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Erosion and Sediment Control Planning and Design Manual

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The contents of this publication were prepared by the authors and should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations. Additional information from professionals, agencies, organizations and institutions with expertise in a particular area may be useful in selecting, designing, and installing certain practices.

The mention of trade names, products or companies does not constitute an endorsement.

This manual is intended for periodic update. Therefore sections of the manual may be changed as practices for erosion and sedimentation control evolve.

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COMPOST BLANKETS

Definition

Compost is the organic product resulting from the controlled biological decomposition of organic material, occurring under aerobic conditions that has been sanitized through the generation of heat and stabilized to the point that it is appropriate for its particular application. Active composting is characterized by a high-temperature phase that sanitizes the product and allows a high rate of decomposition. This is followed by a lower-temperature phase that allows the compost to stabilize while it continues to decompose at a slower rate. Compost should possess no objectionable odors. It shall not contain substances toxic to plants, and shall not resemble the raw material from which it was derived. Compost is not a fertilizer.

It is recommended that compost utilized on construction sites in North Carolina meet the minimum rules and regulations for proper thermophilic composting set forth by NCDENR, defined by USEPA, described in 40 Code of Federal Regulations Part 503, Appendix B, and as described in Table 6.18a.

Most compost contains a wood based fraction (e.g., bark, ground brush, wood chips, etc.) which is typically removed before the compost is used as a soil amendment. However, this coarser, woody fraction of the compost plays an important role in erosion and sediment control. For certain compost applications it may be advantageous to add fresh, ground bark or composted, properly sized wood based material to a compost product to improve its efficacy in a particular application.

Compost materials may be considered fill material when placed in wetlands or riparian buffers. Prior to installation in these areas consult with the U.S. Army Corp of Engineers, and the NCDENR Division of Water Quality for permitting requirements.

Compost Blankets

A compost blanket is a slope stabilization, erosion control, and vegetation establishment practice used on construction sites to stabilize bare, disturbed, or erodible soils. Compost blankets may be used for temporary erosion control and in the process of providing permanent vegetative cover.

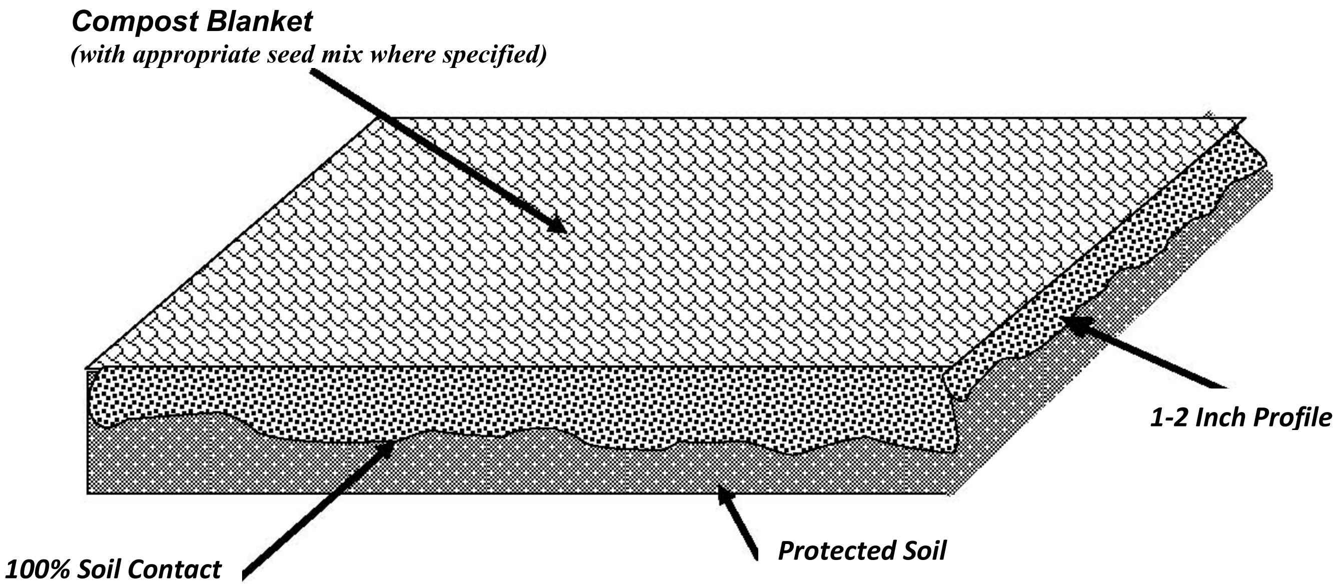

Figure 6.18a Compost Blanket Installation

Conditions Where Practice Applies

Compost blankets should be considered when soil is poor. Compost blankets can be placed on rocky slopes and shallow or infertile soils to improve the growth medium for grasses. Care should be taken not to apply compost where it can raise the nutrient level of streams. When the blanket is specified for permanent stabilization, vegetative cover shall be incorporated with the compost at rates shown in the seeding specification on the approved plan and maintained until the permanent cover is established. Where specified for temporary stabilization the blanket must be installed and maintained as specified in the construction sequence on the approved plan. A temporary vegetative cover or nurse crop should be considered for incorporation with temporary compost blankets.

