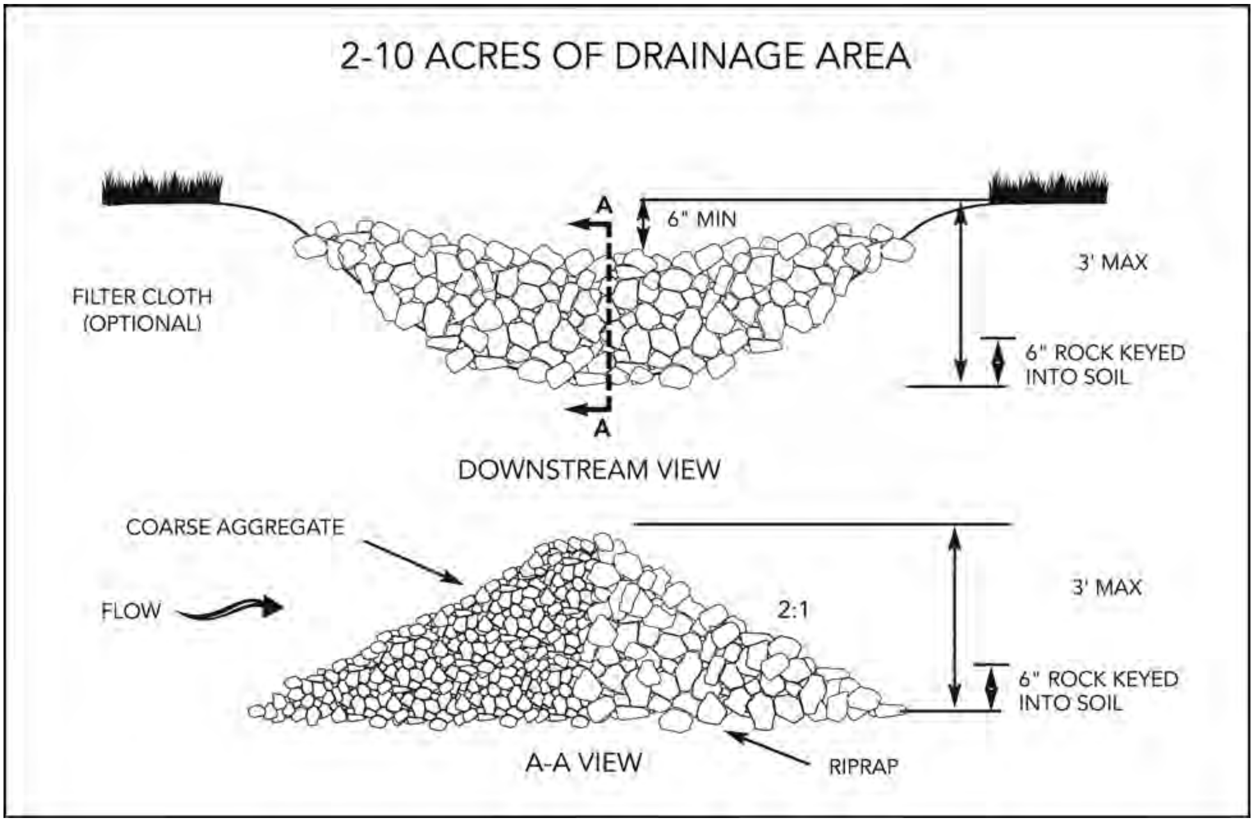


Figure 9-16 Rock Check Dam – 2-10 Ac.

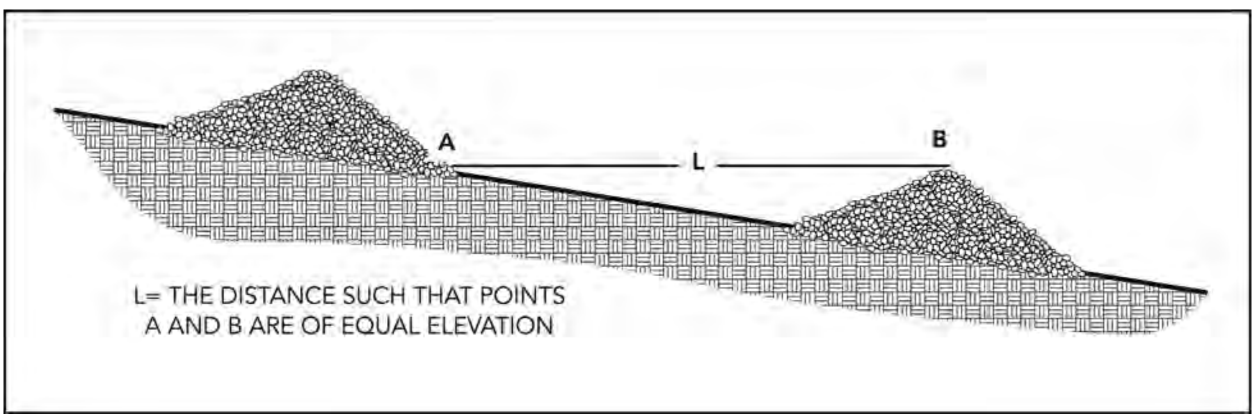
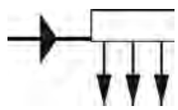


Figure 9-17 Spacing Between Check Dams

9.5.10 Level Spreader

Symbol:



BMP Guideline

Definition: A level spreader is an outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.

Purpose: The purpose of a level spreader is to convert concentrated runoff to sheet flow and release it uniformly onto areas stabilized by existing vegetation.

Conditions Where Practice Applies:

Where there is a need to divert stormwater away from disturbed areas to avoid overstressing erosion prevention measures; where sediment free storm runoff can be released in sheet flow down a stabilized slope without causing erosion. This practice applies only in those situations where the spreader can be constructed on undisturbed soil and the area below the level lip is uniform with a slope of 10 percent or less and is stabilized by natural vegetation. The runoff water should not be allowed to reconcentrate after release unless it occurs during interception by another measure (such as a permanent pond or detention basin) located below the level spreader.

Design Criteria: (Figure 9-18 and Figure 9-19)

1. Determine the capacity of the spreader by estimating the peak flow expected from a 10-year storm. For flows greater than 20 cfs, the measure shall be designed by a qualified engineer.

2. A 20-ft. transition section should be formed in the diversion channel so that the width of the diversion will smoothly tie in with the width of the spreader to ensure more uniform outflow. The grade of the channel for the last 20 ft. of the dike or diversion entering the level spreader shall be less than or equal to 1 percent.

3. The grade of the level spreader channel shall be 0 percent.

4. The depth of the level spreader, as measured from the lip, shall be at least 6 in. The depth may be made greater to increase temporary storage capacity, improve trapping of debris and to enhance settling of any suspended solids.

5. The length, width and depth of the spreader shall be as follows:

Design Flow (cfs)	Min. Depth (ft.)	Width of Lower Side Slope of Spreader (ft.)	Length (ft.)
0-10	0.5	6	10
10-20	0.6	6	20

6. The release of the stormwater will be over the level lip onto an undisturbed well vegetated area with a maximum slope of 10 percent. The level lip should be of uniform height and zero grade over the length of the spreader. The level lip may be stabilized by vegetation or may be of a rigid non-erodible material depending upon the expected design flow: 0-4 cfs may be stabilized by vegetative means; 5-20 cfs shall be stabilized by rigid means. A vegetated lip must be constructed with an

erosion resistant material, such as jute or excelsior 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 lumber or concrete curbing should be used.

Construction Guidelines:

1. Level spreaders shall be constructed on undisturbed soil (not fill material).
2. The entrance to the spreader shall be shaped in such a manner to insure that runoff enters directly onto the channel.
3. Construct a 20 ft. transition section from the diversion channel to blend smoothly to the width and depth of the spreader.
4. The level lip shall be constructed at 0 percent grade to insure uniform spreading of stormwater runoff.
5. Protective covering for vegetated lip shall be minimum of 4 ft. wide extending 6 in. over the lip and buried 6 in. deep in a vertical trench on the lower edge. The upper edge should butt against smoothly cut sod and be securely held in place with closely spaced heavy duty wire staples.
6. Rigid level lip should be entrenched at least 2 in. below existing ground and securely anchored to prevent displacement. An apron of 0.5 in. to 1.5 in. coarse aggregate should be placed to top of level lip and extend downslope at least three ft. Place filter fabric under aggregate and use galvanized wire mesh to hold aggregate securely in place.
7. The released runoff must outlet onto undisturbed stabilized areas with slope not exceeding 10 percent. Slope must be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.
8. Immediately after its construction, appropriately seed and mulch the entire disturbed area of the spreader.

Inspection and Maintenance:

The measure shall be inspected after every rainfall and repairs made, if required. Level spreader lip must remain at 0 percent slope to allow for proper function of measure. The contractor shall avoid the placement of any material on and prevent construction traffic across the structure. If the measure is damaged by construction traffic, it shall be repaired immediately.

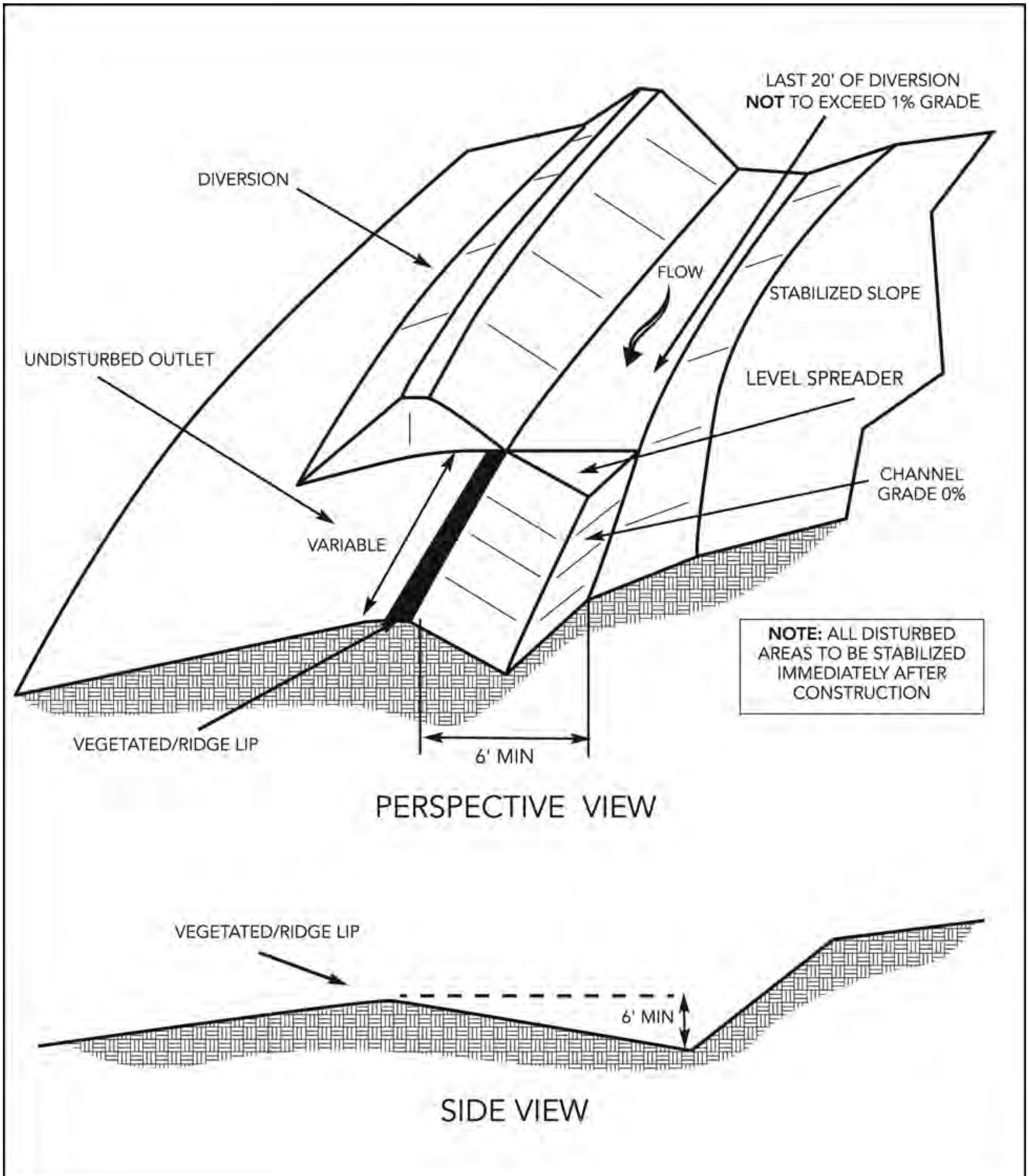


Figure 9-18 Level Spreader Perspective View

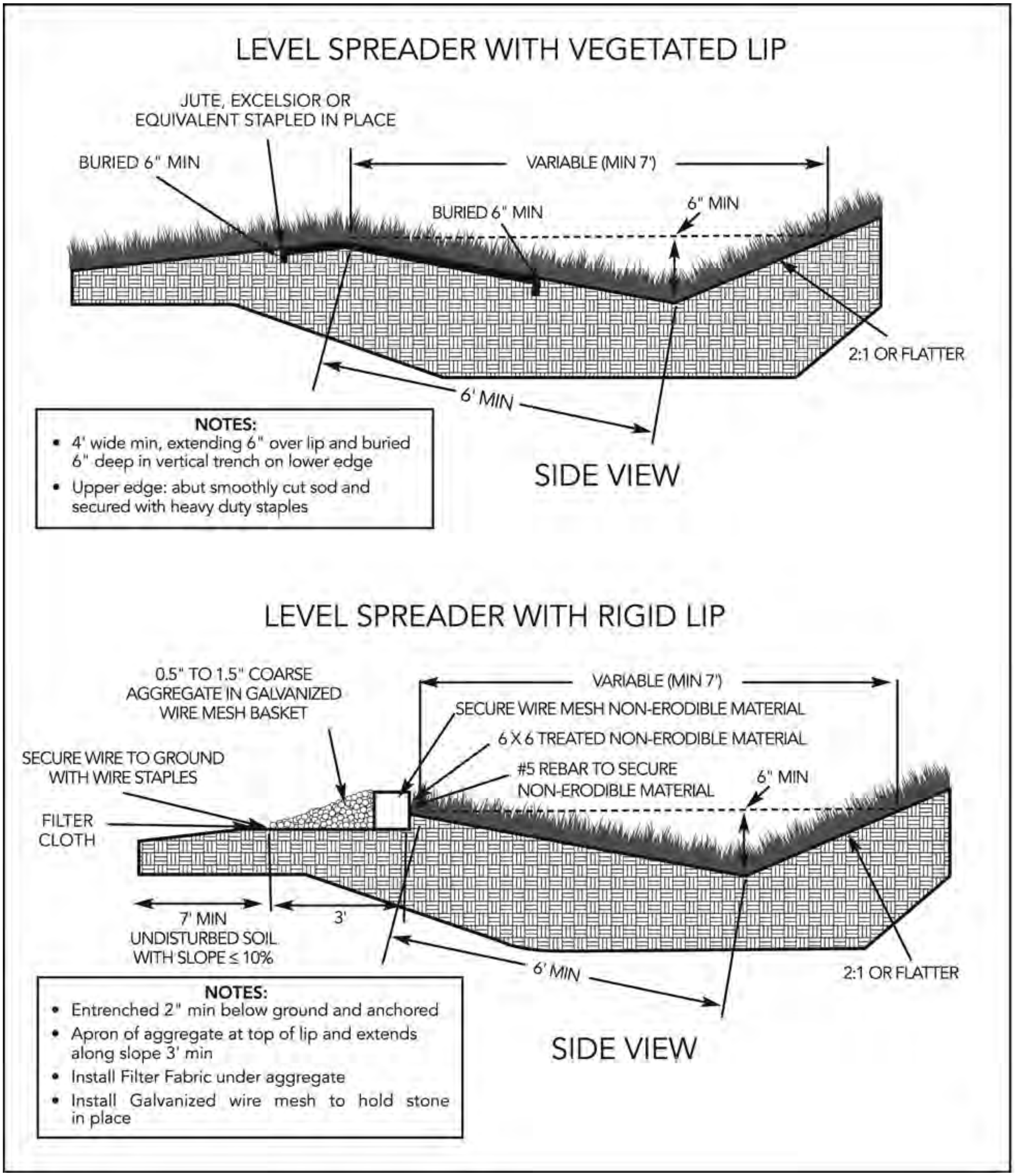


Figure 9-19 Level Spreader Cross-Section

9.5.11 Temporary Slope Drain

Symbol:

BMP Guideline

Definition: A temporary slope drain consists of flexible tubing or conduit extending from the top to the bottom of a cut or fill slope.

Purpose: The purpose of temporary slope drain is to temporarily conduct concentrated stormwater runoff safely down the face of a cut or fill slope without causing erosion on or below the slope.

Conditions Where Practice Applies:

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

Design Criteria: (Figure 9-20)

1. The maximum allowable drainage area per slope drain is 5 ac.
2. The slope drain shall consist of heavy duty flexible material designed for this purpose. The diameter of the slope drain shall be equal over its entire length. Reinforced hold down grommets shall be spaced at 10 ft. (or less) intervals. Slope drains shall be sized as listed below:

Maximum Drainage Area (ac.)	Pipe Diameter (in.)
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

3. The entrance to the slope drain shall consist of a standard flared end section for metal pipe culverts with appropriate inlet protection as set forth in Culvert Inlet Protection (Section 9.5.6). If ponding will cause a problem at the entrance and make such protection impractical, appropriate sediment removing measures shall be taken at the outlet of the pipe. Extension collars shall consist of 12 in. long corrugated metal pipe. Watertight fittings shall be provided.
4. End sections made of heavy duty flexible material may be utilized if determined by the implementing agency to provide a stable inlet or outlet section.
5. An earthen dike shall be used to direct stormwater runoff into the temporary slope drain.
6. The height of the dike at the centerline of the inlet shall be equal to the diameter of the pipe plus 6 in. Where the dike height is greater than 18 in. at the inlet, it shall be sloped at the rate of 3:1 or flatter to connect with the remainder of the dike.
7. The outlet of the slope drain must be protected from erosion.

Construction Guidelines:

1. The measure shall be placed on undisturbed soil or well compacted fill.
2. The entrance section shall slope towards the slope drain at the minimum rate of 0.5 in. per ft.
3. The soil around and under the entrance section shall be hand tamped in 8 in. lifts to the top of the dike to prevent piping failure around the inlet.
4. The slope drain shall be securely staked to the slope at the grommets provided.
5. The slope drain sections shall be securely fastened together and have watertight fittings.
6. Install erosion protection at the inlet and outlet.

Inspection and Maintenance:

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

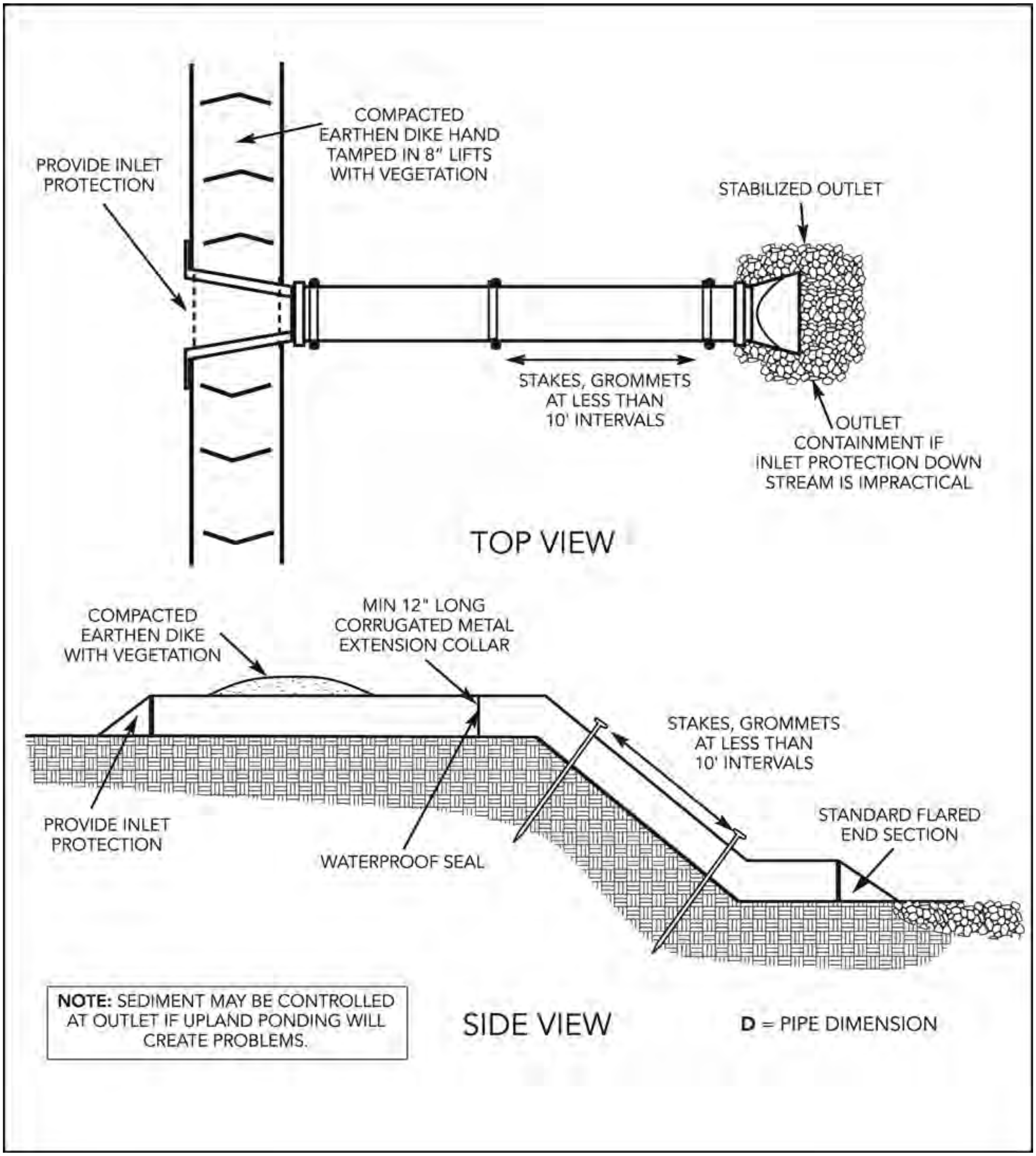
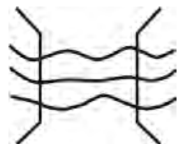


Figure 9-20 Temporary Slope Drain

9.5.12 Temporary Vehicular Stream Crossing

Symbol:



BMP Guideline

Definition: A temporary vehicular stream crossing is a temporary structural span installed across a flowing watercourse for use by construction traffic. Structures may include bridges, round pipes, pipe arches, or oval pipes.

Purpose: The purpose of the temporary vehicular stream crossing is to provide a means for construction traffic to cross flowing steams without damaging the channel or banks and to keep sediment generated by construction traffic out of the watercourse.

Conditions Where Practice Applies:

Generally applicable to flowing streams with drainage areas less than 1 sq. mile. Structures which must handle flow from larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.

Design Criteria:

1. Temporary Bridge Crossing: (Figure 9-20)

    a. Structures may be designed in various configurations. However, the materials used to construct the bridge must be able to withstand the anticipated loading of the construction traffic.

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

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

    d. A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 ft. (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 ft. is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with Section 9.5.8, Temporary Fill Diversion. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

    e. Appropriate perimeter control such as Silt Fence (Section 9.5.4) or Turbidity Curtain (Section 9.5.13) must be employed when necessary along banks of stream parallel to the vehicular crossing.

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

2. Temporary Culvert Crossing (Figure 9-22)

   a. Where culverts are installed 2 in. coarse aggregate or larger will be used to form the crossing. The depth of aggregate cover over the culvert shall be equal to one half the diameter of the culvert or 12 in., whichever is greater. To protect the sides of the aggregate from erosion, riprap shall be used.

   b. If the structure will remain in place for up to 14 days, the culvert shall be large enough to convey the flow from a 2-year frequency storm without appreciably altering the stream flow characteristics. See Table 9-7 for aid in selecting an appropriate culvert size. If the structure will remain in place 14 days to one year, the culvert shall be large enough to convey the flow from a 10-year frequency storm. In this case, the hydrologic calculation and subsequent culvert size must be done for the specific watershed characteristics. If the structure must remain in place over 1 year, it must be designed as a permanent measure by a qualified professional.

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

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

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

   f. The slope of the culvert shall be at least 0.25 in. per ft.

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

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

   i. The approaches to the structure shall consist of aggregate pads made of 2 in. coarse aggregate, a minimum of 6 in. thick, and equal to the width of the structure.

   j. A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 ft. (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 ft. is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with Section 9.5.8 Temporary Fill Diversion. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

3. All local, state, and federal approvals must be attained.

<u>Construction Guidelines</u>:

1. Temporary Bridge Crossing

    a. Clearing and excavation of the streambed and banks shall be kept to a minimum.

    b. The temporary bridge structure shall be constructed at or above bank elevation to prevent the entrapment of floating material and debris.

    c. Abutments shall be placed parallel to and on stable banks.

    d. Bridges shall be constructed to span the entire channel. If the channel width exceeds 8 ft. (as measured from top of bank to top of bank) then a footing, pier or bridge support may be constructed within the waterway. One additional footing, pier or bridge support will be permitted for each additional 8 ft. width of channel. No footing, pier or bridge support, however, will be permitted within the channel for waterways which are less than 8 ft. wide.

    e. Stringers shall either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.

    f. Decking materials shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.

    g. Run planking (optional) shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.

    h. Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option which will provide additional safety.

    i. Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.

    j. All areas disturbed during installation shall be stabilized within 7 calendar days of that disturbance.

    k. When the temporary bridge is no longer needed, all structures including abutments and other bridging materials should be removed immediately.

    l. Final cleanup shall consist of removal of the temporary bridge from the waterway, protection of banks from erosion, and removal of all construction materials. All removed materials shall be stored outside the floodplain of the stream. Removal of the bridge and cleanup of the area shall be accomplished without construction equipment working in the waterway channel.

2. Temporary Culvert Crossing

   a. Clearing and excavation of the streambed and banks shall be kept to a minimum.

   b. The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration.

   c. Filter cloth shall be placed on the streambed and stream banks prior to placement of the pipe culvert(s) and aggregate. The filter cloth shall cover the streambed and extend a minimum of 6 in. and a maximum of one ft. beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability.

   d. The culvert(s) shall extend a minimum of one ft. beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case shall the culvert exceed 40 ft. in length.

   e. The culvert(s) shall be covered with a minimum of one ft. of aggregate. If multiple culverts are used, they shall be separated by at least 12 in. of compacted aggregate fill. At a minimum, the bedding and fill material used in the construction of the temporary access culvert crossings shall be 2 in. coarse aggregate.

   f. When the crossing has served its purpose, all structures including culverts, bedding and filter cloth materials shall be removed. Removal of the structure and cleanup of the area shall be accomplished without construction equipment working in the waterway channel.

   g. Upon removal of the structure, the stream shall immediately be shaped to its original cross section and properly stabilized.

<u>Inspection and Maintenance</u>:

Both structures shall be inspected after every rainfall and at least once a week, whether it has rained or not, and all damages repaired immediately.

Table 9-7 Pipe Diameter (Inches) for Stream Crossings*

Drainage Area (Acres)	Average Slope of Watershed			
	1%	4%	8%	16%
1 – 25	24	24	30	30
26 – 50	24	30	36	36
51 – 100	30	36	42	48
101 – 150	30	42	48	48
151 – 200	36	42	48	54
301 – 350	42	48	60	60
351 – 400	42	54	60	60
451 – 500	42	54	60	72
501 – 550	48	60	60	72
551 – 600	48	60	60	72
601 – 640	48	60	72	72

*Note: Table is based on United States Department of Agriculture (USDA)-SCS Graphical Peak Discharge Method for 2-year frequency storm event.

CN = 65; Rainfall depth = 3.5 inches

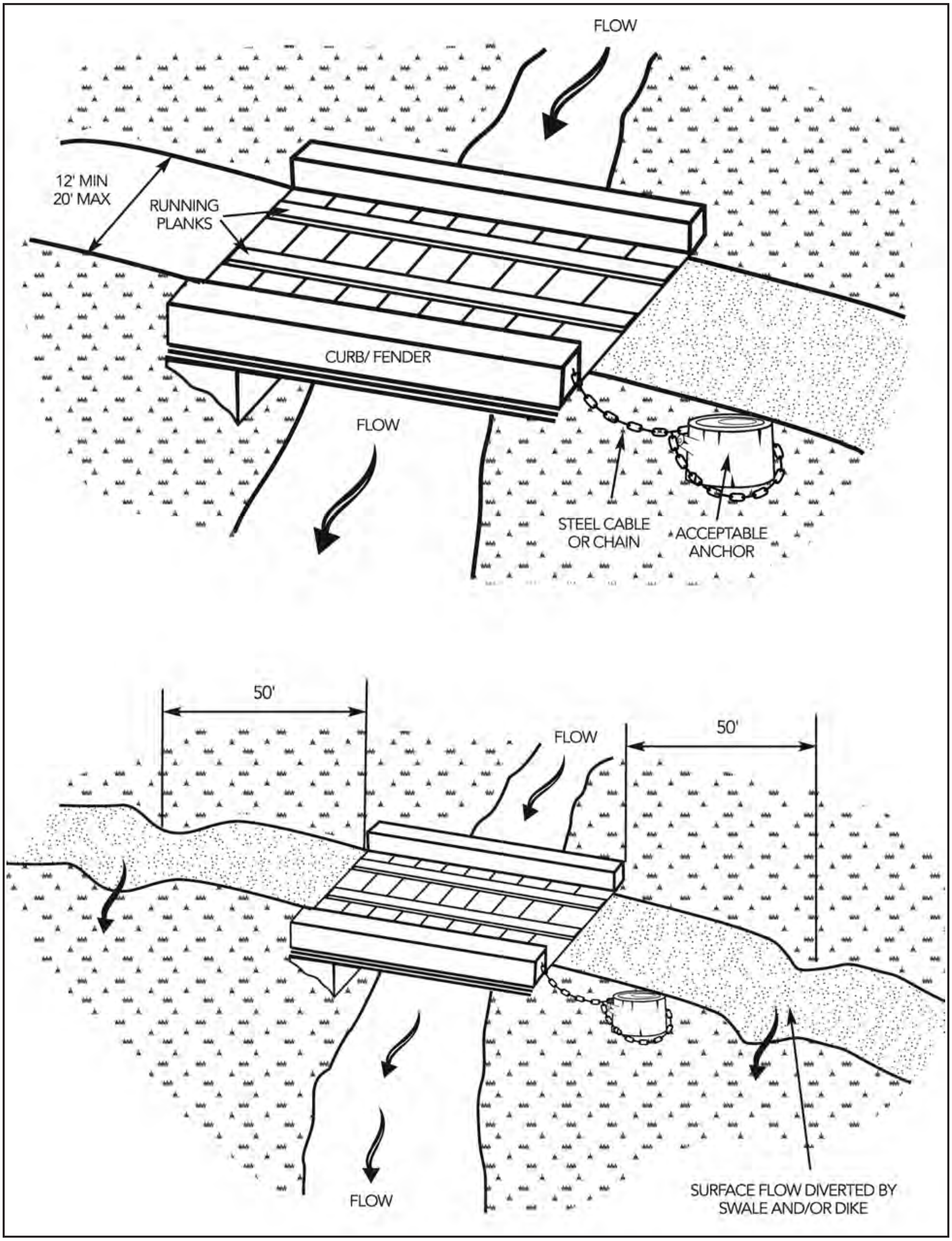


Figure 9-21 Temporary Bridge Crossing

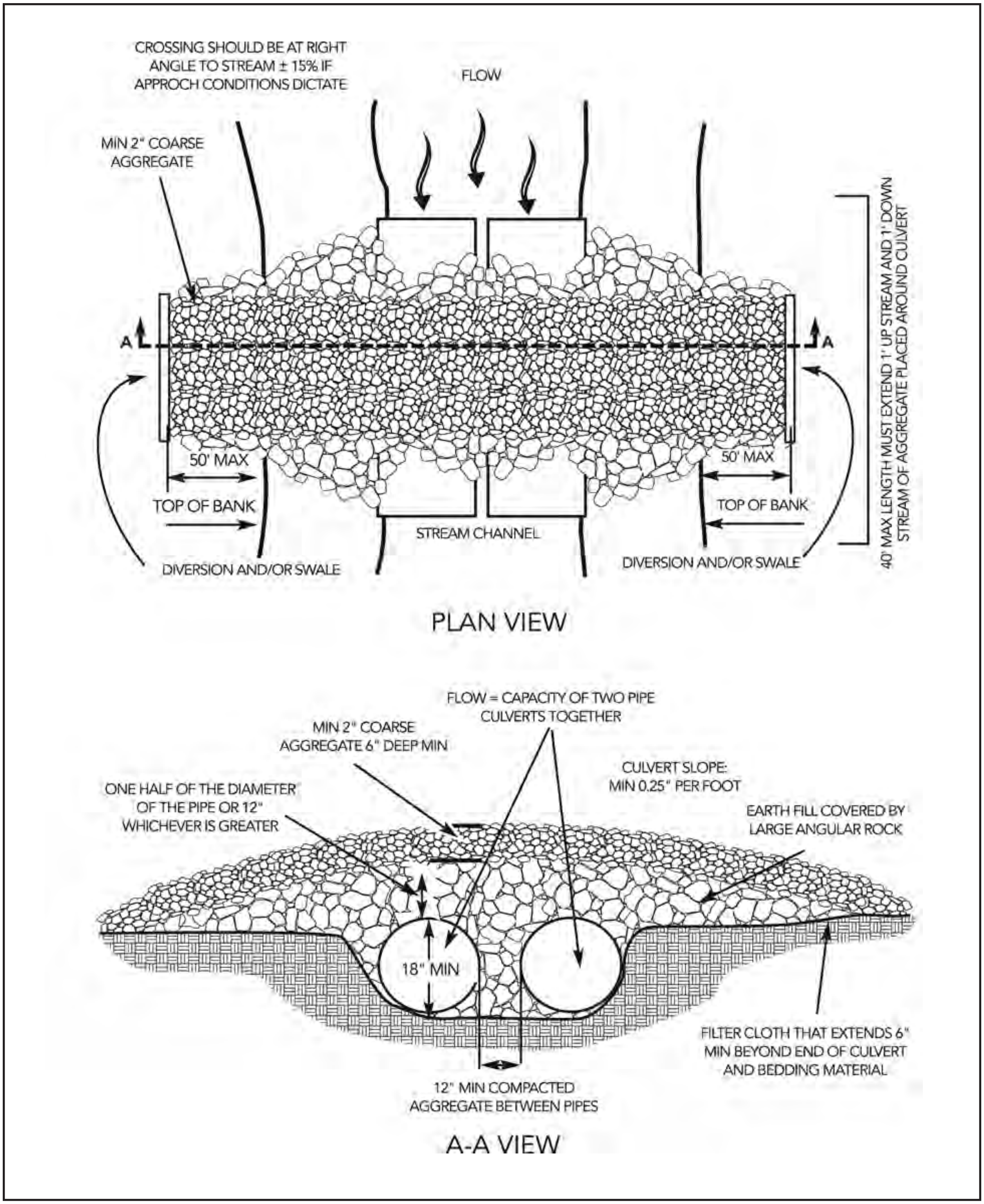
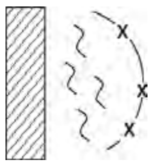


Figure 9-22 Temporary Culvert Crossing

9.5.13 Turbidity Curtain

Symbol:



BMP Guideline

Definition: A turbidity curtain is a floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water.

Purpose: The purpose of a turbidity curtain is to isolate an active construction area within a lake or pond and to provide sedimentation protection for a watercourse from up-slope land disturbance or from dredging or filling within the watercourse.

Conditions Where Practice Applies:

Applicable to watercourses or lakes where intrusion into the areas by construction activities and subsequent sediment movement is unavoidable. This practice will not reduce the amount of disturbance from work performed in water, but it will minimize the area that is affected.

Design Criteria: (Figure 9-23, Figure 9-24 and Figure 9-25)

1. Turbidity curtains should extend the entire depth of the watercourse whenever the watercourse in question is not subject to significant wind and wave forces.
2. In wind and wave action situations, the curtain should never be so long as to touch bottom. A minimum one ft. "gap" should exist between the weighted lower end of the skirt and the bottom at "mean" low water. In these situations it is not practical to extend the curtain to a depth lower than 10 to 12 ft. below the surface.
3. Turbidity curtains should be located parallel to the direction of flow of a moving body of water. Turbidity curtains should not be placed across the main flow of a significant body of moving water.
4. When sizing the length of the floating curtain, allow an additional 10-20 percent variance in the straight line measurement.
5. An attempt should be made to avoid an excessive amount of joints in the curtain; a minimum continuous span of 50 ft. between joints is a good rule of thumb.
6. For stability reasons, a maximum span of 100 ft. between joints is also a good rule to follow.
7. The ends of the curtain, both floating upper and weighted lower, should extend well up into the shoreline, especially if high water conditions are expected. The ends shall be secured firmly to the shoreline (preferably to rigid bodies such as trees or piles) to fully enclose the area where sediment may enter the water.

Construction Guidelines:

1. Barriers shall be a bright color (yellow or "international" orange are recommended) that will attract the attention of nearby boaters.
2. The curtain fabric must meet the following requirements:

Physical Property	Requirement
Thickness, mils	45
Weight, oz./sq. yd.	18
Grab tensile strength, lbs.	300
UV Inhibitor	Included

3. Seams in the fabric shall be either vulcanized welded or sewn, and shall develop the full strength of the fabric.
4. Floatation devices shall be flexible, buoyant units contained in an individual floatation sleeve or collar attached to the curtain. Buoyancy provided by the floatation units shall be sufficient to support the weight of the curtain and maintain a freeboard of at least 3 in. above the water surface level.
5. Load lines must be fabricated into the bottom of turbidity curtains. The bottom loading shall consist of chain incorporated into the bottom hem of the curtain of sufficient weight to serve as ballast to hold the curtain in a vertical position. Additional anchorage shall be provided as necessary.
6. Bottom anchors must be sufficient to hold the curtain in the same position relative to the bottom of the watercourse without interfering with the action of the curtain. The anchor may dig into the bottom (grappling hook, plow, or fluke-type) or may be weighted (mushroom type) and should be attached to a floating anchor buoy via an anchor line. The anchor line would then run from the buoy to the top load line of the curtain.
7. In the calm water of lakes or ponds, it is usually sufficient to merely set the curtain end stakes or anchor points (using anchor buoys if bottom anchors are employed), then tow the curtain in the furled condition out and attach it to the stakes or anchor points. Following this, any additional stakes or buoyed anchors required to maintain the desired location of the curtain may be set and these anchor points made fast to the curtain. Only then, the furling lines should be cut to let the curtain skirt drop.
8. Always attach anchor lines to the floatation device, not to the bottom of the curtain. Care should be taken to protect the skirt from damage as the turbidity curtain is dragged from the water.
9. The site selected to bring the curtain ashore should be free of sharp rocks, broken cement, debris, etc., so as to minimize damage when hauling the curtain over the area.

Inspection and Maintenance:

1. The developer/owner shall be responsible for maintenance of the filter curtain for the duration of the project in order to ensure protection of the watercourse.
2. Should repairs to the geotextile fabric become necessary, there are normally repair kits available from manufacturers; manufacturer's instructions must be followed to ensure the adequacy of repairs.
3. When the curtain is no longer required as determined by the inspector, the curtain and related components shall be removed in such a manner as to minimize turbidity. Remaining sediment shall be sufficiently settled before removing the curtain. Sediment may be removed and the original depth (or plan elevation) restored. Any spoils must be taken to upland areas and stabilized.

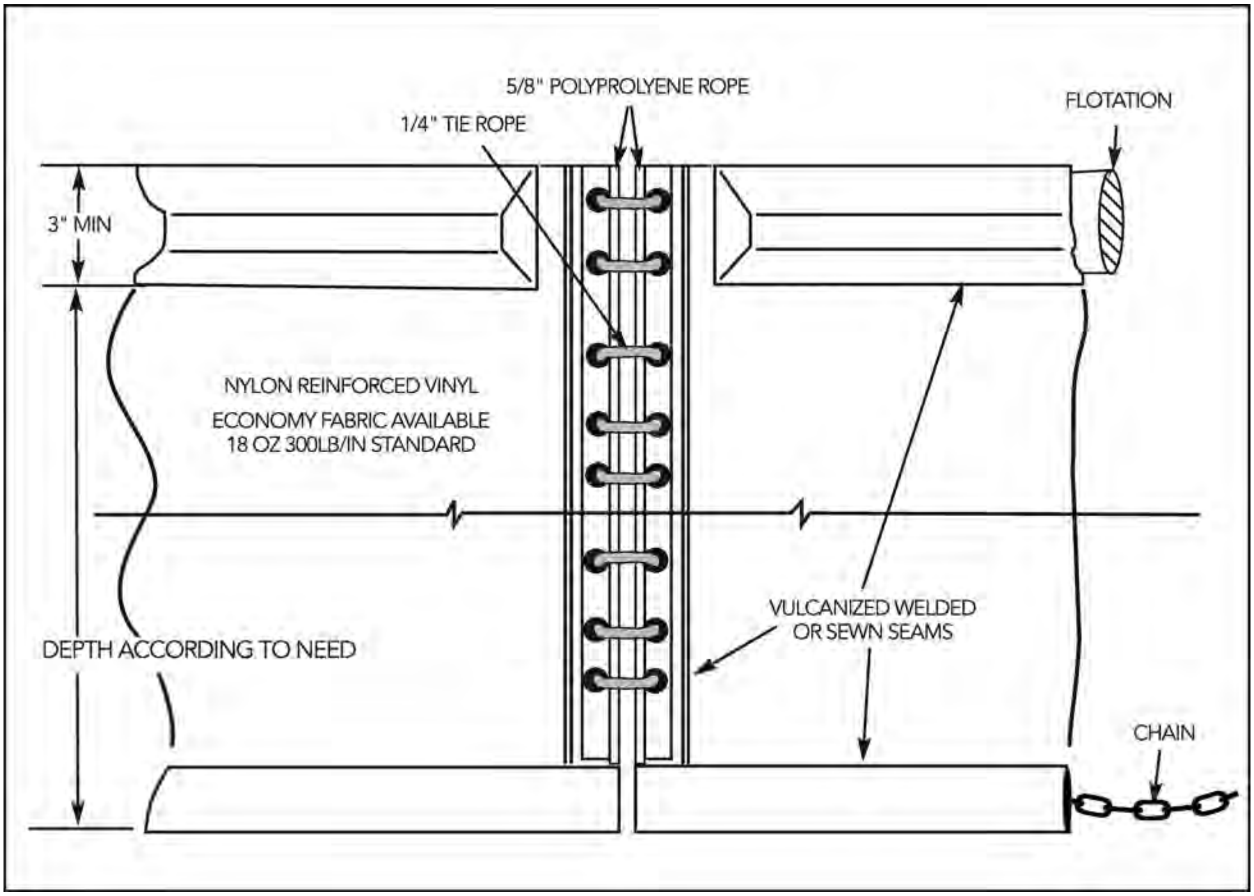


Figure 9-23 Turbidity Curtain

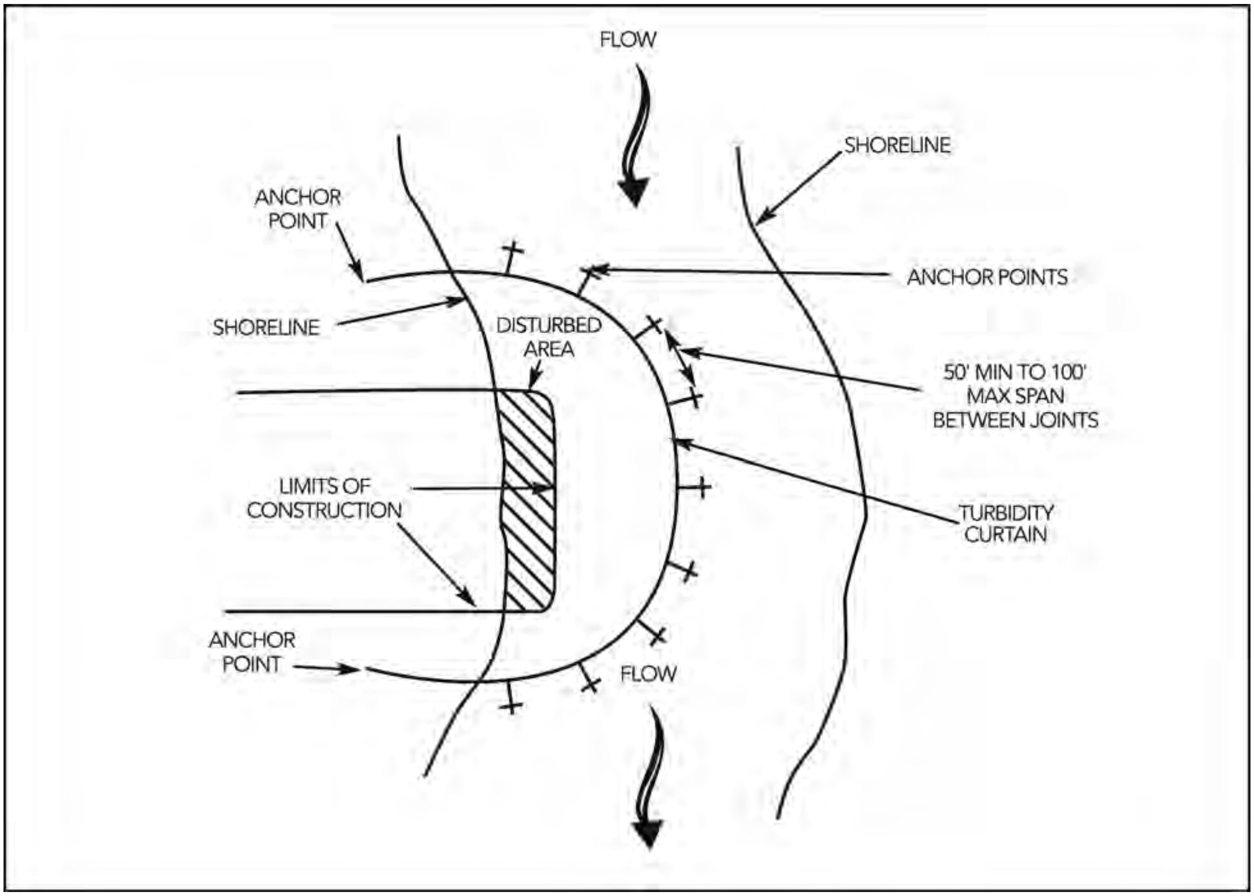


Figure 9-24 Turbidity Curtain – Typical Layouts: Streams, Ponds, and Lakes

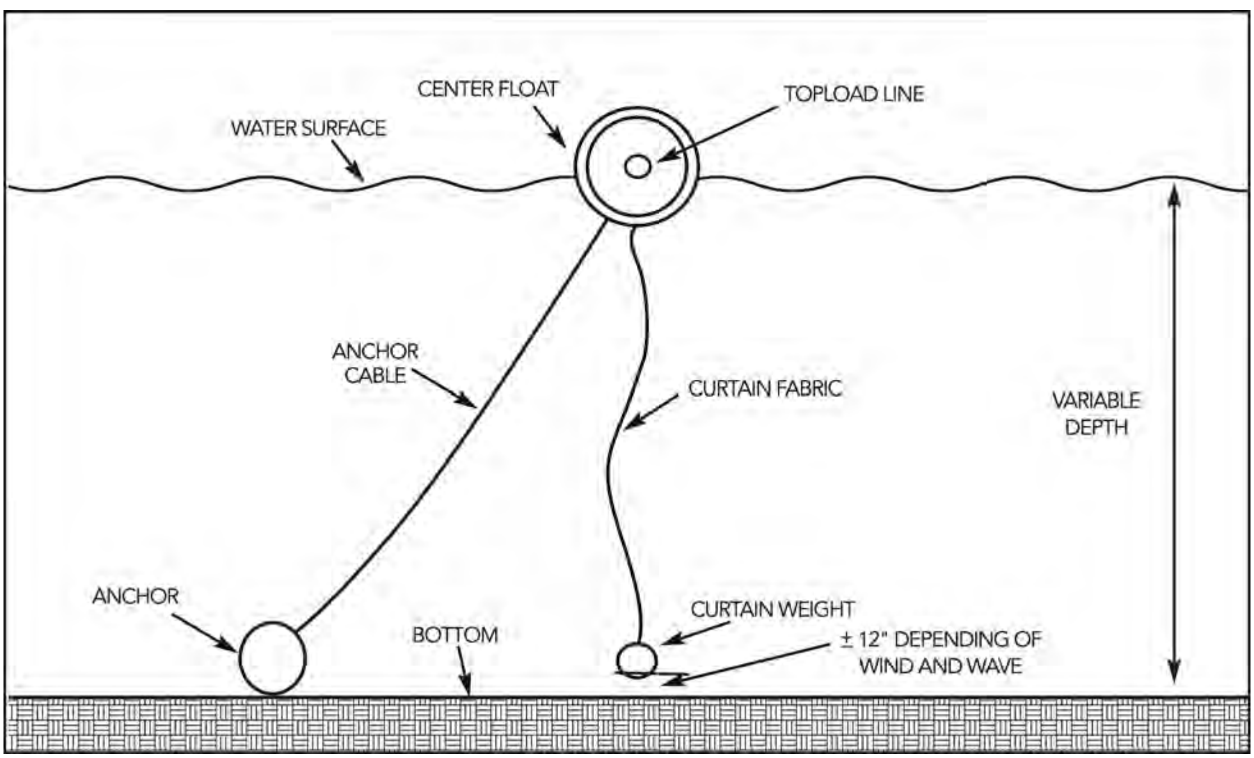
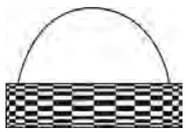


Figure 9-25 Turbidity Curtain

9.5.14 Temporary Sediment Trap

Symbol:



BMP Guideline

Definition: A temporary sediment trap is a temporary ponding area formed by constructing an earthen embankment with an aggregate outlet.

Purpose: The purpose of a temporary sediment trap is to detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out.

Conditions Where Practice Applies:

Below disturbed areas where the total contributing area is less than 3 ac. The sediment trap may be constructed either independently or in conjunction with a Temporary Diversion Dike, Section 9.5.7.

Design Criteria: (Figure 9-26 and Figure 9-27)

1. Sediment traps should be used only for small drainage areas. If the contributing drainage area is 3 ac. or greater, refer to Section 9.5.15, Temporary Sediment Basin.

2. Sediment traps, along with other perimeter controls intended to trap sediment, shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

3. The sediment trap must have an initial storage volume of 134 cu. yd. per ac. of drainage area, half of which shall be in the form of “wet” storage to provide a stable settling medium. The “wet” storage will normally be excavated below the ground surface and be a constant pool of water. If the terrain permits, and sediment control can be achieved, a sediment trap may be designed and constructed so the wet storage volume is mostly dewatered over an extended period after sediment has been trapped and settled out. The remaining half of the required storage volume shall be in the form of a drawdown or dry storage which will provide extended settling time during less frequent, larger storm events. Sediment shall be removed from the basin when the volume of the wet storage is reduced by one-half.

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

    $V_1 = 0.85 \times A_1 \times D_1$
    V_1 = The wet storage volume in cu. ft.
    A_1 = The surface area of the flooded area at the base of the aggregate outlet in sq. ft.
    D_1 = The maximum depth in ft., measured from the low point in the trap.

    b. For a sediment trap, the dry storage volume may be approximated as follows:

    $V_2 = (A_2 + A_2)/2 \times D_2$ where
    V_2 = The dry storage volume in cu. ft.
    A_1 = The surface area of the flooded area at the base of the aggregate outlet in sq. ft.
    A_2 = The surface area of the flooded area at the crest of the aggregate outlet in sq. ft.
    D_2 = The depth in ft., measured from the top of the designed wet storage volume.

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

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

6. The outlet for the sediment trap shall consist of an aggregate section of the embankment located at the low point in the basin. A combination of coarse aggregate and riprap shall be used to provide for filtering/detention, as well as outlet stability. The coarse aggregate shall be 0.75 – 1.5 in. clean aggregate (smaller aggregate sizes will enhance filter efficiency) and riprap shall be Nebraska Department of Roads (NDOR) Specifications Type A or B. Filter cloth shall be placed at the aggregate-soil interface to act as a "separator". The minimum length of the outlet shall be 6 ft. times the number of ac. comprising the total area draining to the trap. The crest of the aggregate outlet must be at least 1 ft. below the top of the embankment to ensure that the flow will travel over the aggregate and not the embankment.

7. The maximum height of the sediment trap embankment shall be 5 ft. as measured from the base of the aggregate outlet. Minimum top widths (W) and outlet heights (H_o) for various embankment heights (H) are shown on the accompanying diagram. Side slopes for the embankment shall be 2:1 or flatter.

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

Construction Guidelines:

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

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

3. The earthen embankment shall be seeded with temporary or permanent vegetation (see Section 9.5.19 and 9.5.20) immediately after installation.

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

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

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

Inspection and Maintenance:

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

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

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

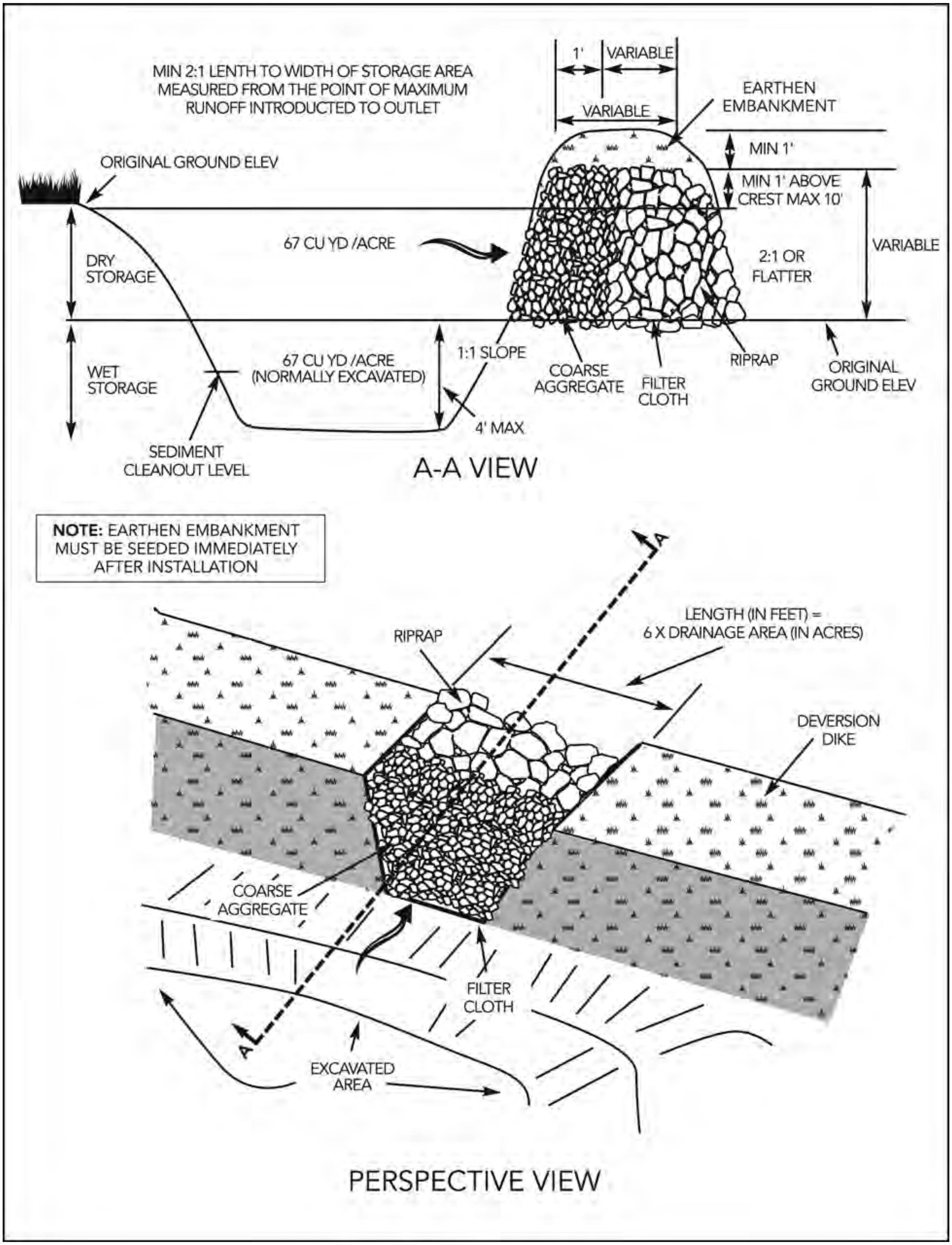
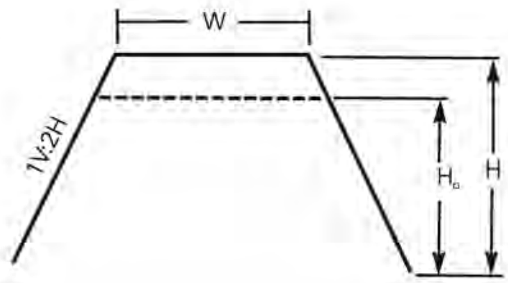


Figure 9-26 Typical Temporary Sediment Trap

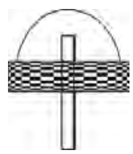


Embankment Height	Outlet Height	Top Width
H	H_o	W
1.5	0.5	2.0
2.0	1.0	2.0
2.5	1.5	2.5
3.0	2.0	2.5
3.5	2.5	3.0
4.0	3.0	3.0
4.5	3.5	4.0
5.0	4.0	4.5

Figure 9-27 Minimum Top Width (W) Required for Sediment Trap Embankments According to Height of Embankment (Feet)

9.5.15 Temporary Sediment Basin

Symbol:



BMP Guideline

Definition: A temporary sediment basin is a temporary barrier or dam with a controlled stormwater release structure formed by constructing an embankment of compacted soil to capture runoff prior to discharging from the project site.

Purpose: The purpose of a temporary sediment basin is to detain sediment-laden runoff from disturbed areas in "wet" and "dry" storage long enough to allow the majority of the sediment to settle out.

Conditions Where Practice Applies:

A temporary sediment basin can be constructed below disturbed areas where the total contributing area is equal to or greater than 3 ac. and less than 100 ac. There must be sufficient space and appropriate topography for the construction of a temporary impoundment. It is recommended that these measures, by virtue of their potential to impound large volumes of water, be designed by a professional in soil erosion and sediment control, professional engineer, or licensed landscape architect.

Design Criteria:

1. A temporary sediment basin should be located so as to intercept the largest possible amount of runoff from the disturbed area. The best locations are generally low areas and natural drainage ways below disturbed areas. Sediment basins should not be located in protected wetlands or waterways. Drainage into the basin can be improved by the use of diversion dikes and ditches. The basin should not be located where its failure would result in the loss of life or interruption of the use or service of public utilities or roads.

2. Sediment basins may remain in place after construction and final site stabilization are completed to serve as post-construction BMPs such as an extended dry detention basin or retention wet pond. Because the most practical location for a sediment basin is often the most practical location for a post-construction BMP, it is often desirable to utilize these structures for permanent stormwater management purposes. It should be noted, however, that in most cases, the outlet structure will differ during the construction and post-construction periods. If the temporary sediment basin is expected to perform as a post-construction BMP, the outlet structure must to be evaluated using criteria in this Chapter and Chapter 8: Stormwater Best Management Practices.

3. The maximum allowable drainage area into a temporary sediment basin shall be 100 ac. The design procedure described in this section is appropriate for design of temporary sediment basins capturing runoff from 50 ac. or less. It is recommended that when the drainage area to any one temporary basin exceeds 50 ac., an alternative design procedure using computer modeling software which more accurately defines the specific hydrology and hydraulics of the site and the sediment basin be used. If an alternative design procedure is used, the temporary sediment basin must meet the design criteria of this chapter.

4. The design storage capacity of the basin must be at least 134 cu. yd. per ac. of total contributing drainage area. One half of the design volume (67 cu. yd. per ac.) shall be in the form of normally wet storage as illustrated in Figure 9-30. Measures shall be included which allow for the wet

storage volume to be drained via gravity or pumped to facilitate cleanout activities. The remaining half (67 cu. yd. per ac.) shall be drawdown, or dry storage volume. The volume of the wet storage shall be measured from the low point of the basin to the elevation corresponding to one half the total storage volume. The drawdown volume shall be measured from the top elevation of the wet storage to the crest of the principal spillway, which corresponds to the full design storage volume (134 cu. yd. per ac.). See Design Criteria item 9 for spillway design criteria.

5. Sediment shall be removed from the basin when the volume of the wet storage has been reduced by one half. The elevation of the sediment cleanout level should be calculated and clearly marked on the plan and riser (since this part of the riser normally will be under water, a mark should appear above the wet storage volume a measured distance above the cleanout elevation).

6. While attempting to attain the desired storage capacities, efforts should be made to keep embankment heights to a minimum. This precaution takes on added significance when the basin will only serve as a temporary measure or will need substantial retrofitting prior to functioning as a post-construction BMP. When site topography permits, the designer should give strong consideration to the use of excavation to obtain the required capacity and to possibly reduce the height of the embankment. This excavation can be performed in a manner which creates a wet storage forebay area or which increases the storage capacity over the entire length of the basin.

7. To improve sediment trapping efficiency of the basin, the effective flow length must be twice the effective flow width. This basin shape may be attained by properly selecting the site of the basin, by excavation, or by the use of baffles.

8. For embankments of less than 10 ft., the embankment must have a minimum top width of 6 ft., and the side slopes must be 2:1 or flatter. In the case of an embankment 10 to 14 ft. in height, the minimum top width shall be 8 ft. and the side slopes shall be 2.5:1 or flatter. Embankments beyond these heights, which are required for containment of the design storm, must be designed in accordance with the requirements and criteria of Chapter 6 Storage Facilities.

9. The outlets for a temporary sediment basin shall consist of a combination of principal and emergency spillways. The principal spillway must be sized to convey the peak flow rate expected from the contributing area for a 2-year storm. The principal and emergency spillway together must pass the peak runoff expected from the contributing drainage area for a 10-year storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 10-year storm. However, an attempt to provide a separate emergency spillway should always be made.

   Runoff computations to determine the peak flow rates for the 2-year and 10-year storm events shall be completed using the recommended hydrology methods as described in Chapter 2 Hydrology and based upon the soil cover conditions which are expected to prevail during the life of the basin (i.e. no ground cover – recently disturbed soils for Rational Method and newly graded areas for SCS Runoff Curve Number).

10. For maximum effectiveness, the principal spillway should consist of a vertical pipe or box (riser) of corrugated metal or reinforced concrete, with a minimum diameter of 15 in., joined by a watertight connection to a horizontal pipe (barrel) extending through the embankment and outletting beyond the downstream toe of the fill. The riser will include a section of perforated pipe to dewater the dry storage volume. If the principal spillway is used in conjunction with a separate

emergency spillway, the principal spillway must be designed to pass at least the peak flow expected from a 2-year storm. The flow through the dewatering orifices cannot be utilized when calculating the design storm elevations because of potential for them to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest. If no emergency spillway is used, the principal spillway must be designed to pass the entire peak flow expected from the 10-year event. The following criteria should also be considered in the design of the principal spillway:

a. The crest of the principal spillway shall be set at the elevation corresponding to a volume equal to at least 134 cu. yd. per ac. If the principal spillway is used in conjunction with an emergency spillway, this elevation shall be a minimum of 1 ft. below the crest of the emergency spillway. In addition, a minimum freeboard of 1 ft. shall be provided between the 10-year water surface elevation and the top of the embankment. If no emergency spillway is used, the crest of the principal spillway shall be a minimum of 3 ft. below the top of the embankment; also, a minimum freeboard of 2 ft. shall be provided between the 10-year water surface elevation and the top of the embankment.

b. An anti-vortex device and trash rack shall be attached to the top of the principal spillway to improve the flow characteristics of water into the spillway and prevent floating debris from blocking the principal spillway. The anti-vortex device shall be of the concentric type.

c. Provisions shall be made to dewater the dry storage volume portion of the basin down to the wet storage elevation. Dewatering of the dry storage should be done in a manner which removes the “cleaner” water without removing the potentially sediment-laden water found in the wet storage area or any appreciable quantities of floating debris. An economical and efficient device for performing the drawdown is a section of perforated riser on the principal spillway. It is necessary to provide for at least a 12-hr. drawdown time of the dry storage volume.

d. The base of the principal spillway must be firmly anchored to prevent floating. If the riser of the spillway is greater than 10 ft. in height, computations must be made to determine the anchoring requirements. A minimum factor of safety of 1.25 shall be used. For risers 10 ft. or less in height, the anchoring may be done in one of the following ways:

    i. A concrete base 18 in. thick and twice the width of the riser diameter shall be used and the riser embedded 6 in. into the concrete.

    ii. A square steel plate, a minimum of 0.25 in. thick and having a width equal to twice the diameter of the riser shall be used; it shall be covered with 2.5 ft. of aggregate or compacted soil to prevent floatation.

e. The barrel of the principal spillway, which extends through the embankment, shall be designed to carry the flow provided by the riser of the principal spillway with the water level at the crest of the emergency spillway. The connection between the riser and the barrel must be watertight. The outlet of the barrel must include energy dissipation devices to prevent erosion or scour of the downstream area. The design of energy dissipation devices is discussed in Chapter 7: Energy Dissipators.

f. Anti-seep collars shall be used on the barrel of the principal spillway within the normal saturation zone of the embankment to increase the seepage length by at least 10% if either the settled height of the embankment exceeds 10 ft., or the embankment has low silt-clay content and the barrel is greater than 10 in. 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. Collars shall not be closer than 2 ft. to a pipe joint. Collars should be placed sufficiently far apart to allow space for hauling and compacting equipment. Precautions should be taken to ensure that 95% compaction is achieved around the collars. Connections between the collars and the barrel shall be watertight.

g. A filter diaphragm may be used in lieu of anti-seep collars. A filter diaphragm consists of a layer of sand and fine aggregate which runs through the dam embankment perpendicular to the barrel. Typically, the structure is 4 to 5 in. in width, approximately one ft. in height and is located at the barrel elevations 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 perforated toe drain. The critical design element of 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 this measure should be based on site specific geotechnical information and should be supervised by a qualified professional.

11. The emergency spillway acts as a safety release for a sediment basin, or any impoundment structure, by conveying the larger, less frequent storms through the basin without damage to the embankment. The emergency spillway also acts as its name implies, in case of an emergency such as excessive sedimentation or damage to the riser which prevents flow through the principal spillway. The emergency spillway shall consist of an open channel constructed adjacent to the embankment over undisturbed material. 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 ft. in length. The control section is a level portion of the spillway channel at the highest elevation in the channel.

12. 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 an emergency spillway to be constructed in undisturbed material. The principal spillway should then be sized to convey up to the 10-year peak flow rate. The following criteria should also be considered in the design of the emergency spillway:

    a. The emergency spillway shall be designed to carry the portion of the peak rate of runoff expected from the 10-year design storm which is not carried by the principal spillway.

    b. The 10-year design storm elevation through the emergency spillway shall be at least 1 ft. below the top of the embankment. The crest of the emergency spillway channel shall be at least 1 ft. above the crest of the principal spillway.

    c. 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.

d. The maximum allowable velocity in the emergency spillway channel will depend upon the type of lining used. Maximum allowable velocities for channel linings are listed in Table 5-3 and Table 5-4. The emergency spillway channel shall return the flow to the receiving channel at a non-eroding velocity.

e. The embankment of the sediment basin shall receive temporary or permanent seeding immediately after installation. Section 9.5.19 and 9.5.20, Temporary Seeding and Permanent Seeding. If excavation is required in the basin, side slopes should not be steeper than 1.5:1.

13. Sediment shall be removed from the basin when the sediment level is no higher than 1 ft. below the bottom of the dewatering device, or one-half of the permanent pool volume, whichever is lower. The material may be used in fill areas on-site or removed to an approved off-site location. Sediment basin plans shall indicate the final disposition of the sediment basin after the upstream drainage area is stabilized. The plans shall include methods for the removal of excess water lying over the sediment, stabilization of the basin site, and the disposal of any excess material. Where the sediment basin has been designed to also serve as a post-construction BMP, plans should also address the steps necessary for conversion from sediment basin to a permanent stormwater feature.

14. The slopes and open standing water of sediment basins can be dangerous. They should be fenced or otherwise made inaccessible to persons or animals.

Construction Guidelines:

1. Design and construction of the temporary sediment basin shall be in compliance with all local, state, and federal regulations and all appropriate permits must be obtained prior to commencement of construction.

2. Sediment basins, along with other perimeter controls intended to trap sediment, shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

3. Areas under the embankment or any structural works related to the basin shall be cleared, grubbed and stripped of topsoil to remove trees, vegetation, roots, or other objectionable material. In order to facilitate cleanout and restoration, the area of most frequent inundation will be cleared of all brush and trees.

4. For earth-fill embankments, a cutoff trench shall be excavated along the centerline of the dam. The trench must extend at least 1 ft. into a stable, impervious layer of soil and have a minimum depth of 2 ft. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 4 ft., but must also be wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction of 95% shall be obtained for the embankment. The trench shall be drained during the backfilling/compacting operations.

5. The fill material shall be taken from approved borrow areas. It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, oversized aggregate, rocks, or other perishable or

objectionable material. The material selected must have enough strength for the dam to remain stable and be tight enough, when properly compacted, to prevent excessive percolation of water through the dam. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material should contain the proper amount of moisture to ensure that 95% compaction will be achieved. Fill material will be placed in 16-in. continuous layers over the entire length of the fill. Compaction shall be obtained by means of an appropriate compactor for the type of embankment fill used. Special care shall be taken in compacting around the anti-seep collars to avoid damage and achieve desired compaction. The embankment shall be constructed to an elevation 5% higher than the design height to allow for settlement.

6. 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. Pervious materials such as sand or crushed aggregate shall not be used as backfill around the barrel or anti-seep collars. Fill material shall be placed around the pipe in 4 in. layers and compacted until 95% compaction is achieved. A minimum of 2 ft. of fill shall be hand compacted over the barrel before crossing it with construction equipment.

7. Vegetative emergency spillways shall not be constructed 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.

8. The embankment and emergency spillway of the sediment basin shall be stabilized with temporary or permanent vegetation immediately after installation of the basin. See Section 9.5.19 and 9.5.20, Temporary Seeding and Permanent Seeding.

9. The construction of the sediment basin shall be carried out in a manner such that it does not result in sediment problems downstream.

10. All federal, state, and local requirements shall be met concerning fencing and signs warning the public of the hazards of soft, saturated sediment and flood waters.

Inspection and Maintenance:

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

Design Procedure for Temporary Sediment Basin

The following design procedure provides a step-by-step method for the design of a temporary sediment basin for contributing areas less than 50 ac. The data sheet found at the end of this section should be used in the final plan to summarize design values calculated.

Step 1. Determine the required basin volume.

The design capacity of the basin must be at least 134 cu. yd. per ac. of total contributing drainage area, half of which shall be in the form of wet storage, and the remaining half as a “drawdown” area or dry storage.

a. Total Storage Volume

$$V_T = A_T \, x \, 134 \, \frac{cu. yd.}{acre}$$

Where:

V_T = The total storage volume for the temporary sediment basin (cu. yd.)
A_T = The total contributing tributary area to the sediment basin (ac.)

b. Wet Storage Volume

$$V_{WS} = 0.5 \, x \, V_T$$

Where:

V_{WS} = The storage volume for the wet storage portion of the sediment basin (cu. yd.)
V_T = The total storage volume for the temporary sediment basin (cu. yd.)

c. Dry Storage Volume

$$V_{DS} = 0.5 \, x \, V_T$$

Where:

V_{DS} = The storage volume for the dry storage portion of the sediment basin (cu. yd.)
V_T = The total storage volume for the temporary sediment basin (cu. yd.)

Step 2. Determine the elevation-area-storage relationship for the sediment basin.

The elevation-area-storage relationship for the sediment basin is determined using 1-ft. contour information at the location where the sediment basin is to be constructed. The design process is an iterative process where design parameters are estimated and refined. Start with a preliminary grading plan and modify the proposed grading as needed to achieve the design criteria. For each elevation, the surface area of the contour within the basin is measured. The incremental volume and cumulative volume in the sediment basin is then calculated.

$$V_{inc} = 0.5 \, x \, (A_i + A_{i+1}) \, x \, 1ft.$$

Where:

V_{inc} = The incremental storage volume between contours ($ft.^3$)
A_i = The surface area of contour elevation i ($ft.^2$)
A_{i+1} = The surface area of contour elevation i + 1 ($ft.^2$)

The cumulative volume is estimated by summing the incremental volumes.

Step 3. Determine the surface area and elevation of the wet storage volume.

The surface area of the wet storage is estimated using the elevation-area-storage relationship for the sediment basin and interpolating the surface area and elevation equal to the wet storage volume (V_{WS}).

Step 4. Determine the surface area and elevation of the top of the dry storage volume.

The surface area of the dry storage volume is estimated using the elevation-area-storage relationship for the sediment pond and interpolating the surface area and elevation equal to the total design volume (V_T).

Step 5. Determine the basin shape.

The shape of the basin must be such that the effective length is twice the effective width.

$$L_e = 2 \times W_e$$

W_e = the effective width, ft.
L_e = the effective length = the length of the flow path from the inflow to the outflow. If there is more than one inflow point, any inflow which carries more than 30% of the peak rate of inflow must meet these criteria, ft.

The correct basin shape can be obtained by proper site selection, excavation, or the use of baffles. Baffles increase the flow length by deflecting the flow. The baffles should be placed halfway between the inflow point and the outflow. (Figure 9-29)

Step 6. Determine whether the basin will have a separate emergency spillway.

Step 7. Set the elevation of the principal spillway crest to the elevation of the total storage volume.

Step 8. Determine the peak flow rate for the 2-year and 10-year storm events.

Runoff computations shall be completed using the recommended hydrology methods as described in Chapter 2 Hydrology and based upon the soil cover conditions which are expected to prevail during the life of the basin (i.e. no ground cover – recently disturbed soils for Rational Method and newly graded areas for SCS Runoff Curve Number).

Step 9. Determine the diameter of the principal spillway riser pipe.

a. If an emergency spillway is included, the principal spillway must at least pass the peak rate of runoff (Q_p) from the basin drainage area for a 2-year storm (Q_2).

b. If an emergency spillway is not included, the principal spillway must pass the peak rate of runoff (Q_p) from the basin drainage area for the 10-year storm (Q_{10}).

c. Refer to Figure 9-31 titled Principal Spillway Design to determine the value of h where h is the difference between the elevation of the crest of the principal spillway and the elevation of the crest of the emergency spillway.

d. Enter Figure 9-32 titled Riser Inflow Curves on the y-axis with Q_p. Q_P is equal to the Q_2 if an emergency spillway is provided and equal to Q_{10} if one is not provided. Choose the smallest riser which will pass the required flow under weir flow conditions with the available head, h.

e. Refer to Figure 9-31 titled Principal Spillway Design to determine H and L, where H is the difference in elevation of the centerline of the outlet of the barrel and the crest of the emergency spillway, and L is the length of the barrel through the embankment.

f. Enter Figure 9-33 from the left column if the barrel is to be constructed with corrugated metal pipe and Figure 9-34 from the left column if the barrel is to be constructed with reinforced concrete pipe with H. Choose the smallest size barrel which will pass the flow provided by the riser. The flow rates shown in Figures 9-33 and 9-34 are for barrel lengths (L) of 70 ft. If L is other than 70 ft., multiply the correction factor shown at the bottom of the table by the flow rate shown in the table to get the flow rate for the actual barrel length.

Step 10. Verify the elevation of the design high water and the required height of the embankment meet design criteria.

a. If an emergency spillway is included, the crest of the principal spillway must be at least 1 ft. below the crest of the emergency spillway.

b. If an emergency spillway is included, the elevation of the peak flow through the emergency spillway (which will be the design high water for the design storm) must be at least 1 ft. below the top of the embankment.

c. If an emergency spillway is not included, the crest of the principal spillway must be at least 3 ft. below the top of the embankment.

d. If an emergency spillway is not included, the elevation of the design high water for the design storm must be 2 ft. below the top of the embankment.

Step 11. Design the emergency spillway.

a. The emergency spillway must pass the remainder of the design storm peak rate of runoff not carried by the principal spillway.

b. Compute the flow over the emergency spillway (Q_e) where $Q_e = Q_{10} - Q_p$

c. Refer to Figure 9-35 titled Excavated Earth Spillway and Table 9-9 Design Data for Earth Spillways.

d. Determine approximate permissible values for B, the bottom width; S, the slope of the exit channel; and X, minimum length of the exit channel.

e. Enter the Table 9-9 Design Data for Earth Spillways and choose an exit channel cross-section which passes the flow over the emergency spillway (Q_e) and meets the other constraints of the site.

f. The maximum permissible velocity for vegetated waterways must be considered when designing an exit channel. Maximum allowable velocities for channel linings are listed in Table 5-3 and Table 5-4 in Chapter 5 of this manual.

g. For a given depth H_p, a decrease in the exit slope from S as given in Table 9-9 Design Data for Earth Spillways decreases spillway discharge, but increasing the exit slope from S does not increase discharge. If an exit slope steeper than the value in Table 9-9 is used, then design procedures should be used to verify adequacy of the exit channel.

h. Data in shaded cells on Table 9-9 Design Data for Earth Spillways should be used with caution, as the resulting sections will be either poorly proportioned or have excessive velocities.

Step 12. Design the anti-vortex device and trash rack for riser pipe.

a. The design procedure for the anti-vortex device and trash rack refers only to riser pipes of corrugated metal. There are numerous ways to provide protection for concrete pipe; these include various hoods and grates and rebar configurations.

b. Refer to Figure 9-36 Anti-Vortex Device Design and Table 9-10 Concentric Trash Rack and Anti-Vortex Device Design Table. Choose cylinder size, support bars, and top requirements based on the diameter of the riser pipe.

Step 13. Determine the number of anti-seep collars required.

a. Anti-seep collars must be used under the conditions specified in the Design Criteria.

b. Anti-seep collars are used to increase the seepage length along the barrel by 10%.

c. Determine the length of the barrel with the saturated zone. This may be done graphically as using Figure 9-37 Pipe Length In Saturated Zone or by solving the following equation:

$$L_s = Y\,(Z + 4)(1 + S/(0.25\ - S))$$

Where:

L_s = Length of barrel in the saturated zone, ft.
Y = Slope of the upstream face of embankment in Z ft. horizontal to one vertical.
S = Slope of the barrel in ft. per ft.

d. Enter Figure 9-39 Number of Anti-Seep Collars Required with Ls. Move horizontally right until one of the lines is intersected. Move vertically until the correct line for barrel diameter is intersected. Move horizontally right to read P, the size of the anti-seep collar.

e. If more than one collar is used, the spacing between collars should be 14 times the projection of the collar above the barrel.

f. Collars should not be located closer than 2 ft. to a pipe joint.

g. See the Figure 9-40 Details of Anti-Seep Collars for further design information.

Step 14. Determine the principal spillway anchoring criteria.

The principal spillway must be firmly anchored to prevent floating. If the riser is over 10 ft. high, the forces acting on the spillway must be calculated. A method of anchoring the spillway which provides a safety factor of 1.25 must be used. If the riser is 10 ft. or less in height, choose one of the two methods as shown on Figure 9-41 Riser Pipe Base Condition For Embankments Less Than 10 Ft. High.

Step 15. Calculate the number of dewatering openings.

Calculate the area and number of dewatering orifices needed to drain the dry storage volume over 12 hrs. Use a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice:

$$A_t = \frac{V_{DS}}{454\,(t)(h_O - h_c)^{1/2}} \qquad n = \frac{183.346(A_t)}{(d)^2}$$

Where:

A_t = total area of dewatering orifice holes (ft.^{2})
n = number of orifice holes
h_o = maximum height from lowest orifice to the principle spillway crest (ft.)
h_c = height from the lowest orifice to the centroid of the orifice configuration (ft.)
t = dewatering time for the dry storage volume {equals 12 hrs.} (hrs.)
V_{DS} = dry storage volume required (cu. yd.)
d = diameter of each orifice hole {minimum equals 2 in.} (in.)

Example Temporary Sediment Basin Design

Problem Statement:

Design a temporary sediment basin to control runoff from a total contributing drainage area of 10 ac. The bottom of the sediment basin is at elevation 1,140.0 ft.

Step 1. Determine the required basin volume.

Determine the required basin volume. The design capacity of the basin must be at least 134 cu. yd. per ac. of total contributing drainage area, half of which shall be in the form of wet storage, and the remaining half as a "drawdown" area or dry storage.

a. Total Storage Volume

$$V_T = A_T \, x \; 134 \; \frac{cu.\ yd.}{ac.}$$

Where:

V_T = The total storage volume for the temporary sediment basin (cu. yd.)
A_T = The total contributing tributary area to the sediment basin (ac.)

$$V_T = 10 \ acres \ x \ 134 \; \frac{cu.\ yd.}{ac.}$$

$$V_T = 1{,}340 \ cu.\ yd.$$

b. Wet Storage Volume

$$V_{WS} = 0.5 \, x \, V_T$$

Where:

V_{PP} = The storage volume for the wet storage portion of the sediment basin (cu. yd.)
V_T = The total storage volume for the temporary sediment basin (cu. yd.)

$V_{WS} = 0.5 \times 1{,}340$ *cu. yd.*

$V_{WS} = 670$ *cu. yd.*

c. Dry Storage Volume

$V_{DS} = 0.5 \times V_T$

Where:

V_{DS} = The storage volume for the dry storage portion of the sediment basin (cu. yd.)
V_T = The total storage volume for the temporary sediment basin (cu. yd.)

$V_{DS} = 0.5 \times 1{,}340$

$V_{DS} = 670$ *cu. yd.*

Step 2. Determine the elevation-area-storage relationship for the sediment basin.

The elevation-area-storage relationship for the sediment pond is determined using 1-ft. contour information at the location where the sediment basin is to be constructed. For each elevation, the surface area of the contour is measured. The incremental volume in the sediment basin is then calculated.

$V_{inc} = 0.5 \times (A_i + A_{i+1}) \times 1$ *ft.*

Where:

V_{inc} = The incremental storage volume between contours ($ft.^3$)
A_i = The surface area of contour elevation i ($ft.^2$)
A_{i+1} = The surface area of contour elevation i + 1 ($ft.^2$)

Example $9{,}425\ ft.^3 = 0.5 \times (9{,}000\ ft. + 9{,}850\ ft.) \times 1\ ft.$

The cumulative volume is the determined by summing the incremental volumes.

Table 9-8 Example Problem Elevation-Area-Storage Relationship

Depth, ft	Elevation,ft	Area[a] ft^2	Incremental Volume (V_{inc})[b], ft^3	Cumulative Volume[c], ft^3	Cumulative Volume[d], cu. yd.
0	1,040	9,000	0	0	0
1	1,041	9,850	9,425	9,425	349
2	1,042	10,750	10,300	19,725	731
3	1,043	11,700	11,225	30,950	1,146
4	1,044	12,650	12,175	43,125	1,597
5	1,045	13,620	13,135	56,260	2,084

[a] Area of each contour elevation as measured on plans

[b] Incremental Volume $V_{inc} = 0.5 \times (A_i + A_{i+1}) \times 1ft$

[c] Cumulative volume is sum of incremental volumes

[d] 27 ft^3 = 1 cu. yd.

Step 3. Determine the surface area and elevation of the wet storage volume.

The surface area of the wet storage volume is estimated using the elevation-area-storage relationship for the sediment basin and interpolating the surface area and elevation equal to the wet storage volume (V_{WS}).

V_{WS} = 670 cu. yd.

The cumulative volume of 670 cu. yd. is achieved between elevation 1,041 ft. and 1,042 ft. Using interpolation, the elevation of cumulative storage equal to 670 cu. yd. is 1,041.8 ft. with a surface area of 10,607 $ft.^2$.

Step 4. Determine the surface area and elevation of the top of the dry storage volume.

The surface area of the dry storage volume is estimated using the elevation-area-storage relationship for the sediment basin and interpolating the surface area and elevation equal to the total storage volume (V_T).

The cumulative volume of 1,340 cu. yd. is achieved between elevations 1,043 ft. and 1,044 ft. Using interpolation, the elevation of cumulative storage equal to 1,340 cu. yd. is 1,043.4 ft. with a surface area of 12,108 ft^2.

Step 5. Determine the basin shape.

The shape of the basin must be such that the effective length is at least twice the effective width.

$$L_e \geq 2 \ x \ W_e \ or \ \frac{L_e}{W_e} \geq 2$$

The effective width is measured from the proposed grading plan as 35 ft. The effective length is measured as 300 ft.

$$\frac{300\,ft.}{35\,ft.} = 8.6 \geq 2$$

The ratio of effective length to effective width is greater than 2; therefore, the basin shape criteria has been satisfied.

Step 6. Determine whether the basin will have a separate emergency spillway.

All sediment basins should have a separate emergency spillway unless site constraints do not allow for one. In this example, the basin will be designed with an emergency spillway.

Step 7. Set the elevation of the principal spillway crest to the elevation of the total storage volume.

Using elevations calculated in Step 4, the elevation of the principal spillway crest is set to 1,043.4 ft.

Step 8. Determine the peak flow rate for the 2-year and 10-year storm events.

Runoff computations shall be completed using the recommended hydrology methods as described in Chapter 2 Hydrology and based upon the soil cover conditions which are expected to prevail during the life of the basin (i.e. no ground cover – recently disturbed soils for Rational Method and newly graded areas for SCS Runoff Curve Number). For this example, the peak runoff flow rate was calculated using the SCS Hydrology method with a CN = 86 and lag time of 10 minutes. Q_2 = 20.7 cfs and Q_{10} = 38.0 cfs.

Step 9. Determine the diameter of the principal spillway riser pipe.

An emergency spillway is included in this design, the principal spillway must at least pass the peak rate from the basin drainage area for a 2-year storm (Q_2 =20.7 cfs).

Refer to Figure 9-31 titled Principal Spillway Design to determine the value of h where h is the difference between the elevation of the crest of the principal spillway and the elevation of the crest of the emergency spillway. In Step 7, the elevation of the crest of the principal spillway was determined to be 1043.4 ft. For this example, the crest of the emergency spillway is set at elevation 1044.5 ft., therefore, h = 1.1 ft. The elevation was chosen because it provides at least one ft. between the principal spillway crest and the emergency spillway crest.

Enter Figure 9-32 titled Riser Inflow Curves on the y-axis with Q_2 = 20.7 cfs and choose the smallest riser which will pass the required flow with the available head, h = 1.1 ft. According to Figure 9-32, a 27-in. riser will pass 20.7 cfs with h = 1.1 ft. but the flow will be orifice flow. Choose the next largest pipe size that will pass 20.7 cfs under weir flow conditions. The riser pipe size is 30 in.