Planning Considerations

Compost blankets have a mulch function and cover 100% of the soil surface, and therefore provide the beneficial effects characteristic to mulches, including: reduced raindrop impact and splash erosion, reduced runoff energy and sheet erosion, buffered soil temperature for plants, decreased moisture evaporation, increased moisture holding capacity at the soil surface, reduced runoff volume and velocity, and increased infiltration. Where planned and applied correctly to a properly prepared subgrade, compost blankets can aid in amending the soil. This can provide benefits to the soil's structure; increased aggregation, aeration, infiltration and percolation, moisture holding capacity, activity of beneficial microbes, availability of nutrients; decreased runoff volume and velocity, and decreased erosion; increased plant health; and long-term site sustainability.

A compost blanket may be considered appropriate for erosion and sediment control in conjunction with other methodologies, during the construction process. Compost blankets should only be used to control sheet flow from rainfall. Blankets may not be utilized in areas of concentrated runoff. Blankets may not be utilized in areas subject to vehicular traffic and use by heavy equipment. Very coarse compost should be avoided, if the slope is to be landscaped or seeded, as it will make planting and crop establishment more difficult.

When planning the use of compost blankets, it is recommended to use products that are certified by the US Composting Council's Seal of Testing (STA) Program (**www.compostingcouncil.org**). This practice will allow for the acquisition of products that are analyzed on a routine basis, using the specified test methods. STA participants are also required to provide a standard product label to all customers, allowing easy comparison to other products. Compost use for compost blankets should be considered mature as defined by USCC-STA Biological Assays Seedling Emergence and Relative Growth test.

Design Criteria

Compost blankets may be used for temporary erosion/sediment control applications. This application is appropriate for slopes up to a 2:1 grade (horizontal distance: vertical distance), and only be used in areas that have sheet flow drainage patterns (not areas that receive concentrated flows). Slopes steeper than 2:1 may require special installation techniques (consult compost supplier for recommendations). The chemical, physical and biological parameters of compost blankets approved for use in this application are described in Table 6.18a. Only compost products that meet all applicable state and federal regulations pertaining to its production and distribution may be used. Approved compost products must meet related state and federal chemical contaminant (e.g., heavy metals, pesticides, etc.) and pathogen limit standards pertaining to the source materials from which it is derived.

Table 6.18a – Compost Blanket Parameters

Parameters[1,4]	**Reported as (units of measure)**	**Surface Mulch to be Vegetated**	**Surface Mulch to be left Un-vegetated**	**Test Method**	**Test Method Name**
pH[2]	pH units	5.0 - 8.5	N/A	TMECC 04.11-A	Electrometric pH Determinations for Compost. 1:5 Slurry Method
Soluble Salt Concentration[2] (electrical conductivity)	dS/m (mmhos/cm)	Maximum 5	Maximum 5	TMECC 04.10-A	Electrical Conductivity for Compost. 1:5 Slurry Method (Mass Basis)
Moisture Content	%, wet weight basis	30 – 60	30 – 60	TMECC 03.09-A	Total Solids and Moisture at 70±5°C
Organic Matter Content	%, dry weight basis	25 – 65	25-100	TMECC 05.07-A	Matter Method. Loss On Ignition Organic Matter Method
Particle Size	% passing a selected mesh size, dry weight basis	• 3" (75 mm), 100% passing • 1" (25mm), 90- 100% passing • 3/4" (19mm), 65-100% passing • 1/4" (6.4 mm),	• 3" (75 mm), 99% passing • 1" (25mm), 90-100% passing • 3/4" (19mm), 65-100% passing • 1/2" (12.5 mm),	TMECC 02.12-B	Laboratory Sample Preparation. Sample Sieving for Aggregate Size Classification

		0-75% passing • Maximum particle length of 6” (152mm)	0-30% passing • Maximum particle length of 6” (152mm)		
Stability[3] Carbon Dioxide Evolution Rate	mg CO_2-C per g OM per day	< 8	N/A	TMECC 05.08-B	Respirometry. Carbon Dioxide Evolution Rate
Maturity (Bioassay) Percent Emergence Relative Seedling Vigor	% (average) % (average)	100% 100%	90-100% 90-100%	TMECC 05.05-A	
Physical Contaminants (man-made inerts)	%, dry weight basis	< 1	< 1		Biological Assays. Seedling Emergence and Relative Growth

[1] Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC, The US Composting Council)

[2] Each specific plant species requires a specific pH range. Each plant also has a salinity tolerance rating, and maximum tolerable quantities are known. When specifying the establishment of any plant or turf species, it is important to understand their pH and soluble salt requirements, and how they relate to the compost in use.

[3] Stability/Maturity rating is an area of compost science that is still evolving, and as such, other various test methods could be considered. Also, never base compost quality conclusions on the result of a single stability/maturity test.

[4] Landscape architects and project (field) engineers may modify the allowable compost specification ranges based on specific field conditions and plant requirements.

Construction Specifications

The following steps shall be taken for the installation of compost blankets for erosion/sediment control. The information shall also be included in the construction sequence on the approved erosion and sediment control plan.
Prepare the soil by removing large clods, rocks, stumps, roots as described in Chapter 6 of this manual.

Apply the compost blanket to 100% of the area as required on the approved plan.