Refer to Figure 9-31 titled Principal Spillway Design to determine H and L, where H is the difference in elevation of the centerline of the outlet of the barrel and the crest of the emergency spillway, and L is the length of the barrel through the embankment. From the preliminary grading plan, H is equal to 15 ft. and L is equal to 80 ft. The barrel will be constructed with reinforced concrete pipe (RCP); therefore, Figure 9-35 is used to estimate the diameter of the barrel pipe. Because the length of the barrel is a length other than 70 ft., the flow rates shown in Figure 9-34 are multiplied by the correction factor shown at the bottom of the table to get the flow rate for the actual barrel length.

For H=15 ft., a 70 ft. long 18-in. RCP will convey 32.1 cfs. The design flow for the barrel pipe is equal to 20.7 cfs. Using a correction factor of 0.97 for an 80-ft. long 18-in. RCP of 0.96, the flow capacity is equal to 0.96 multiplied by 32.1 cfs. The flow capacity is 30.8 cfs which is larger than the design flow. An 18-in. barrel pipe will be used in this design.

Step 10. Verify the elevation of the design high water and the required height of the embankment meet design criteria.

Check that the crest of the principal spillway must be at least 1 ft. below the crest of the emergency spillway. The principal spillway is at elevation 1143.4 ft. and the emergency spillway elevation is 1044.5 ft., a difference of 1.1 ft.

If an emergency spillway is included, the elevation of the peak flow through the emergency spillway (which will be the design high water for the design storm) must be at least 1 ft. below the top of the embankment.

The top of the embankment is 1046.5 ft. which is 2.5 ft. above the emergency spillway elevation.

Step 11. Design the emergency spillway.

The emergency spillway must pass the remainder of the design storm peak rate of runoff not carried by the principal spillway. Compute the flow over the emergency spillway (Q_e) where $Q_e = Q_{10} - Q_2$.

Q_e = *38.0 cfs - 20.7 cfs + 17.3 cfs*

Refer to Figure 9-35 titled Excavated Earth Spillway and Table 9-8 Design Data for Earth Spillways. Determine approximate permissible values for b, the bottom width; s, the slope of the exit channel; and X, minimum length of the exit channel.

Enter the Table 9-8 Design Data for Earth Spillways and choose an exit channel cross-section which passes the flow over the emergency spillway (Q_e) and meets the other constraints of the site. Using Table 9-8 and Q_e = 17.3 cfs, several emergency spillway configurations could be used. One combination of variables that achieves the design objectives is:

H_P = depth of water over the emergency spillway = 0.8 ft.
B = bottom width of control section= 12 ft.
Q_e = peak flow over emergency spillway = 19 cfs
v = velocity in exit channel =3.5 ft. per second
S = longitudinal slope of exit channel = 3.5 ft. per 100 ft.
X = length of exit channel = 44 ft.

The maximum permissible velocity for vegetated waterways must be considered when designing an exit channel. Maximum allowable velocities for channel linings are listed in Table 5-3 and Table 5-4 in Chapter 5 of this manual.

The emergency spillway is to be planted in Bermuda grass. Table 5-4 shows maximum velocity for bermuda grass and easily eroded soils is between 4 and 6 ft. per second. The velocity of 3.5 ft. per second for the chosen design is below the maximum recommended velocity.

The elevation of the peak flow through the emergency spillway (which will be the design high water for the design storm) must be at least 1 ft. below the top of the embankment. The elevation of the emergency spillway is 1,044.5 ft. plus the depth of the water over the emergency spillway of 0.8 ft. is equal to 1,045.3 ft. which is the elevation of the peak flow over the spillway. The difference between the top of embankment elevation of 1,046.5 ft. and the peak flow elevation of 1,045.0 ft. is 1.5 ft. which is greater than the 1 ft. requirement.

Step 12. Design the anti-vortex device and trash rack for riser pipe.

The design procedure for the anti-vortex device and trash rack refers only to riser pipes of corrugated metal. There are numerous ways to provide protection for concrete pipe; these include various hoods and grates and rebar configurations.

Refer to Figure 9-36 Anti-Vortex Device Design and Table 9-10 Concentric Trash Rack and Anti-Vortex Device Design Table. Choose cylinder size, support bars, and top requirements based on the diameter of the riser pipe.

Step 13. Determine the number of anti-seep collars required.

Determine the length of the barrel with the saturated zone. This may be done graphically using Figure 9-37 Pipe Length In Saturated Zone or by solving the following equation:

$$L_s = Y \times (Z + 4) \times \left[1 + \frac{S}{(0.25 - S)}\right]$$

Where:

L_s = Length of barrel in the saturated zone, ft.
Y = Slope of the upstream face of embankment , in Z ft. horizontal to 1 vertical
S = Slope of the barrel, ft./ft.

For this example, the slope of the upstream face of embankment is 2.5 horizontal to 1 vertical and the slope of the barrel is 2-percent or 0.02 ft. per ft.

$$L_s = 2.5 \times (2.5 + 4) \times \left[1 + \frac{.02}{(0.25 - 0.02)}\right]$$

L_s = 18 ft.

Use Figure 9-38 to determine the number and size of collars required. Enter the figure from the left side with a saturated length of 18 ft. and move horizontally until the line labeled as “1 Collar” is reached. Then move vertically to a line representing a barrel diameter of 18 in. (1.5 ft.). This line can be interpolated between the 1 ft. and 2 ft. diameter lines. Move horizontally to determine the anti-seep collar size for one collar and an 18-in. barrel size. The anti-seep collar should be 3.2 ft. by 3.2 ft. if one collar is used.

If more than one collar is used, the spacing between collars should be 14 times the projection of the collar above the barrel. Collars should not be located closer than 2 ft. to a pipe joint. See the Figure 9-39 Details of Anti-Seep Collars for further design information.

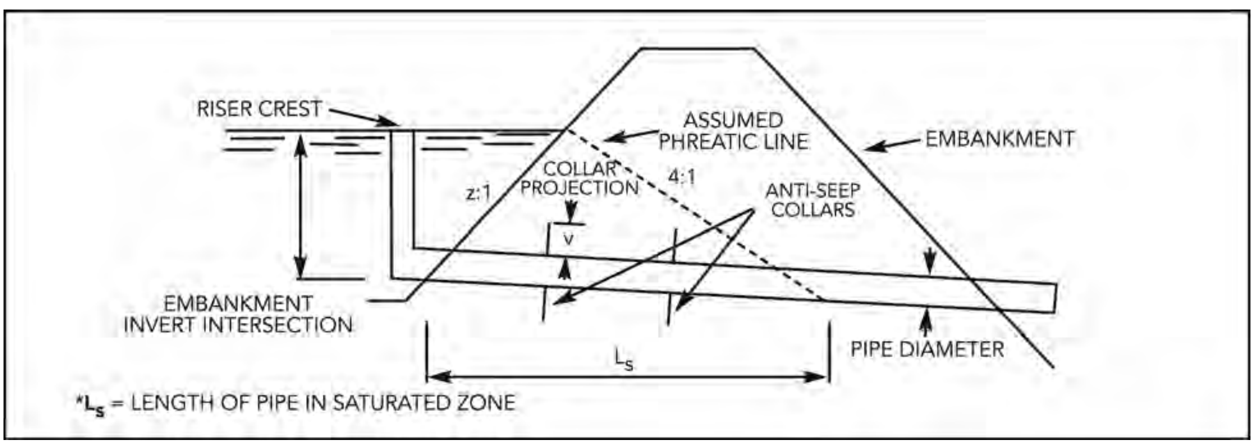


Figure 9-28 Anti-Seep Collar Design

Step 14. Determine the principal spillway anchoring criteria.

The principal spillway must be firmly anchored to prevent its floating. The height of the riser in this example is 10 ft. or less in height; therefore, either of the two methods shown on Figure 9-40 Riser Pipe Base Condition For Embankments Less Than 10 Ft. High can be used to anchor the riser pipe.

Step 15. Calculate the number of dewatering openings.

Calculate the area and number of dewatering orifices needed to drain the dry storage volume over 12 hrs. Use a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice:

$$A_t = \frac{V_{DS}}{454\,(t)\,(h_o - h_c)^{1/2}}$$

Where:

A_t = total area of dewatering orifice holes (ft.^{2})
n = number of orifice holes
h_o = maximum height from lowest orifice to the principle spillway crest (ft.) = 1043.4 ft. - 1041.8 ft. = 1.6 ft.
h_c = height from the lowest orifice to the centroid of the orifice configuration (ft.) = 1.6 / 2 = 0.8 ft.
t = dewatering time for the dry storage volume {equals 12 hrs.} (hrs.)
V_{DS} = dry storage volume required (cu. yd.)
d = diameter of each orifice hole {minimum equals 2 in.} (in.)

$$A_t = \frac{670}{454\,(12)\,(1.6 - 0.8)^{1/2}}$$

$$A_t = 0.137\ ft.^2$$

$$n = \frac{183.346\,(A_t)}{(d)^2}$$

$$n = \frac{183.346\,(0.137)}{(2)^2}$$

$$n = 6.3 \text{ round up to } 7$$

The number of 2-in. orifice openings required to release the dry storage volume within 12 hrs. is 7.

The following Temporary Sediment Basin Design Data Sheet shall be filled out and submitted when applying for permit for construction of a temporary sediment basin. An example Temporary Sediment Basin Design Data Sheet is found in Appendix A.

Temporary Sediment Basin Design Data Sheet

(with emergency spillway or without emergency spillway)

Project: ____

Basin #: ____________ Location: ____________________

Total area draining to basin: ________ac.

Elevation of bottom of sediment basin = _______ ft.

Basin Volume Design (Step 1)

1. Total Storage Volume (134 cu. yd. per ac. multiplied by total area draining to basin in ac.)

   134 cu. yd. x _____ ac. = _______ cu. yd.

2. Wet Storage Volume (Minimum required is 50% of Total Storage Volume)

   0.50 x _____ Total Storage Volume = _______ wet storage cu. yd.

3. Clean Out Volume

   0.50 x _____ Wet Storage Volume = _______ clean out volume cu. yd.

4. Dry Storage Volume (Minimum required is 50% of Total Storage Volume)

   0.50 x _____ Total Storage Volume = _______ dry storage cu. yd.

Elevation-Area-Storage-Relationship (Step 2)

Depth, ft	Elevation,ft	Area[a], ft^2	Incremental Volume (V_{inc})[b], ft^3	Cumulative Volume[c], ft^3	Cumulative Volume[d], cu. yd.
0			0	0	0
1					
2					
3					
4					
5					

[a] Area of each contour elevation as measured on plans
[b] Incremental Volume
[c] Cumulative volume is sum of incremental volumes
[d] 27 $ft.^3$ = 1 cu. yd.

Step 3 Results

5. Surface area and elevation of the wet storage volume.

   Wet Storage Elevation = ft.

   Surface area for wet storage __________ $ft.^2$

6. Surface area and elevation of the Clean Out Volume.

   Clean Out Elevation = ft.

   Surface area for Clean Out Volume ________________ $ft.^2$

Step 4 Results

7. Surface area and elevation of the Total Storage Volume.

   Top of Total Storage Volume = ft.

   Surface area for Total Storage Volume ________________ $ft.^2$

Step 5 Results

Basin Shape (at a minimum the effective length should be twice the effective width*)

8. Length of Flow, ft. L_e ______________ =_________________
   Effective Width, ft. W_e ______________

   *If > 2, baffles are not required ______________
   *If < 2, baffles are required ______________

Step 6 Results

Will the basin have a separate emergency spillway? Yes____. No____.

Step 7 Results (Elevation of principal spillway crest is equal to elevation of total storage volume in Step 4)

9. Principle Spillway (Riser) Elevation = _________________ ft

Step 8 Results

Runoff

10. Q_2 = __________________cfs (Chapter 2.5)

11. Q_{10} = __________________cfs (Chapter 2.5)

Step 9 Results

Principal Spillway Design

12. With emergency spillway, required minimum spillway capacity, $Q_p = Q_2$. (riser and barrel)
    Design Q_p = __________________cfs.

    Without emergency spillway, required minimum spillway capacity, $Q_p = Q_{10}$. (riser and barrel)
    Design Q_p = __________________cfs.

13. Emergency Spillway Crest =_________________ft.

14. Design High Water (10 Year Storm minimum) = ___________________ft

15. With emergency spillway:

    Assumed available head (h) = _________________________ft. (using Q_2)

    h = Crest of Emergency Spillway Elevation – Crest of Riser Elevation

    Without Emergency spillway:

    Assumed available head (h) = ____________________ft. (using Q_{10})

    h = 10-Year Elevation – Principal Spillway (Riser) Elevation

16. With emergency spillway:

    Barrel length (L) = _________________ft.

    Inlet Head (H) on barrel through embankment = _____________________ft.
    From Pipe Flow Charts (Figure 9-33 and 9-34)

17. Barrel diameter = in.

18. Riser diameter (D_r) = in. Actual head (h) = ft.
    From Riser Inflow Curves (Figure 9-32)

    Note: Avoid orifice flow conditions.

Step 10 Results

19. Height difference between the principle spillway elevation and the emergency spillway elevation __________ft. (1 ft. minimum).

20. With emergency spillway: Top of Embankment (minimum of 1 ft. above 10-year design storm elevation) _________ ft.

21. Without emergency spillway: Top of Embankment (minimum of 2 ft. above 10-year design storm elevation) _________ ft.

22. Height difference between the emergency spillway elevation and the top of embankment elevation _________ft. (1 ft. minimum).

Step 11 Results

Emergency Spillway Design

23. Required spillway capacity Q_e = Design Q_{Total} – Q_2 =_____________________cfs.

24. Bottom width of control section (b) = __________________ft.; the longitudinal slope of the exit channel (S) = ft./100 ft.; and the length of the exit channel (X) = _______________ft.

    From Design Data Table for Emergency Spillways (Table 9-8)

25. 2-Year Storm Elevation = __________ft.

Step 12 Results

26. Trash rack and anti-vortex device

Diameter = ________ in.

Height = ________ in.

From Trash Rack/Anti-vortex device Design Table (Table 9-10)

Steps 13 Results

Anti-Seep Collar Design

27. Depth of water at principal spillway crest (Y) = ________________ft.

Slope of upstream face of embankment (Z) = ______________:1.

Slope of principal spillway barrel (S_b) = ______________%

Length of barrel in saturated zone (L_s) = ________________ft.

28. Number of collars required ____________________________________= dimensions =______________

From Anti-seep Collar Graphs (Figure 9-38 and 9-39)

Step 14 Results

29. Height of Principal Spillway Riser _________ ft.

Riser 10 ft. or less use either concrete base _________ or a steel base_________.

Riser over 10 ft. must be designed with a safety factor of 1.25 _________.

Step 15 Results

30. Dewatering Orifice Invert Elevation= ___________________________ft.

31. Number of dewatering orifices ______________

32. Diameter* of dewatering orifices ________________in.

*Minimum = 2 in. diameter

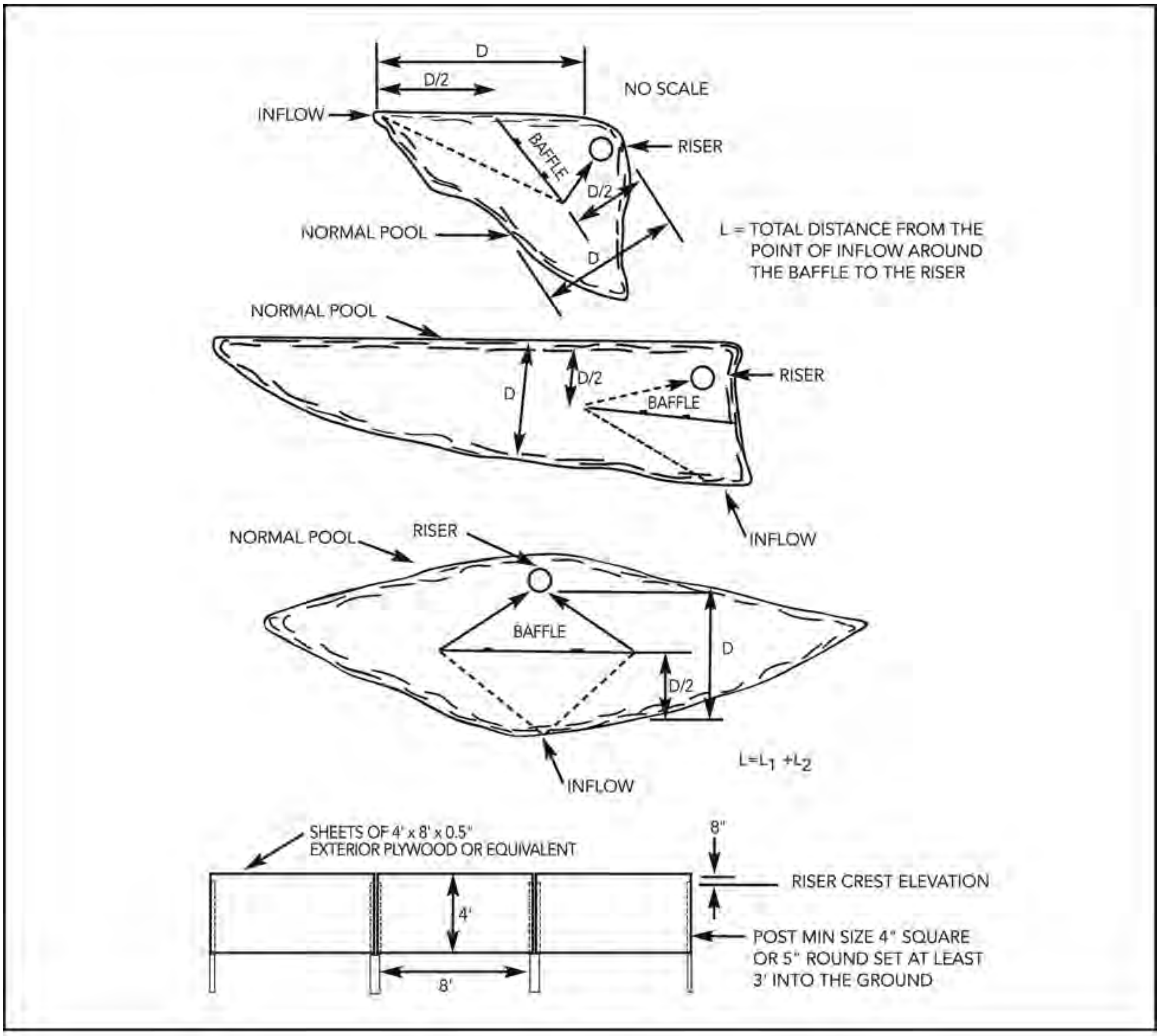


Figure 9-29 Baffle Locations In Sediment Basin

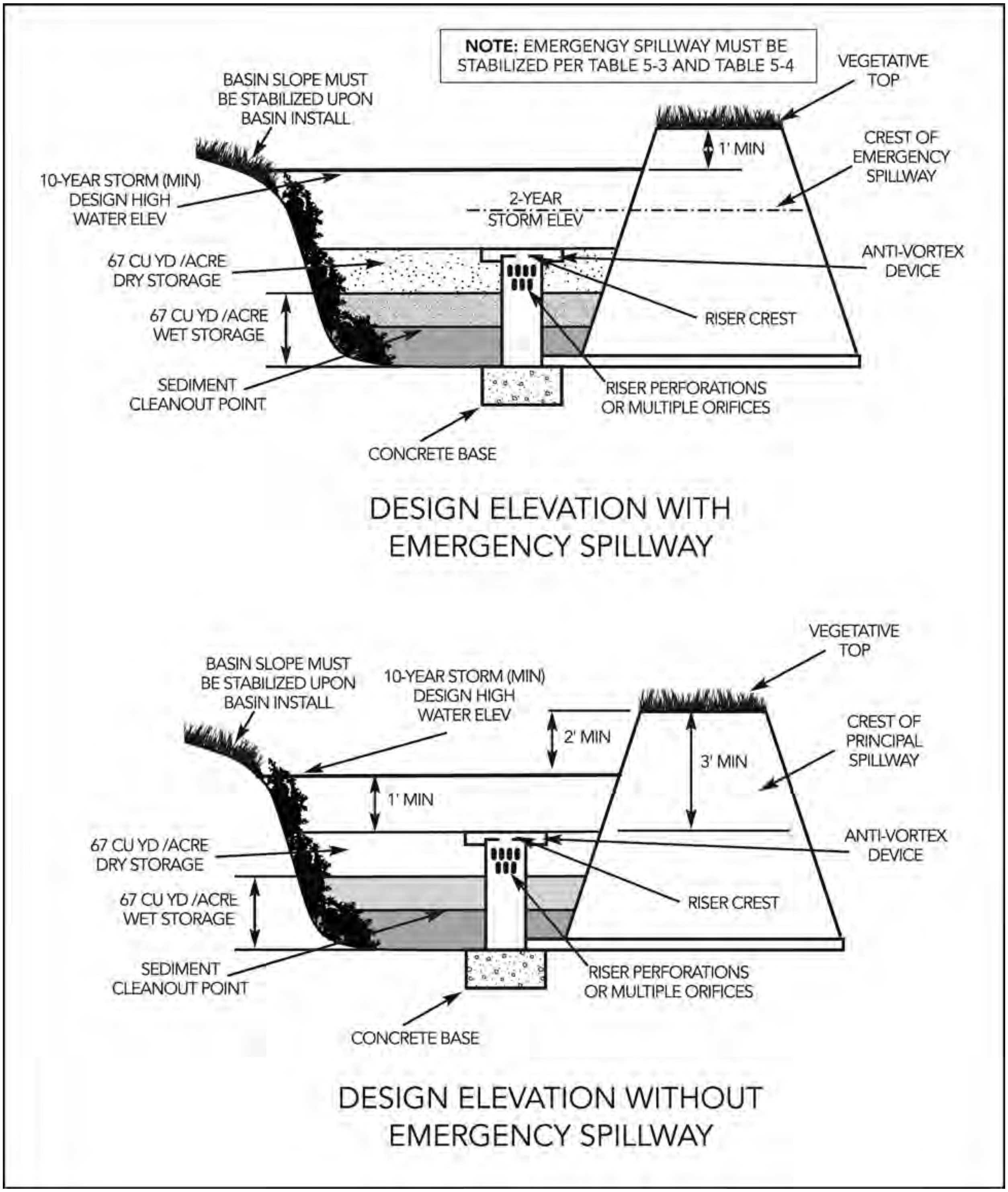


Figure 9-30 Design Elevation for Temporary Sediment Basin

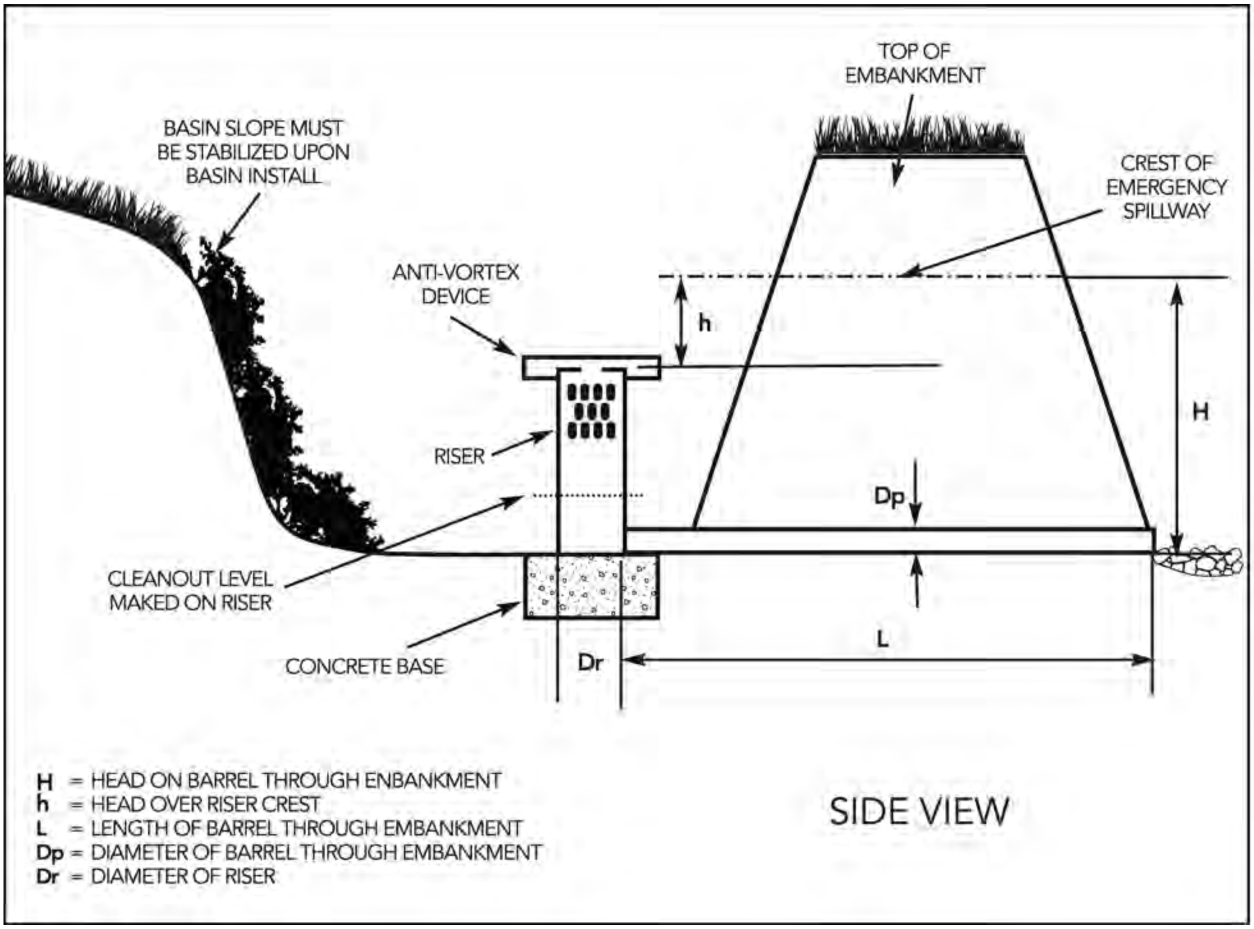


Figure 9-31 Principal Spillway Design

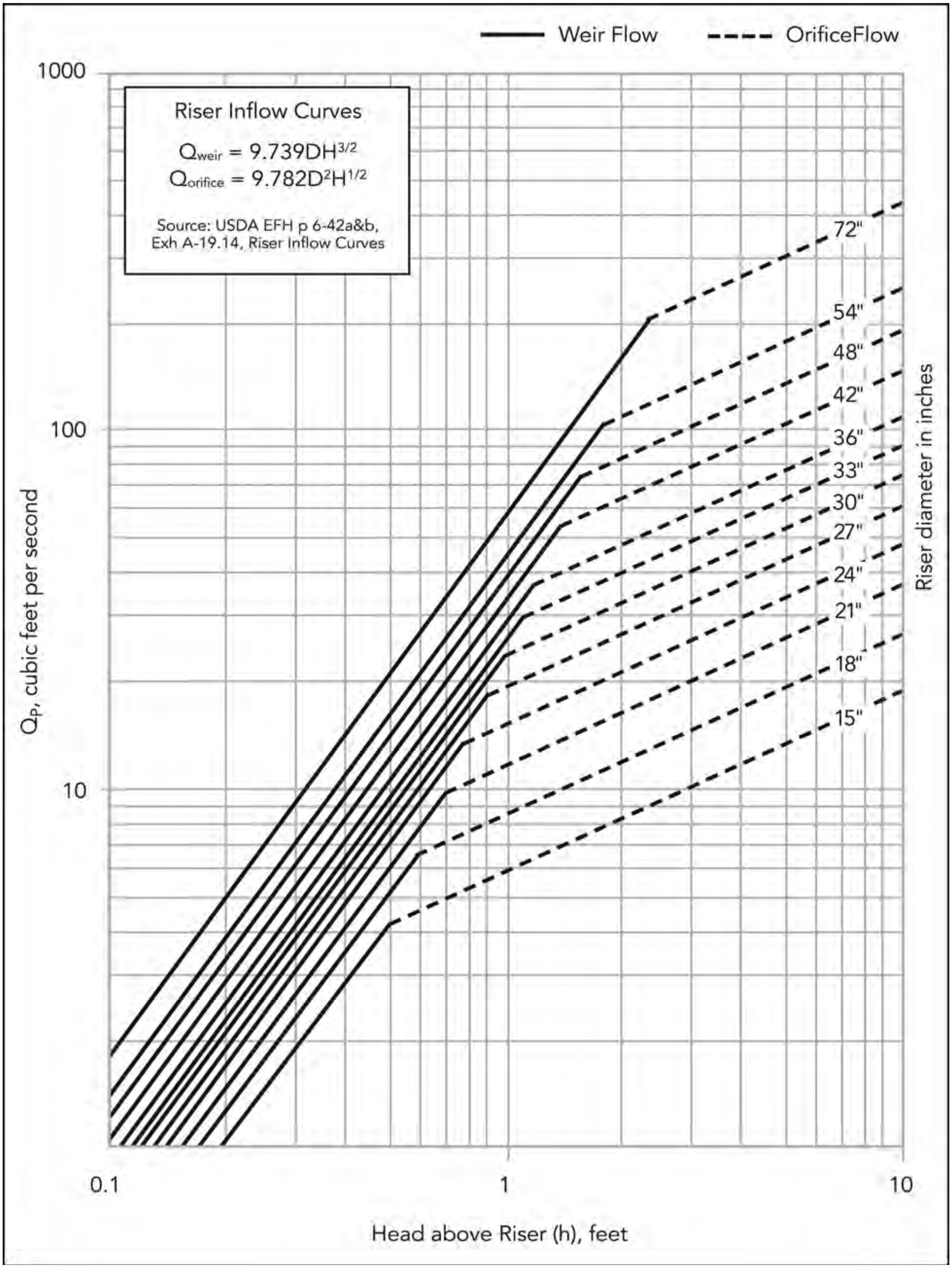


Figure 9-32 Riser Inflow Curves

FOR CORRUGATED METAL PIPE INLET $K_m = K_e + K_b + 1.0$ AND 70 FEET OF CORRUGATED METAL PIPE CONDUIT (Full Flow Assumed)
Note correction factor for pipe lengths other than 70 feet diameter of pipe in inches

H, In Feet	6"	8"	10"	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1	0.33	0.70	1.25	1.98	3.48	5.47	7.99	11.0	18.8	28.8	41.1	55.7	72.6	91.8	113	137	163	191	222	255	290
2	0.47	0.99	1.76	2.80	4.92	7.74	11.3	15.6	26.6	40.8	58.2	78.8	103	130	160	194	231	271	314	360	410
3	0.58	1.22	2.16	3.43	6.02	9.48	13.8	19.1	32.6	49.9	71.2	96.5	126	159	196	237	282	331	384	441	502
4	0.67	1.40	2.49	3.97	6.96	10.9	16.0	22.1	37.6	57.7	82.3	111	145	184	226	274	326	383	444	510	580
5	0.74	1.57	2.79	4.43	7.78	12.2	17.9	24.7	42.1	64.5	92.0	125	162	205	253	306	365	428	496	570	648
6	0.82	1.72	3.05	4.86	8.52	13.4	19.6	27.0	46.1	70.6	101	136	178	235	277	336	399	469	544	624	710
7	0.88	1.86	3.30	5.25	9.20	14.5	21.1	29.2	49.8	76.3	109	147	192	243	300	362	431	506	587	674	767
8	0.94	1.99	3.53	5.61	9.84	15.5	22.6	31.2	53.2	81.5	116	158	205	260	320	388	461	541	628	721	820
9	1.00	2.11	3.74	5.95	10.4	16.4	24.0	33.1	56.4	86.5	123	167	218	275	340	411	489	574	666	764	870
10	1.05	2.22	3.94	6.27	11.0	17.3	25.3	34.9	59.5	91.2	130	176	230	290	358	433	516	605	702	806	917
11	1.10	2.33	4.13	6.58	11.5	18.2	26.5	36.6	62.4	95.6	136	185	241	304	376	454	541	635	736	845	962
12	1.15	2.43	4.32	6.87	12.1	19.0	27.7	38.2	35.2	99.9	142	193	252	318	392	475	565	663	769	883	1004
13	1.20	2.53	4.49	7.15	12.6	19.7	28.8	39.8	67.8	104	148	201	262	331	408	494	588	690	800	919	1045
14	1.25	2.63	4.66	7.42	13.0	20.5	29.9	41.3	70.4	108	154	208	272	343	424	513	610	716	830	953	1085
15	1.29	2.72	4.83	7.68	13.5	21.2	30.9	42.8	72.8	112	159	216	281	355	439	531	631	741	860	987	1123
16	1.33	2.81	4.99	7.93	13.9	21.9	32.0	44.2	75.2	115	165	223	290	367	453	548	652	765	888	1019	1160
17	1.37	2.90	5.14	8.18	14.3	22.6	32.9	45.5	77.5	119	170	230	229	378	467	565	672	789	915	1051	1195
18	1.41	2.98	5.29	8.41	14.8	23.2	33.9	46.8	79.8	120	174	236	308	389	480	581	692	812	942	1081	1230
19	1.45	3.06	5.43	8.64	15.2	23.9	34.8	48.1	82.0	126	179	243	316	400	494	597	711	834	967	1111	1264
20	1.49	3.14	5.57	8.87	15.6	24.5	35.7	49.4	84.1	129	184	249	325	410	506	613	729	856	993	1139	1297
21	1.53	3.22	5.71	9.09	15.9	25.1	36.6	50.6	86.2	132	188	255	333	421	519	628	747	877	1017	1168	1329
22	1.56	3.29	5.85	9.30	16.3	25.7	37.5	51.8	88.2	135	193	261	341	430	531	643	765	898	1041	1195	1360
23	1.60	3.37	5.98	9.51	16.7	26.2	38.3	53.0	90.2	138	197	267	348	440	543	657	782	918	1064	1222	1390
24	1.63	3.44	6.11	9.72	17.0	26.8	39.1	54.1	92.1	141	201	273	356	450	555	671	799	937	1087	1248	1420
25	1.66	3.51	6.23	9.92	17.4	27.4	39.9	55.2	94.0	144	206	279	363	459	566	685	815	957	1110	1274	1450
26	1.70	3.85	6.6	10.1	17.7	27.9	40.7	56.3	95.9	147	210	284	370	468	577	699	831	976	1132	1299	1478
27	1.71	3.65	6.48	10.3	18.1	28.4	41.5	57.4	97.7	150	214	290	377	477	588	712	847	994	1153	1324	1507
28	1.76	3.72	6.60	10.5	18.4	29.0	42.3	58.4	99.5	153	218	295	384	486	599	725	863	1013	1174	1348	1534
29	1.79	3.78	6.71	10.7	18.7	29.5	43.0	59.5	101	155	221	300	391	494	610	738	878	1030	1195	1372	1561
30	1.82	3.85	6.83	10.9	19.1	30.0	43.7	60.5	103	158	225	305	398	503	620	750	893	1048	1216	1396	1588
L, In Feet	Correction Factors For Other Pipe Lengths																				
20	1.69	1.63	1.58	1.53	1.47	1.42	1.37	1.34	1.28	1.24	1.20	1.18	1.16	1.14	1.13	1.11	1.10	1.10	1.09	1.08	1.08
30	1.44	1.41	1.39	1.36	1.32	1.29	1.27	1.24	1.21	1.18	1.15	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.07	1.06	1.06
40	1.28	1.27	1.25	1.23	1.21	1.20	1.18	1.17	1.14	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.05	1.04
50	1.16	1.16	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.04	1.03	1.03	1.03
60	1.07	1.07	1.07	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.03	1.02	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.94	.94	.95	.95	.95	.95	.96	.96	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99	.99	.99
90	.89	.89	.90	.90	.91	.91	.92	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97	.97	.97	.97	.94
100	.85	.85	.86	.86	.87	.88	.89	.89	.90	.91	.92	.93	.93	.94	.94	.95	.95	.95	.96	.96	.94
120	.78	.79	.79	.90	.81	.82	.83	.83	.85	.86	.87	.89	.89	.90	.91	.89	.92	.93	.93	.94	.92
140	.72	.73	.74	.75	.76	.77	.78	.79	.81	.82	.84	.85	.86	.87	.88	.86	.89	.90	.91	.91	.90
160	.68	.69	.69	.70	.71	.73	.74	.75	.77	.79	.80	.82	.83	.84	.85	.86	.87	.88	.89	.89	

Figure 9-33 Pipe Flow Chart, n = 0.025

FOR REINFORCED CONCRETE PIPE INLET $K_m = K_e + K_b = 0.65$ AND 70 FEET OF REINFORCED CONCRETE PIPE CONDUIT
(Full Flow Assumed) Note correction factor for pipe lengths other than 70 feetdiameter of pipe in inches

H, In Feet	12"	15"	18"	21"	24"	30"	36"	42"	49"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1	3.22	5.44	8.29	11.8	15.9	26.0	38.6	53.8	71.4	91.5	114	139	167	197	229	264	302	342
2	4.55	7.69	11.7	16.7	22.5	36.8	54.6	76.0	101	129	161	197	236	278	324	374	427	483
3	5.57	9.42	14.4	20.4	27.5	45.0	66.9	93.1	124	159	198	241	289	341	397	458	523	592
4	6.43	10.9	16.6	23.5	31.8	52.0	77.3	108	143	183	228	278	334	394	459	529	604	683
5	7.19	12.2	18.5	26.3	35.5	58.1	86.4	120	160	205	255	311	373	440	513	591	675	764
6	7.88	13.3	20.3	28.8	38.9	63.7	94.6	132	175	224	280	341	409	482	562	647	739	837
7	8.51	14.4	21.9	31.1	42.0	68.8	102	142	189	242	302	368	441	521	607	699	798	904
8	9.10	15.4	23.5	33.3	44.9	73.5	109	152	202	259	323	394	472	557	685	748	854	966
9	9.65	16.3	24.9	35.3	47.7	78.0	116	161	214	275	342	418	500	590	688	793	905	1025
10	10.2	17.2	26.2	37.2	50.2	82.2	122	170	226	289	361	440	527	622	725	836	954	1080
11	10.7	18.0	27.5	39.0	52.7	86.2	128	178	237	304	379	462	553	653	761	877	1001	1133
12	11.1	18.9	28.7	40.8	55.0	90.1	134	186	247	317	395	482	578	382	794	916	1045	1184
13	11.6	19.6	29.9	42.4	57.3	93.7	139	194	257	330	411	502	601	710	827	953	1088	1232
14	12.0	20.4	31.0	44.1	59.4	97.3	145	201	267	342	427	521	624	736	858	989	1129	1278
15	12.5	21.1	32.1	45.6	61.5	101	150	208	277	354	442	539	646	762	888	1024	1169	1323
16	12.9	21.8	33.2	47.1	63.5	104	155	215	286	366	457	557	667	787	917	1057	1207	1367
17	13.3	22.4	34.2	48.5	65.5	107	159	222	294	377	471	574	688	812	946	1090	1244	1409
18	13.7	23.1	35.2	49.9	67.4	110	164	228	303	388	484	591	708	835	973	1121	1280	1450
19	14.0	23.7	36.1	51.3	69.2	113	168	234	311	399	497	607	727	858	1000	1152	1315	1489
20	14.4	24.3	37.1	52.6	71.0	116	173	240	319	409	510	623	746	880	1026	1182	1350	1528
21	14.7	24.9	38.0	53.9	72.8	119	177	246	327	419	523	638	764	902	1051	1211	1383	1566
22	15.1	25.5	38.9	55.2	74.5	122	181	252	335	429	535	653	782	923	1076	1240	1415	1603
23	15.4	26.1	39.8	56.5	76.2	125	186	258	342	439	547	68	800	944	1100	1268	1447	1639
24	15.8	26.7	40.6	57.7	77.8	127	189	263	350	448	559	682	817	964	1123	1295	1478	1674
25	16.1	27.2	41.5	58.9	79.4	130	193	269	357	458	571	696	834	984	1147	1322	1509	1708
26	16.4	27.7	42.3	60.0	81.0	133	197	274	364	467	582	710	850	1004	1169	1348	1539	1742
27	16.7	28.3	43.1	61.2	82.5	135	201	279	371	476	593	723	867	1023	1192	1373	1568	1775
28	17.0	28.8	43.9	62.3	84.1	138	204	285	378	484	604	737	883	1041	1214	1399	1597	1808
29	17.3	29.3	44.7	63.4	85.5	140	208	290	384	493	615	750	898	1060	1235	1423	1625	1840
30	17.6	29.8	45.4	64.5	97.0	142	212	294	391	501	625	763	913	1078	1256	1448	1653	1871
L, In Feet	Correction Factors For Other Pipe Lengths																	
20	1.30	1.24	1.21	1.18	1.15	1.12	1.10	1.08	1.07	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.03
30	1.22	1.18	1.15	1.13	1.12	1.09	1.08	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02
40	1.15	1.13	1.11	1.10	1.08	1.07	10.5	1.05	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02
50	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01
60	1.04	1.04	1.03	1.03	10.3	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.96	.97	.97	.97	.98	.98	.98	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99
90	..93	.94	.94	.95	.95	.96	.97	.97	.98	.98	.98	.98	.98	.99	.99	.99	.99	.99
100	.90	.91	.92	.93	.93	.95	.95	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99
120	.84	.86	.87	.89	.90	.91	.93	.94	.94	.95	.96	.96	.96	.97	.97	.97	.97	.98
140	.80	.82	.83	.85	.86	.88	.90	.91	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97
160	.76	.78	.80	.82	.83	.86	.88	.89	.90	.91	.92	.93	.94	.94	.95	.95	.95	.96

Figure 9-34 Pipe Flow Chart, n = 0.013

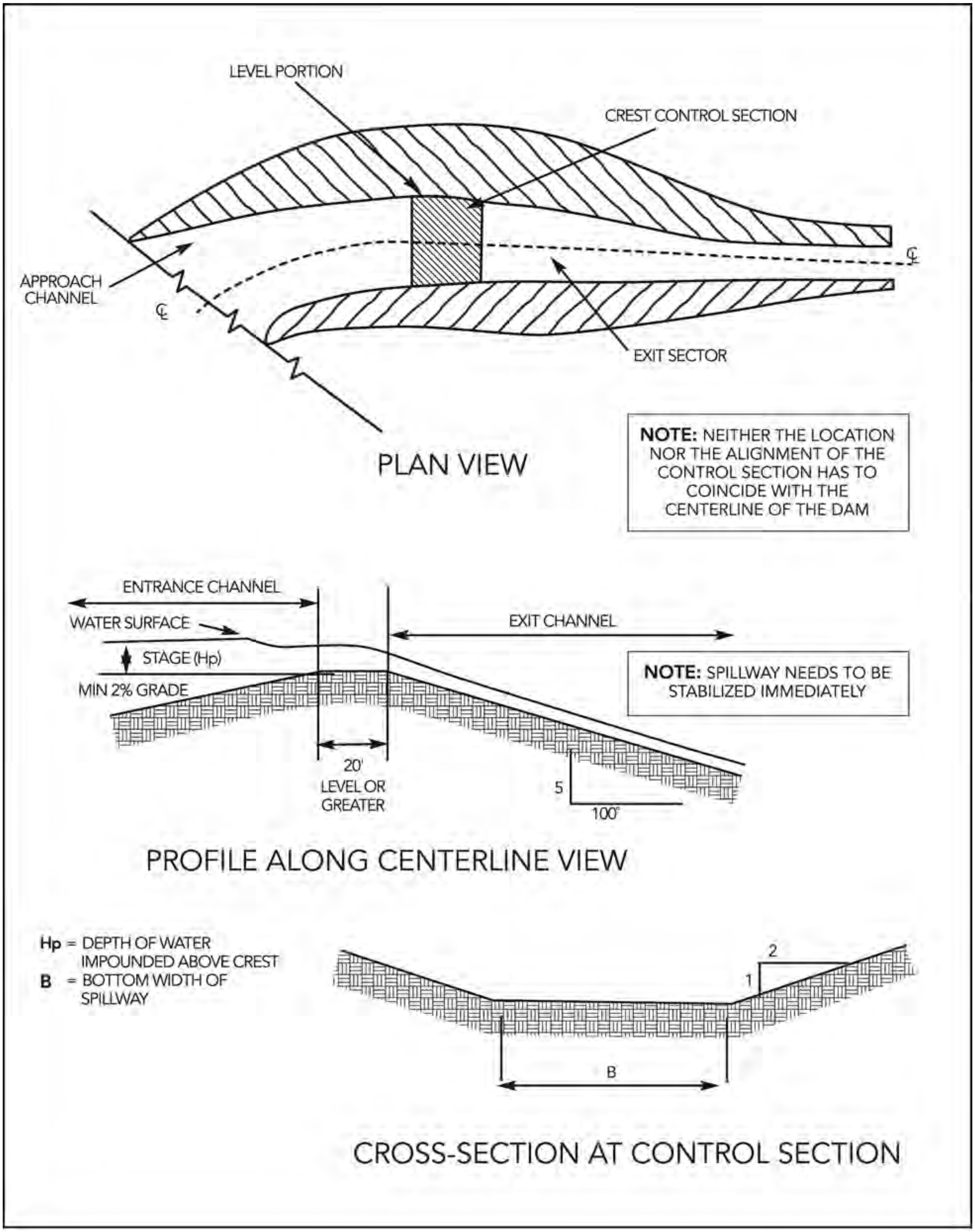


Figure 9-35 Excavated Earth Spillways

Table 9-9 Design Data for Excavated Earth Spillway

Stage (Hp) in Feet	Spillway Variable[1]	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_e	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_e	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_e	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_e	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_e	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_e	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_e	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_e	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
	V	4.4	4.4	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_e	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_e	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	4.9	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]Spillway Variables
Qe = flow through emergency spillway, cfs
V = velocity in exit channel, ft/sec
S = longitudinal slope of exit channel, ft/100 ft
X = length of exit channel, ft

Table 9-9 Design Data for Excavated Earth Spillway (continued)

Stage (Hp) in Feet	Spillway Variable[1]	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_e	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_e	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_e	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_e	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_e	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_e	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_e	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_e	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
	V	4.4	4.4	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_e	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_e	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	4.9	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]Spillway Variables
Qe = flow through emergency spillway, cfs
V = velocity in exit channel, ft/sec
S = longitudinal slope of exit channel, ft/100 ft
X = length of exit channel, ft

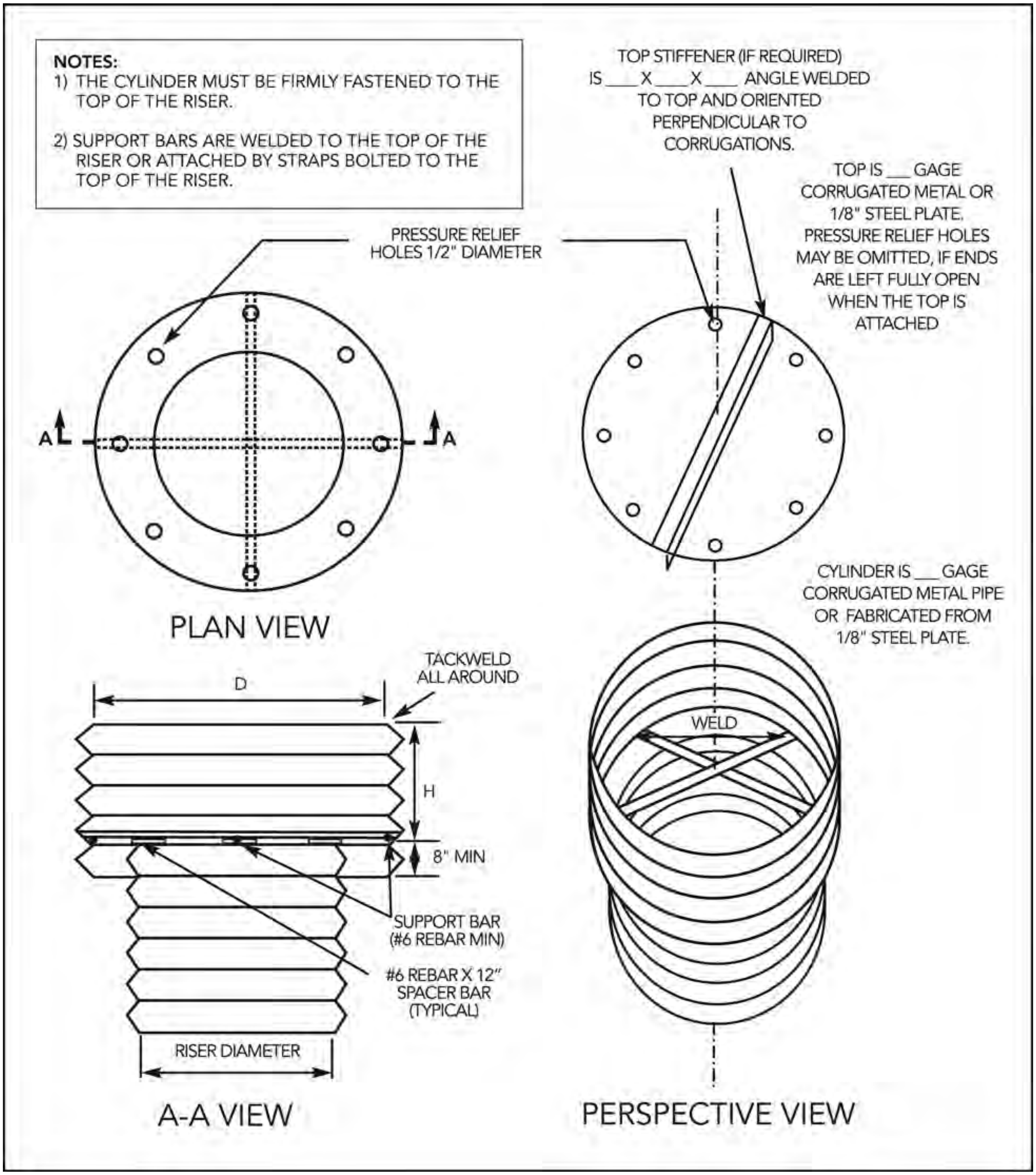


Figure 9-36 Anti-Vortex Device Design

Table 9-10 Concentric Trash Rack and Anti-Vortex Device Design

Riser Diameter, Inches	Cylinder		Height, Inches	Minimum Size Support Bar	Minimum Top	
	Diameter, Inches	Thickness, Gage			Thickness	Stiffener
12	18	16	6	#6 Rebar or 1 ½ x 1 ½ x 3/16 angle	16 ga. (F&C)	-
15	21	16	7	" "	" "	-
18	27	16	8	" "	" "	-
21	30	16	11	" "	16 ga. (C), 14 ga. (F)	-
24	36	16	13	" "	" "	-
27	42	16	15	" "	" "	-
36	54	14	17	#8 Rebar	14 ga. (C), 12 ga. (F)	-
42	60	16	19	" "	" "	-
48	72	16	21	1 ¼" pipe or 1 ¼ x ¼ angle	14 ga. (C), 10 ga. (F)	-
54	78	16	25	" "	" "	-
60	90	14	29	1 ½" pipe or 1 ½ x 1 ½ x ¼ angle	12 ga. (C), 8ga. (F)	-
66	96	14	33	2" pipe or 2 x 2 x 3/16 angle	12 ga. (C), 8 ga. (F) w/stiffener	2 x 2 x ¼ angle
72	102	14	36	" "	" "	2 ½ x 2 ½ x ¼ angle
78	114	14	39	2 ½" pipe or 2 x 2 x ¼ angle	" "	" "
84	120	12	42	2 ½" pipe or 2 ½ x 2 ½ x ¼ angle	" "	2 ½ x 2 ½ x 5/16 angle

Notes:

1. The criterion for sizing the cylinder is that the area between the inside of the cylinder and the outside of the riser is equal to or greater than the area inside the riser. Therefore, the above table is invalid for use with concrete pipe risers.

2. Corrugation for 12"-36" pipe measures 2.67" x 0.5"; for 42"-84" the corrugation measures 5" x 1" or 8" x 1".

3. C = corrugated; F = flat.

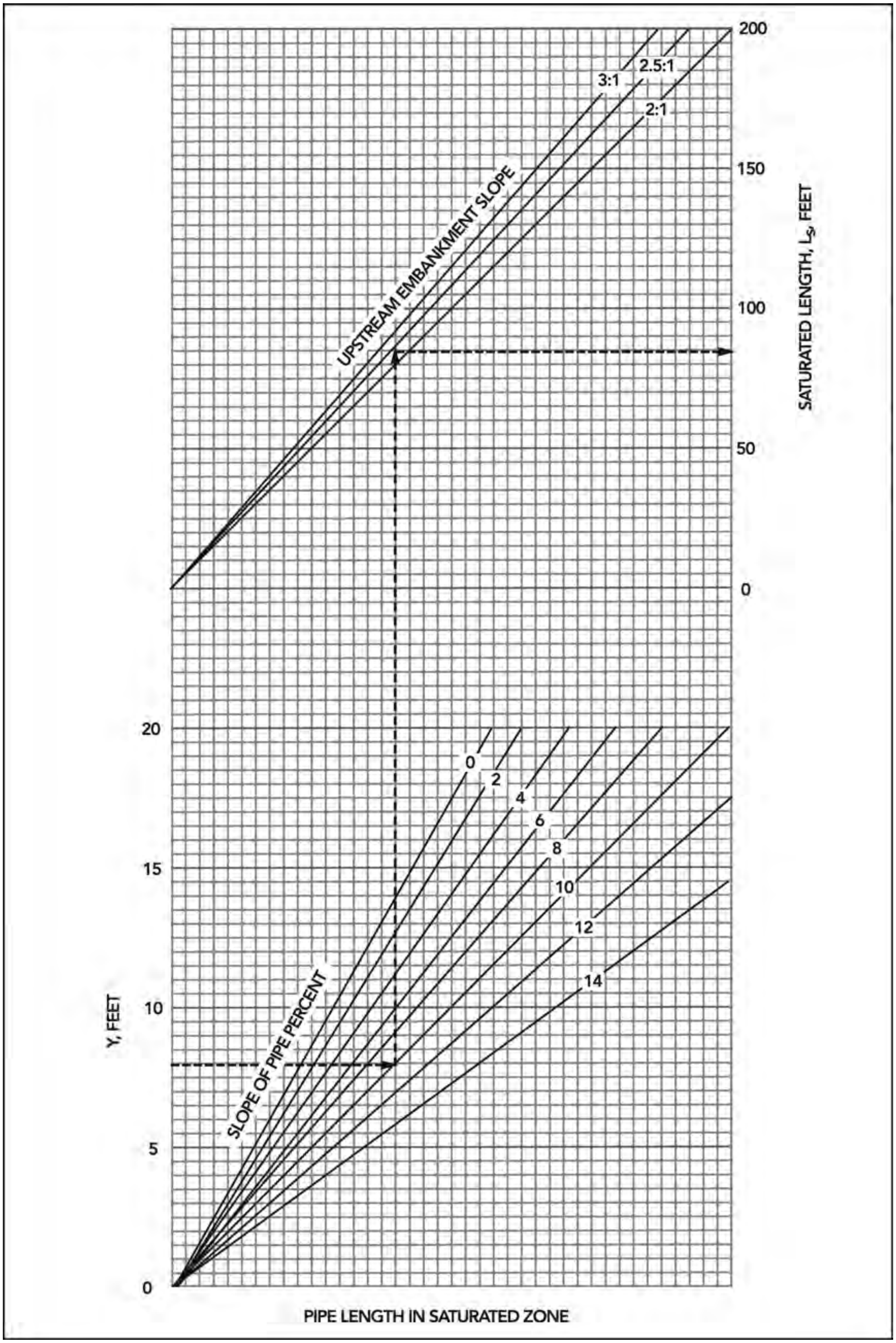


Figure 9-37 Pipe Length In Saturated Zone

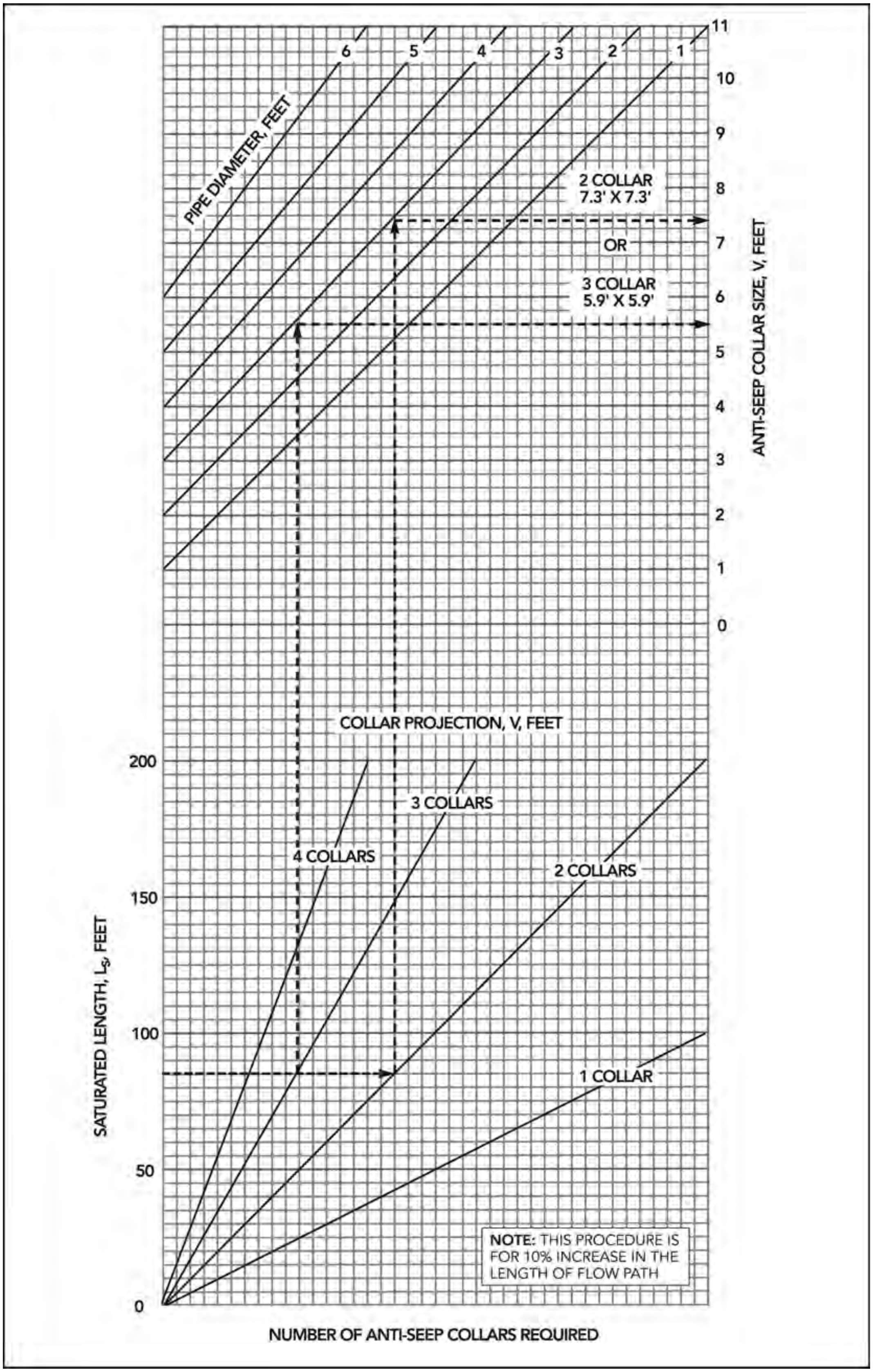


Figure 9-38 Number of Anti-Seep Collars Required

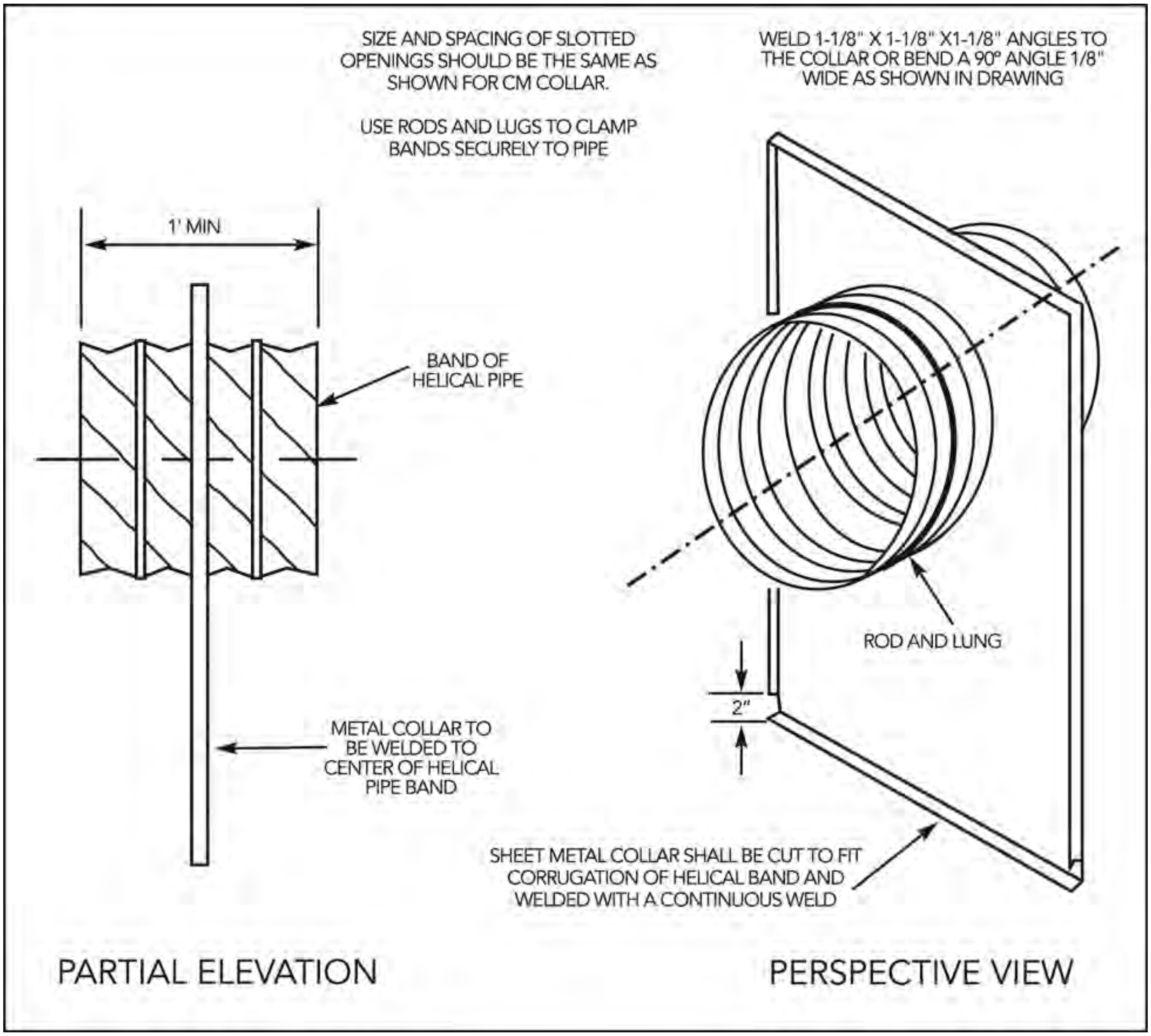


Figure 9-39 Detail of Anti-Seep Collar

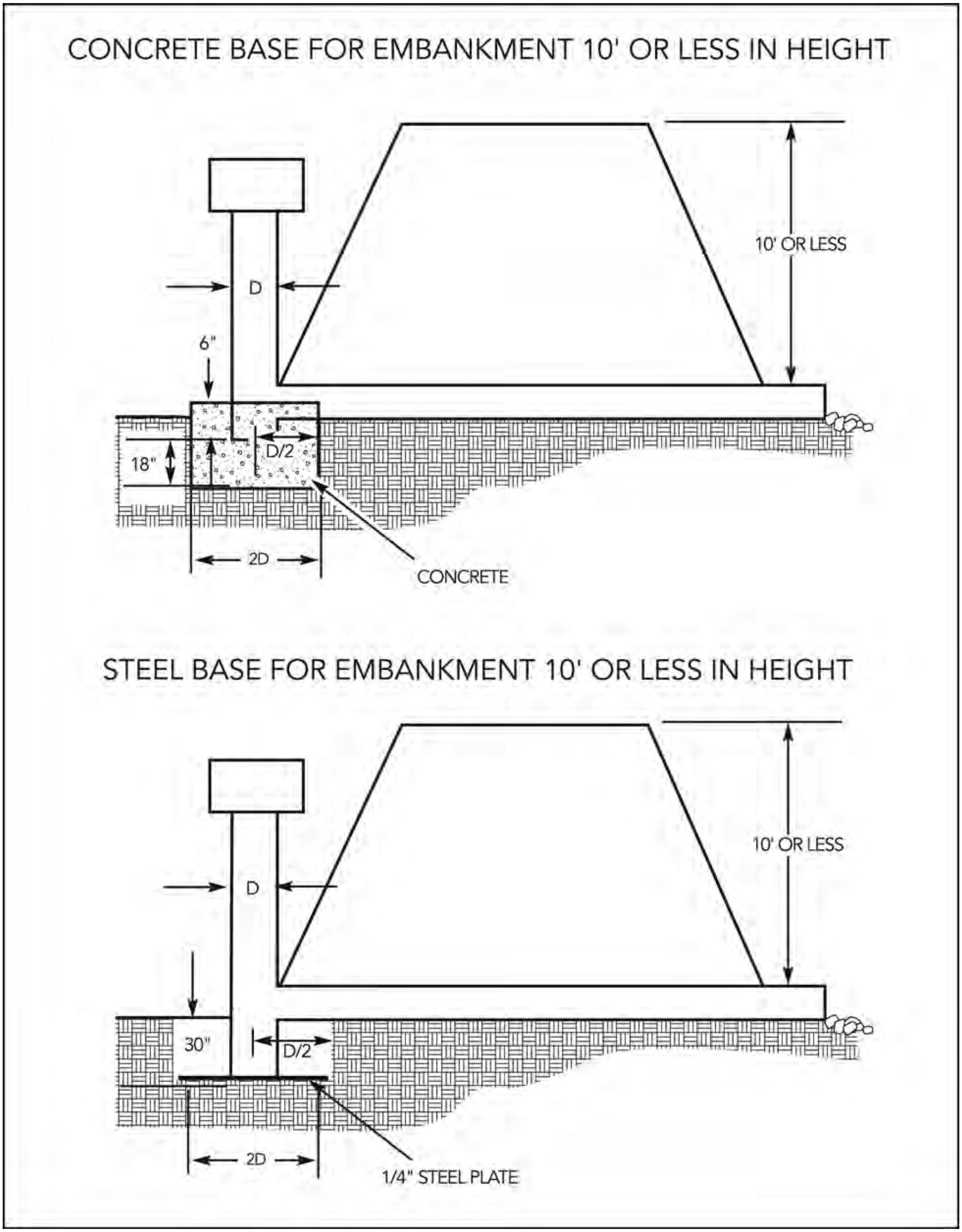
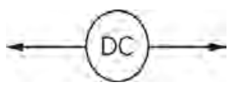


Figure 9-40 Riser Pipe Base Conditions for Embankments Less Than 10 Feet

9.5.16 Dust Control

Symbol:



BMP Guideline

Definition: Dust control is the practice of reducing surface and air movement of dust during land disturbing, demolition and construction activities.

Purpose: The purpose of dust control is to prevent surface and air movement of dust from exposed soil surfaces and reduce the presence of airborne substances which may present health hazards, traffic safety problems or harm animal or plant life.

Conditions Where Practice Applies:

In areas subject to surface and air movement of dust where on-site and off-site damage is likely to occur if preventative measures are not taken.

Design Criteria:

1. Vegetative Cover – In areas subject to little or no construction traffic, a vegetatively stabilized surface will reduce dust emissions (See Section 9.5.19, Temporary Seeding).

2. Mulch – When properly applied, mulch offers a fast, effective means of controlling dust. Not recommended for areas within heavy traffic pathways. Binders or tackifiers should be used to tack organic mulches (See Section 9.5.22, Mulching).

3. Tillage – This practice is designed to roughen and bring clods to the surface. It is an emergency measure which should be used before wind erosion starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12 in. apart, spring-toothed harrows, and similar plow are examples of equipment which may produce the desired effect.

4. Irrigation – This is the most commonly used dust control practice. The site is sprinkled with water until the surface is wet. Repeat as needed. It offers fast protection for haul roads and other heavy traffic areas.

5. Spray-On Adhesives – Use on "mineral" soils (not effective on "muck" soils). Traffic should be kept off areas.

Adhesive	Water Dilution (Adhesive: Water)	Type of Nozzle	Application Rate (Gallons/Ac.)
Anionic Asphalt Emulsion	7:1	Coarse Spray	1,200
Latex Emulsion	12.5:1	Fine Spray	235
Resin in Water	4:1	Fine Spray	300

6. Aggregate – Aggregate can be used to stabilize roads or other areas during construction (see Section 9.5.3, Construction Road Stabilization).

7. Barriers – A board fence, wind fence, sediment fence, or similar barrier can help to control air currents and blowing soil. Place barriers perpendicular to prevailing air currents at intervals of about 15 times the barrier height. Where dust is a known problem, existing windbreak vegetation should be preserved.

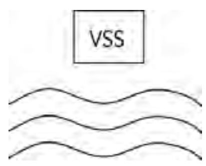
8. Calcium Chloride – This chemical may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage. Application rates should be strictly in accordance with supplier's specified rates.

9. Permanent Vegetation – The application of Permanent Seeding (see Section 9.5.20) and saving existing trees and large shrubs can help reduce soil and air movement from construction sites.

10. Controlling Dust from Sawcutting Operations – Two methods to control dust from sawcutting operations include wet dust suppression and local exhaust ventilation (LEV). Wet dust suppression involves spraying water onto the cutting disk to reduce dust emissions and should not be used for electrically operated saws. A minimum flow rate of 0.5 Liters per minute (7.9 gallons per hr.) is required to optimize dust suppression (HSE 2012). The LEV method can be used for all hand-held saws. It uses a dust collecting hood connected to a vacuum cleaner to capture dust. This system does not produce a wet slurry. To prevent the recirculation of dust, vacuums should be fitted with an H Class 13 HEPA filter (HSE 2012).

9.5.17 Vegetative Stream Bank Stabilization

Symbol:



BMP Guideline

Definition: Vegetative stream bank stabilization is the use of vegetation in stabilizing streambanks.

Purpose: To protect streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies:

Along banks in creeks, streams and rivers subject to erosion from excess runoff. This practice is generally applicable where bankfull flow velocity does not exceed 5 ft. per second and soils are erosion resistant. Above 5 ft. per second, structural measures are generally required.

Design Criteria:(Figure 9-41, Figure 9-42, Figure 9-43 and Figure 9-44)

1. Plants provide erosion protection to streambanks by reducing stream velocity, binding soil in place with a root mat and covering the soil surface when high flows tend to flatten vegetation against the banks. For these reasons, vegetation should always be considered first. One disadvantage of vegetation is that it lowers the carrying capacity of the channel, which may promote flooding. Therefore, maintenance needs and the consequences of flooding should be considered. The following items should be considered in evaluation vegetative stabilization:

    a. The frequency of bankfull flow based on anticipated watershed development.

    b. The channel slope and flow velocity, by design reaches.

    c. The antecedent soil conditions.

    d. Present and anticipated channel roughness ("n") values.

    e. The location of channel bends along with bank conditions.

    f. The location of unstable areas and trouble spots. Steep channel reaches, high erosive banks and sharp bends may require structural stabilization measures such as riprap, while the remainder of the stream bank may require only vegetation.

2. Where stream bank stabilization is required, any applicable approvals or permits from local, state or federal agencies must be obtained prior to working in these areas.

3. At the edge of all natural watercourses, plant communities exist in a characteristic succession of vegetative zones, the boundaries of which are dependent upon site conditions such as steepness and shape of the bank and the seasonal and local variations in water depth and flow rate. Streambanks typically exhibit the following zonation:

    a. Aquatic plant zone – This zone is normally permanently submerged. Vegetation in this zone typically reduces the water's flow rate by friction. The roots of these plants help to bind the soil, and they further protect the channel from erosion because the water flow tends to flatten them against the banks and bed of the stream.

b. Reed bank zone – The lower part of this zone is normally submerged for only about half the year. Vegetation in this zone binds the soil together with their roots, rhizomes and shoots and slows the water's flow rate by friction.

c. Shrub zone – This zone is flooded only during periods of average high water. Vegetation in this zone is highly adaptable to water with a high regenerative capacity. These plants hold the soil with their root systems and slow water speed by friction. They also protect tree trunks from damage caused by breaking ice and help to prevent formation of strong eddies around large trees during flood flows. Shrub zone vegetation is particularly beneficial along the impact bank of a stream meander, where maximum scouring tends to occur. Infringement of shrub vegetation into the channel tends to reduce the channel width, increasing the probability of floods. However, brief flooding of riverside woods and undeveloped bottomlands does no significant damage, and the silt deposits in these wooded areas are less of a problem than failed banks.

d. Tree zone - This zone is flooded only during periods of very high water. These trees hold soil in place with their root systems.

4. The aquatic plant zone is difficult to implant and establish naturally when reed bank vegetation exists. There are presently many experts in this field at the federal, state and private sector levels who can be consulted concerning successful establishment of plants in the aquatic zone. The tree zone is least significant in terms of protecting banks from more frequent erosion force flows, since this zone is seldom flooded.

5. Establishment of reed bank vegetation can be done by various different procedures. The common reed, reed canary grass, common cattail and great bulrush are considered suitable plantings for the reed bank zone. Planting methods are as follows:

a. Planting in clumps – The oldest and most common method of planting reeds is planting in clumps. The stems of the reed colony are scythed, then square clumps are cut out of the ground and placed in pits prepared in advance on the chosen site. The clumps are planted at a depth where they will be submerged to a maximum of two-thirds of their height.

b. Planting rhizomes and shoots – Less material is needed for the planting of rhizomes and shoots, a procedure which can be used to establish the previously mentioned plants. Slips are taken from existing beds during the dormant season, after the stems have been cut. Rhizomes and shoots are carefully removed from the earth without bruising the buds or tips of the sprouts. They are placed in holes or narrow trenches, along the line of the average summer water level, so that only the stem sprouts are showing above the soil.

c. Planting stem slips – It is possible to plant stem slips along slow moving streams. Usually, three slips are set in a pit 12 to 20 in. deep. If the soil is packed or strong, the holes must be made with a dibble bar or some other metal planting tool. The pits should be located approximately one ft. apart.

d. Reed rolls – In many cases, the previously described methods do not consolidate the banks sufficiently during the period immediately after planting. Combined structures have, therefore, been designed, in which protection of the bank is first insured by structural materials. Along slow to fairly fast streams, the most effective method of establishing reed bank vegetation has been found to be the use of reed rolls. A trench 18 in. wide and deep is dug behind a row of stakes. Wire netting, such as 0.5 in. hardware cloth is then stretched from both sides of the trench between upright planks. Onto the netting are dumped fill material such as coarse aggregate, sod, or soil and other organic material. This material is then covered by reed clumps until the two edges of the wire netting can just be held together with wire. The upper edge of the roll should be no more than 2 in. above the level of the water. Finally, the planks are taken out, and any gaps along the sides of the roll are filled in with earth. This method provides greater protection from the possibility of a heavy flow washing away the vegetative materials before they have a chance to become established. New products such as prefabricated jute logs are also available for this type of planning.

e. Seeding – Reed canary grass can be sown 5.0 in. deep on very damp bank soil, provided that the seeded surface is not covered by water for six months after sowing. Seed at a rate of 12 – 15 pounds per ac. Reed canary grass is a cool season grass and should not be seeded in the summer.

f. Vegetation and aggregate facing – Reed bank and other types of vegetation can be planted in conjunction with riprap or other aggregate facing by planting clumps, rhizomes or shoots in the crevices and gaps along the line of the average summer water level.

6. Establishment of shrub zone vegetation can be done by various different procedures. Stands of full grown trees are of little use for protecting streambanks apart from the binding of soil with their roots. Shrubwood provides much better protection, and in fact, riverside stands of willow trees are often replaced naturally by colonies of shrub-like willows. Plants should be used which can easily adapt to the stream and site conditions. Planting methods are as follows:

    a. Seeding and sodding – Frequently, if the stream is small and a good seedbed can be prepared, grasses can be used along to stabilize the streambanks. To seed the shrub zone, first grade eroded or steep streambanks to a maximum slope of 2:1 (3:1 preferred). Existing trees greater than 4 in. in diameter should be retained whenever possible. Topsoil should be conserved for reuse. Seeding mixtures should be selected and operations performed according to Section 9.5.20, Permanent Seeding. Some type of erosion prevention blanket should be installed according to Section 9.5.23, Soil Stabilization Blankets and Matting. Sod can also be placed in areas where grass is suitable. Sod should be selected and installed according to Section 9.5.21, Sodding. Turf should only be used where the grass will provide adequate protection, necessary maintenance can be provided, and establishment of other stream bank vegetation is not practical or possible.

    b. Many shrub species can be put into the soil as cuttings, slips, or stems. Again, the first step in the planting process is to grade eroded or steep slopes to a maximum slope of 2:1 (3:1 preferred), removing overhanging bank edges. Fresh cuttings should be 0.375 – 0.5 in. thick and 12 to 18 in. long. They should be kept moist. If not used at once, they should be stored in cool moist sand. Rooted cuttings should be planted vertically in the bank with one to two in. of wood protruding above the ground surface. They should be stuck in a hole large enough to accommodate the root system when well spread. The plant roots must be maneuvered into the bottom of the hole so they will grow down instead of up. The roots should not be twisted, nor should they be exposed above the ground surface. After the plant is placed, the dibble bar can be installed a few in. away from the plant to close the hole. The soil should be tamped adequately to provide complete contract between the soil and the cutting. Cuttings should be planted 1 ft. on center in at least 3 rows located at the top, middle and bottom of the shrub zone. Since these plants are generally not effective for the first two years, grasses can be seeded immediately following their planting to provide initial stream bank protection. Seeding, mulching or use of erosion prevention blankets should be done in accordance with Section 9.5.19, Temporary Seeding; 9.5.22, Mulching; and 9.5.23, Soil Stabilization Blankets and Matting.

c. Live Fascine rolls – Live fascine rolls are bound, cylindrical shaped rolls of live branch cuttings which are placed into a shallow trench along the streambank. They are typically between five and ten ft. in length and 6 to 8 in. in diameter. They can be set against the bank, above the ordinary high water mark. Additional live fascine roll design and construction details are described in Section 9.5.30.

d. Willow Mattresses – The degree of stream bank protection can be increased by using willow mattresses or packed fascine work. Willow mattresses consist of 4 to 8 in. thick layers of growing branches set perpendicular to the direction of the current or sloping downstream, with the broad ends of the branches oriented downwards. The branches are held together with interweaving wire or other branches at intervals of 24 to 32 in., set parallel to the direction of the current or at an angle of 30 degrees. If several layers of mattress are necessary, the tops of the lower layers should cover the bases of the upper layers. The bottom layer is fixed at the base in a trench, and the whole mattress structure should be covered with 2 to 10 in. of earth or fine aggregate.

e. Packed fascine work – Packed fascine work consists essentially of layers of branches laid one across the other to a depth of 8 to 12 in. and covered with fascine rolls. The spaces between the fascine rolls are filled with aggregate and soil so that no gaps remain; and a layer of soil and aggregate 8 to 12 in. thick is added on top. Packed fascine work is particularly suitable for repairing large breaches in the banks of streams with high water levels.

f. Combination with aggregate facing – In many places the bank is not adequately protected by vegetation until the roots are fully developed, and temporary protection must be provided. There is a wide choice of methods, including the planting of woody plants in the crevices of aggregate facing.

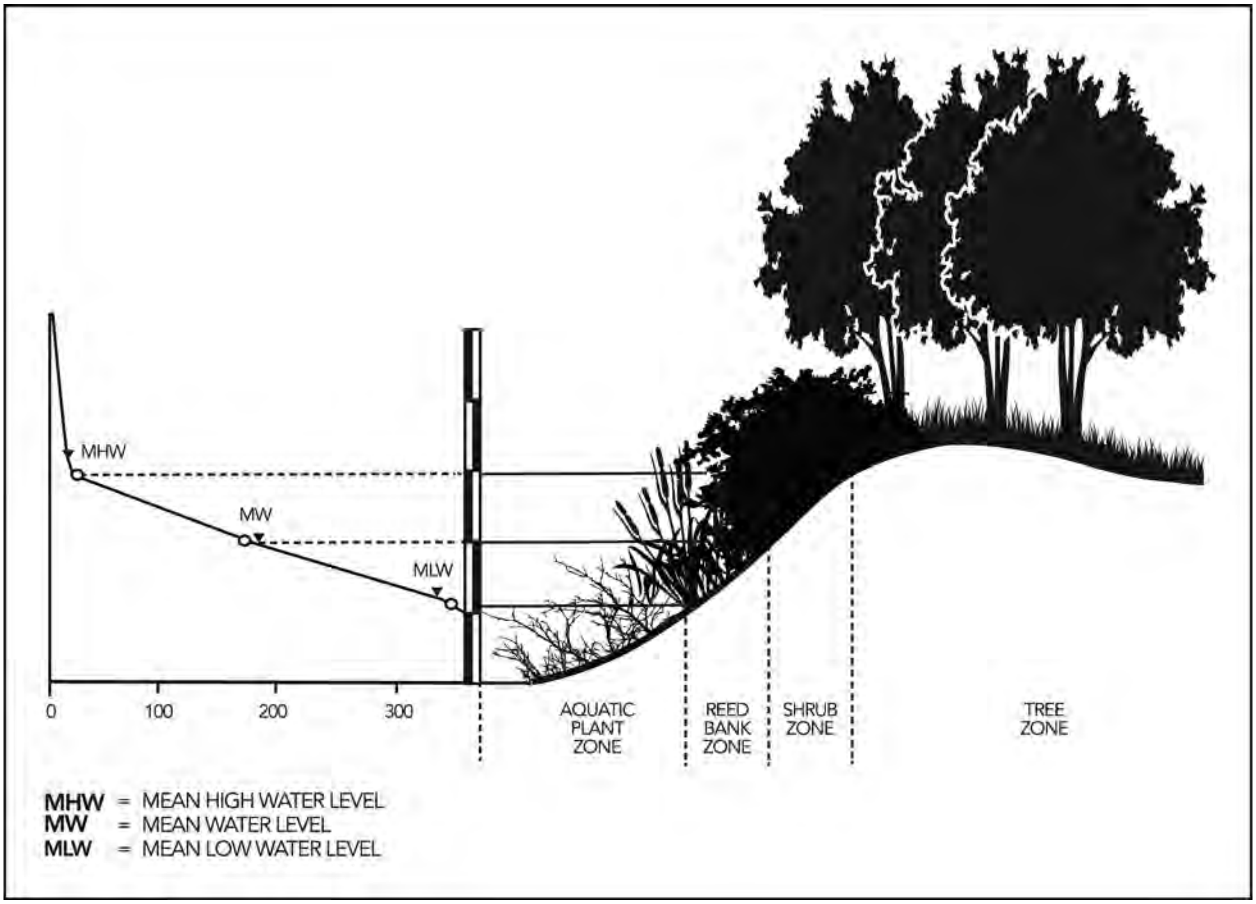


Figure 9-41 Typical Annual Curve of Water Levels Correlated with Typical Vegetative Zones.