1. The blanket shall cover 100% of the bare or disturbed soil area, whereas, no native soil shall be visible in or through the compost blanket. It shall be applied at the application rates, as specified in Table 6.18b. Seed shall be thoroughly mixed with the compost prior to application or surface applied to the compost blanket at time of application at the appropriate rates as prescribed by the approved plan.

2. Compost blankets shall be installed at least 10 ft over and beyond the shoulder of the slope and/or into the edge of existing vegetation to ensure runoff does not undercut the blanket. When installing into the edge of existing vegetation, care must be taken not to disturb the existing root mat.

3. Compost blanket application rates should be designed and specified based on specific site (e.g., soil characteristics, existing vegetation) and climatic conditions, as well as particular project related requirements and calculated storm water runoff.

4. Compost blankets installed on slopes greater than or equal to 4:1 shall be tracked. Blankets on 3:1 slopes shall be tracked and secured with an adequate rolled erosion control product. (See Practice Standard 6.17 *Rolled Erosion Control Products* (RECP) for installation procedure.) Where high winds and wind erosion are expected, RECPs shall be installed over the compost blanket, regardless of slope. All other installation procedures and specifications will be as shown on the approved plan and described in the approved construction sequence. Compost shall be uniformly applied as described in the approved construction sequence with the appropriate equipment. If required, thorough watering may be used to improve settling of the blanket.

Table 6.18b– Compost Blanket Application Rates

Annual Rainfall/Flow Rate	**Total Precipitation & Rainfall Erosivity Index**	**Application Rate For Vegetated* Compost Surface Mulch**	**Application Rate For Unvegetated Compost Surface Mulch**
Low	1”-25”, 20-90	1”–1 ½” (25 mm – 37.5mm)	1”–1 ½” (25 mm – 37.5mm)
Average	26”-50”, 91-200	1”–1 ½” (25 mm – 37.5mm)	1 ½”–2” (37 mm – 50 mm)
High	51” and above, 201 and above	1”-2” (25 mm - 50 mm)	2”-4” (50mm – 100mm)

*these lower application rates should only be used in conjunction with seeding, and for compost blankets applied during the prescribed planting season for the particular region.

Maintenance

Inspect compost blankets weekly and within 24 hours of a rainfall event of ½ inch or greater. If failure or damage to the blanket occurs or if vegetation does not establish within the expected germination time of the selected seed type, reapply compost and seed to the affected area to return it to the original condition. Take additional measures as necessary to establish permanent ground cover. Compost blankets shall be inspected until permanent vegetation is established. RECP placed over the compost blanket should be repaired if it has been moved or damaged by wind or storm runoff and/or if part of or the whole blanket is not in contact with the soil surface.

Compost Sampling And Characterization Of Compost

Sampling procedures to be used for purposes of this specification (and the Seal of Testing Assurance program) are as provided in 02.01 Field Sampling of Compost Materials, 02.01-B Selection of Sampling Locations for Windrows and Piles of the Test Methods for the Examination of Compost and Composting (TMECC), Chapter 2, Section One, Sample Collection and Laboratory Preparation, jointly published by the USDA and USCC (2002 publishing as a part of the USDA National Resource Conservation Technical Bulletin Series). The sample collection section is available online at http://compostingcouncil.org/tmecc/.

Test Methods to be used for purposes of this specification are as provided in The Test Methods for the Examination of Compost and Composting (TMECC), Jointly published by the USDA and USCC (2002 publishing as a part of the USDA National Resource Conservation Technical Bulletin Series). A list of such methods is provided online at http://compostingcouncil.org/tmecc/

References

Chapter 3 Vegetative Considerations
Chapter 6 Surface Stabilization
6.03, Surface Roughing
6.10, Temporary Seeding
6.11, Permanent Seeding
6.17, Rolled Erosion Control Products

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RUNOFF CONTROL MEASURES

6.24 RIPARIAN AREA SEEDING

Definition

Controlling runoff and erosion in riparian areas by establishing temporary annual and perennial native vegetative cover.

Purpose

To protect riparian areas from erosion and decrease sediment yield in adjacent streams using temporary annual vegetation as an immediate cover and establish perennial native herbaceous vegetation.

Conditions Where Practice Applies

Disturbed riparian areas between streams and uplands where permanent herbaceous vegetation is needed to stabilize the soil and provide long-term protection.

Planning Considerations

Native vegetation species are defined as plant species that naturally occur in the region in which they evolved. These plants are adapted to local soil types and climatic variations and generally require little to no maintenance. Many of the species have evolved deep, extensive root structures that help stabilize soils and reduce erosive forces of rainfall and overland stream flow. Native species possess certain characteristics that allow them not only to survive, but also to thrive under local conditions. Further, naturally occurring plant communities provide optimal habitat for terrestrial and aquatic fauna. Other agency permits (i.e., ACOE 404 and DWQ 401) may specify further conditions for establishment of native woody vegetation and limits on use of mechanical equipment.

Seeding a mixture of perennial native grasses, rushes, and sedges is a common way to establish permanent ground cover within riparian areas. Both labor and material costs are lower than installation of propagated plants, though some sites may require installation of established vegetation due to site limitations. Selecting a seed mixture with different species having complementary characteristics will allow vegetation to fill select niches within the varying riparian area and respond to different environmental conditions.

Despite the advantages, several disadvantages of seeding riparian areas with native seed may include:

- Potential for erosion or washout during the establishment stage;
- Longer time for germination and establishment;
- Seasonal limitation on suitable seeding dates;
- Specificity of species at each site;
- Need for water and appropriate temperatures during germination and early growth; and
- Need for invasive plant/competition control.