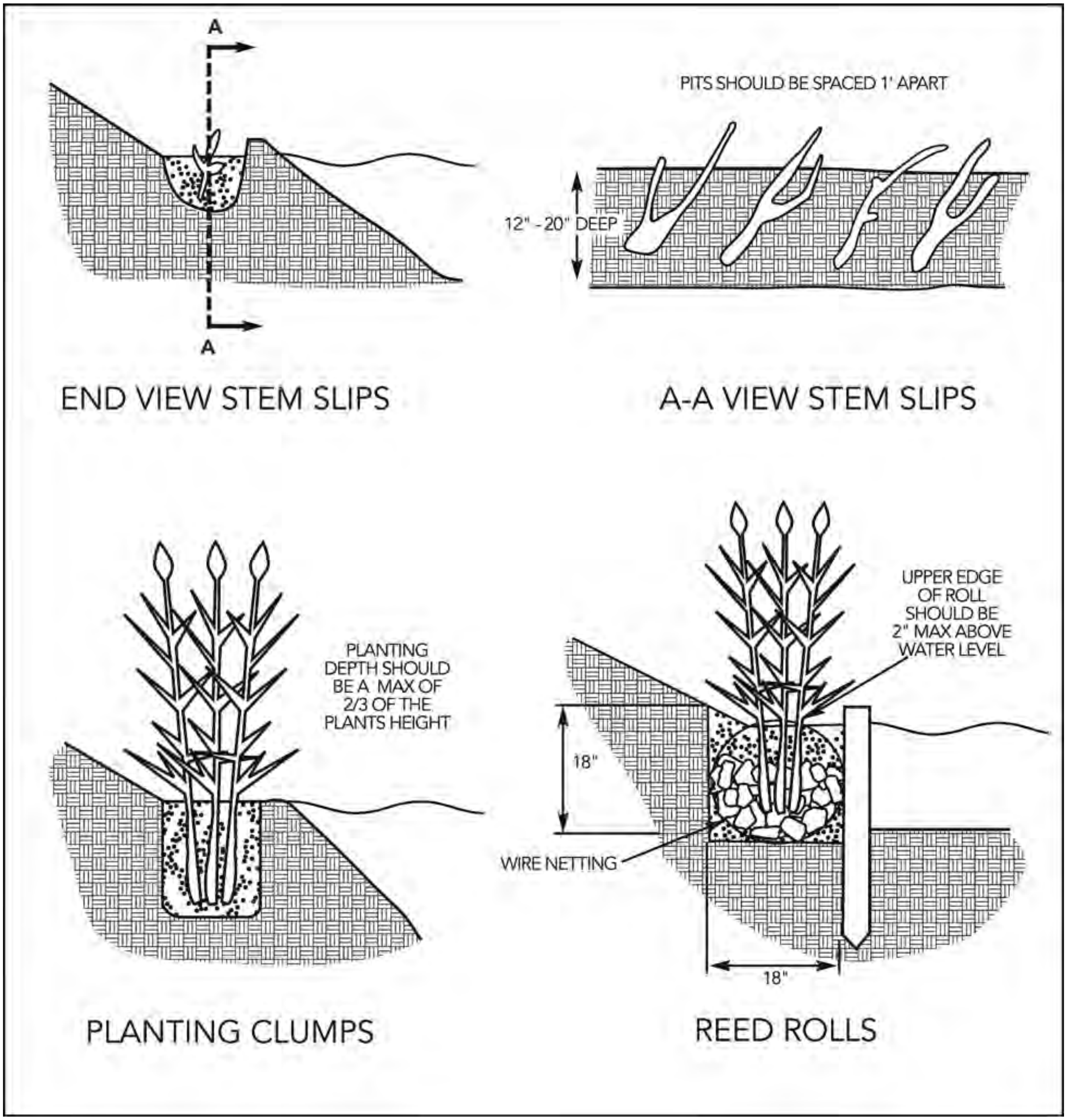


Figure 9-42 Methods of Establishing Reed Bank Vegetation

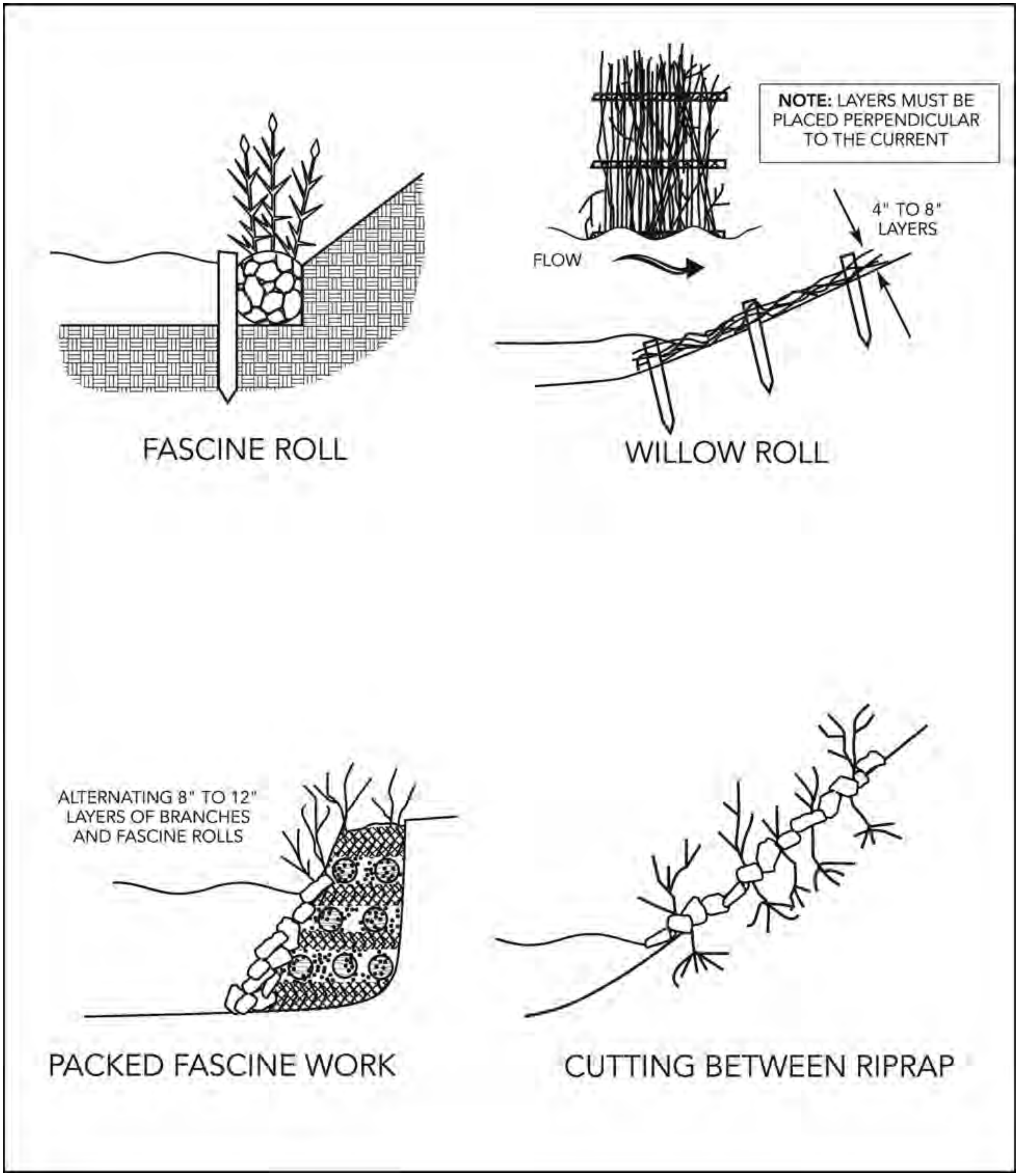


Figure 9-43 Methods of Establishing Shrub Zone Vegetations

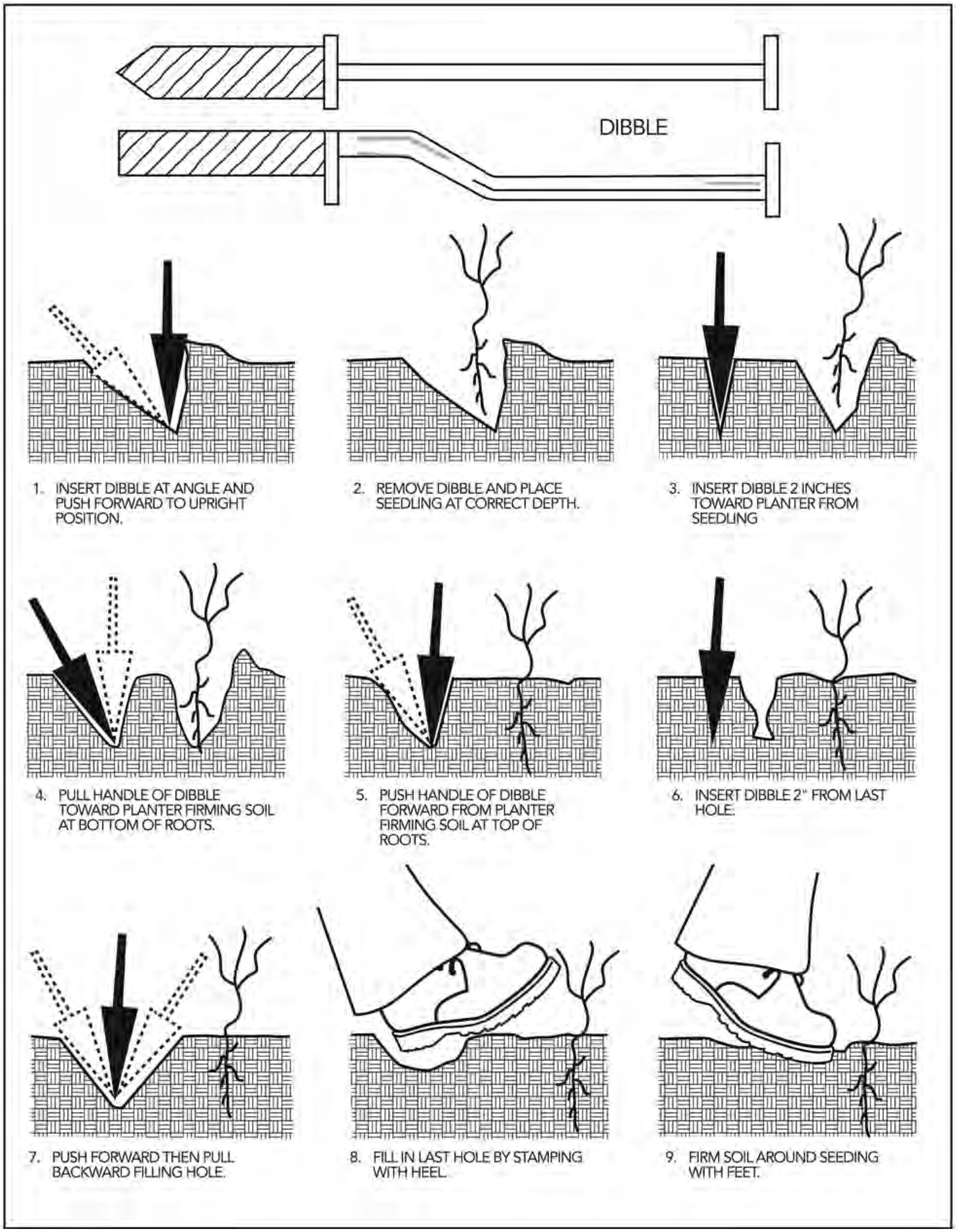
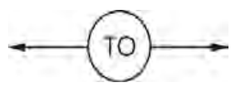


Figure 9-44 Dibble Planting

9.5.18 Topsoiling

Symbol:



BMP Guideline

Definition: Topsoiling consists of methods of preserving and using the surface layer of undisturbed soil, often enriched in organic matter, in order to obtain a more desirable planting and growth medium.

Purpose: The purpose of topsoiling is to provide a suitable growth medium for final site stabilization with vegetation.

Conditions Where Practice Applies:

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

Design Criteria:

1. Assure that an adequate volume of topsoil exists on the site. Topsoil will be spread at a compacted depth of 2-4 in. (depths closer to 4 in. are preferred).
2. Locate the topsoil stockpile so that it meets guidelines and does not interfere with work on the site.
3. Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding, or planting.
4. Do not apply topsoil to subsoil if the two soils have contrasting textures.
5. Topsoil and subsoil must be properly bonded or water will not infiltrate the soil profile evenly.

<u>Construction Guidelines</u>:

1. Field exploration of the site should be made to determine if there is sufficient surface soil of good quality to justify stripping.

2. Topsoil should be friable and loamy. It shall be free of debris, trash, stumps, rocks, roots, and noxious weeds, and shall give evidence of being able to support healthy vegetation. It shall contain no substance that is potentially toxic to plant growth.

3. Topsoil should be tested by a recognized laboratory for the following criteria:

    a. Organic matter content shall be not less than 1.5 percent by weight.

    b. pH range shall be from 6.5-7.5. If pH is less than 6.0, lime shall be added in accordance with soil test results or in accordance with the recommendations of the vegetative establishment practice being used.

    c. Soluble salts shall not exceed 500 ppm.

4. Topsoil operations shall not be performed when the soil is wet or frozen. Stripping shall be confined to the immediate construction area. A 4-5 in. stripping depth is common, but depth may vary depending on the particular soil. All perimeter dikes, basins, and other sediment controls shall be in place prior to stripping.

5. Topsoil shall be stockpiled in such a manner that natural drainage is not obstructed and no off-site sediment damage shall result. Side slopes of the stockpile shall not exceed 2:1.

6. Perimeter controls must be placed around the stockpile immediately; seeding of stockpiles shall be completed within seven days of the formation of the stockpile if it is to remain dormant for longer than 30 days.

7. Before topsoiling, establish needed erosion and sediment control practices such as diversions, grade stabilization structures, berms, dikes, level spreaders, waterways, sediment basins, etc. These practices must be maintained during top soiling.

8. Previously established grades on the areas to be top soiled shall be maintained according to the approved plan.

9. Where the pH of the subsoil is 6.0 or less, or the soil is composed of heavy clays, agricultural limestone shall be spread in accordance with the soil test or the vegetative establishment practice being used.

10. After the areas to be top soiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by discing or scarifying to a depth of at least 2 in. to ensure bonding of the topsoil and subsoil.

12. Topsoil shall not be placed while in a frozen or muddy condition, when topsoil or subgrade is excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed sodding or seeding. The topsoil shall be uniformly distributed to a minimum compacted depth of 2 in. on 3:1 or steeper slopes and 4 in. on flatter slopes. Any irregularities in the

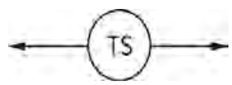
surface, resulting from top soiling or other operations, shall be corrected in order to prevent the formation of depressions or water pockets.

13. It is necessary to compact the topsoil enough to ensure good contact with the underlying soil and to obtain a level seedbed for the establishment of high maintenance turf. However, undue compaction is to be avoided as it increases runoff velocity and volume, and deters seed germination. Avoid unnecessary compaction by heavy machinery whenever possible. In areas which are not going to be mowed, the topsoil should be finished with a roughened surface to retain moisture.

14. No sod or seed shall be placed which has been treated with soil sterilants until sufficient time has elapsed to permit dissipation of toxic materials.

9.5.19 Temporary Seeding

Symbol:



BMP Guideline

Definition: Temporary seeding is the establishment of temporary vegetative cover on disturbed areas by seeding with appropriate rapidly growing annual plants.

Purpose: The purpose of temporary seeding is to reduce erosion and sedimentation by stabilizing disturbed areas that will not be brought to final grade for a period of thirty days or more, reduce damage from sediment and runoff to downstream or off-site areas, and to provide protection to bare soils exposed during construction until permanent vegetation or other erosion prevention measures can be established.

Conditions Where Practice Applies:

Where exposed soil surfaces are not to be fine-graded for periods longer than 14 days. Such areas include denuded areas, soil stockpiles, dikes, dams, sides of sediment basins, temporary roadbanks, etc. A permanent vegetative cover shall be applied to areas that will be left dormant for a period of more than 1 year.

Construction Guidelines:

1. Prior to seeding, install all necessary erosion prevention practices such as dikes, waterways, and basins.

2. Provide proper shaping of the area to be seeded in a manner such that seedbed preparation and seeding operations can be carried out.

3. Seedbed Preparation:

   a. If the area has been recently loosened or disturbed, no further roughening is required. When the area is compacted, crusted or hardened, the soil surface shall be loosened by discing, raking, harrowing, or other acceptable means. Seedbed preparation should not be undertaken when excessively wet conditions exist. Seedbed shall be prepared to a depth of approximately 3 in.

   b. If the soil being seeded is fertile topsoil (see Section 9.5.18, Topsoiling), fertilizer is not required. However, if subsoil is to be seeded, it will most likely be deficient in nutrients required for seed germination and growth. 450 pounds per ac. of 10-20-20 fertilizer should be used, and it is essential that this fertilizer be incorporated into the top 2-4 in. of soil during seedbed preparation.

4. Seeding:

   a. Certified seed shall be used on all temporary seedings. Select plants appropriate to the season and site conditions from those listed in the accompanying table. Other seedings may be used as recommended by qualified agronomists or soil conservationists.

Table 9-11 Plants Appropriate for Temporary Seeding

Species	Rate Per Acre of Pure Live Seed (lbs per acre)
Alfalfa	40
With One of the Following:	
Spring Oats (Spring)	40
Annual Rye Grass (Summer)	40
Winter Wheat (Fall)	40
Total Lbs. Pure Live Seed Per Acre	**80**

b. Seed should be evenly applied with a cyclone spreader, drill, cultipacker seeder, or hydroseeder. Small grains shall be planted no more than 1.5 in. deep and grasses no more than 0.5 in. deep.

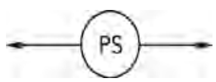
5. When seeding on critical sites or adverse soil conditions, mulch material will be applied immediately after seeding. Seedings during optimum seeding dates and with favorable soils on very flat areas may not need to be mulched. Mulching shall be done in accordance with Section 9.5.22, Mulching.

Inspection and Maintenance:

Areas which fail to establish vegetative cover adequate to prevent rill erosion will be re-seeded as soon as such areas are identified. Seeding can be applied via hydraulic mulches. Seasonal watering should be performed as necessary. Control weeds by mowing.

9.5.20 Permanent Seeding

Symbol:



BMP Guideline

Definition: Permanent Seeding is the establishment of perennial cover on disturbed areas by planting seed.

Purpose: The purpose of permanent seeding is to reduce erosion and sediment yield from disturbed areas, to permanently stabilize disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials, to improve wildlife habitat and to enhance natural beauty.

Conditions Where Practice Applies:

Disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil and rough-graded areas which will not be brought to final grade for a year or more.

Construction Guidelines:

1. Prior to seeding, install all necessary erosion prevention practices such as dikes, waterways, and basins.

2. Provide proper shaping of the area to be seeded in a manner such that seedbed preparation and seeding operations can be carried out.

3. Soil conditions needed for the establishment and maintenance of permanent seeding shall be as follows:

    a. Enough fine-grained material to maintain adequate moisture and nutrient supply.

    b. Sufficient pore space to permit root penetration. A bulk density of 1.2 to 1.5 indicates that sufficient pore space is present. A fine granular to crumb-like structure is also favorable.

    c. Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans shall be 12 in. or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.

    d. A favorable pH range for plant growth. If the soil is so acidic that a pH range of 6.0-7.0 cannot be attained by addition of pH-modifying materials, then the soil is considered an unsuitable environment for plant roots and further soil modification would be required.

    e. Freedom from toxic amounts of materials harmful to plant growth.

    f. Freedom from excessive quantities of roots, branches, large aggregate, large clods of earth, trash of any kind. Clods and aggregate may be left on slopes steeper than 3:1 if they do not significantly impede good seed soil contact.

    g. If any of the above criteria cannot be met, then topsoil shall be applied in accordance with Section 9.5.18, Topsoiling.

4. Seedbed Preparation:

   a. Flat areas and slopes up to 3:1 grade shall be loose and friable to a depth of at least 3 in. The top layer of soil shall be loosened by raking, discing or other acceptable means before seeding.

   b. Slopes steeper than 3:1 shall have the top 1-3 in. of soil loose and friable before seeding.

   c. When the area is compacted, crusted or hardened, the soil surface shall be loosened by discing, raking, harrowing, or other acceptable means. Seedbed preparation should not be undertaken when excessively wet conditions exist.

   d. Soil amendments shall be applied according to the recommendations of a soil test. When soil testing is not available, apply agricultural grade limestone at the rate of 2 tons per ac.; apply 10-20-10 or equivalent nutrients at the rate of 1,000 pounds per ac. Lime and fertilizer shall be incorporated into the top 4-6 in. of the soil by discing or other means whenever possible.

5. Seeding:

   a. Design a seed mix by using the accompanying Table 9-13 and Table 9-14. Mixtures for permanent plantings will contain a mixture of two or more species. A single species may be used on some residential or recreational areas.

   b. Certified seed will be used on all permanent seedings. Permanent seedings shall have a minimum of 60 Plants/sq. ft.

   c. Seed should be evenly applied with a cyclone spreader, drill, cultipacker seeder, or hydroseeder on a firm, moist seedbed. Maximum seeding depth shall be 0.25 in. on clayey soils and 0.5 in. on sandy soils, when using other than hydroseeder method of application.

   d. If hydroseeding is used and the seed and fertilizer is mixed, they will be mixed on-site and the seeding shall be immediate without interruption. A maximum application rate of 150 lbs. of solids/100 gallons of water is to be used if legume seed is in the mixture.

   e. Cool-season dominant mixtures shall be applied August 15 – April 30. Warm-season dominant mixtures shall be applied October 1 – June 15.

   f. A protective cover crop of annual plants may be seeded for erosion protection until establishment of the permanent vegetation. Cover crop planting may be done in conjunction with permanent seeding or immediately after permanent seeding has taken place. Select cover crop plants appropriate to the season and site conditions from those listed in the accompanying table.

Table 9-12 Plants Appropriate to the Season and Site Conditions

Time of Year	Species	Seeding Rate
March 15 – May 15	Spring Oats	2 bu/AC.
May 16 – July 15	Grain Sorghum (drilled)	10-20 lbs./AC.
	Forage Sorghum (drilled)	10-20 lbs./AC.
	Hybrid Sundangrass	20-30 lbs./AC
July 16 – October 15	Spring Oats	2 bu./AC.
	Winter Wheat	1.5 bu./AC.
	Rye	1.5 bu./AC.
October 15 – March 15	No Planting, use mulches	

6. All permanent seedings shall be mulched immediately upon completion of seed application. Mulching shall be done in accordance with Section 9.5.22, Mulching.

Inspection and Maintenance:

1. In general, a stand of vegetation cannot be determined to be fully established until it has been maintained for one full year after planting.

2. New seedings shall be supplied with adequate moisture. Supply water as needed, especially late in the season, in abnormally hot or dry conditions, or on adverse sites. Water applications shall be controlled to prevent excessive runoff.

3. Inspect all seeded areas for failures and make necessary repairs, replacements, and reseedings within the planting season, if possible.

   a. If stand is inadequate for erosion prevention, overseed and fertilize using half of the rates originally specified.

   b. If stand is 60 percent damaged, re-establish following seedbed and seeding recommendations.

   c. If stand has less than 40 percent cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. The soil must be tested to determine if acidity or nutrient imbalances are responsible. Re-establish the stand following seedbed and seeding recommendations.

Table 9-13 Plant Selection by Grasses and Legumes

Grasses or Legumes	Lbs. to Furnish 60 Plants /sq. ft. Per Acre	Loams, Clay-loams, and Clays						Sands & Loamy Sand				Remarks
		A	B	C	D	E	F	A	D	E	F	
Native Grasses:												
Big bluestem	15.9	X	0	-	-	X	-	0	-	-	-	
Buffalo grass (burs)	46.2	0	-	-	X	0	X	-	-	-	0	
Blue grama	3.3	X	0	-	X	X	X	X	X	X	X	
Little bluestem	9.9	X	-	-	0	X	0	X	0	X	0	
Prairie sandreed	9.6	-	-	-	-	-	-	X	-	X	-	Plant with mixtures
Reed canary grass	4.8	X	X	X	-	X	-	X	-	X	-	
Sand bluestem	23.1	-	-	-	-	-	-	X	0	X	-	Wet Area
Sideoats grama	13.5	X	-	-	X	X	X	0	0	0	0	
Western wheatgrass	24.0	X	X	0	0	X	0	X	0	X	0	
Sand love grass	2.1	-	-	-	-	-	-	X	X	X	X	
Switch grass	6.6	X	X	X	0	X	-	X	0	X	-	
Indian grass	15.0	X	0	-	-	X	-	0	-	0	-	
Introduced Grass:												
Fairway wheatgrass	16.0	-	-	-	X	-	0	-	0	0	0	Bunchy
Intermediate wheatgrass	30.0	X	0	-	0	X	0	X	0	X	0	Not long lived
Smooth brome	19.4	X	0	-	0	X	0	X	0	X	-	
Kentucky bluegrass	1.2	-	-	-	X	-	X	-	X	-	X	
Perennial ryegrass	11.6	X	X	-	X	0	X	X	X	0	X	
Tall fescue	11.6	0	0	0	X	X	X	X	X	X	X	
Creeping foxtail	3.4	X	X	X	-	-	-	-	-	-	-	
Legumes:												
Alfalfa	19.5	-	-	-	0	0	X	-	0	0	X	Low erosion prevention
Birdsfoot trefoil	10.5	-	-	-	X	0	X	0	0	X	X	
Red clover	14.4	-	-	-	X	0	X	0	0	X	X	
Crown vetch	36.0	X	-	-	-	X	0	X	-	X	-	In solid stands
Purple prairie clover	9.6	X	-	-	X	X	X	X	X	X	X	
Cicer milk vetch	29.1	X	-	-	-	X	0	X	-	X	-	In solid stands
Hairy vetch	120.0	-	-	-	-	-	0	0	0	X	0	
Forbes:												
Roundhead lespedeza	17.1	X	-	-	-	X	-	X	-	X	-	
Thickspike gayfeather	24.0	X	-	-	-	X	-	X	-	X	-	
Dotted gayfeather	18.9	X	-	-	X	X	X	X	X	X	X	
Shellleaf permstemon	9.6	X	-	-	0	X	0	X	0	X	X	
Maximilian sunflower	17.4	X	-	-	-	X	-	X	-	X	-	

KEY:
X Best — A Dam, Diversion, Dike — D Heavy Traffic & Recreation
0 Fair — B Channels — E Roadside
- Poor — C Shoreline & Low Areas — F Residential & Development Sites

Source: LPSNRD Manual, 1994

Table 9-14 Plant Selection Table by Seeding Date

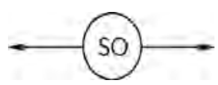
Grasses or Legumes	Lbs. to Furnish 60 PLS/sq. ft. Per Acre	Loams, Clay-loams, and Clays						Sands & Loamy Sand				Remarks
		A	B	C	D	E	F	A	D	E	F	
Warm-Season Dominant: October 1 - June 15												
Big bluestem	4.0	X	0	-	-	X	-	X	-	X	-	For sands and loamy sands substitute sand bluestem for big bluestem, 1.8 lbs of prairie sandreed for sideoats grama and 0.2 lb. PLS sand love grass for tall fescue.
Sideoats grama	2.9	X	0	-	-	X	-	X	-	X	-	
Switch grass	0.7	X	0	-	-	X	-	X	-	X	-	
Indian grass	3.6	X	0	-	-	X	-	X	-	X	-	
Tall fescue	2.1	X	0	-	-	X	-	X	-	X	-	
Buffalo grass (burs)	38.0	-	-	-	X	X	X	-	X	-	X	
Blue grama	0.6	-	-	-	X	X	X	-	X	-	X	
Buffalo grass (burs)	32.3	0	-	-	X	X	X	-	X	-	X	
Blue grama	0.3	0	-	-	X	X	X	-	X	-	X	
Sideoats grama	2.7	0	-	-	X	X	X	-	X	-	X	
Switch grass	3.8	-	X	X	-	-	-	X	-	X	-	Wet areas
Reed canary grass	2.0	-	X	X	-	-	-	X	-	X	-	
Cool-Season Dominant: August 15 – April 30												
Smooth brome	14.4	X	0	-	-	X	-	X	-	0	-	Add 10 lbs. wheatgrass to replace 7.2 lbs. of brome or 3.6 lbs. of tall fescue.
Switch grass	1.7	X	0	-	-	X	-	X	-	0	-	
Tall fescue	7.3	X	X	0	-	X	-	0	-	0	-	
Switch grass	2.4	X	X	0	-	X	-	0	-	0	-	
Perennial ryegrass	5.2	-	-	-	X	-	X	-	X	-	X	Less than 5 years
Alfalfa	10.8	-	-	-	X	-	X	–	X	-	X	
Red clover	3.9	-	-	-	X	-	X	-	X	-	X	Substitute 0.6 lbs. PLS sand love grass to replace tall fescue for sands and loamy sands.
Dotted gayfeather	1.9	-	-	-	X	-	X	-	X	-	X	
Maximilian sunflower	6.3	-	-	-	X	-	X	-	X	-	X	

KEY:
X Best — A Dam, Diversion, Dike — D Heavy Traffic & Recreation
0 Fair — B Channels — E Roadside
- Poor — C Shoreline & Low Areas — F Residential & Development Sites

Source: LPSNRD Manual, 1994

9.5.21 Sodding

Symbol:



BMP Guideline

Definition: Sodding is used to stabilize fine-graded disturbed areas by establishing permanent grass stands with sod.

Purpose: The purpose of sodding is to establish permanent turf immediately, to prevent erosion and damage from sediment and runoff by stabilizing the soil surface, to reduce the production of dust and mud associated with bare soil surfaces, to stabilize drainage ways where concentrated overland flow will occur and for use as a filtering device for sediments in areas prior to achieving permanent stabilization.

Conditions Where Practice Applies:

Disturbed areas which require immediate vegetative covers, or where sodding is preferred to other means of grass establishment. Locations particularly suited to stabilization with sod are: waterways carrying intermittent flow, areas around drop inlets or in grassed swales, and residential or commercial lawns where quick use or aesthetics are factors.

Construction Guidelines:(Figure 9-45 and Figure 9-46)

1. Site Preparation:

    a. Prior to soil preparation, areas to be sodded shall be cleared of all trash, debris, and of all roots, brush, wire, grade stakes and other objects that would interfere with planting, fertilizing or maintenance operations.

    b. All areas receiving sod shall be uniformly fine graded and be brought to final grade in accordance with the approved plan. Hard-packed earth shall be scarified prior to placement of sod.

    c. Soil amendments shall be applied according to the recommendations of a soil test. When soil testing is not available, apply agricultural grade limestone at the rate of 2 tons per ac.; apply 10-10-10 or equivalent nutrients at the rate of 1,000 pounds per ac. Lime and fertilizer shall be incorporated into the top 3-6 in. of the soil by discing, harrowing or other acceptable means.

    d. Areas to be topsoiled and topsoil used shall fulfill the requirements of Section 9.5.18, Topsoiling. No sod shall be spread on soil which has been treated with soil sterilants or any other toxic herbicides until enough time has elapsed to permit dissipation of toxic materials.

2. Material Requirements:

    a. Class of turfgrass sod shall be Nebraska State Certified, or Nebraska State approved sod. The sod shall be in strips or blocks of a native grass mixture, switch grass, prairie cord grass, reed canary grass, or other suitable grasses. Bluegrass sod is used only when the area is irrigated. Sod materials are to be taken from good, solid thick stands.

b. Sod shall be machine cut at a uniform soil thickness of 0.75 in., plus or minus 0.25 in., at the time of cutting. Measurement for thickness shall exclude top growth and thatch.

c. Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape when suspended vertically with a firm grasp on the upper 10 percent of the section.

d. Individual pieces of sod shall be cut to the supplier's width and length. Maximum allowable deviation from standard widths and lengths shall be 5 percent. Broken pads and torn or uneven ends will not be acceptable.

e. Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.

f. Sod shall be harvested, delivered and installed within a 24-hr. period. Sod not transplanted within this period of time shall be inspected and approved prior to its installation.

3. Sod Installation:

a. Sod shall not be laid on soil surfaces that are frozen.

b. During periods of high temperature, the soil shall be lightly irrigated immediately prior to laying the sod.

c. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and tightly wedged against each other. The edge of the sod at the top of slopes shall be turned slightly under a layer of soil compacted under the edge to enable surface water to flow over and onto the sod surface. Lateral joints shall be staggered to promote more uniform growth and strength. Any spaces between joints shall be filled with topsoil and all edges of sod covered with topsoil at least 2 in. in depth. Insure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids which would cause air drying of the roots.

d. On slopes 3:1 or greater, or whenever erosion may be a problem, sod shall be laid with staggered joints and secured by stapling or other approved methods. Sod shall be installed with the length perpendicular to the slope (on the contour).

e. As sodding of clearly defined areas is complete, sod shall be rolled or tamped to provide firm contact between roots and soil.

f. After rolling, sod shall be irrigated to a depth sufficient that the underside of the sod pad and the soil 4 in. below the sod is thoroughly wet.

4. Sodded Waterways:

a. Care should be taken to prepare the soil adequately in accordance with this guideline. The sod type shall consist of plant materials able to withstand the designed velocity.

b. Sod strips in waterways shall be laid perpendicular to the direction of flow. Care should be taken to butt ends of strips tightly.

c. After rolling or tamping, sod shall be pegged or stapled (See Figure 9-46) to resist washout during the establishment period. Jute mesh or other netting may be pegged over the sod for extra protection in critical areas depending on the slope.

d. All other guidelines for this practice shall be adhered to when sodding a waterway.

Inspection and Maintenance:

1. Until such time a good root system becomes developed, in the absence of adequate rainfall, watering shall be performed as often as necessary to maintain moist soil to a depth of at least 4 in.

2. The first mowing shall not be attempted until the sod is firmly rooted, usually 2-3 weeks. Not more than one third of the grass leaf shall be removed at any one cutting. Grass height shall be maintained between 2 and 3 in. unless otherwise specified.

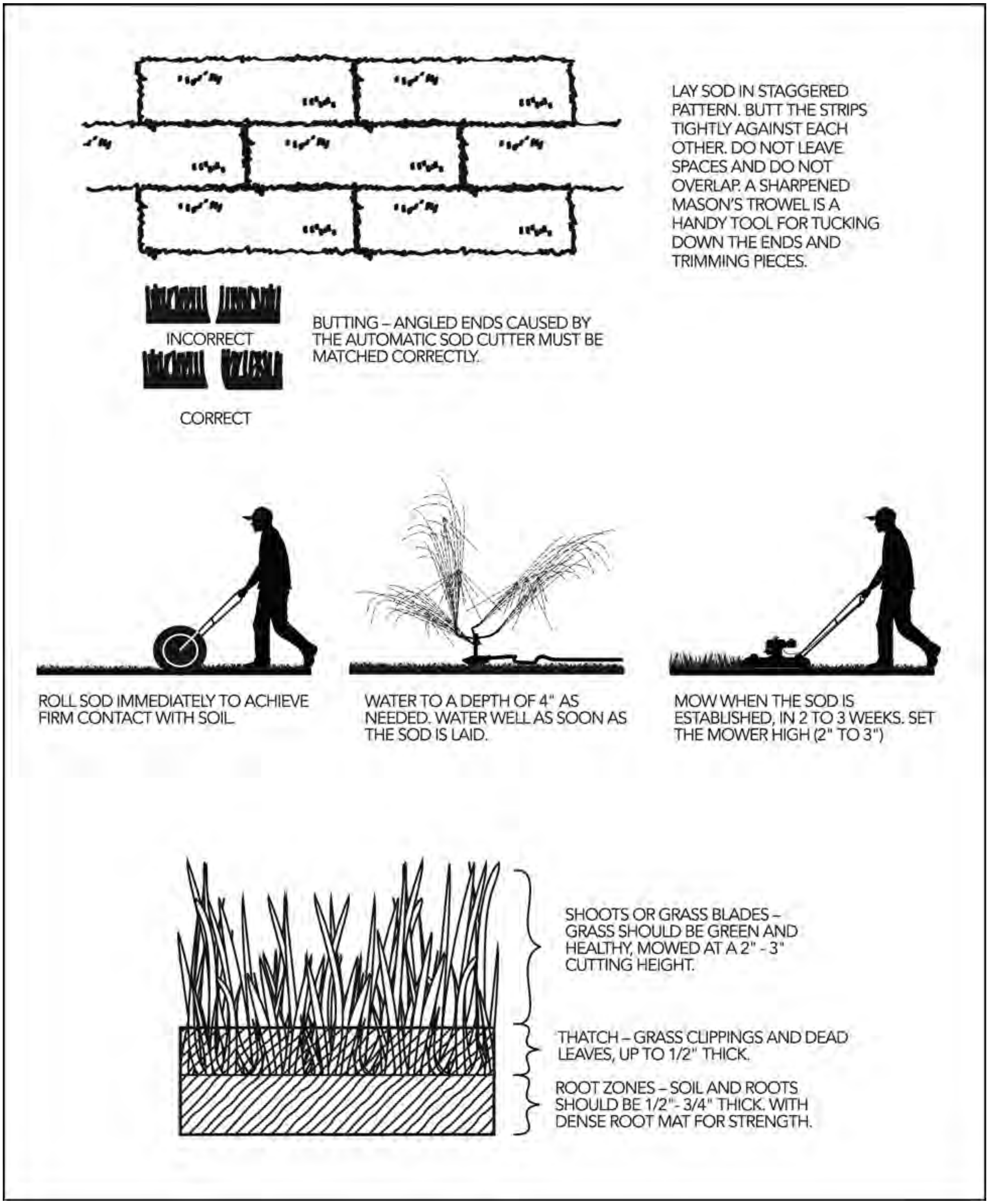


Figure 9-45 Sodding

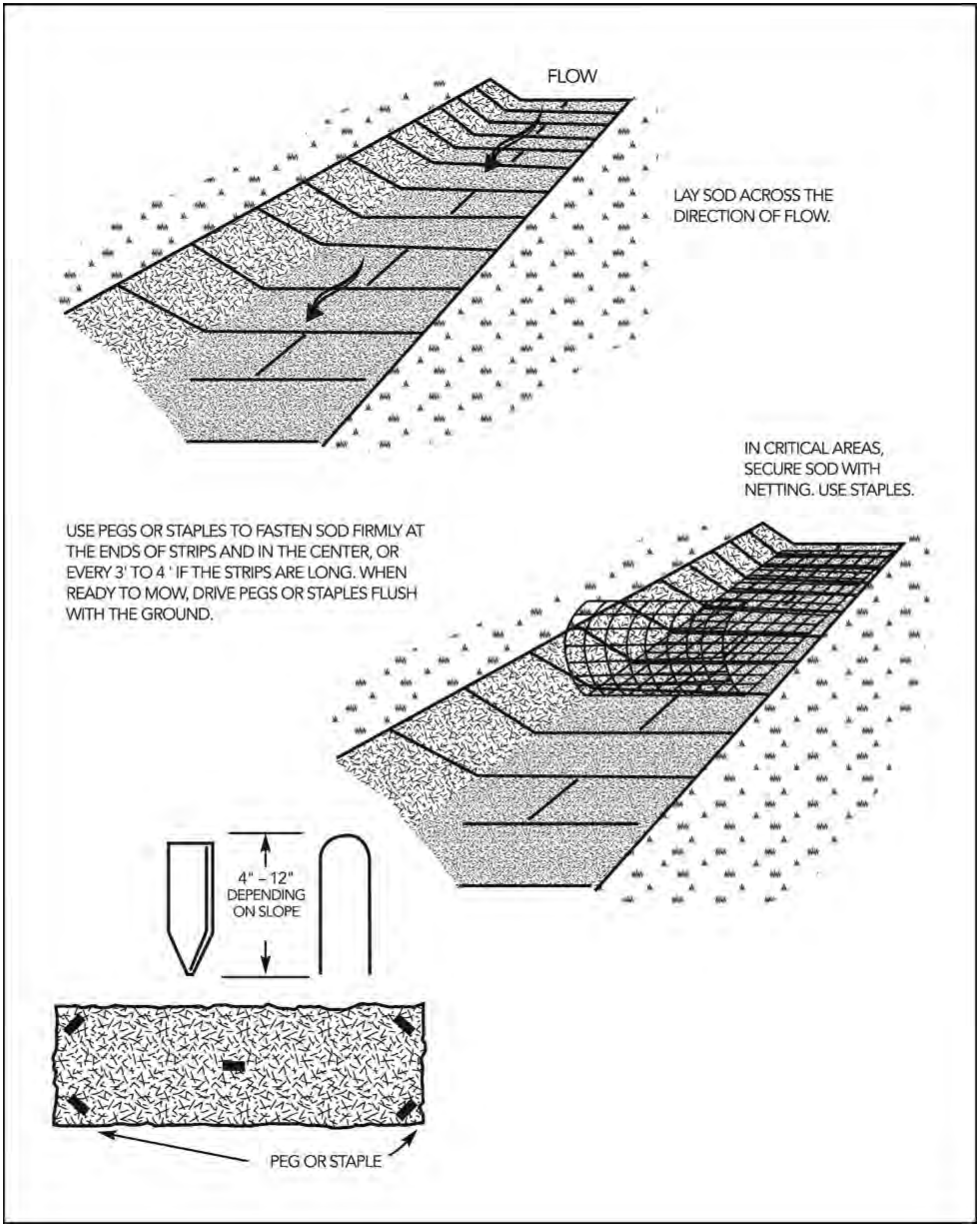
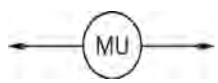


Figure 9-46 Sodded Waterways

9.5.22 Mulching

Symbol:



BMP Guideline

Definition: Mulching is the application of plant residues or other suitable materials to the soil surface. Mulching materials include straw or hay, wood cellulose fiber, corn stalks, wood chips, grass, or aggregate.

Purpose: The purpose of mulching is to prevent erosion by protecting the soil surface from raindrop impact, reducing the velocity of overland flow, and improving infiltration of runoff. Mulching is most effective when used in conjunction with vegetation. Mulch helps foster the growth of soil stabilizing vegetation by holding seeds, fertilizers, and topsoil in place, retaining moisture and providing insulation against extreme heat and cold.

Conditions Where Practice Applies:

Mulching can be used at anytime where protection of the soil surface is desired, particularly on steep slopes and critical areas such as near waterways. Mulch can be used in conjunction with seeding to establish vegetation in areas where vegetation is difficult to establish, or by itself to provide temporary protection of the soil surface.

Construction Guidelines:

1. Site Preparation:

    a. Prior to mulching, install any needed erosion and sediment control practices such as diversions, grade stabilization structures, berms, dikes, grassed waterways and sediment basins.

    b. Complete required shaping of area in a manner such that mulching operations can be carried out.

    c. Loosen compacted soil to a minimum depth of 4 in. if using mulch while seeding. Soil amendments shall be incorporated and surface roughening accomplished as needed. Seed shall be applied prior to mulching except where seed is to be applied as part of a hydroseeder slurry containing fiber mulch, or where seed is to be applied following organic mulch spreading during winter months.

2. Materials:

    a. Organic mulches should be used in any area where vegetation is desired. Select mulch material based on site requirements, climate/season, availability of materials, and availability of labor and equipment and as indicated in Table 9-15.

    b. Mulch materials shall be spread uniformly by hand or machine. When spreading straw mulch by hand, divide the area to be mulched into approximately 1,000 sq. ft. sections and spread 90-100 lbs. (2 tons per ac.) of straw in each section.

c. Hydraulically applied mulches, including hydromulch, bonded fiber matrix, and fiber reinforced matrix shall be on the NDOR approved products list as found at http://www.dor.state.ne.us/mat-n-tests/pdfs-docs/eros-sed-prod-list.pdf.

d. If tackifier is used, it shall be food grade hydrolyzed guar gum powder. It shall be mixed with cellulose fibers based on the manufacturer's recommendations, but not less than 3 percent of the dry weight of the cellulose fiber mulch.

3. Anchoring Mulch:

a. Mulching must be anchored immediately to minimize loss by wind and water. This may be done by one of the following methods (listed by preference) depending upon the size of area, erosion hazard and cost.

i. Mulch Anchoring Tool and Tracking – A mulch anchoring tool is a tractor drawn implement designed to punch and anchor mulch into the top three in. of soil. Discs of the anchoring tool shall be set approximately 9 in. apart and the grooves should be more than 3 in. deep. This practice offers maximum erosion prevention but is limited to flatter slopes where equipment can operate safely. Tilling, disking, and harrowing should be done such that the ridges or depressions run across the slope along the contour. "Tracking" is the process of cutting mulch into the soil using a bulldozer or other equipment that runs on cleated tracks. Tracking is used primarily on slopes 3:1 or steeper. Tracking should be done up and down the slope with horizontal cleat depressions running across the slope.

ii. Mulch Nettings – Staple lightweight biodegradable paper, plastic or cotton netting over the mulch according to manufacturer's recommendations.

iii. Liquid Mulch Binders – Use of liquid mulch binders and tackifiers. Application should be heavier at edges, in valleys, and at crests of banks and other areas where the mulch has a greater potential to be moved by wind or water. All other areas should have a uniform application of binder. Binders may be applied after the mulch is spread or may be sprayed into the mulch as it is being blown onto the soil. The use of synthetic binders is preferred. Apply at rates recommended by the manufacturer.

iv. Peg and Twine – Drive 8 to 10 in. wooden pegs to within 2 to 3 in. of the soil surface every 4 ft. in all directions. Stakes may be driven before or after applying mulch. Secure mulch to the soil surface by stretching twine between pegs in a crisscross within a square pattern. Secure twine around each peg with two or more turns.

Inspection and Maintenance:

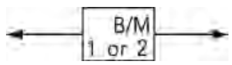
All mulches and soil coverings should be inspected periodically (particularly after rainstorms) to check mulch layer condition and check for erosion. Where erosion is observed in mulched areas, additional mulch should be applied. Nets and mats should be inspected after rainstorms for dislocation or failure. If washouts or breakage occur, reinstall netting or matting as necessary after repairing damage to the slope or ditch. Inspections should take place until grasses are firmly established. Where mulch is used in conjunction with ornamental plantings, inspect periodically throughout the year to determine if mulch is maintaining coverage of the soil surface, and repair as needed.

Table 9-15 Organic Mulch Materials And Application Rates

Mulches:	Rates:		Notes:
	Per Acre	Per 1,000 sq. ft.	
Hay	1.5 tons	65 – 70 lbs.	Free from weeds and coarse matter. Must be anchored. Spread with mulch blower or by hand. Material shall be dry cured native prairie hay, native grass from seed growing operations, native grass hay from planted warm season stands. Brome hay is not acceptable due to its shallow roots structure (per Nebraska Department of Roads Drainage and Erosion Control Manual, August 2006).
Straw	2 tons	90 – 100 lbs.	Free from weeds and coarse matter. Must be anchored. Spread with mulch blower or by hand.
Fiber Mulch	0.5 – 1 ton	35 lbs.- 45 lbs.	Do not use as mulch for winter cover or during hot, dry periods. Apply as slurry with hydroseeder.
Corn Stalks	4 – 6 tons	185 – 275 lbs.	Cut or shredded in 4-6" lengths. Air-dried. Do not use in fine turf areas. Apply with mulch blower or by hand.
Wood Chips	5 – 6 tons	185 – 275 lbs.	Free of coarse matter. Air- dried. Treat with 12 lbs nitrogen per ton. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand.
Hydraulic Mulch	Wood cellulose fiber at 1,200-1,500 lbs Bonded fiber matrix at 2,000-3,500 lbs.	Wood cellulose fiber at 28-35 lbs, and bonded fiber matrix at 46-80 lbs.	The wood cellulose fiber shall be mixed with water, and the mixture shall contain a maximum of 50 lbs. of wood cellulose fiber per 100 gallons of water.
Bark Chips or Shredded Bark	50 – 70 cu. yds.	1 – 2 cu. yds.	Free of coarse matter. Air- dried. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand. Do not use asphalt tack.