A temporary, non-invasive, and non-competitive annual grass species should be incorporated with the native seeding. This will provide an immediate cover over the site that serves to:

- Prevent bare soil exposure and hold soil in place; and
- Provide a nurse crop for native seeds while they become established.

Temporary annual species should be planted at a low density so they do not suppress growth of permanent species.

Successful plant establishment can be maximized through good planning, knowledge of soil characteristics, selections of suitable plant species for each site, proper seedbed preparation, and timely planting and maintenance.

Selecting Plant Materials

Permanent seed species within the seed mixture should be selected based on natural occurrence of each species in the project site area. Climate, soils, and topography are major factors affecting the suitability of plants for a particular site and these factors vary widely across North Carolina, with the most significant contrasts occurring among the three major physiographic regions of the state – Mountains, Piedmont, and Coastal Plain. Even within the riparian area, there may be need for different species depending on site conditions (i.e. dry sandy alluvial floodplains with wet pockets). Therefore, thoughtful planning is required when selecting species for individual sites in order to maximize successful vegetation establishment.

Seeds adapted to North Carolina should be purchased from a reputable seed grower and should be certified. Do not accept seed containing "prohibited" noxious weed seed. For successful broadcast seeding, seeds should be cleaned. If warm season grasses with "fluffy" seeds are used, a specialized warm season grass drill should be employed. Cultivars should be selected based on adaptation to site region. Stratification, either naturally or artificially, is required for most native seed species to ensure proper germination.

Table 6.24a provides suitable temporary seed species with recommended application rates and optimal planting dates. Temporary annual seed selection should be based on season of project installation. A single species selection for temporary cover is acceptable. In some cases where seasons overlap, a mixture of two or more temporary species may be necessary; however, application rates should not exceed the total recommended rate per acre. Temporary seed should be mixed and applied simultaneously with the permanent seed mix if optimal planting dates allow.

Table 6.24a Temporary Seeding Recommendations

Common Name	Scientific Name	Rate per Acre	Optimal Planting Dates		
			Mountains	*Piedmont*	*Coastal Plain*
Rye grain	Secale cereale	30 lbs	Aug. 15 - May 15	Aug. 15 - May 1	Aug. 15 - Apr. 15
Wheat	Triticum aestivum	30 lbs	Aug. 15 - May 15	Aug. 15 - May 1	Aug. 15 - Apr. 15
German millet	Setaria italica	10 lbs	May 15 - Aug. 15	May 1 - Aug. 15	Apr. 15 - Aug. 15
Browntop millet	Urochloa ramosa	10 lbs	May 15 - Aug. 15	May 1 - Aug. 15	Apr. 15 - Aug. 15

Tables 6.24b-6.24d provide selections of native permanent seeds based on physiographic regions. Included in these tables are species, cultivars, appropriate percentage rates of mixture, and optimal planting times. **No specific seeding rate is given in order to allow for custom seed mixes based on site characteristics and season. However, permanent seed inclusion in the**

mixture should total 15 pounds of pure live seed (PLS) per acre drilled or 15 to 20 pounds PLS per acre broadcast applied. At least four species should be selected for the mixture, including one species from each type (warm season, cold season, wetland); selection of more than four species is recommended for increasing chances of successful vegetation establishment. If other species such as wildflowers are added to the mix, they should not be counted in the minimum seeding rate for grasses.

Seedbed Preparation

Disturbed soils within riparian areas must be amended to provide an optimum environment for seed germination and seedling growth. The surface soil must be loose enough for water infiltration and root penetration. The pH of the soil must be such that it is not toxic and nutrients are available. Riparian areas are generally considered rich in nutrients due to flooding and deposition, however, these areas can be highly variable (i.e., narrow steep corridors in the mountains, artificial fill material on top of alluvial floodplains in the Piedmont). Soil analysis should be performed to determine nutrient and lime needs of each site. Appropriate levels of phosphorus and potassium are critical for permanent seed establishment. Appropriate pH levels are between 5.5 and 7. Riparian buffers regulated for nutrient management may be limited to a single application of fertilizer.

Construction activities within the riparian area can greatly compact soils. Suitable mechanical means such as disking, raking, or harrowing must be employed to loosen the compacted soil prior to seeding.

Planting

Seeding rates of native herbaceous species are given in pounds of pure live seed due to the variability in the germination and purity of native seed. Reputable seed growers and dealers will buy and sell native seed by the pure live seed pound. When the seed is sown, the amount of pure live seed must be converted to pounds of bulk (actual) seed to sow the proper amount of seed. The amount of bulk (actual) seed is calculated by dividing the amount of pure live seed by the germination and purity as decimals. For example, a ten pound pure live seed per acre seeding rate with seed with 50 percent germination and 50 percent purity will require 40 pounds of bulk (actual) seed (40-10/0.5*0.5).

Planting dates given in the seeding mixture specifications (Tables 6.24b – 6.24d) are designated as “optimal”. Seeds properly sown within the “optimal” dates have a high probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as you deviate from them, the probability of failure increases rapidly. Always take this into account when scheduling land-disturbing activities. Many perennial native species require a cold, wet treatment (stratification) before they will germinate at the rate noted on the seed tag. Seeding before the local date of last frost usually provides enough exposure to cold moist conditions to meet these requirements. Seeding before that date also insures early germination that will decrease the chance that seedlings will be affected by summer droughts. Seed sown late may not germinate until the next year after it has laid in the ground through a winter.