9.5.23 Soil Stabilization Blankets and Matting

Symbol:



BMP Guideline

Definition: Soil stabilization blankets and matting involves the installation of a protective covering (blanket) or a soil stabilization mat on a prepared surface, slope, channel or shoreline.

Purpose: The purpose of this BMP is to stabilize soil, to protect disturbed soil from erosive forces, to increase infiltration, and/or to conserve soil moisture in order to promote establishment of vegetation.

Conditions Where Practice Applies:

Soil stabilization blankets and matting can be used on:

1. Slopes and disturbed soils where mulch would have to be anchored and other methods such as crimping or tackifying are not feasible and or adequate.
2. Short steep slopes (generally 3:1 or steeper) or slopes where concentrated flows exist or highly erodible soils are present.
3. Locations where seeding is likely to be too slow in providing adequate protective cover.
4. Critical slopes adjacent to sensitive areas, such as streams, wetlands, shorelines and existing development.
5. Vegetated channels where the velocity of design flow/concentrated flow exceeds "allowable" velocity.
6. Areas prone to sloughing of topsoil.
7. Seedbed areas which require thermal consistency and moisture retention.
8. Streambanks where moving water is likely to wash out new plantings.
9. Areas where the forces of wind prevent standard mulching practices from remaining in place until vegetation becomes established.
10. Slope areas where underground springs are present and discharging to the surface.

Design Criteria: (Figure 9-47, Figure 9-48, Figure 9-49, Figure 9-50 and Figure 9-51)

1. Degradable Blankets (Treatment 1) – is a degradable soil stabilization blanket which includes "combination" blankets consisting of a plastic netting which covers and is intertwined with a natural organic or man-made mulch; or, a jute mesh which is typically homogeneous in design and can act alone as a soil stabilization blanket. Treatment 1 should be used to help establish vegetation on previously disturbed slopes. The materials which compose the blankets will deteriorate over time and should only be used in permanent conveyance channels with the recognition that the system's resistance to erosion is ultimately based on the type of permanent vegetation established and the existing soil characteristics. During the establishment of vegetation, Treatment 1 should not be subjected to shallow or deep concentrated flows moving at greater than 4 ft. per second

2. Long-term Non-Degradable Channel Applications (Treatment 2) – is a soil stabilization matting which consists of a non-degradable, 3-dimensional plastic structure which can be filled with soil prior to planting. This configuration provides a matrix for root growth where the matting becomes entangled and penetrated by roots, forming continuous anchorage for surface growth and promoting enhanced energy dissipation. Treatment 2 can be used on problem slopes (typically 3:1 or greater), and in stormwater conveyance channels. Treatment 2 is non-degradable, so it can be used in permanent conveyance channels and can withstand higher velocities of flow than the vegetation and soil would normally allow. However, a 10 ft. per second velocity of flow should be the maximum allowed in a conveyance system which uses Treatment 2.

Construction Guidelines:

Degradable Blankets (TREATMENT 1)
(Product Types 1A through 1F on Table 9-16)

1. Blankets should be manufactured in rolls for ease of installation.

2. During establishment of vegetation, matting/blanket shall not be subjected to shallow or deep concentrated flows moving greater than 4 ft./s.

3. Blanket Materials:

   a. Combination Materials: Combination material blankets shall consist of a photo-degradable plastic netting which covers and is entwined in a natural organic or man-made mulching material. Mulching materials shall consist of wood fibers, wood excelsior, straw, coconut fiber, man-made fibers, or a combination of the same.

      i. Blankets shall be of consistent thickness with the mulching material/fibers evenly distributed over its entire length. The mulching material/fibers must interlock or intertwine to form a dense layer which not only resists raindrop impact, but will allow vegetation to penetrate the blanket.

      ii. The blanket shall be non-toxic to vegetation and to the germination of seed and shall not be injurious to the unprotected skin of humans. At a minimum the plastic netting must cover the top side of the blanket and posses a high web strength. The netting shall be entwined with the mulching material/fiber to maximize strength and provide for ease of handling.

   b. Jute Mesh: Jute mesh shall be uniform, open, plain weave, of undyed and unbleached single jute yarn.

      i. The yarn shall be of loosely twisted construction and shall not vary in thickness by more than one half of its normal diameter.

      ii. Jute mesh shall have an average weight of 0.90 lbs per sq. yd. with a tolerance of 5 percent.

   c. Other Blanket Materials: Other products may be used upon the approval of the City. These products shall conform to the manufacturer's specifications and be installed in accordance with the manufacturer's recommendations. In no case should these products cover less than 30 percent of the soil surface.

Table 9-16 Rolled Erosion Prevention Product Physical Properties Chart

PRODUCT TYPE	PRODUCT DESCRIPTION	MATERIAL COMPOSITION	FUNCTIONAL LONGEVITY	BLANKET SIZE		ACCEPTABLE MATRIX FILL MATERIAL
				MIN. ROLL WIDTH (FT)	MIN. THICKNESS (in) (ASTM D 6525)	
DEGRADABLE BLANKETS (Treatment 1)						
1A	Slope Protection Netting	A photodegradable synthetic mesh or woven biodegradable natural fiber netting	12 Months	6.5	N/A	N/A
1B	Lt. Weight Quick Degrading Erosion Prevention Blanket	Processed degradable natural and/or polymer fibers mechanically bound by a single rapidly degrading synthetic or natural fiber netting	3 Months	4.0	0.30	Straw or Excelsior
1C	Lt. Weight Single Net Erosion Prevention Blanket	Processed degradable natural fibers mechanically bound by a single degradable synthetic or natural fiber netting	12 Months	6.5	0.30	Straw or Excelsior
1D	Lt. Weight Double Net Erosion Prevention Blanket	Processed degradable natural fibers mechanically bound between two degradable synthetic or natural fiber nettings	12 Months	6.5	0.30	Straw or Excelsior
1E	Med. Weight Double Net Erosion Prevention Blanket	An erosion prevention blanket composed of degradable natural fibers and/or processed slow degrading natural fibers mechanically bound between two slow degrading synthetic or natural fiber nettings to form a continuous matrix	24 Months	6.5	0.30	Straw, Excelsior, or Coconut Fibers
1F	Heavy Duty Erosion Prevention Blanket	An erosion prevention blanket composed of degradable natural fibers and/or processed slow degrading natural fibers mechanically bound between two slow degrading synthetic or natural fiber nettings to form a continuous matrix	36 Months	6.5	0.30	Excelsior or Coconut Fibers
LONG TERM NON-DEGRADABLE CHANNEL APPLICATIONS (Treatment 2)						
2A	Turf Reinforcement Mat	Long term, non-degradable rolled erosion prevention product composed of UV stabilized, non-degradable synthetic fibers, filaments, nettings and/or wire mesh processed into three dimensional reinforcement matrices designed for permanent and critical hydraulic applications where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation. Turf reinforcement mats provide sufficient thickness, strength, and void space to permit soil filling and/or retention and the development of vegetation within the matrix.	N/A	6.5	0.25	Excelsior, Coconut, or Polymer Fibers
2B	Turf Reinforcement Mat		N/A	6.5	0.50	100% UV Stabilized Polypropylene Fibers
2C	Turf Reinforcement Mat		N/A	6.5	0.50	100% UV Stabilized Polypropylene Fibers

Source: NDOR, August 2006. Drainage Design and Erosion Control Manual.

4. Anchoring Staples: Staples for anchoring Treatment 1 shall be Number 11 gauge wire or heavier. Their length shall be a minimum of 6 in. with a distance of 1-in. to 2-in. between the staple legs. A larger staple with a length of up to 12 in. should be used on loose, sandy, or unstable soils. Other anchoring methods such as wooden stakes, bio-degradable plastic staples , live willows, or steel pins that provide proper embedment and support may also be used per the manufacturer's recommendations.

5. Installation Requirements:

   a. After the site has been shaped and graded to the approved final grade, prepare a friable seedbed relatively free from clods and rocks more than 1 in. in diameter and any foreign material that will prevent uniform contact of the protective covering with soil surface.

   b. Lime, fertilize and seed in accordance with planting plan and Section 9.5.20 Permanent Seeding. When using jute mesh on a seeded area, apply approximately half the seed after laying the mat. The protective covering can be laid over sprigged areas where small grass plants have been inserted into the soil. Where ground covers are to be planted, lay the protective covering first and then plant through the material as per planting design. When combination blankets are used, seed and soil amendments should be applied before laying the net.

   c. See Figure 9-48 for orientation of Treatment 1 for different topographic conditions.

   d. Laying and Stapling Requirements (see Figure 9-47, Figure 9-48 and Figure 9-49)

      i. Start laying the protective covering from the top of the channel or top of slope and unroll down-grade.

      ii. Allow to lay loosely on soil, blankets should not be stretched.

      iii. Upslope ends of the protective covering should be buried in an anchor slot no less than 6 in. deep as shown in Figure 9-51. Tamp earth firmly over the material. Staple the material at a minimum of every 12 in. across the top end.

      iv. Edges of the material shall be stapled every 3 ft. Where multiple widths are laid side by side, the adjacent edges shall be overlapped a minimum of 2 in. and stapled together.

      v. Staples shall be placed down the center, staggered with the edges at 3 ft. intervals.

      vi. On highly erodible soils and on slopes steeper than 4:1, erosion check slots should be made every 50 ft. as shown in Figure 9-51. Insert a fold of the material (separate piece) into a 6 in. trench and tamp firmly. Staple the fold to the "main" blanket at a minimum of 12 in. intervals across the upstream and downstream portion of the blanket.

      vii. When joining a new roll of blanket to another, insert the new roll into an anchor slot, as with upslope ends. Overlap the end of the previous roll a minimum of 12 in., and staple across the end of the roll just below the anchor slot and across the material every 12 in.

vii. At the point at which the material is discontinued at the bottom of slope or channel, or at which time the protective covering meets a structure of some type, fold 4 in. of the material underneath and staple every 12 in.

ix. At bottom of slopes, spread blanket out onto a level area before anchoring. Turn ends less than 4 in., and staple across end every 12 in.

x. After installation check that the blanket is in uniform contact with the soil, all lap joints are secure, all staples are driven flush with the ground, and all disturbed areas have been seeded. Tenting is unacceptable. If the blanket is not sufficiently bonded, animal entrapment can occur in the netting. Place stakes or pins anywhere there is a depression in the underlying soil.

xi. Where snake and small animal entrapment is a threat, Treatment 1 products should be used which incorporate mesh with larger apertures (greater than 1-in. openings).

Long-Term Non-Degradable Channel Applications (TREATMENT 2)
(Product Types 2A through 2C on Table 9-16)

1. The allowable maximum velocity during vegetation establishment shall be 10 ft. per second.

2. At the outlet end of pipe installations and in locations of more concentrated flows due to smaller cross sectional areas, stabilization matting should be used in conjunction with rock rip rap. Selection and placement of rip rap shall be based on the channel slope and design discharge of the flow. Refer to the Chapter 7 Energy Dissipators. The matting shall be properly anchored at the downstream end ahead of the rip rap section.

3. Matting shall consist of any of a number of products which provide a three dimensional geomatrix of nylon, polyethylene, or randomly oriented monofilaments, forming a mat. Matting material shall contain ultra-violet (UV) inhibiting stabilizers to ensure endurance and provide “permanent root reinforcement”.

4. Matting shall be selected according to flow rates, soil characteristics, intended use and manufacturer’s recommendations.

5. Staples shall be selected that conform to dimensions in Figure 9-48 and installed according to Figure 9-49.

6. After site has been shaped and graded to the approved final grade, prepare a friable seedbed relatively free from clods and rocks more than 1 in. in diameter, and any foreign material that will prevent contact of the soil stabilization mat with the soil surface. If necessary, redirect any runoff away from the ditch or slope during installation.

7. Lime, fertilize and seed in accordance with seeding or other type of planting plan paying particular attention to the plant selection that may have been chosen for the matted area. If the area has been seeded prior to installing the mat, make sure and reseed all areas disturbed during installation.

8. Mulch shall be applied following installation of Treatment 2 in accordance with Section 9.5.22 Mulching.

9. See Figures 9-47 and 9-49 for laying and stapling requirements.
10. Follow manufacturer's recommendations for securing and joining mats regarding check slot installation, upstream and downstream terminal slots, new roll overlaps and multiple width installations. If no recommendations exist, follow guidelines outlined under Treatment 1.
11. After installation, check that the blanket is in uniform contact with the soil, all required slots and lap joints are in-place and secure, all staples are driven flush with the ground, and all disturbed areas have been seeded. Tenting is unacceptable. If the blanket is not sufficiently bonded/stapled, animal entrapment can occur in the netting. Place stakes or pins anywhere there is a depression in the underlying soil.
12. Treatment 2 materials are not recommended for use where snake and small animal entrapment may be a threat.

Inspection and Maintenance:

All soil stabilization blankets and matting should be inspected periodically following installation, particularly after rainstorms to check for erosion and undermining. Any dislocation or failure should be repaired immediately. If washouts or breakage occurs, reinstall the material after repairing damage to the slope or ditch. Continue to monitor these areas until which time they become permanently stabilized; at that time annual inspections should be adequate.

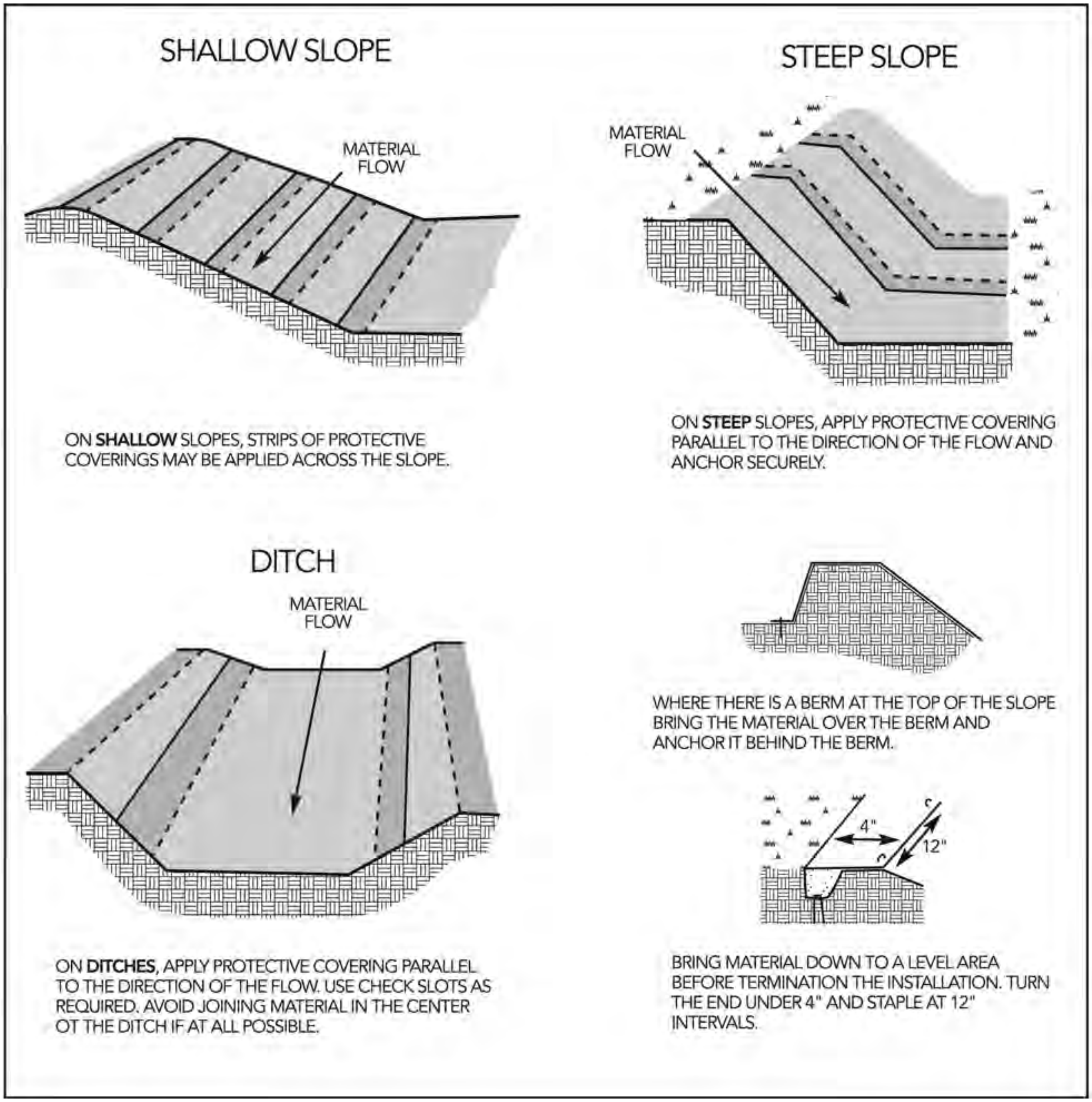
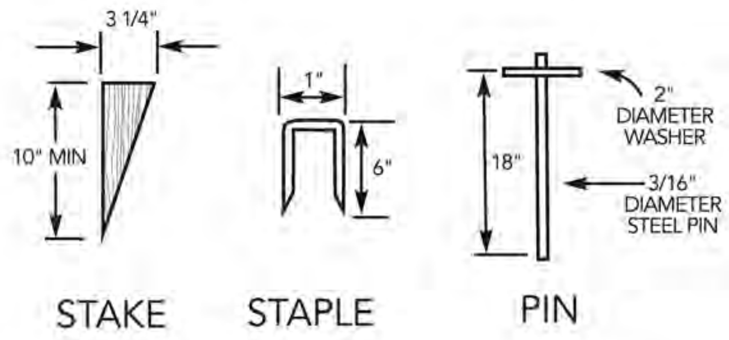


Figure 9-47 Typical Orientation of Treatment – 1 (Soil Stabilization Blanket)



STAKE: 1 X 4 TRIANGULAR SURVEY STAKE, MINIMUM 10" IN LENGTH. PLACEMENT OF THE STAKE ACROSS THE FLOW OF THE WATER IS THOUGHT TO PROVIDE A "PINBALL EFFECT" TO HELP SLOW THE VELOCITY.

STAPLE: 11 GAUGE STEEL, MINIMUM 1" WIDE BY 6" IN LENGTH STEEL STAPLES. 2" X 8" STAPLES MAY BE REQUIRED IN CERTAIN SOIL CONDITIONS.

PIN: STEEL PINS, 3/16 DIAMETER STEEL PIN BY 18" IN LENGTH WITH A 2" DIAMETER WASHER ON TOP. (SEE ILLUSTRATION)

Figure 9-48 Typical Treatment – 1
Installation Criteria (Soil Stabilization Blanket)

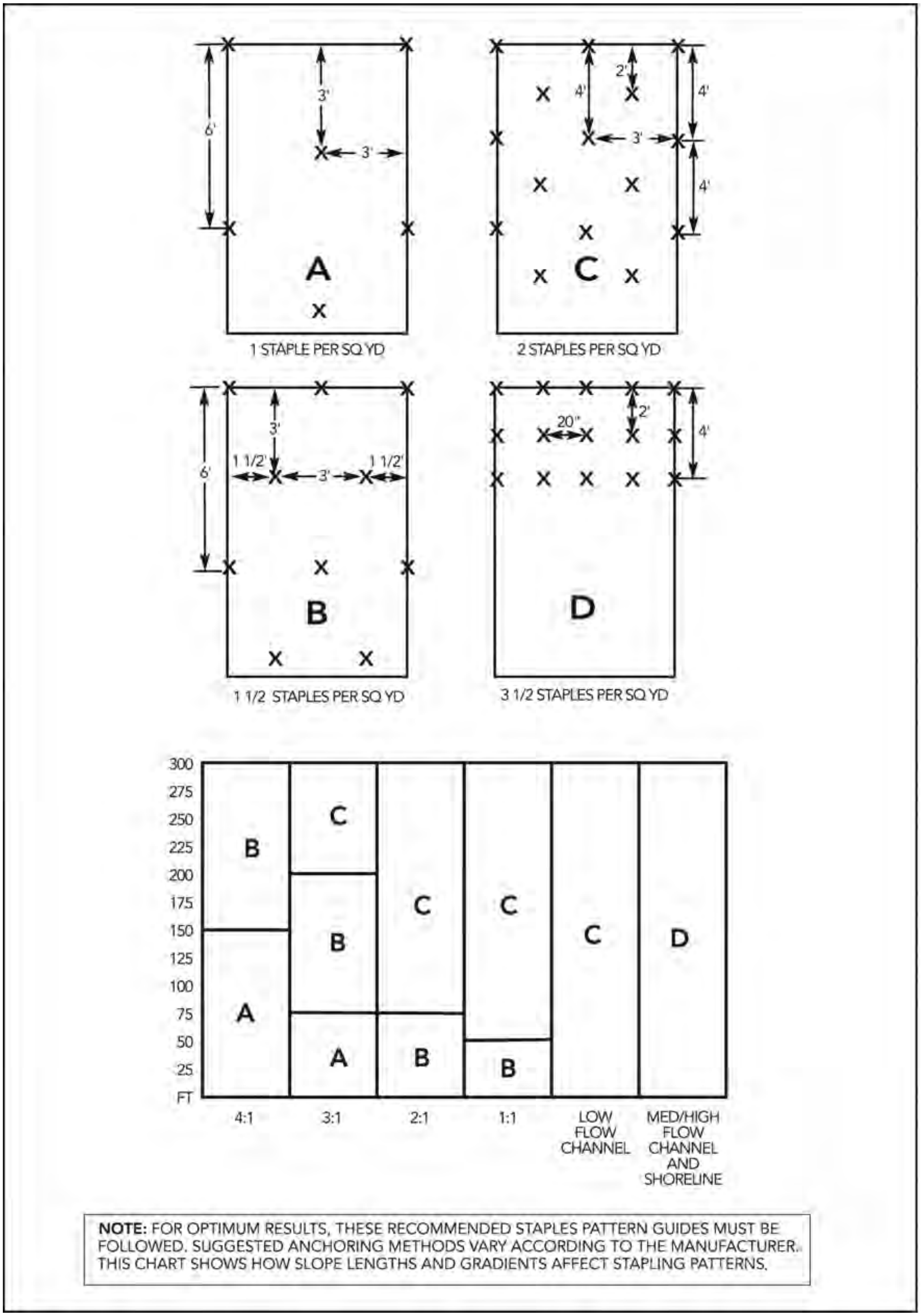
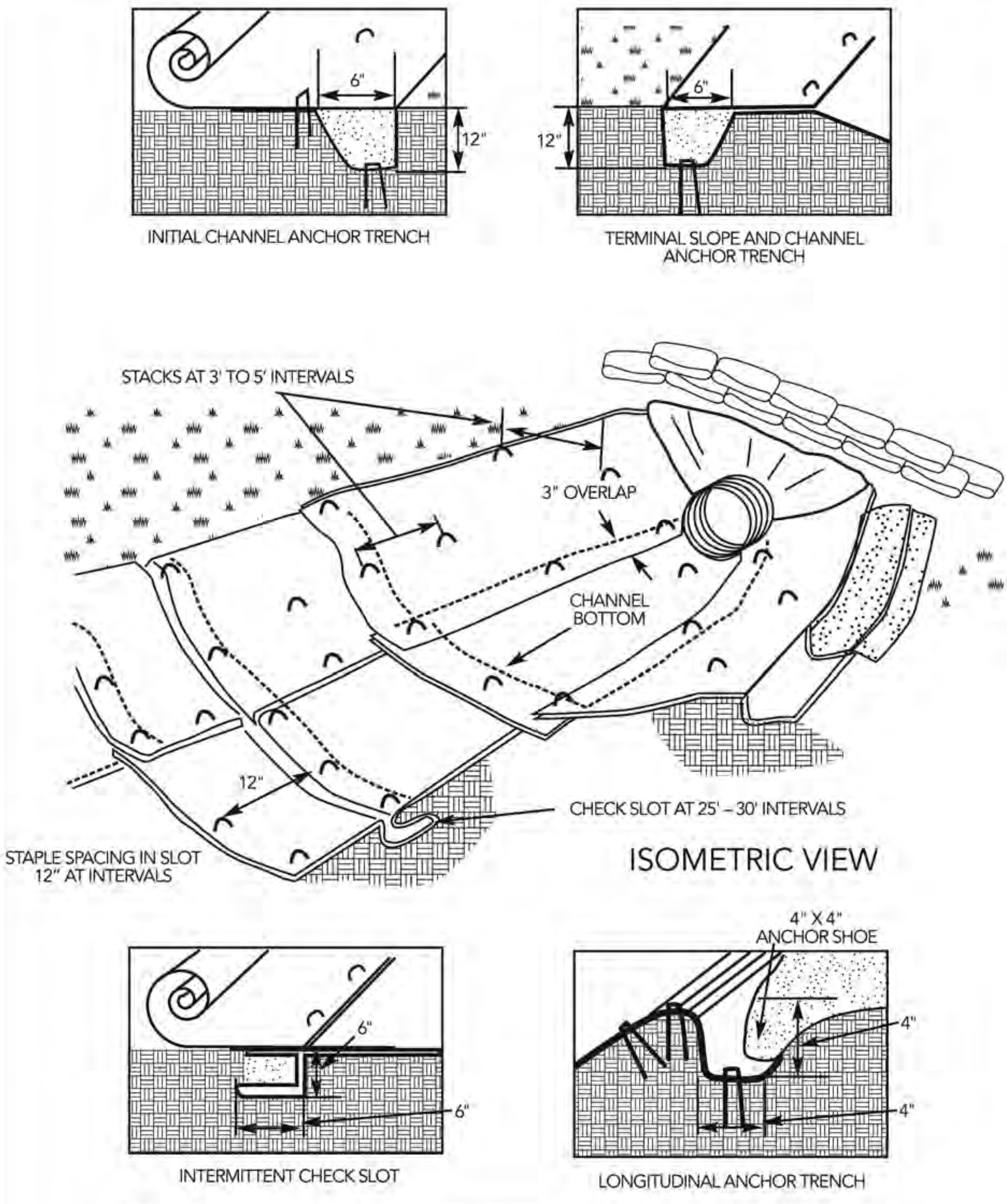


Figure 9-49 Stakes, Staples, and Pins for Installation of Treatment – 2 (Soil Stabilization Matting)



NOTE:
1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURER'S SPECIFICATIONS.
2. STAKE OR STAPLE LAYOUT PER MANUFACTURER'S SPECIFICATIONS.
3. INSTALL PER MANUFACTURER'S RECOMMENDATIONS.

Figure 9-50 General Staple Pattern Guide and Recommendations for Treatment – 2 (Soil Stabilization Matting)

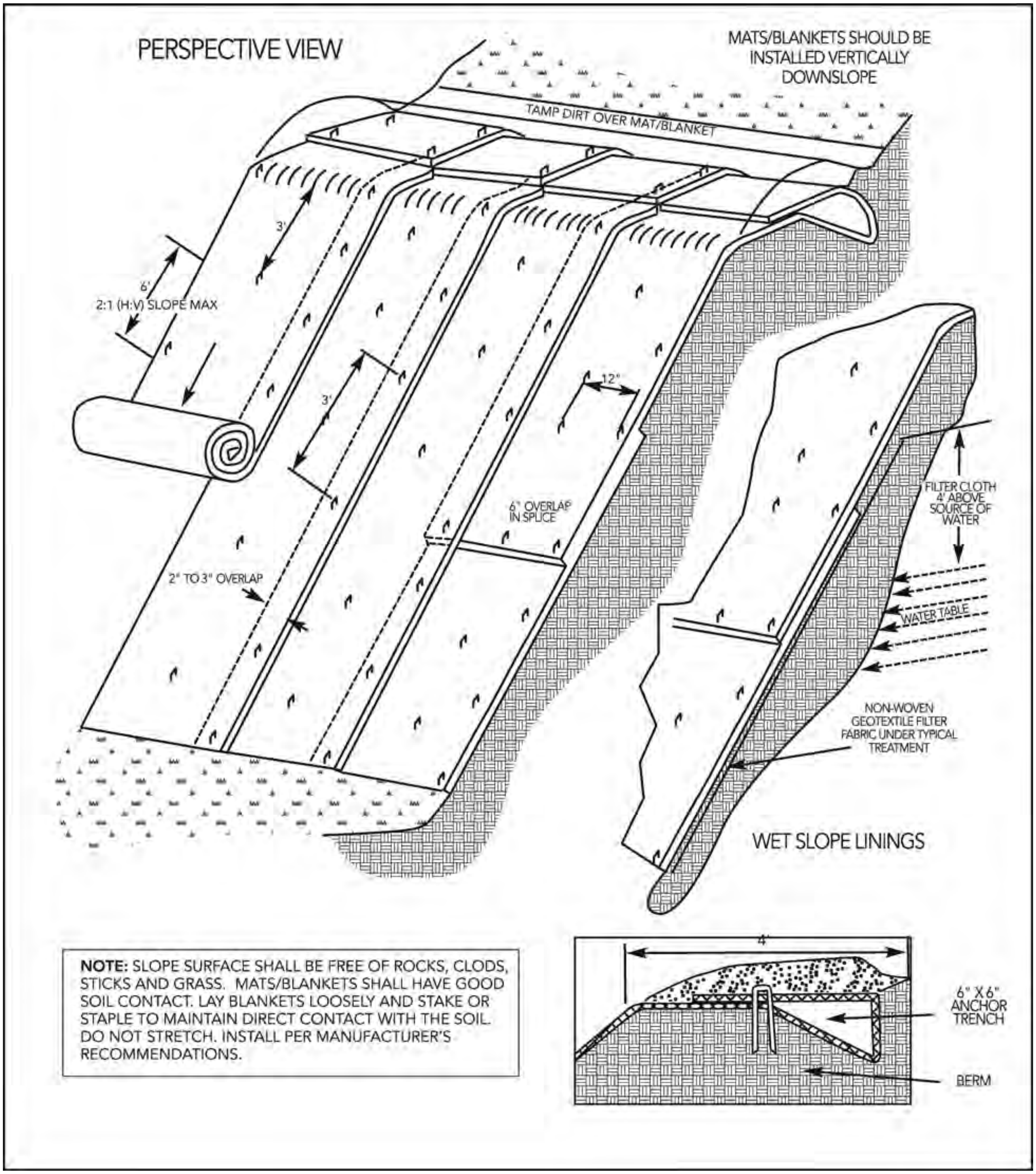
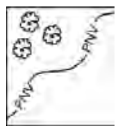


Figure 9-51 Typical Treatment – 2
Soil Stabilization - Matting Installation

9.5.24 Preserving Natural Vegetation

Symbol:



BMP Guideline

Definition: Preserving natural vegetation is the practice of identifying and preserving well-established existing vegetation areas by prohibiting land disturbing activity.

Purpose: Preserving natural vegetation areas maintains existing stabilized ground surface and slopes to reduce erosion potential. Preserving natural vegetation can also act to filter stormwater runoff and reduce runoff volume, improving runoff water quality and helping to reduce downstream flooding potential.

Conditions Where Practice Applies:

Preserving natural vegetation is applicable where vegetation exists as a predevelopment condition of the site. Preserving natural vegetation areas can be especially beneficial for floodplains, wetlands, stream banks, and steep slopes. This practice can be applied in areas where erosion prevention measures are difficult to establish, install, or maintain, in areas planned for later phased construction activity and in areas where no construction activity will occur.

Design Criteria:

Preservation of natural vegetation areas requires pre-construction planning. Planning should include consideration of the site size, equipment size and maneuvering needs, the natural hydrology of the site, and the preconstruction vegetation condition.

1. Site size should be taken into consideration when choosing equipment needs (smaller equipment should be used on smaller sites to avoid unnecessary natural vegetation removal).
2. Vehicle routes should take into consideration equipment sizes and maneuvering needs to minimize clearing natural vegetation.
3. The natural hydrology of the site should be field verified prior to designing grading activities, as grading changes can result in environmental conditions which can kill vegetation (US EPA, 2008).
4. Once the areas which can remain undisturbed are determined, the preconstruction vegetation condition should be checked to determine the viability of the vegetation.
    a. Preconstruction vegetation which is well established and is stabilizing the ground surface should be protected as it can help reduce the occurrence of erosion.
    b. Other considerations include whether the vegetation are desirable bushes, vines, grasses and trees which should be protected wherever possible to avoid unnecessary disturbance and vegetation replacement costs.

Construction Guidelines:

1. Designers should take climate into consideration and the likelihood of precipitation during construction activities. Omaha receives 66 percent of its precipitation (18.38 in.) between the months of May and September (Neild and Newman, n.d.). Construction activities should be

scheduled around anticipated precipitation events whenever feasible. Monitoring current and forecasted weather conditions in conjunction with maintaining an up-to-date construction planning schedule (see Section 9.6.1 Construction Scheduling and Sequencing) is beneficial for determining the least disruptive time for site activities. Site activities in preserved areas which are expected to occur over an extended length of time can have a detrimental effect on preserved natural vegetation if precipitation occurs and appropriate temporary erosion and sediment control activities are not utilized. Appropriate temporary erosion and sediment control BMP will vary by site, and may include;

a. 9.5.4 Silt Fence

b. 9.5.8 Temporary Fill Diversion

c. 9.5.14 Temporary Sediment Trap

d. 9.5.23 Soil Stabilization Blankets and Matting

e. 9.5.25 Wattle

f. 9.5.26 Compost Sock

2. Other considerations can be addressed during the preparation of a site map by identifying the locations of trees and boundaries of environmentally sensitive areas and buffer zones intended for preservation. Avoid these areas when planning the location of roads, buildings, and other structures. Ensure protective boundaries around contiguous natural areas and tree drip lines which provide enough distance from construction activity to protect the root zone from damage.

3. Consider the following factors when selecting areas where natural vegetation will be preserved:

a. *Area.* Avoid removing vegetation from areas where erosion prevention measures would be difficult to establish, install or maintain.

b. *Buffer zones*. A 50-ft. wide protective zone which serves as a water pollution control setback for separating pollution hazards from waterways. (In order to minimize sediment discharges if any waters of the U.S. are located on or adjacent to a project site, a 50-ft. buffer or undisturbed natural vegetation that alone or with additional sediment control and erosion prevention measures achieves a reduction in sediment load equivalent to that achieved by a 50-ft. buffer of undisturbed natural vegetation is required under 40 CFR Part 450 and is described in the NPDES General Permit for Discharges from Construction Activities Part 2.1.2 [US EPA, 2012]).

c. *Sensitive areas*. Protect areas which require preservation under local, state and federal regulations.

d. *Establishment of vegetation*. Preservation of established vegetation reduces the time needed to establish new vegetation.

e. *Tree vigor*. Preserve healthy trees as they are less susceptible to damage, disease, and insects.

f. *Tree age.* Preserve older trees if they are healthy.

g. *Tree species.* Preserve species that are well-suited to present and future site conditions. Keeping a mixture of evergreens and hardwoods can help to conserve energy.

h *Wildlife benefits.* Choose vegetation types which are preferred by native wildlife for food, cover, and nesting.

4. The steps for preserving natural vegetation are:

    a. Before clearing activities begin, use signs, flags or fencing to clearly mark the area to be preserved.

    b. Install barriers to prohibit equipment and vehicles from entering preserved areas.

    c. Keep all equipment, materials, topsoil, and fill dirt outside the preserved areas.

    d. Grade and replace vegetation as needed as construction activities are completed.

    e. If any tree or shrub which was slated for preservation is damaged, remove and replace it, with a tree of the same or similar species with a 2-in. or larger caliper from nursery stock, when construction activity is complete.

    f. After all construction is finished remove barriers from around preserved areas and trees.

<u>Inspection and Maintenance</u>:

1. Before and during construction: Inspect preservation areas to verify flags or barrier around protected area has not been removed. Repair and replace flagging/barrier as needed.

2. Repair or replace damaged vegetation immediately to maintain the integrity of the natural system. When planning for new vegetation, choose types which enhance the existing vegetation. If fertilization is needed, use the following practices to minimize adverse water quality affects:

    a. Apply fertilizers at the minimum rate and to the minimum area needed.

    b. Work the fertilizer deeply into the soil to reduce exposure of nutrients to stormwater runoff.

    c. Apply fertilizer at lower application rates with a higher application frequency.

    d. Limit hydro-seeding, which is simultaneously applying lime and fertilizers.

    e. Ensure that erosion and sediment controls are in place to prevent fertilizers and sediments from being transported offsite.

9.5.25 Wattle

Symbol:

BMP Guideline

Definition: Wattles, also called fiber logs or fiber rolls, are tube-shaped erosion prevention devices filled with straw, flax, rice, coconut fiber, or compost material. Rolls are wrapped in UV-degradable polypropylene netting or 100-percent biodegradable material, depending on longevity requirements.

Purpose: Wattles perform as a temporary erosion and sediment control barrier. Wattles help slow, filter, and spread overland flows which in turn reduce erosion and minimize rill and gully development. The use of wattles improves receiving water quality by filtering runoff and capturing sediments. The effects of long or steep slopes can be addressed with wattles installed in combination with straw mulch, erosion prevention blankets, hydraulic mulches, or soil stabilization blankets and matting for slope stabilization.

Conditions Where Practice Applies:

Wattle use is applicable in areas of low shear stress. They can be used along sidewalks to prevent sediment from bare lots from washing onto sidewalks and streets. Wattles can be placed in front of drain inlets to prevent sediment from entering the stormwater system.

Design Criteria: (Figure 9-52)

On the toe, top, face, and at-grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.

1. Fiber rolls can be suitable in the following settings:
    a. The end of a downward slope where it transitions to a steeper slope.
    b. Perimeter of a project.
    c. As check dams in unlined ditches.
    d. Along the downslope side of exposed soil areas.
    e. Perimeter of temporary stockpiles.
2. Wattles are bound on each end and at four ft. intervals with biodegradable ties. Wattles are typically between 8 to 10 in. in diameter. The length of the wattle is determined based on the length of the area where the wattle is being used. Wattles with a minimum 20 in. in diameter should be used at the bottom of shallow slopes (5:1 or greater). Stacking of multiple smaller diameter wattles can be used to achieve the overall protection expected from a larger diameter wattle. Wattles must be trenched and staked to be effective. Table 9-17 provides information on maximum distance between wattles depending on slope.

Table 9-17 Distance Between Wattles

Slope	Distance Between Wattles
2:1 (horizontal:vertical) or greater slope	10 feet apart
Between 2:1 and 4:1 (horizontal:vertical) slope	30 feet apart
4:1 (horizontal:vertical) or flatter slope	20 feet interval

Source: CASQA, 2009

Installation Steps:

1. If installing on projects with slopes angle the outer edges of the wattle downward to prevent ponding behind the middle of the roll, while turning the ends upslope to prevent runoff from moving around the wattle.

    a. Install wattles perpendicular to runoff flow direction and parallel to the slope contour.

    b. Place wattle in a trench approximately 3 to 5 in. deep.

    c. Wattles should be staked to avoid floating away. Stake should be approximately 24 in. long. Stakes should be driven in to the ground deep enough to anchor roll, leaving 3 to 5 in. of the stake above the wattle. Place stakes approximately 4 ft. apart.

    d. Wattles are typically placed closer together in areas with steeper slopes and soft, loamy soil. Wattles should be installed beginning at the base of the slope working up.

    e. When using multiple wattles along the contour they should overlapped.

Inspection and Maintenance:

Minimal maintenance is required. Periodically inspect wattles to verify the wattle is still firmly anchored and not damaged. Inspect wattles after prolonged rain events. Replace or repair missing or damaged wattles as necessary. When using wattles on rough surfaces such as pavement, wattles are more easily damaged and should be inspected more frequently to prevent wattle content from entering storm inlets, especially if the wattle is being used to protect the storm inlet.

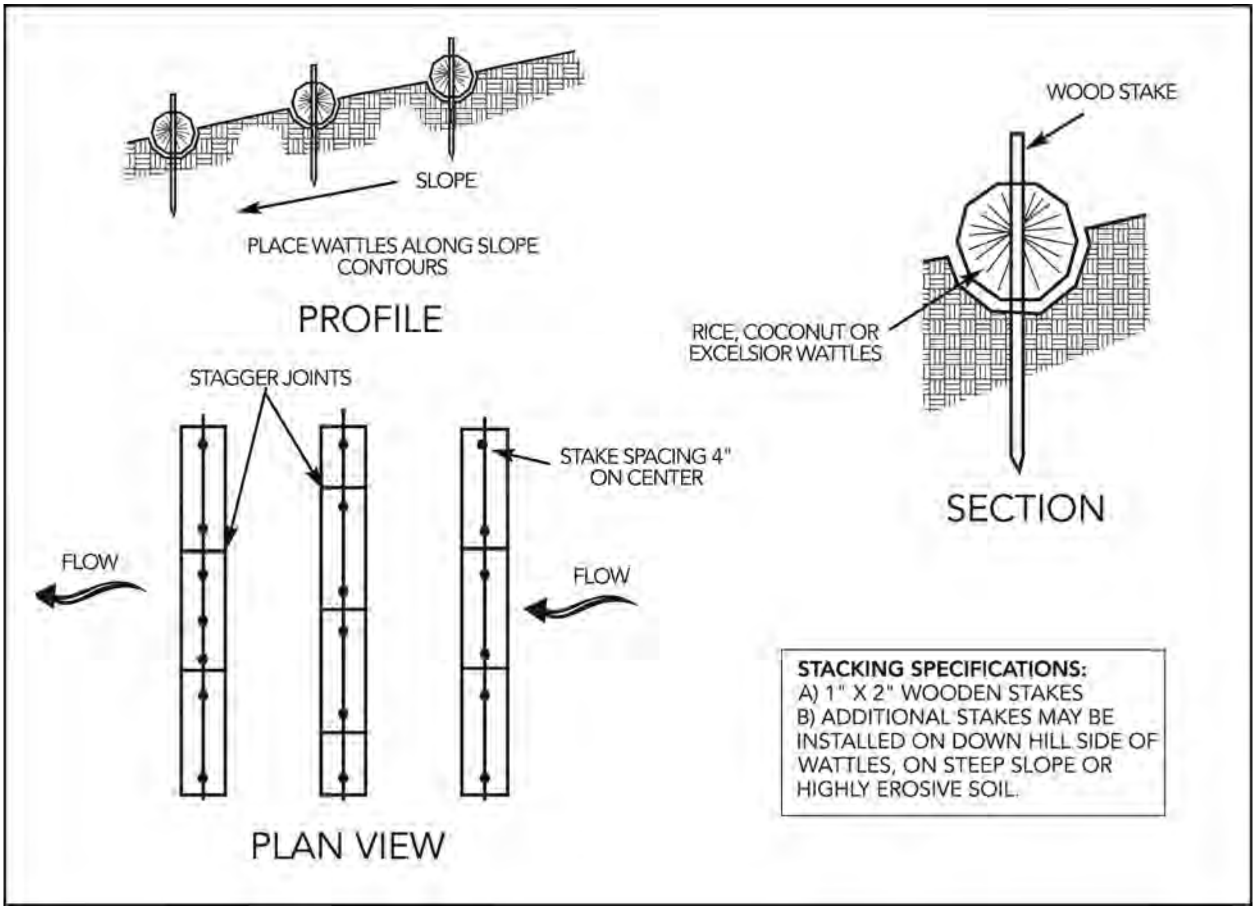


Figure 9-52 Wattles

9.5.26 Compost Sock

Symbol:

BMP Guideline

Definition: A compost sock is a mesh tube filled with composted material which is placed perpendicular to sheet flow runoff to prevent erosion and retain sediment in disturbed areas.

Purpose: A compost sock provides a three-dimensional filter which retains sediment and other soluble pollutants while allowing filtered water to continue to flow on and around construction sites.

Conditions Where Practice Applies:

Compost sock(s) can be used for disturbed areas with unconcentrated stormwater runoff occurs. Compost socks can be used on a steeper slope application if they are spaced closely or used in combination with other BMPs.

Compost socks can be used where drainage areas of 0.25 ac. per 100 ft. of compost sock are not exceeded and where flow does not exceed one cu. ft. per second but should not be used in close proximity to a body of water.

Compost socks are typically spaced along the length of the slope as follows (CalTRANS, 2012):

1. 10 ft. on center for slopes steeper than 2:1 (horizontal:vertical)
2. 15 ft. on center for slopes from 2:1 to 4:1 (horizontal:vertical)
3. 20 ft. on center for slopes from 4:1 to 10:1 (horizontal:vertical)
4. 50 ft. on center for slopes flatter than 10:1 (horizontal:vertical)

Compost sock(s) can be used:

1. For perimeter sediment control,
2. On compacted or frozen soils,
3. On slopes up to 2:1 (horizontal:vertical),
4. In sensitive environmental areas where disruption of vegetated root systems or of wildlife migration should be avoided (US EPA, 2012.)

Design Criteria: (Figure 9-53)

1. Compost socks can be purchased pre-assembled or the compost sock can be assembled onsite. Compost socks which are pre-assembled and/or the mesh tube required for on-site assembly are typically purchased from vendors who specialize in erosion and sediment control products. The compost sock mesh tube can range from fully biodegradable to high strength, more appropriate for vehicular applications. If biodegradable socks are used, seed should be added to the composted material in the mesh tube prior to placement.
2. The compost shall be derived from plant material, and the result of biological degradation and

transformation of plant derived materials under conditions that promote anaerobic decomposition. The material shall be well composted, free of viable weed seeds, and stabilize with regard to oxygen consumption and carbon dioxide generation. The compost shall have a moisture content that has no visible free water or dust produced when handling the material. It shall meet the criteria presented in Table 9-18, as reported by the U.S. Composting Council STA Compost Technical Data Sheet provided by the vendor. OmaGro is a locally produced compost product that is acceptable for use in soil conditioning.

Table 9-18 Compost Criteria for Compost Socks

Compost Criteria
One hundred percent of the material must pass through a half inch screen
The pH of the material shall be between 6 and 8
Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0% by weight.
Organic matter should be between 35 and 65 percent
Soluble salt content shall be less than 6.0 mmhos/cm
Maturity should be greater than 80%
Stability shall be 7 or less
Carbon/nitrogen ratio shall be less than 25:1
Trace metal test result = "pass"
The compost must have a dry bulk density ranging from 40 to 50 lbs./ft^3.

3. At locations which require filter socks with a length greater than 200-ft., the socks should be sleeved (refer to construction guidelines).

Construction Guidelines:

Steps to assembling a compost sock:

1. Fill sock with composted material (use of pneumatic blower is common), knot the end when desired length is achieved. Length of the compost sock should correspond with the width of the slope to ensure stormwater does not break through where two compost socks meet.

2. If placing socks end to end is necessary, sleeve the ends. Overlapping (sleeve) the sock is necessary to reduce the opportunity for water to penetrate the joint.

   Overlapping (sleeve) steps:

   a. After one sock is filled and knotted, the end of the next sock is pulled over the first sock at a length of 1 to 2 ft. overlapping the first and creating a "sleeve". Once the overlap is in place filling of the next sock can commence.

3. Diameter of the compost sock varies depending on steepness and length of slope for the application as shown on Table 9-19. Steeper and longer slope areas require a compost sock with a larger diameter.

4. Compost socks, regardless of length, must be anchored in place, typically by placing stakes through

Table 9-19 Compost Sock Slopes, Slope Lengths, and Diameter

Slope (rise:run)	Slope Length (feet)	Sock Diameter Minimum (inches)
<50:1	250	12
50:1–10:1	125	12
10:1–5:1	100	12
3:1–2:1	50	18
>2:1	25	18

Source: Oregon Department of Environmental Quality (ODEQ), 2004 (US EPA, 2006)

the center of the sock. Socks which have been overlapped (sleeved) should be staked at the overlap area to keep the socks together. A minimum of two-in. wide wooden stakes should be placed at a minimum interval of 10 ft. along the length of the sock for longer compost sock applications (AASHTO, 2010). The top of the stake should be 3 to 4 in. higher than the top of the compost sock.

Typically the compost sock is placed perpendicular to unconcentrated runoff. In concentrated flow areas the compost sock can be placed in an inverted V going up slope to reduce the velocity of the runoff and prevent ponding, as shown on Figure 9-53. The ends of the sock shall be turned up the slope to prevent runoff and sediment from flowing around compost sock (CASQA, 2009).

Inspection and Maintenance:

1. Routine inspection should be performed per the City's permit and guidelines.

2. The compost socks should be inspected regularly and after each rainfall to verify they are intact and maintaining their shape. Remove the accumulated sediments from behind the compost sock when the sediments are approximately one-half the height of the sock.

3. If excessive ponding and sedimentation occurs behind the compost sock, an additional sock can be added on top or in front of the existing compost sock. If sedimentation overtopped the compost sock during a storm event, consider installing an additional filter sock on top of the original, placing an additional compost sock further upstream on the slope, or combining the use of the compost sock with an additional BMP.

4. Inspection and maintenance of compost sock(s) should continue occurring until the area above the compost sock has been permanently stabilized.

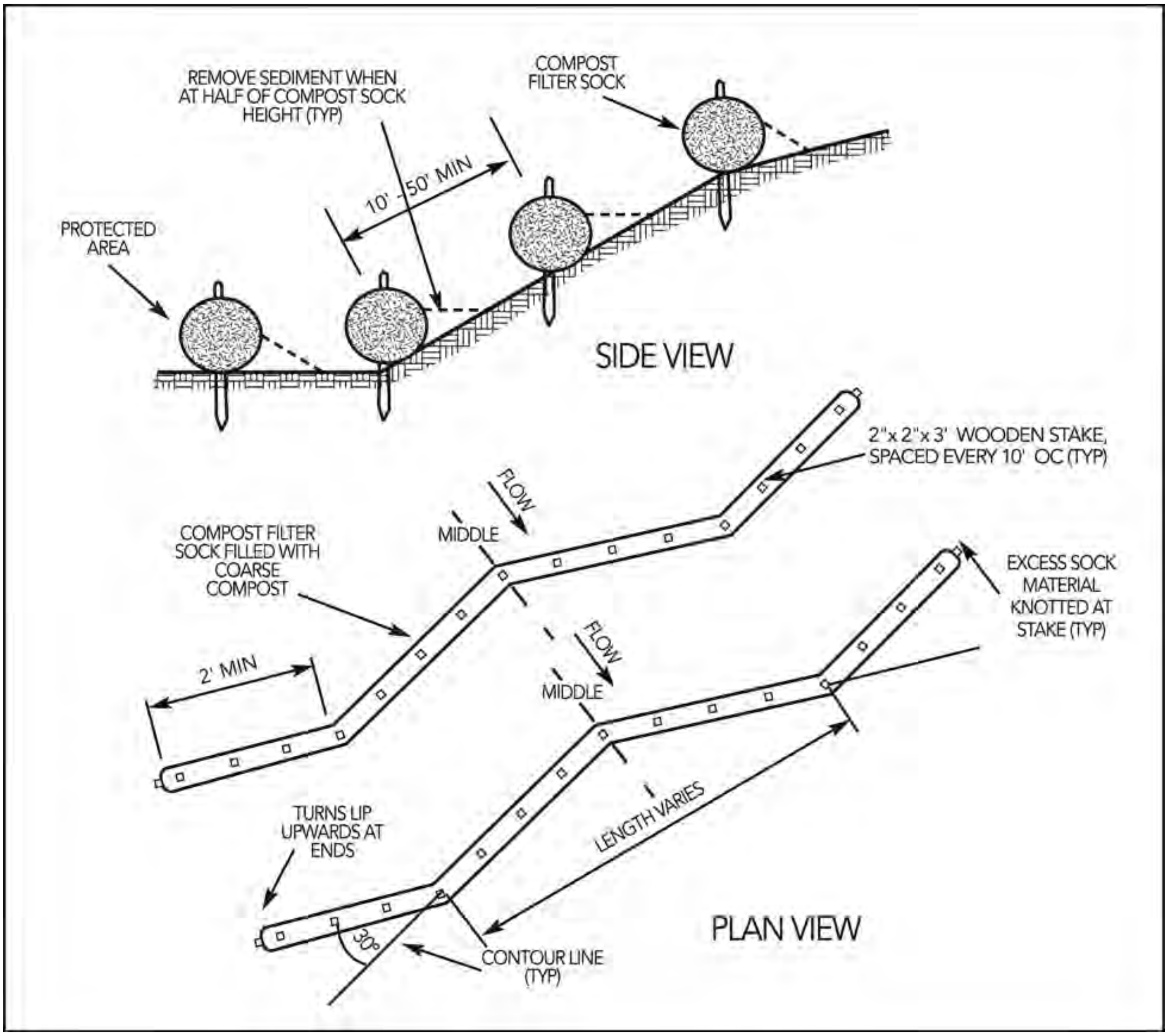
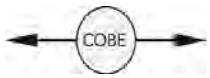


Figure 9-53 Compost Sock Plan View

9.5.27 Compost Berm

Symbol:



BMP Guideline

Definition: A compost berm is a dike, trapezoidal in cross section, composed of compost.

Purpose: The compost berm is placed perpendicular to sheet flow runoff to prevent erosion and retain sediment in disturbed areas.

Conditions Where Practice Applies:

Compost berms can be used on construction sites with relatively small drainage areas, with slopes up to 2:1 (horizontal:vertical). In steeper slope applications compost berms can be stacked behind each other along the slope or used in combination with other BMPs. Do not install near water or storm inlet.

Design Criteria:

1. The compost shall be derived from plant material, and the result of biological degradation and transformation of plant derived materials under conditions that promote anaerobic decomposition. The material shall be well composted, free of viable weed seeds, and stabilized with regard to oxygen consumption and carbon dioxide generation. The compost shall have a moisture content that has no visible free water or dust produced when handling the material. It shall meet the criteria presented in Table 9-20, as reported by the U.S. Composting Council STA Compost Technical Data Sheet provided by the vendor. OmaGro is a locally produced compost product that is acceptable for use in compost berms.

Table 9-20 Compost Criteria for Compost Berms

Compost Criteria
One hundred percent of the material must pass through a half inch screen
The pH of the material shall be between 6 and 8
Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0% by weight.
Organic matter should be between 35 and 65 percent
Soluble salt content shall be less than 6.0 mmhos/cm
Maturity should be greater than 80%
Stability shall be 7 or less
Carbon/nitrogen ratio shall be less than 25:1
Trace metal test result = “pass”
The compost must have a dry bulk density ranging from 40 to 50 lbs./ft^3.

2. Compost berms can be used where drainage areas of 0.25 ac. per 100 ft. of compost sock are not exceeded and where flow does not exceed one cu. ft. per second (US EPA, 2006).

3. Typically a compost berm is a continuous length. The height and width of the compost berm for a site can be determined by either estimating stormwater runoff (Table 9-21) or slope and slope length (Table 9–22).

Table 9-21 Berm Dimensions Based on Estimated Precipitation

Annual Rainfall/ Flow Rate	Precipitation/year (Rainfall Erosivity Index)	Berm Dimensions (height x width)
Low	1 to 25 inches	1 ft x 2 ft to 1.5 ft x 3 ft
Average	26 to 50 inches	1 ft x 2 ft to 1.5 ft x 3 ft
High	51 inches and greater	1.5 ft x 3 ft to 2 ft x 4 ft

Source: Alexander, 2003 (US EPA, 2010)

Table 9-22 Berm Dimensions Based on Slope and Slope Length

Annual Rainfall/ Flow Rate	Precipitation/year (Rainfall Erosivity Index)	Berm Dimensions (height x width)
Low	1 to 25 inches	1 ft x 2 ft to 1.5 ft x 3 ft
Average	26 to 50 inches	1 ft x 2 ft to 1.5 ft x 3 ft
High	51 inches and greater	1.5 ft x 3 ft to 2 ft x 4 ft

Source: ODEQ, 2004 (US EPA, 2010)

4. Compost berms are most effective in areas experiencing non-concentrated stormwater runoff flows. The use of a 2-in. thick compost layer on the upslope of a berm helps prevent flow from concentrating. Silt fence, wattle or compost sock can be used with a compost berm in steeper applications to disperse flow and prevent the occurrence of concentrated flows.

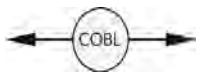
5. Compost berms can be installed by hand, or by using equipment (backhoe, bulldozer, grading blade, etc.) The compost should be uniformly compacted and shaped into a trapezoid.

Inspection and Maintenance:

1. The compost berms should be inspected per the City's permit requirements. It is recommended to inspect the berms after each rainfall.
    a. Check that the berms are not plugged with silt. Stormwater flows should be able to filter through the compost berms and not be retained by them.
    b. Remove accumulated sediments from behind the compost berms when the sediments are approximately one-third the height of the compost berm.
    c. Replace any eroded areas of the compost berm.
2. The compost berms should remain in place until the upstream drainage area has been permanently stabilized.

9.5.28 Compost Blanket

Symbol:



BMP Guideline

Definition: A compost blanket is a layer of loosely applied compost or composted material placed on disturbed areas to prevent erosion and retain sediment.

Purpose: Compost blankets assist in intercepting precipitation and increase infiltration and evapotransporation of water. Compost blankets act as a buffer to absorb rainfall energy thereby reducing soil compaction and erosion while maintaining soil permeability until temporary or permanent vegetation has established.

Conditions Where Practice Applies:

Compost blankets are most effective in the following applications:

1. Where land disturbing activities have ceased to cover open ground and prevent erosion from precipitation,

2. As a means of temporary ground cover to absorb rainfall while temporary and/or permanent vegetation is being established.

Design Criteria:

1. The compost shall be derived from plant material, and the result of biological degradation and transformation of plant derived materials under conditions that promote anaerobic decomposition. The material shall be well composted, free of viable weed seeds, and stabilized with regard to oxygen consumption and carbon dioxide generation. The compost shall have a moisture content that has no visible free water or dust produced when handling the material. It shall meet the criteria presented in Table 9-23, as reported by the U.S. Composting Council STA Compost Technical Data Sheet provided by the vendor. OmaGro is a locally produced compost product that is acceptable for use in compost blankets.

    a. Apply compost at a depth of two in. to create a blanket.

    b. For slopes greater than 2:1, compost blankets should be used with additional stabilizers or erosion prevention practices.

Table 9-23 Compost Criteria for Soil Conditioning

Compost Criteria
One hundred percent of the material must pass through a half inch screen
The pH of the material shall be between 6 and 8
Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0% by weight.
Organic matter should be between 35 and 65 percent
Soluble salt content shall be less than 6.0 mmhos/cm
Maturity should be greater than 80%
Stability shall be 7 or less
Carbon/nitrogen ratio shall be less than 25:1
Trace metal test result = "pass"
The compost must have a dry bulk density ranging from 40 to 50 lbs./ft^3.

Maintenance:

1. Inspect compost blanket until temporary and/or permanent vegetation is established per the City's permit requirements.

    a. If compost blanket erodes or vegetation does not establish, repair area with a reapplication of compost blanket.

    b. If gullies form in the compost blanket, the area shall be regraded and the compost blanket reapplied. The use of additional erosion prevention devices in conjunction with the compost blanket may need to be installed.

9.5.29 Wheel Wash Area

Symbol:

BMP Guideline

Definition: A wheel wash area is a designated area to wash vehicular or equipment wheels to prevent the transfer of mud, dust or contaminants from leaving a construction site.

Purpose: A wheel wash area can reduce or eliminate the tracking of sediment onto streets or other impervious areas thereby reducing the opportunity for sediment to enter storm systems and waterways.

Conditions Where Practice Applies:

A designated wheel wash location is applicable whenever construction entrance road stabilization (refer to Section 9.5.2) activities do not prevent the tracking of construction site mud, dust or contaminants onto a public road or other paved area.

Design Criteria: (Figure 9-54, Figure 9-55 and Figure 9-56)

1. A wheel wash area should be located at the designated point where vehicular traffic will be leaving a construction site and entering a street, alley, sidewalk, parking area, or other impervious surface. (Wheel wash areas are typically located within the planned construction entrance area for a site, described in Section 9.5.2).

2. A wheel wash area requires a turnout or doublewide entrance/exit to avoid having vehicles entering a construction site driving through the wheel wash area.

3. Clearly identify the designated wheel wash area with signs.

4. The designated wheel wash area must be outside of defined buffer zones (an area between disturbed area and surface water [refer to Section 9.5.24 for additional buffer zone description]).

5. Wash water should not contain any soaps or solvents.

6. Prior to discharge from the construction site, treat used wash water by directing it through a sediment trap or equivalent treatment process to meet pollution prevention requirements as described in the NPDES General Permit for Discharges from Construction Activities Part 2.3.3.2.a (US EPA, 2012).

7. A wheel wash area may be equipped with rumble strips to increase agitation.

8. Maintain a water level between 12 and 14 in. in the wash pool to avoid damage to truck hubs.

Construction Guidelines:

Install the wheel wash at the construction entrance (refer to Section 9.5.2) prior to beginning construction activities. A plan view, section and elevation of a typical wheel wash area are shown in Figures 9-54 through 9-56, respectively.

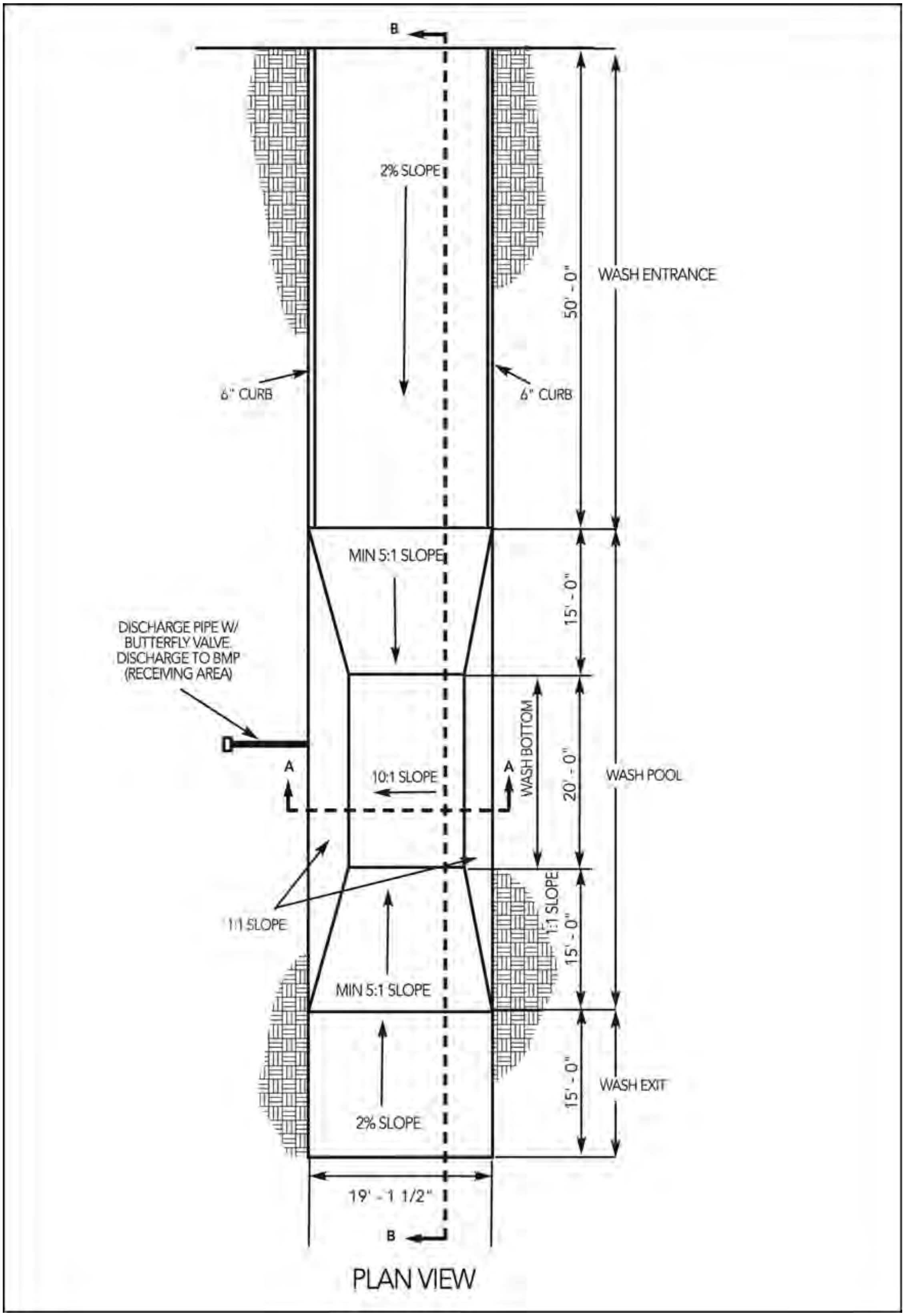


Figure 9-54 Wheel Wash Plan View

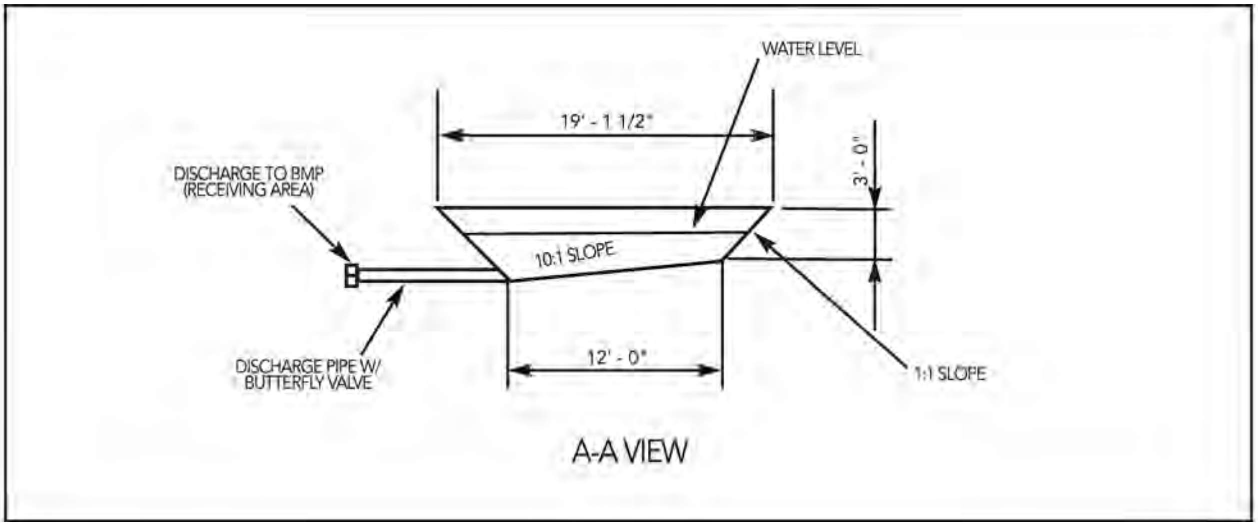


Figure 9-55 Wheel Wash Section (Section A-A)

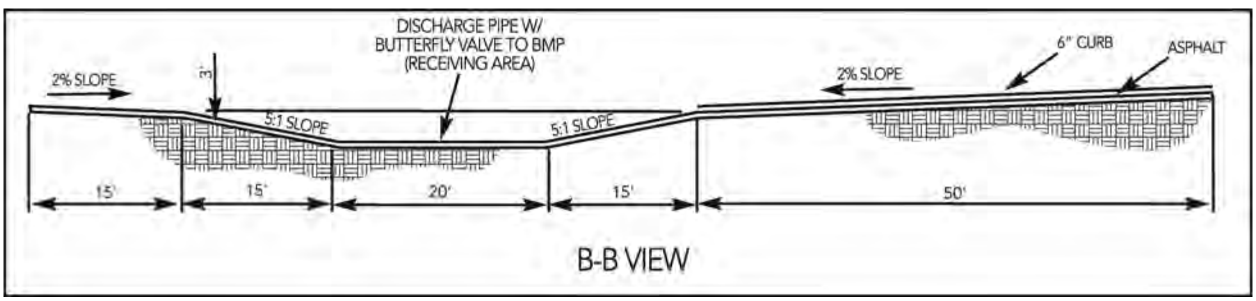


Figure 9-56 Wheel Wash Elevation View (Section B-B)

1. Construct wheel wash entrance and exit to slope towards wash pool area.
   a. The wheel wash entrance should be approximately 50 ft. long constructed with a 2-percent slope towards the wash pool. An asphalt curb should be installed on both sides of the wash area entrance to direct water and create a pool.
   b. The wheel wash exit should be approximately 15 ft. long with a 2-percent slope to direct water toward the wash pool.
2. Design wash bottom with slight slope (10:1) to allow sediment to flow to low side for the prevention of re-suspension of sediment.
3. Use a low profile truck to test for adequate clearance in entering and exiting the wheel wash area prior to paving with asphalt.
4. Pave wheel wash area using a minimum of six to eight in. of asphalt treated base (ATB), depending on subgrade.

   a. If subgrade consists of crushed rock base material, a minimum of six in. of ATB should be installed.

   b. If subgrade is a good quality native subgrade, a minimum of eight in. of ATB should be installed.

5. Install a receiving area on the low side of the wheel wash area for the discharged water. The receiving area could consist of another BMP performing as a sediment trap. Other options include using a sump area. The minimum dimensions of the sump area should be sized to accommodate equipment access for removal of discharged water and sediment. Wheel wash discharge cannot be directly discharged into the public storm sewer system.

6. Install pipe on the receiving area side of wheel wash area.

   a. Install discharge pipe with butterfly valve (sized to remove wash water) sloping toward receiving area and/or other structural BMP.

7. Direct drain pipes and any discharge pipes from wash area entrance and exit to sump area.

8. Midpoint spray nozzles can be installed in the wheel wash area to assist in wheel cleaning as required by the City. The installation of spray nozzles should be done to manufacturer and City building code specifications. Installation of spray nozzles may require a six-in. sleeve under wash area entrance to accommodate pipes for spray assembly.

Inspection and Maintenance:

1. Contractor should provide the City with a Wheel Wash Area Operation and Maintenance Plan to include:

   a. The traffic flow plan.

   b. A wheel wash water source.

   c. Details regarding maintenance of discharge receiving area.

   d. A wash area discharge plan.

2. Change wash water once a day at a minimum. Construction sites with traffic consisting of 10 or more trucks per hr. should change the wash water more frequently.

3. Weekly, inspect the integrity of each component of wheel wash area. Repair and/or replace as necessary.

9.5.30 Live Fascine Rolls

Symbol:

BMP Guideline

Definition: A live fascine roll is a bound, cylindrical shaped roll of live branch cuttings which is placed into a shallow trench along sloped land, such as a streambank. Placement of multiple rolls can provide slope stability and prevent erosion.

Purpose: A live fascine roll aids in permanently stabilizing slopes by intercepting water flow down the slope. The established permanent live vegetation provides a root system which increases soil stability through increased infiltration and sediment retention.

Conditions Where Practice Applies:

Live fascine rolls are advantageous in areas which would benefit from permanent protection through the introduction or reintroduction of live woody vegetation. They can be used to protect sloped sites, such as streambanks and channels which are experiencing or may experience erosion. Live fascine rolls should only be used on slopes with a horizontal to vertical ratio of 1:1 or less. Live fascine rolls should be placed in areas which will not require mowing.

Design Criteria: (Figure 9-57)

1. Live branch cuttings used in the live fascine roll must be from native species which root easily, such as willows or shrub dogwoods. Live fascine rolls should not be prepared more than 2 days in advance of installation. If live fascine rolls are pre-assembled, they should be covered, kept moist and stored in a shaded area until installation.

2. Live fascine rolls should be installed in shallow trenches in line with the natural contours. Installation of live fascine rolls at an angle along the slope facilitates drainage and lessens erosion and shallow sliding. When used along streambanks or channels, place live fascine rolls above the ordinary high-water (OHW) mark as shown on Figure 9-57.

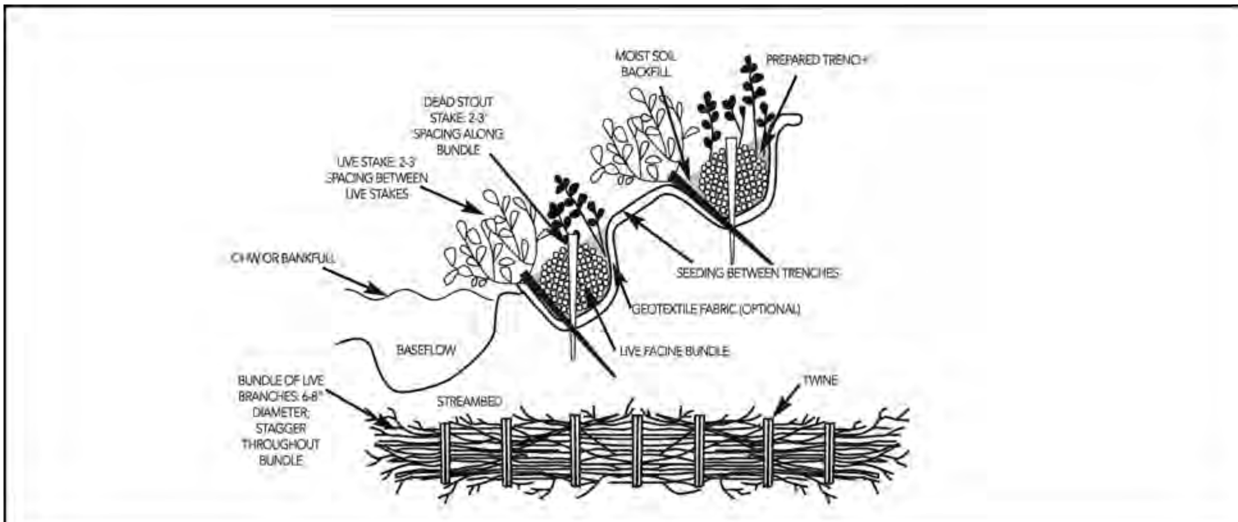


Figure 9-57 Live Fascine Roll Example (USDA Forest Service, 2002)

Both live and dead stakes are utilized to secure the live fascine rolls. Live stakes provide the additional benefit of being another source of permanent vegetation.

Construction Guidelines:

1. The material for the live fascine rolls should be prepared as follows:

    a. Cuttings should be long, straight branches with a uniform diameter. The diameter can range from 0.5 to 1.5 in.

    b. Stagger the cutting's throughout the bundle in order to evenly distribute the tops along the length of the live fascine roll. Ensure all growing tips are oriented in the same direction. This will help facilitate well spaced vegetation growth.

    c. Tie uniformly sized cuttings into a live fascine roll approximately 6 to 8 in. in diameter. The twine used to bundle fascines should be untreated. The length of the live fascine roll is determined by site conditions and handling limitations. A live fascine roll is typically between five and ten ft. in length.

2. The material for the live and dead stakes should be prepared as follows:

    a. At a minimum, the live stakes and dead stout stakes should be 2.5 ft. long to adequately anchor the live fascine roll.

    b. Dead stout stakes should be approximately 2-in. by 2-in. (material for stakes: untreated 2-in. by 4-in. wood, split diagonally lengthwise.) Discard any stakes which break when hammered in place.

    c. Live stakes should have a diameter between 2 to 4 in.

3. The trench for placement of the live fascine roll should be approximately 10-in. wide and deep enough to leave approximately half the height of the live fascine roll above the ground surface. Hand excavation is recommended if site sensitivity precludes the use of trenchers.

4. Live fascine rolls should be installed per the following guidelines, as described in Table 9-24 and as shown on Figure 9-57.

Table 9-24 Live Fascine Roll Installation Guidelines

Slope Horizontal : Vertical	Distance Between Live Fascine Trenches Non-erosive Soil (feet apart)[1]	Distance Between Live Fascine Trenches Erosive Soil (feet apart)[1]
3:1 to flatter	5-7	3-5
3:1 to 1:1	3-5	3[2]

[1] USDA Natural Resources Conservation Services (NRCS), 1996
[2] Recommend to use with other BMP system

Begin installation of fascine rolls at the bottom of the slope working up the slope.

Installation steps:

1. Prepare live fascine roll, live stakes and dead stout stakes.

2. Dig first trench at the base of the slope. Place live fascine rolls in trench with ends overlapped a minimum of six in.

3. Dig next trench. The second trench should be located a distance from the first trench as recommended in Table 9-24.

4. Use excavated soil to partially cover the previously placed live fascine rolls. Place moist soil around the live fascine rolls. Leave approximately 10 to 20 percent of each fascine roll visible after installation.

5. Place erosion prevention measures between trenches. Erosion prevention measures can consist of mulch combined with seeding (refer to Section 9.5.20 Permanent Seeding) or soil stabilization blankets and matting (refer to Section 9.5.23) or a compost blanket (refer to Section 9.5.28).

6. Place dead stout stakes through the live fascine roll at approximately 2 to 3 ft. intervals. Drive stake top to a height level with the live fascine roll. The use of dead stout stakes anchors the live fascine roll.

7. Install live stakes between the placement of the dead stout stakes at approximately 2 to 3 ft. intervals, along the down slope side of the trench and next to the live fascine roll. Leave live stakes protruding approximately three in. above the live fascine roll to promote vegetation growth.

8. Trench the final row over the top edge of slope to disrupt stormwater sheet flow.

Inspection and Maintenance:

A failed live fascine roll does not need to be removed as it continues to function in reducing erosion and promoting slope stability. Slope erosion and debris accumulation adjacent to and affecting the performance of the live fascine should be addressed as it occurs.

First Year Maintenance

1. Inspect area of live fascine roll installation after each high water event for washout, erosion, debris, and vegetation establishment. At a minimum the installation should be inspected at the beginning and end of the first year's growing season.

2. Repair washouts and erosion as identified during the inspections. Repairs can be performed by utilizing the live fascine roll installation process.

3. Remove any excess debris which could threaten the health and establishment of the vegetation.

Long-Term Maintenance

1. Inspect annually after first year, until permanent vegetation is established.

2. Once permanent vegetation is established the fascine roll no longer requires inspection and standard maintenance practices for the area should be followed.

9.5.31 Chemically Enhanced Sand Filtration

Symbol:

BMP Guideline

Definition: Chemically enhanced sand filtration involves using a chemical additive to promote coagulation and flocculation of silt and clay particles in conjunction with a typical sand filtration treatment system.

Purpose: The purpose of chemically enhanced sand filtration is to enhance gravity settling and lower the turbidity of the discharged water by removing smaller particulates such as clay and fine silt.

Conditions Where Practice Applies: Chemically enhanced sand filtration applies to drainage areas where traditional settling basins are inadequate to remove smaller particulates and/or where turbidity is a concern or regulated. Use of chemicals in conjunction with sand filtration can also reduce/remove phosphorous, total and dissolved metals, PCBs and other organics. The use of chemicals for particulate precipitation should be approved of by the City prior to use.

Design Criteria: (Figure 9-58 and Figure 9-59)

1. Typical enhanced sand filtration involves a pre-engineered batch or flow-through system that injects chemicals followed by mixing to promote coagulation and flocculation of fine particulates prior to discharge of the treated stormwater. Ahead of sand filtration is typically a sediment basin to capture the site runoff prior to treatment.

    a. For a batch treatment system, stormwater runoff is collected, stored or contained in a cell, basin or tank until treatment is complete and then discharged. The batch treatment process incorporates a period of time for treatment in a settling, mixing, and/or holding tanks before discharge. See Figure 9-58 for a schematic of a typical batch treatment process. Multiple treatment cells/basins may be required in order to treat the anticipated flows as the batch process typically takes 30 minutes to several hrs. for complete settling.

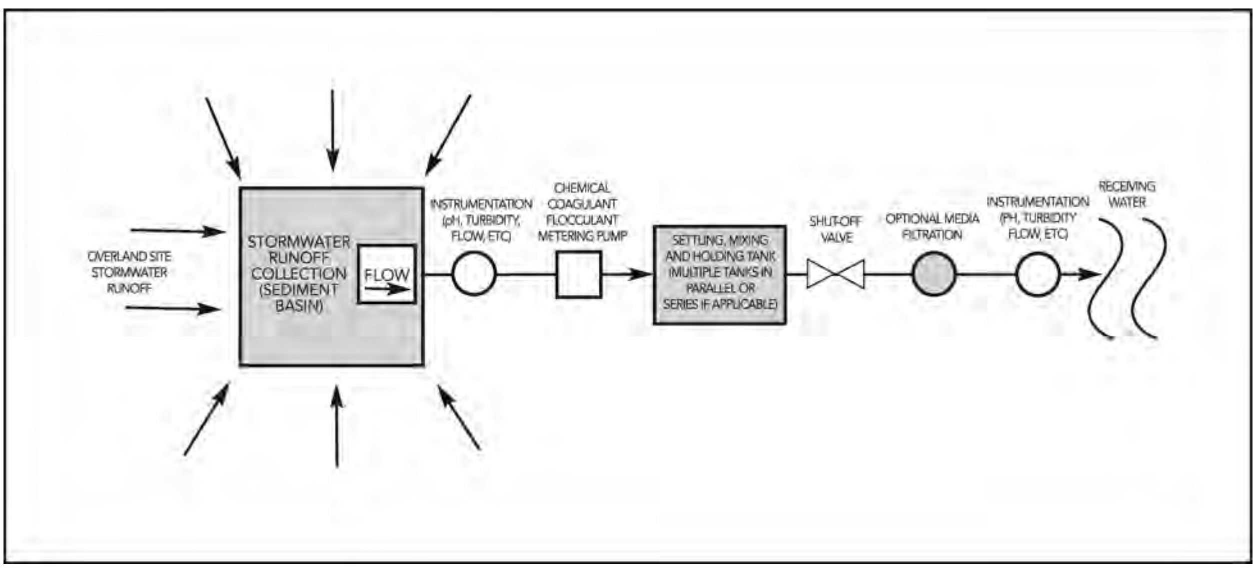


Figure 9-58 Typical Batch Treatment Process

b. A flow-through system involves pumping stormwater runoff from a collection, storage, or containment area, treating the water, and then discharging. The flow-through systems are continuously discharging flow. Refer to Figure 9-59 for a schematic of a typical flow-through treatment process.

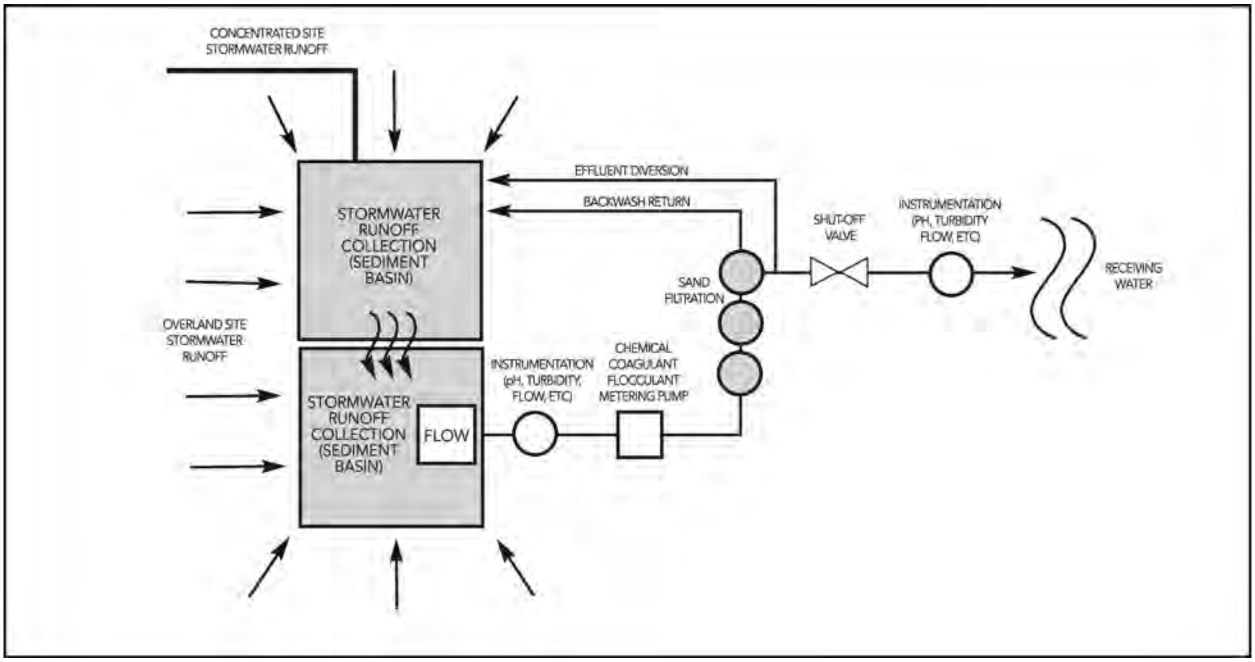


Figure 9-59 Typical Flow-Through Treatment Process

2. The effluent of the filtration system shall meet the requirements of the site for discharge rates and runoff quality.

3. Erosion and sediment control BMPs should be implemented on the site to prevent erosion and discharge of sediment to the chemically enhanced sand filter and the basin shall be stabilized to minimize contributing sediment loads to the process.

4. Design considerations for the system include:

    a. Desired effluent water quality.

    b. Runoff influent flow characteristics.

    c. Runoff quantity.

    d. Available space for storage ahead of the sand filter. The design engineer shall consider the final site layout and whether the forebay/basin shall be used as part of the developments/sites long term post-construction water quality control. This shall be addressed in the project planning phase.

    e. Allowable effluent release rates.

    f. Effluent stormwater quality requirements.

g. Pre-approval from the City on the chemicals proposed for use.

h. Chemical compatibility with anticipated water quality.

i. Approved disposal locations for used sand or other filtration media.

5. A plan must be developed and approved by the City prior to use which addresses:

a. Operation and maintenance of the system.

b. Monitoring, sampling, and reporting protocols.

c. Health and safety.

d. Spill prevention and response.

e. Disposal methods.

6. Chemically-enhanced sand filtration systems shall meet the follow criteria:

a. Chemicals must be non-toxic to plants, animals, and aquatic organisms. Approval from the City is required prior to chemical use.

b. The pH of the stormwater must be in the range recommended by the chemical manufacturer (typically 6.5 to 8.5) for chemicals to be effective.

c. Chemical coagulants are added to destabilize the suspended particles by reducing the net electrical repulsive forces at particle surfaces. The chemical must be rapidly mixed into the water to ensure proper dispersion. Flocculation is the agglomeration of the destabilized particles by chemical joining and bridging. Flocculation increases the rate of settling, to produce the lowest turbidity, and to maintain a chemical dosage rate as low as possible.

d. The amount of energy (i.e. mixing, agitation) input into the treated runoff should be optimized. Too little mixing or agitation will produce insufficient floc. Too much mixing or agitation will destroy the floc and reduce particle removal effectiveness.

e. The outlet flow of the system should be designed to minimize the velocity and prevent the discharge of flocs.

f. Discharge from a batch system should be directed to a secondary filtering system such as a sand filter and/or a vegetated swale to maximize capture of flocs that may be released.

g. The system shall be operated by a trained technician with working knowledge of sand filtration systems and certified to operate these types of systems. . The City requires submission of proof of training (i.e. copy of certificate) prior to SWPPP and permit approval.

h. Enlist the assistance of a knowledgeable service provider who can evaluate the physical, chemical and regulatory requirements.