Apply seed uniformly with a cyclone seeder, drop-type spreader, drill, or hydroseeder on a firm, friable seedbed. When using a drill, equipment should be calibrated in the field for the desired seeding rate. In fine soils, seeds should be drilled ¼ to ½ inch. In coarse sandy soils, seeds should be planted no deeper than ¾ inch. Cover broadcast seed by lightly raking or chain dragging; then firm the surface with a roller or cultipacker to provide good seed contact.

Mulch all plantings immediately after seeding (Practice 6.14, Mulching). If planting on stream banks steeper than 10 percent or areas subject to flooding, a biodegradable RECP (Practice 6.17, Rolled Erosion Control Products) is recommended to hold seed and soil in place.

Table 6.24b Permanent Seeding Recommendations -- Mountain Region

Common Name	Scientific Name	Cultivars	Type*	Percentage of Mix	Optimal Planting Dates	Soil Drainage Adaptation	Shade Tolerance	Height
Switchgrass	Panicum virgatum	**Cave-in-rock --** well drained **Blackwell --** well drained **Shelter --** well drained **Kanlow --** poorly drained **Carthage --** well drained	Warm Season	10-15%	Dec. 1 - Apr. 15	Cultivar Dependent	Poor	6
Indiangrass	Sorghastrum nutans	**Rumsey, Osage, Cheyenne**	Warm Season	10-30%	Dec. 1 - Apr. 15	Well-drained to Droughty	Poor	6
Deertongue	Dichanthelium clandestinum	**Tioga**	Warm Season	5-25%	Dec. 1 - Apr. 15	Poorly-drained to Droughty	Moderate	6
Big Bluestem	Andropogon gerardii	**Roundtree, Kaw, Earl**	Warm Season	10-30%	Dec. 1 - Apr. 15	Well-drained to Droughty	Poor	6
Little Bluestem	Schizachyrium scoparium	**Aldous, Cimarron**	Warm Season	10-30%	Dec. 1 - Apr. 15	Well-drained to Droughty	Poor	4
Sweet Woodreed	Cinna arundinacea		Warm Season	1-10%	Dec. 1 - Apr. 15	Poorly-drained to Well-drained	Moderate	5
Rice Cutgrass	Leersia oryzoides		Warm Season	5-25%	Dec. 1 - Apr. 15	Poorly-drained	Poor	5
Redtop Panicgrass	Panicum rigidulum		Warm Season	10-20%	Dec. 1 - Apr. 15	Well-drained	Poor	3.5
Eastern Gammagrass	Tripsacum dactyloides		Warm Season	10-20%	Dec. 1 - Apr. 15	Well-drained to Poorly-drained	Poor	4.5
Purple top	Tridens flavus		Warm Season	5-10%	Dec. 1 - Apr. 15	Well-drained to Droughty	Poor	2.5
Indian Woodoats	Chasmanthium latifolium		Cold Season	1-10%	Mar. 1 - May 15, July 15 - Aug. 15	Well-drained to Droughty	Moderate	4
Virginia Wildrye	Elymus virginicus		Cold Season	5-25%	Mar. 1 - May 15, July 15 - Aug. 15	Well-drained to Droughty	Moderate	3
Eastern Bottle-brush Grass	Elymus hystrix		Cold Season	5-10%	Mar. 1 - May 15, July 15 - Aug. 15	Well-drained to Droughty	Moderate	3
Winter Bentgrass	Agrostis hyemalis		Cold Season	10-20%	Mar. 1 - May 15, July 15 - Aug. 15	Well-drained	Moderate	3.5
Rough Bentgrass	Agostis scabra		Cold Season	10-20%	Mar. 1 - May 15, July 15 - Aug. 15	Poorly-drained	Poor	2.5
Soft Rush	Juncus effusus		Wetland	1-10%	Dec. 1 - May 15, Aug. 15 - Oct.. 15	Poorly-drained	Poor	4
Shallow Sedge	Carex lurida		Wetland	1-10%	Dec. 1 - May 15, Aug. 15 - Oct.. 15	Poorly-drained	Poor	3
Fox Sedge	Carex vulpinoidea		Wetland	1-10%	Dec. 1 - May 15, Aug. 15 - Oct.. 15	Poorly-drained	Poor	3
Leathery Rush	Juncus coriaceus		Wetland	2-5%	Dec. 1 - May 15, Aug. 15 - Oct.. 15	Poorly-drained	Poor	2

*Pick at least four species, including one from each type.

Table 6.24c Permanent Seeding Recommendations -- Piedmont Region

Common Name	Scientific Name	Cultivars	Type*	Percentage of Mix	Optimal Planting Dates	Soil Drainage Adaptation	Shade Tolerance	Height
Switchgrass	Panicum virgatum	**Blackwell --** well drained **Shelter --** well drained **Kanlow --** poorly drained **Carthage --** well drained	Warm Season	10-15%	Dec. 1 - Apr. 1	Cultivar Dependent	Poor	6
Switchgrass	Panicum virgatum	**Alamo --** poorly-drained	Warm Season	10-15%	Dec. 1 - May 1	Cultivar Dependent	Poor	6
Indiangrass	Sorghastrum nutans	**Rumsey, Osage, Cheyenne**	Warm Season	10-30%	Dec. 1 - Apr. 1	Well-drained to Droughty	Poor	6
Indiangrass	Sorghastrum nutans	**Lometa**	Warm Season	10-30%	Dec. 1 - May 1	Well-drained to Droughty	Poor	6
Deertongue	Dichanthelium clandestinum	**Tioga**	Warm Season	5-25%	Dec. 1 - Apr. 1	Poorly-drained to Droughty	Moderate	2
Big Bluestem	Andropogon gerardii	**Roundtree, Kaw, Earl**	Warm Season	10-30%	Dec. 1 - Apr. 1	Well-drained to Droughty	Poor	6
Little Bluestem	Schizachyrium scoparium	**Cimarron**	Warm Season	10-30%	Dec. 1 - Apr. 1	Well-drained to Droughty	Poor	4
Sweet Woodreed	Cinna arundinacea		Warm Season	1-10%	Dec. 1 - Apr. 1	Poorly-drained to Well-drained	Moderate	5
Rice Cutgrass	Leersia oryzoides		Warm Season	5-25%	Dec. 1 - Apr. 1	Poorly-drained	Poor	5
Redtop Panicgrass	Panicum rigidulum		Warm Season	10-20%	Dec. 1 - Apr. 1	Well-drained	Poor	3.5
Beaked Panicgrass	Panicum anceps		Warm Season	10-20%	Dec. 1 - Apr. 1	Poorly-drained	Moderate	3.5
Purple top	Tridens flavus		Warm Season	5-10%	Dec. 1 - Apr. 1	Well-drained to Droughty	Poor	2.5
Eastern Gammagrass	Tripsacum dactyloides		Warm Season	5-10%	Dec. 1 - Apr. 1	Well-drained to Poorly-drained	Poor	4.5
Indian Woodoats	Chasmanthium latifolium		Cold Season	1-10%	Feb. 15 - Apr. 1, Aug. 15 - Oct. 15	Well-drained to Droughty	Moderate	4
Virginia Wildrye	Elymus virginicus		Cold Season	5-25%	Feb. 15 - Apr. 1, Aug. 15 - Oct. 15	Well-drained to Droughty	Moderate	3
Eastern Bottle-brush Grass	Elymus hystrix		Cold Season	5-10%	Feb. 15 - Apr. 1, Aug. 15 - Oct. 15	Well-drained to Droughty	Moderate	3
Rough Bentgrass	Agrostis scabra		Cold Season	10-20%	Feb. 15 - Apr. 1, Aug. 15 - Oct. 15	Poorly-drained	Poor	2.5
Winter Bentgrass	Agrostis hyemalis		Cold Season	2-5%	Feb. 15 - Apr. 1, Aug. 15 - Oct. 15	Well-drained	Moderate	3.5
Soft Rush	Juncus effusus		Wetland	1-10%	Dec. 1 - May 1, Sep. 1 - Nov. 1	Poorly-drained	Poor	4
Shallow Sedge	Carex lurida		Wetland	1-10%	Dec. 1 - May 1, Sep. 1 - Nov. 1	Poorly-drained	Poor	3
Fox Sedge	Carex vulpinoidea		Wetland	1-10%	Dec. 1 - May 1, Sep. 1 - Nov. 1	Poorly-drained	Poor	3
Leathery Rush	Juncus coriaceus		Wetland	2-5%	Dec. 1 - May 1, Sep. 1 - Nov. 1	Poorly-drained	Poor	2

* Pick at least four species, including one from each type.