7. Sizing of System:

    a. The system (including sediment basin) shall be designed with a capacity to hold 1.5 times the runoff volume for a 10-year, 24-hr. storm event. The system shall be able to treat this volume of runoff within 72 hrs. The runoff volume of the watershed area to be treated from this storm event shall be calculated using the Rational Method with a runoff coefficient of 1.

    b. The system design criteria shall include calculations for required storage prior to treatment, allowable discharge rates to surface waters and the required treatment system footprint. In most cases, increasing the size of sediment basin storage will reduce the cost of water treatment.

8. The outlet control structure shall be designed to ensure detention/holding of the chemicals inside the unit for the optimum length of time specified by the chemical manufacturer.

9. Monitoring and control of the system is necessary to ensure that the discharged stormwater meets the designed/required effluent quality and to ensure that the chemical additives are not being released in excess of state water quality requirements. If the effluent does not meet the applicable standards, it should be recycled to the untreated sediment basin where it can be retreated. Additional monitoring may be required based on the existing conditions, quality and requirements in place on the receiving waters. This shall be addressed on a site by site basis.

    a. The system should record a daily cumulative/total flow volume as well as a minimum of flow rates and volumes every 15 minutes.

    b. The system shall be designed to provide a method for controlling coagulant dose to prevent overdosing.

    c. The influent and effluent turbidity must be continuously monitored and recorded at a minimum of every 15 minutes.

    d. The type and amount of chemical used for pH adjustment must be continuously monitored and recorded at a minimum of every 15 minutes.

    e. Dose rate of chemical used for the system must be continuously monitored and recorded at a minimum of every 15 minutes.

    f. Laboratory duplicates (monthly) for residual coagulant analysis must be performed and records maintained on-site.

    g. Effluent flow shall be monitored and recorded for residual chemical/additive levels. Residual chemical test method shall produce a result within one hr. of sampling.

    h. The system shall be designed to provide auto shutoff or recirculation in the event that the effluent measurements exceed turbidity or pH.

    i. In the event of power failure or other catastrophic event, the system shall default to recirculation or safe shut down.

Construction Guidelines:

1. Sand Filtration should be used downstream of chemical coagulation and flocculation.

    a. Although there are several variations, sand filters typically consist of a sand filter bed or a multi-chambered treatment train. Sand filters provide filtration and removal of suspended solids from the stormwater. When used without chemicals, a traditional sand filter is effective is removing larger total suspended solids and moderate removal for total phosphorus.

    b. The filter bed/basin/tank shall be equipped with an underdrain system which allows the filtered liquid to be drawn off while retaining the filter medium in place. As suspended particle-laden stormwater passes through the sand bed, particles are trapped within the bed.

    c. The filter bed should be at least 18 in. thick above the underdrain system. A minimum of six in. of aggregate (0.5 to 2 in. in diameter) shall be provided under the sand for the underdrain system and a layer of permeable geotextile fabric should be used to separate the layers of sand and aggregate. The underdrain system should be four-in. perforated PVC pipe with two in. of aggregate on top.

    d. The sand shall meet the requirements for "washed concrete sand" as specified for fine aggregate in ASTM C-33.

    e. Once the pressure drops across the filter, such that flow is impeded, the filter shall be backwashed. Backwash water should be returned to the untreated water in the sediment basins.

    f. For surface style sand filters, a liner shall be incorporated into the design to minimize basin leakage and potential groundwater contamination. Clay liners and geomembranes are acceptable lining methods.

        i. Clay liner should have a minimum thickness of 12 in. If a geomembrane is used in lieu of a clay liner, it should have a minimum thickness of 30 in. and be ultraviolet resistant.

        ii. For geomembranes, documentation must be provided to show that the liner material will provide the required performance. The following are recommended performance standards for geomembranes associated with enhanced chemical sand filtration.

2. Designs that include covered or contained filtration should be accessible to control personnel via access doors to facilitate surveillance and controlling of the basins as needed.

3. Other types of filtration, which include mixed media filters, bag, and cartridge filters may be used pending approval from the City.

4. Sediment Basins:

    a. Sediment basins or storage ponds can be used to capture/detain sediment-laden stormwater runoff before it is treated. Sediment basins not only detain flow prior to treatment, they also provide pre-treatment settling capacity. The basin is dewatered through the suction of the filtration system unit(s). An overflow shall be provided for extreme storm events.

b. The sediment basin is constructed by excavation or by erecting an earthen embankment across a low area or drainage swale. Sizing and design of the temporary sediment basin shall be as described in Section 9.5.15, Temporary Sediment Basin.

c. For embankment type basins, ensure the embankment material is "keyed" into the soil to minimize potential for leaks.

d. The designer shall ensure that a liner is incorporated into the temporary sediment basin design to minimize basin leakage and potential groundwater contamination. Clay liners and geomembranes are acceptable lining methods.

   i. Clay liner should have a minimum thickness of 12 in. If a geomembrane is used in lieu of a clay liner, is should have a minimum thickness of 30 miles and be ultraviolet resistant.

   ii. For geomembranes, documentation must be provided to show that the liner material will provide the required performance.

Inspection and Maintenance

1. Generated solids shall be removed from the treatment storage units as necessary to ensure that the system maintains the required storage volume and treatment capability.

2. Caution shall be given to removal and disposal of chemically enhanced sand during maintenance or final removal. Handling and disposal of solids generated shall be done in accordance with all local, state, and federal laws and regulations. Sediment shall be non-toxic and may be incorporated into the site away from drainageways pending approval from the City.

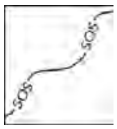
3. The sand filter shall be inspected monthly and after storm events to assess the filtration capacity of the filter.

4. Sand filter should be backwashed as necessary to maintain the designed flow output and quality.

5. For applications with prolonged use, sand should be replaced every 1 to 2 years to maintain removal efficiency.

9.5.32 Soil Binders

Symbol:



BMP Guideline

Definition: Soil binders are emulsion materials applied to exposed soil surfaces to penetrate the top soil and bind the soil particles together.

Purpose: The purpose of soil binders is to temporarily stabilize soils and prevent water and wind erosion of exposed soils at construction sites.

Conditions Where Practice Applies:

Soil binders are sprayed onto disturbed areas that require short-term protection. They are typically used in areas where vegetation cannot be established, in areas where vegetation is not desired (such as soil stock piles) or are used prior to establishment of vegetation. They are also often used in combination with other vegetative or perimeter BMPs to enhance erosion and sediment control.

Design Criteria:

1. Soil binding materials include plant-based adhesives, vinyl, asphalt, rubber, and cementitious. The appropriate soil binding material depends on soil material, location of anticipated use, and existing vegetation. Typically, the soil binders are mixed into a slurry and applied using hydro-mulching equipment.

2. Soil binders shall be non-toxic to humans, plants and animals.

3. Soil binders are not for use on:
    a. Soils composed primarily of silt and clay.
    b. When rain is predicted before the total drying time is achieved.
    c. Frozen soil.
    d. Standing water.
    e. Areas of swift-moving or concentrated flow.

Guidelines:

1. Prior to application, roughen application area by crimping or track walking.

2. Soil binders shall be applied immediately upon completion of grading/roughening activities.

3. Soil binders are meant to be a temporary means to prevent erosion. The useful life depends on the product being utilized. The useful life shall be determined by manufacturer's recommendations.

4. Soil binders require a minimum curing time until they become fully effective, as indicated by the manufacturer.

5. Soil binders shall be applied per manufacturer's instructions. (If not applied per manufacturer's specifications, the effectiveness and ability to reduce erosion is compromised).

6. Avoid spraying soil binders on impervious surfaces such as walkways, roadways, walls, and lined channels.

7. Typical application rates are included in Table 9-25. Actual application rates shall be determined in consultation with the manufacturer.

Table 9-25 Typical Application Rules for Soil Binders

Material	Soil Binder Description	Application Information	Typical Application Rates and Drying Times
Guar	Plant-based, short lived, non-toxic, biodegradable	Mix with water (11 to 15 lbs per 1,000 gallons)	40 to 70 lbs per acre
Psyllium	Plant-based, short lived, non-toxic, biodegradable, permits germination of seed	Apply as a dry powder or in a water based slurry	80 to 200 lbs per acre; requires up to 18 hours drying time
Starch	Plant-based, short lived, non-ionic, cold water soluble	Mix with water	150 lbs per acre; requires up to 12 hours drying time
Pitch and Rosin Emulsion	Plant-based, long lived, non-ionic	Mix 5 to 10 parts water to 1 part emulsion (varies depending on soil type)	As specified by manufacturer
Acrylic Copolymer and Polymers	Polymeric emulsion blend binder	Diluted 10 parts water to 1 part polymer	1,175 gal per acre, up to 48 hour drying time
Liquid Polymers of Methacrylates and Acrylates	Polymeric emulsion blend binder	Diluted per manufacturers recommendations	20 gal per acre, up to 18 hour drying time
Copolymers of Sodium Acrylates and Acrylamides	Polymeric emulsion blend binder, non-toxic dry powder	Mix with water	3 to 20 depending on slope
Poly-Acrylamide and Copolymer of Acrylamide	Polymeric emulsion blend binder	Diluted 11 lb per 1,000 gal of water	5 lbs per acre
Hydro-Colloid Polymer	Polymeric emulsion blend binder	Mix with water	55 to 60 lb per acre; up to 4 hours drying time
Emulsified Petroleum Resin	Petroleum/Resin based emulsion, more typically used in areas prone to wind erosion	Not available	Rates vary, up to 4 hours drying time
Gypsum	Cementitious-based binder	Mixes with water and mulches	4,000 to 12,000 lb per acre; up to 8 hours drying time

Inspection and Maintenance:

1. Inspect stabilized areas before and after rain events, freeze-thaw events, and at a minimum weekly for signs of erosion.

2. Reapply the soil binder to exposed areas as necessary.

9.6 Good Housekeeping BMPs

The use of the following BMPs will set the minimum requirements for control practices used within a SWPPP. Uses of the following guidelines in conjunction with the minimum standards outlined in previous chapters will allow the designer of the SWPPP greater flexibility in selection of control practices, while complying with the requirements necessary for the impacted PCWP Permitting Communities acceptance.

9.6.1 Construction Scheduling and Sequencing

Description and Purpose: Construction scheduling and sequencing is the development of a written plan that includes sequencing of construction activities (CASQA, 2009). The schedule should include the coordination of land-disturbing activities with the installation of erosion and sediment control measures (US EPA, 2006). The goal is to reduce onsite erosion and offsite sedimentation through scheduling and performing erosion and sediment control measures prior to beginning any land-disturbing activities.

Conditions Where Practice Applies:

All construction projects should have proper sequencing of erosion prevention activities included in the scheduling process, especially during the rainy periods.

Implementation:

1. When possible avoid grading and soil disturbing activities in typically rainy periods.
2. Plan the project and develop the schedule showing every phase of construction. Include seasonal information establishing timeframes when rains would affect soil disturbing activities.
3. Utilize schedule to plan sequential activities which support the re-stabilization of disturbed areas as soon as feasible. Sequential activities include closing current trenching prior to initiating more trenching, along with incorporating seeding and vegetation as work progresses.
4. Provide details of each BMP scheduled for implementation and use during the rainy season.
5. Include dates which have non-stormwater discharge activities such as dewatering, drilling, grinding, mortar mixing, painting, pavement cleaning, saw cutting, etc. (CASQA, 2009)
6. Schedule the stabilization activities for non-active areas to occur as soon as feasible.
7. Monitor weather forecasts.
8. Keep erosion prevention measures in place year round to address unseasonal rainfall, wind and vehicle tracking.
9. Schedule permanent erosion prevention measures to be performed during appropriate seasons, and include establishment of vegetation during appropriate planting times.

Inspection and Maintenance:

1. Verify work is proceeding according to schedule. Adjust schedule to address any deviations in progress.

2. Maintain sediment trapping devices to keep them in operational conditions throughout the year.

3. Follow the construction sequence throughout the project and modify schedule prior to any changes in construction activities are executed. Update the schedule if a site inspection indicates the need for additional erosion and sediment control.

9.6.2 Sanitary Waste Management

Description and Purpose: Proper sanitary waste management prevents the discharge of pollutants to stormwater from sanitary waste by providing convenient, well-maintained facilities, and arranging for regular service and disposal.

Conditions Where Practice Applies:

Sanitary waste management practices are suitable for use at all construction sites that use temporary or portable sanitary waste systems.

Implementation:

1. Only contract with a supplier of temporary sanitary waste facilities that disposes of or treats the waste in accordance with state and local requirements.

2. Temporary sanitary facilities will be located away from drainage facilities, watercourses, traffic circulation, and in a convenient location.

3. When subjected to high winds or risk of high winds, temporary sanitary facilities will be secured to prevent overturning.

4. Wastewater will not be discharged or buried within the project site.

5. Sanitary facilities will be maintained in good working order by a licensed service.

6. Regular waste collection by a licensed hauler will be arranged before facilities overflow.

Education:

1. Employees, subcontractors, and suppliers will be educated on sanitary waste storage, disposal procedures and the potential dangers to humans and the environment from sanitary wastes.

2. A continuing education program will indoctrinate new employees.

Inspection and Maintenance:

1. Inspect and verify that temporary sanitary facilities are in place prior to the commencement of construction activities. While construction activities are under way, inspect weekly.

2. Arrange for regular waste collection.

3. If high winds are expected, portable sanitary facilities will be secured with spikes or weighed down to prevent over turning.

9.6.3 Solid Waste Management

Description and Purpose: Solid waste management procedures and practices have been designed to prevent or reduce the discharge of pollutants to stormwater from solid or construction waste by providing designated waste collection containers, arranging for regular disposal, and training employees and subcontractors.

Conditions Where Practice Applies:

1. Solid waste generated from trees and shrubs removed during land clearing, demolition of existing structures (rubble), and building construction.
2. Scrap or surplus construction wastes and building materials including scrap metals, rubber, plastic, glass pieces, packaging materials and masonry products.
3. Domestic wastes including food containers such as beverage cans, coffee cups, paper bags, plastic wrappers, and cigarettes.

Implementation:

The following steps will be done to keep a clean site and reduce stormwater pollution:

1. Use only watertight dumpsters onsite.
2. Provide an adequate number of containers with lids or covers to keep rain out and to prevent loss of wastes when it is windy.
3. Locate waste containers with liquid in a covered area or provide secondary containment. See Figure 9-60.
4. Collect site litter regularly, especially during rainy and windy conditions.
5. Arrange for regular waste collection before containers overflow.
6. Clean up immediately if a container does spill.

Education:

1. Prohibit littering by employees, subcontractors, and visitors.
2. Dumpsters will be located at least 50 ft. from drainage facilities and watercourses and will not be located in areas prone to flooding or ponding.
3. The contractor's superintendent will oversee and enforce proper solid waste management procedures and practices.
4. The contractor's superintendent will instruct employees and subcontractors on identification of solid waste and hazardous waste.
5. The contractor's superintendent will require that employees and subcontractors follow solid waste handling and storage procedures.
6. The contractor's superintendent will make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.

Inspection and Maintenance:

1. The contractor’s superintendent will verify that dumpster is in before the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly to verify continued BMP implementation.

2. The contractor’s superintendent will inspect construction dumpster’s area regularly.

3. The contractor’s superintendent will arrange for regular waste collection.

9.6.4 Material Delivery and Storage

Description and Purpose: Prevent, reduce, or eliminate the discharge of pollutants from material delivery and storage to the stormwater system, streams or lakes by storing materials in specifically designated areas, installing secondary containment, conducting regular inspections, minimizing the storage of hazardous materials onsite, and training employees and subcontractors.

Conditions Where Practice Applies:

These procedures will be used at all construction sites with delivery and storage of erodible, hazardous, oil based, or other polluting materials.

Implementation:

The following steps will be taken to minimize risk.

Deliveries

1. Deliveries will be located away from traffic.

2. Material delivered and stored will be located near the site entrances (lot level near proposed drive way) and away from area or curb inlets, steams, or waterways.

3. If possible delivery areas will be in locations that are to be paved.

Storage

1. Temporary Storage will be located away from traffic.

2. An up-to-date inventory of all stored material will be kept.

3. Chemicals, drums or bagged material will be on a pallet, inside a secondary containment (Earthen dike, horse trough, or wading pool for non-reactive materials).

4. Chemicals will be kept in their original containers.

5. Storage sites shall be well marked and located away from drainage courses and systems. In no case should any liquid storage drum, tank, or other vessel (including portable toilets) be stored over storm drains.

Practices

1. An ample supply of appropriate spill cleanup material will be kept near storage areas and be accessible.

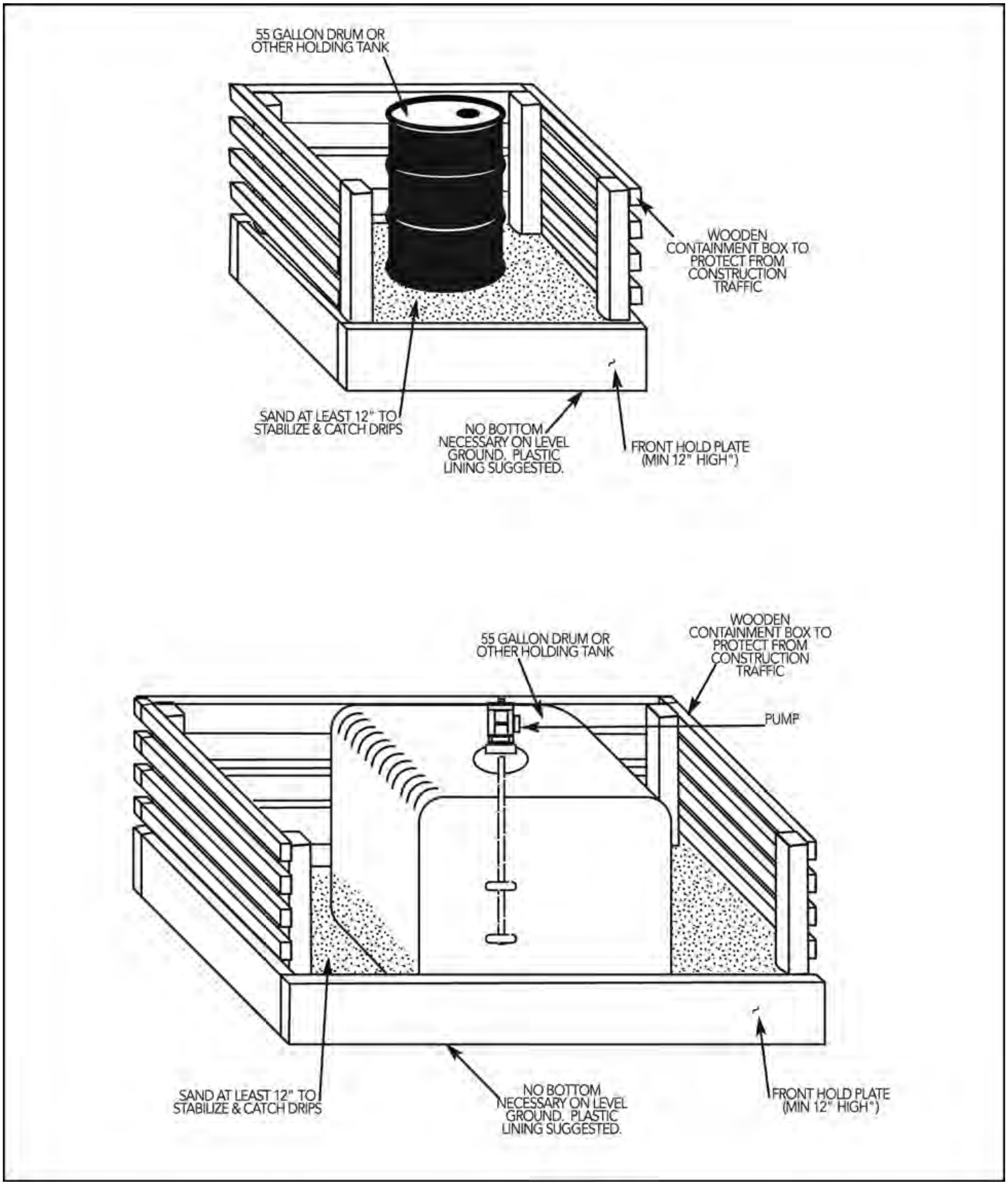


Figure 9-60 Spill Control Structures

2. Drummed, barreled, or bagged materials will be indoors within existing structures when available.

3. Provide secondary containment for liquid storage areas. Containment can include any or all of the following:
   - Covers or canopies
   - Reverse grading
   - Area berms to contain flows
   - Drain pans or drop cloths to catch spills leaks when removing or changing fluids
   - Spill control structures (Figure 9-60)

4. A temporary containment facility will:

   a. Be designed to accommodate all pollutants amounting to or exceeding a volume of 55 gallons.

   b. Be designed to provide for a spill of 10 percent of the total stored, or 100 percent of the capacity of the largest container, whichever is greater.

   c. Be designed so that material used to contain a spill should be impervious to the stored material for a minimum contact time of 72 hrs.

   d. Be maintained free of spills or accumulated rainfall.

   e. Have space between the stored material, and access for emergency response.

   f. Not store incompatible materials (i.e. ammonia & chlorine) in the same containment.

   g. Drums, Barrels or bags, stored outdoors, will be tarped during non-working hrs.

5. Stock piles will be located a minimum of 50 ft. from concentrated flows in stormwater, drainage courses, and unprotected inlets (area or curb)

   a. Active stockpiles will be protected in accordance with the following practices:

      i. Runoff will be controlled using berms, dikes, fiber rolls, silt fence or other appropriate controls.

   b. Inactive stockpiles will be protected in accordance with the following practices:

      i. Stockpiles will be vegetatively covered or tarped.

      ii. Runoff will be controlled using berms, dikes, fiber rolls, silt fence or other appropriate controls.

Education:

Employees, subcontractors and suppliers will be educated on delivery and storage procedures and their responsibilities.

Inspection and Maintenance:

1. Inspections will be conducted to verify that all measures are in place and functioning.

2. Repairs and/or replacement of controls and covers as needed.

9.6.5 Street Cleaning / Sweeping

Description and Purpose: Street cleaning and maintenance includes the use of front-end loaders, shovels and sweepers to remove tracked sediment from the streets and paved surfaces. Street cleaning prevents sediment from entering storm drains and loading sediment basins and /or receiving streams.

Conditions Where Practice Applies:

Street cleaning will be done anywhere sediment is tracked from a site onto a public or private paved street or surface, typically at points of entry. Flushing sediment off of the surface into the storm system will never be an acceptable practice.

Implementation:

The following steps will be taken to keep the streets clean:

1. Access points will be limited and controlled; this allows cleaning efforts to be focused and effective.
2. Entrance points will be evaluated daily for track-out.
3. Visible sediment tracking will be cleaned or swept daily.
4. Kick brooms or dry sweeping will not be used; these spread the dirt, and generate dust.
5. If sediment is not mixed with debris or trash, it will be incorporated back into the project site.

Education:

1. Employees, subcontractors and suppliers will be educated on track-out and street cleaning procedures, and their responsibilities.
2. A continuing education program will indoctrinate new employees.

Inspection and Maintenance:

The following steps will be taken:

1. Evaluate access points daily for sediment tracking.
2. When tracked or spilled sediment is found on paved surfaces, it will be removed daily. During times of heavy track-out, such as during rains, cleaning may be done several times throughout the day.
3. Unknown spills or objects will not be mixed with the sediment.
4. If sediment is mixed with other pollutants, it will be disposed of properly at an authorized landfill.

9.6.6 Vehicle and Equipment Fueling

Description and Purpose: Vehicle equipment fueling procedures and practices are designed to prevent fuel spills and leaks, and reduce or eliminate contamination of stormwater. This will be accomplished by fueling as outlined below, implementing spill controls, and training employees and requiring subcontractors to have personnel trained in proper fueling procedures.

Conditions Where Practice Applies:

Fueling management practices are suitable for use at all construction sites that use fueling tanks or fueling truck systems.

Limitations:

With the exception of tracked equipment such as bulldozers and large excavators, mobile construction equipment will be transported to designated fueling areas.

Implementation:

1. Offsite-fueling stations will be used as much as possible.
2. "Topping-off" of fuel tanks will be discouraged.
3. Absorbent spill cleanup materials and spill kits will be available in fueling areas or on fueling trucks, and will be disposed of properly after use.
4. Drip pans or absorbent pads will be used during fueling, unless the fueling is performed over an impermeable surface in a dedicated fueling area.
5. Absorbent materials will be used on small spills. Spills will not be hosed down or buried. Used adsorbent materials will be removed promptly and disposed of properly.
6. Fueling will take place in areas protected from stormwater run-on and runoff, and will be located at least 50 ft. away from downstream drainage facilities and watercourses. Designated fueling areas will be identified in the SWPPP.
7. Protect fueling areas with berms or dikes to prevent run-on, runoff, and to contain spills.
8. Nozzles used in fueling will be equipped with an automatic shutoff to control drips. Fueling operations will not be left unattended.
9. All requirements will be observed for any stationary above ground storage tanks.

Education:

1. Employees, subcontractors, and suppliers will be educated on vehicle equipment fueling, spill cleanup, disposal procedures and the potential dangers to the environment.
2. A continuing education program will indoctrinate new employees.

Inspection and Maintenance:

1. Vehicles and equipment will be routinely inspected for leaks. Leaks will be repaired immediately or problem vehicles or equipment will be removed from the project site.

2. An ample supply of spill cleanup materials will be available. All fuel tanks must have secondary containment.

3. Spills will be cleaned up immediately, and contaminated soil and cleanup materials will be properly disposed of. If mobile fueling operation is used, supplier will have spill equipment and procedures on the truck. If stationary fuel storage is used, the Site Manager will have the equipment and procedures on site.

9.6.7 SWPPP Notification Sign

A SWPPP notification sign must be posted conspicuously near the main entrance of the construction site. If displaying near the main entrance is infeasible, the notice can be posted in a local public building such as the town hall or public library. The sign or other notice must contain the information shown on the SWPPP Notification Sign Example in Figure 9-61.

Figure 9-61 SWPPP Notification Sign Example

9.6.8 Concrete Washout

Definition: A concrete washout is an area used to contain concrete and liquids resulting from cleaning of equipment used to transport and place cementitious material.

Purpose: The purpose of a concrete washout area is to capture and consolidate cementitious liquids and to prevent migration of the material to surface water and groundwater as to prevent environmental and human health impacts. In addition, concrete washout areas make it possible to recycle the collected liquids and solids for reuse.

Conditions Where Practice Applies:

Concrete washouts should be used at all sites where equipment used to deliver, mix or place cementitious material (including concrete, mortar, plaster, stucco, grout, or similar material) is being used and subsequently cleaned/washed on site. Washed equipment can include, but is not limited to, concrete truck drums and chutes, hoppers, wheelbarrows and hand tools.

Design Criteria: (Figure 9-62 and Figure 9-63)

1. The concrete washout area should meet all local, state, and Federal stormwater quality requirements.
2. The use of the washout facility should be temporary and shall be regularly monitored for capacity. The facility is to be designed with sufficient size and quantity as to contain all liquids generated by washout operations.
3. Concrete washouts should be placed near a location where concrete is being placed, in an accessible and convenient location for concrete trucks and equipment. On larger construction sites, multiple concrete washouts may be required. Signage should be used to indicate the location of the concrete washout(s). Ingress/egress to these locations shall be maintained.
4. Large washout facilities shall be constructed with stabilized construction entrances per Section 9.5.2. If applicable, construction entrances shall be graded such that water generated on the stabilized entrance shall flow towards the washout facility.
5. The washout shall not be located within 50 ft. of storm drains, open ditches/swales, or water bodies.
6. Concrete washouts can be:
    a. Lined excavated pits in the ground or aboveground lined holding areas constructed of berms, sandbags or straw bales
    b. Commercially manufactured prefabricated containers

Construction Guidelines:

1. Below grade holding areas shall:
    a. Be lined with an impermeable liner with a minimum thickness of 10-mil.
    b. Be designed to contain all liquids generated by washout operations.

c. Include a soil base free of rocks and sharp objects that could compromise the integrity of the liner.

d. Have a minimum of 10 ft. by 10 ft. flat area at the bottom and a minimum of 3 ft. high sloped embankments as illustrated in the Figure 9-62.

2. Above-ground holding areas shall:

    a. Be lined with an impermeable liner with a minimum thickness of 10-mil.
    b. Be designed to contain all liquids generated by washout operations.
    c. Include a soil base free of rocks and sharp objects that could compromise the integrity of the liner.
    d. Hay bales shall be used along the perimeter of the facility. The plastic lining shall be wrapped over the top of the hay bale and the hay bale and liner shall be properly anchored as illustrated in Figure 9-63.

3. Commercially manufactured prefabricated containers shall all be used and maintained in accordance with manufacturer's directions. They should be properly sized to accommodate the flows generated by washout operations. Common container types include:

    a. Vinyl washout containers
    b. Metal washout containers
    c. Chute washout boxes
    d. Chute washout bucket and pumps

4. Concrete washout filters can be used with the intent of recycling washout materials and should be used in conjunction with a containment facility listed above.

Inspection and Maintenance:

1. Concrete washout areas should be inspected regularly to verify adequate capacity and integrity of the containment. The washout area must be cleaned or a new washout area be ready for use when the existing washout capacity reaches 75-percent full. Additionally, the following inspections shall take place weekly at a minimum:

    a. Above and below ground holding areas:

        i. Check that the liner is free of punctures, holes, and tears.
        ii. Confirm that the hay bales and liner are adequately anchored.

2. For above and below grade storage facilities, and other commercially manufactured containment structures:

    a. Allow liquids to evaporate or vacuum off excess liquids. Vacuumed liquids shall be treated to remove metals and reduce the pH and then conveyed/delivered to the wastewater treatment plant for treatment or other acceptable means of disposal.
    b. Remove hardened solids by breaking up solids as necessary.
    c. Dispose of hardened materials to the landfill or recycle.

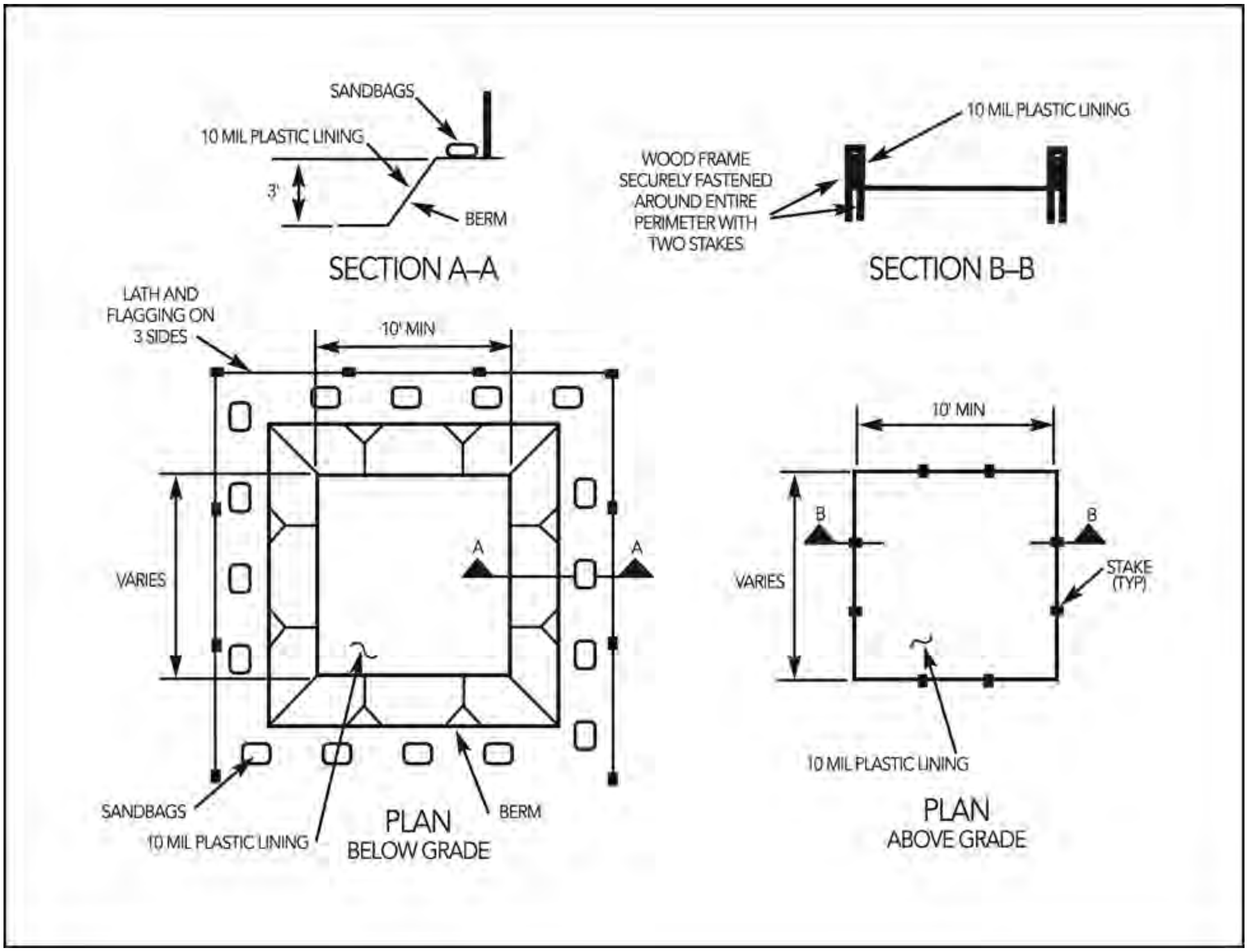


Figure 9-62 Installation of Below Grade Washout Facility

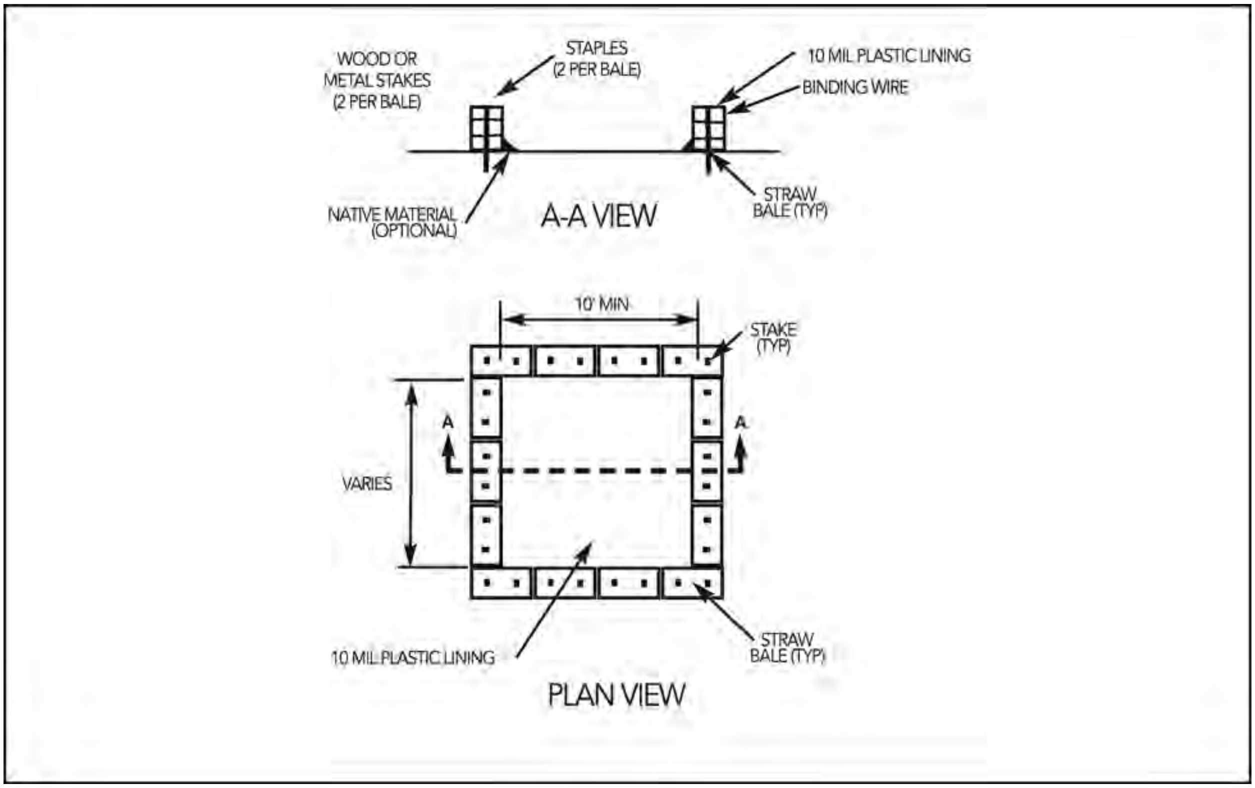


Figure 9-63 Installation of Above Grade Washout Facility

3. If recycling of material is desired the following may be considered:

   a. Cementitious material remaining inside the truck after delivery shall be taken back to the ready mix plant for reuse in other concrete structures or dumped and allowed to hardened so it can be crushed and recycled as aggregate.

   b. When using concrete washout filters, treated washwater can be reused as washwater for subsequent equipment or as material for making new concrete. The aggregates, sands, and fines can be used on the construction site as needed or returned to the ready mix plant for reuse in new concrete.

   c. Hardened concrete can be crushed and reused as a construction material.

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Appendix 9-A
Temporary Sediment Basin Design
Data Sheet Example

Temporary Sediment Basin Design Data Sheet

(with emergency spillway or without emergency spillway)

Project: Example Problem

Basin #: One Location: Omaha

Total area draining to basin: 10 acres.

Elevation of bottom of sediment basin = 1,140 feet.

Basin Volume Design (Step 1)

1. Total Storage Volume (134 cubic yards per acre multiplied by total area draining to basin in acres)

   134 cubic yards x 10 acres = 1,340 cubic yards

2. Wet Storage Volume (Minimum required is 50% of Total Storage Volume)

   0.50 x 1,340 Total Storage Volume = 670 wet storage cubic yards

3. Dry Storage Volume (Minimum required is 50% of Total Storage Volume)

   0.50 x 1,340 Total Storage Volume = 670 dry storage cubic yards

Elevation-Area-Storage-Relationship (Step 2)

Depth, ft	Elevation,ft	Area[a], ft^2	Incremental Volume (V_{inc})[b], ft^3	Cumulative Volume[c], ft^3	Cumulative Volume[d], cu. yd.
0	1,040	9,000	0	0	0
1	1,041	9,850	9,425	9,425	349
2	1,042	10,750	10,300	19,725	731
3	1,043	11,700	11,225	30,950	1,146
4	1,044	12,650	12,175	43,125	1,597
5	1,045	13,620	13,135	56,260	2,084

[a] Area of each contour elevation as measured on plans

[b] Incremental Volume $V_{inc} = 0.5\ x\ (A_i\ +\ A_{i+1})\ x\ 1\ ft$

[c] Cumulative volume is sum of incremental volumes

[d] 27 ft^3 = 1 cu. yd.

Step 3 Results

4. Surface area and elevation of the wet storage volume.

   Wet Storage Elevation = 1,041.8 ft

   Surface area for wet storage 10,603 ft^2

Step 4 Results

5. Surface area and elevation of the Total Storage Volume.

   Top of Total Storage Volume = 1,043.4 ft

   Surface area for Total Storage Volume 12,059 ft^2

Step 5 Results

Basin Shape (at a minimum the effective length should be twice the effective width*)

6. Length of Flow, ft L_e 300 = 8.6
   Effective Width, ft W_e 35

   *If > 2, baffles are not required X
   *If < 2, baffles are required ____

Step 6 Results

7. Will the basin have a separate emergency spillway? Yes X. No___.

Step 7 Results (Elevation of principal spillway crest is equal to elevation of total storage volume in Step 4)

8. Principle Spillway (Riser) Elevation = 1,043.4 ft

Step 8 Results

Runoff

9. Q_2 = 20.7 cfs (Chapter 2.5)

10. Q_{10} = 38 cfs (Chapter 2.5)

Step 9 Results

Principal Spillway Design

11. With emergency spillway, required minimum spillway capacity, $Q_p = Q_2$. (riser and barrel) Design Q_p = 20.7 cfs.

    Without emergency spillway, required minimum spillway capacity, $Q_p = Q_{10}$. (riser and barrel) Design Q_p = N/A cfs.

12. Emergency Spillway Crest = 1,044.5 ft

13. Design High Water (10 Year Storm minimum) = 1045.3 ft

14. With emergency spillway:

    Assumed available head (h) = 1.1 ft. (using Q_2)

    h = Crest of Emergency Spillway Elevation – Crest of Riser Elevation

Without Emergency spillway:

Assumed available head (h) = N/A ft. (using Q_{10})

h = 10-Year Elevation – Principal Spillway (Riser) Elevation

15. With emergency spillway:

Barrel length (L) = 80 ft.

Inlet Head (H) on barrel through embankment = 15 ft.
From Pipe Flow Charts (Figure 9-33 and 9-34)

16. Barrel diameter = 18 in.

17. Riser diameter (D_r) = 30 in. Actual head (h) = 1.1 ft.
From Riser Inflow Curves (Figure 9-32)

Note: Avoid orifice flow conditions.

Step 10 Results

18. Height difference between the principle spillway elevation and the emergency spillway elevation 1.1 ft (1 foot minimum).

19. With emergency spillway: Top of Embankment (minimum of 1 foot above 10-year design storm elevation) 1046.5 ft.

20. Without emergency spillway: Top of Embankment (minimum of 2 foot above 10-year design storm elevation) N/A ft.

21. Height difference between the emergency spillway elevation and the top of embankment elevation 2.5 ft (1 foot minimum).

Step 11 Results

Emergency Spillway Design

22. Required spillway capacity Q_e = Design Q_{Total} – Q_2 = 17.3 cfs.

23. Bottom width of control section (b) = 12 ft.; the longitudinal slope of the exit channel (S) = 3.3 ft/100 ft; and the length of the exit channel (X) = 44 ft.

From Design Data Table for Emergency Spillways (Table 9-8)

24. 2-Year Storm Elevation = _________ ft.

Step 12 Results

25. Trash rack and anti-vortex device

Diameter = 42-54 in.

Height = 15-17 in.

From Trash Rack/Anti-vortex device Design Table (Table 9-10)

Steps 13 Results

Anti-Seep Collar Design

26. Depth of water at principal spillway crest (Y) = 2.5 ft.

    Slope of upstream face of embankment (Z) = 2.5 :1.

    Slope of principal spillway barrel (S_b) = 2 %

    Length of barrel in saturated zone (L_s) = 18 ft.

27. Number of collars required 1 = dimensions = 3.2' x 3.2'

    From Anti-seep Collar Graphs (Figure 9-38 and 9-39)

Step 14 Results

28. Height of Principal Spillway Riser 10 ft.

    Riser 10 feet or less use either concrete base X or a steel base ______.

    Riser over 10 feet must be designed with a safety factor of 1.25 N/A.

Step 15 Results

29. Dewatering Orifice Invert Elevation= 1,041.8 ft

30. Number of dewatering orifices 7

31. Diameter* of dewatering orifices 2 in.

    *Minimum = 2 in diameter

Appendix 9-B

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