Table 6.24d Permanent Seeding Recommendations -- Coastal Plain Region

Common Name	Scientific Name	Cultivars	Type*	Percentage of Mix	Optimal Planting Dates	Soil Drainage Adaptation	Shade Tolerance	Height
Switchgrass	Panicum virgatum	**Blackwell --** well drained **Shelter --** well drained **Kanlow --** poorly drained **Carthage --** well drained	Warm Season	10-15%	Dec. 1 - Apr. 1	Cultivar Dependent	Poor	6
Switchgrass	Panicum virgatum	**Alamo --** poorly-drained	Warm Season	10-15%	Dec. 1 - May 1	Cultivar Dependent	Poor	6
Indiangrass*	Sorghastrum nutans*	**Rumsey, Osage, Cheyenne**	Warm Season	10-30%	Dec. 1 - Apr. 1	Well-drained to Droughty	Poor	6
Indiangrass*	Sorghastrum nutans*	**Lometa**	Warm Season	10-30%	Dec. 1 - May 1	Well-drained to Droughty	Poor	6
Big Bluestem	Andropogon gerardii	**Earl**	Warm Season	10-30%	Dec. 1 - Apr. 1	Well-drained to Droughty	Poor	6
Little Bluestem	Schizachyrium scoparium	**Cimarron**	Warm Season	10-30%	Dec. 1 - Apr. 1	Well-drained to Droughty	Poor	4
Sweet Woodreed	Cinna arundinacea		Warm Season	1-10%	Dec. 1 - Apr. 1	Poorly-drained to Well-drained	Moderate	5
Rice Cutgrass	Leersia oryzoides		Warm Season	5-25%	Dec. 1 - Apr. 1	Poorly-drained	Poor	5
Redtop Panicgrass	Panicum rigidulum		Warm Season	10-20%	Dec. 1 - Apr. 1	Well-drained	Poor	3.5
Beaked Panicgrass	Panicum anceps		Warm Season	10-20%	Dec. 1 - Apr. 1	Poorly--drained	Moderate	3.5
Eastern Gammagrass	Tripsacum datyoides		Warm Season	5-10%	Dec. 1 - Apr. 1	Well-drained to Poorly-drained	Poor	4.5
Purple top	Tridens flavus		Warm Season	5-10%	Dec. 1 - Apr. 1	Well-drained to Droughty	Poor	2.5
Indian Woodoats	Chasmanthium latifolium		Cold Season	1-10%	Feb. 15 - Mar. 20, Sep. 1 - Nov. 1	Well-drained to Droughty	Moderate	4
Virginia Wildrye	Elymus virginicus		Cold Season	5-25%	Feb. 15 - Mar. 20, Sep. 1 - Nov. 1	Well-drained to Droughty	Moderate	3
Rough Bentgrass	Agrostis scabra		Cold Season	10-20%	Feb. 15 - Mar. 20, Sep. 1 - Nov. 1	Poorly-drained	Poor	2.5
Soft Rush	Juncus effusus		Wetland	1-10%	Dec. 1 - Apr. 15	Poorly-drained	Poor	4
Shallow Sedge	Carex lurida		Wetland	1-10%	Dec. 1 - Apr. 15	Poorly-drained	Poor	3
Fox Sedge	Carex vulpinoidea		Wetland	1-10%	Dec. 1 - Apr. 15	Poorly-drained	Poor	3
Leathery Rush	Juncus coriaceus		Wetland	2-5%	Dec. 1 - Apr. 15	Poorly-drained	Poor	2

* Only Lometa in eastern coastal plain (Plant Hardiness Zone 8).
* Pick at least four species, including one from each type.

Maintenance

Many of the recommended permanent grass species may require two years for establishment, depending on site conditions. Inspect seeded areas for failure and make necessary repairs, soil amendments, and reseedings. If weedy exotic species have overtaken the area after the first growing season, the invading species must be eradicated to allow native species to grow. Native vegetations are difficult to manage and take longer to establish. Monitor the site until long term stability has been established.

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INDEX

SEDIMENT TRAPS AND BARRIERS

6.61 SEDIMENT BASIN

Definition

An earthen embankment suitably located to capture sediment with a primary spillway system consisting of a riser and barrel pipe.

Purpose

To retain sediment on the construction site, and prevent sedimentation in off-site streams, lakes, and drainageways.

Conditions Where Practice Applies

Special limitation – This practice applies only to the design and installation of sediment basins where failure of the structure would not result in the loss of life, damage to homes or buildings, or interrupt the use of public roads or utilities. All high hazard potential dams and structures taller than 25 feet, and that also have a maximum storage capacity of 50 acre-feet or more are subject to the N.C. Dam Safety Law of 1967.

Sediment basins are needed where drainage areas exceed design criteria of other measures. Specific criteria for installation of a sediment basin are as follows:

- Keep the drainage area less than 100 acres;
- Ensure that basin location provides a convenient concentration point for sediment-laden flows from the area served;
- Ensure that basin location allows access for sediment removal and proper disposal under all weather conditions; and
- Keep the basin life limited to 3 years, unless it is designed as a permanent structure;

Do not locate sediment basins in intermittent or perennial streams.

Planning Considerations

Select key locations for sediment basins during initial site evaluation. Install basins before any land-disturbance takes place within the drainage area.

Select basin sites to capture sediment from all areas that are not treated adequately by other sediment controls. Always consider access for cleanout and disposal of the trapped sediment. Locations where a pond can be formed by constructing a low dam across a natural swale are generally preferred to sites that require excavation. Where practical, divert sediment-free runoff away from the basin.

Sediment trapping efficiency is primarily a function of sediment particle size and the ratio of basin surface area to inflow rate. Therefore, design the basin to have a large surface area for its volume. Figure 6.61a shows the relationship between the ratio of surface area to peak inflow rate and trap efficiency observed by Barfield and Clar (1986).

Sediment basins with an expected life greater than 3 years should be designed as permanent structures. Often sediment basins are converted to stormwater ponds. In these cases, the structure should be designed by a qualified professional engineer experienced in the design of dams. Permanent ponds and artificial lakes are beyond the scope of this practice standard. USDA Soil Conservation Services Practice Standard Ponds Code No. 378 provides criteria for design of permanent ponds.

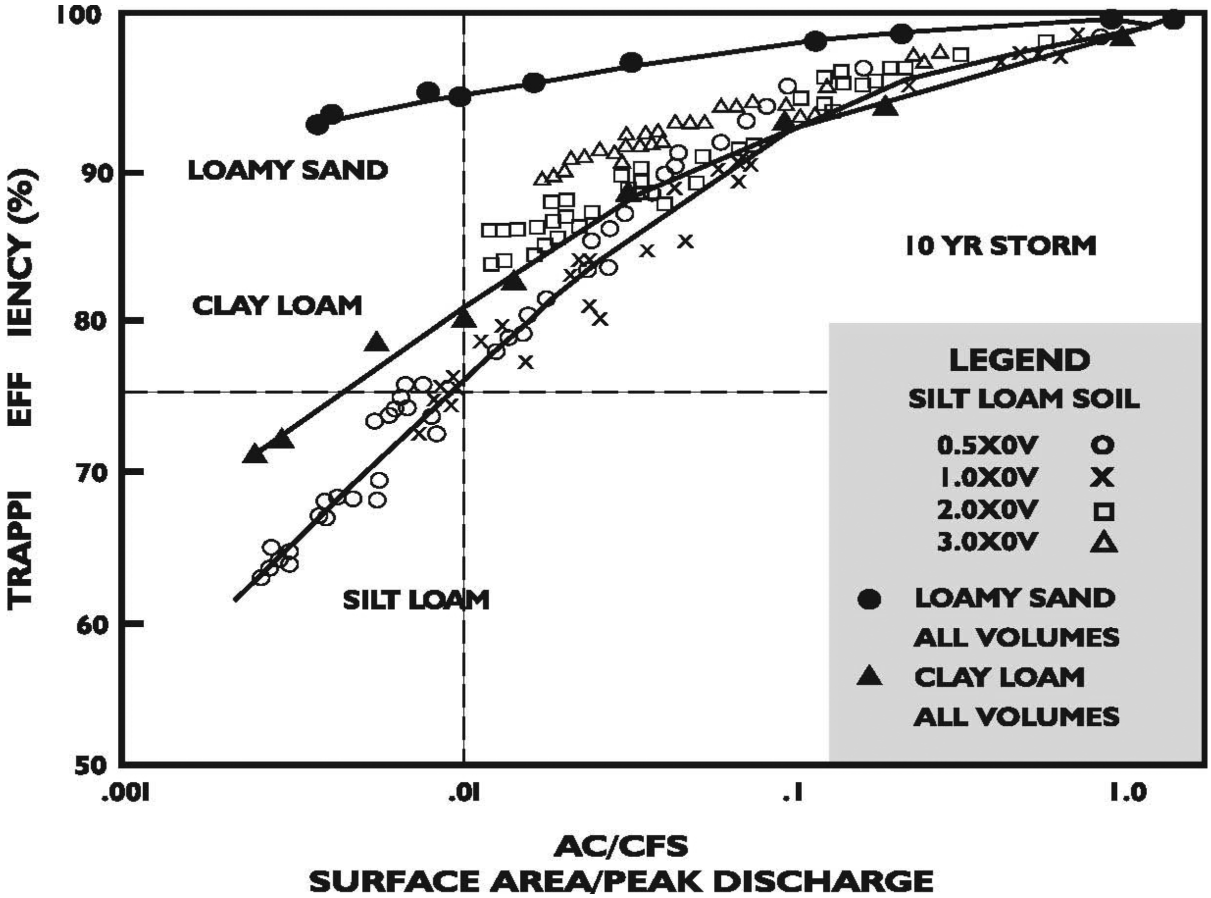


Figure 6.61a Relationship between the ratio of surface area to peak inflow rate and trap efficiency.

Design Criteria

Summary:	**Temporary Sediment Basin:**
Primary Spillway:	Riser/Barrel Pipe
Maximum Drainage Area:	100 acres
Minimum Sediment Storage Volume:	1800 cubic feet per acre of disturbed area
Minimum Surface Area:	435 square feet per cfs of Q_{10} peak inflow
Minimum L/W Ratio:	2:1
Maximum L/W Ratio:	6:1
Minimum Depth:	2 feet
Dewatering Mechanism:	Skimmer(s) attached at bottom of riser pipe or flashboard riser
Minimum Dewatering Time:	48 hours
Baffles Required:	3 baffles*

(*Note: Basins less than 20 feet in length may use 2 baffles.)

Drainage areas- Limit drainage areas to 100 acres.

Design basin life- Ensure a design basin life of 3 years or less.

Dam height- Limit dam height to 15 feet. Height of a dam is measured from the top of the dam to the lowest point at the downstream toe. Volume is measured from the top of the dam when determining if the dam impounds enough water to be regulated by the Dam Safety Law.

Basin locations- Select areas that:

- Provide capacity for sediment storage from as much of the planned disturbed area as practical;
- Exclude runoff from undisturbed areas where practical;
- Provide access for sediment removal throughout the life of the project and;
- Interfere minimally with construction activities.

Basin shape- Ensure that the flow length to basin width ratio is at least 2:1 to improve trapping efficiency. This basin shape may be attained by site selection or excavation. Length is measured at the elevation of the principal spillway.

Storage volume- Ensure that the sediment storage volume of the basin, as measured to the elevation of the crest of the principal spillway, is at least 1,800 ft^3/acre for the disturbed area draining into the basin (1,800 ft^3 is equivalent to a ½ inch of sediment per acre of basin drainage area).

Remove sediment from the basin when approximately one-half of the storage volume has been filled.

Spillway capacity- The spillway system must carry the peak runoff from the 10-year storm with a minimum 1 foot freeboard in the emergency spillway.
Base runoff computations on the disturbed soil cover conditions expected during the effective life of the structure.

Principal spillway- Construct the principal spillway with a vertical riser connected to a horizontal barrel that extends through the embankment and outlets beyond the downstream toe of the dam, or an equivalent design.

- Capacity- The primary spillway system must carry the peak runoff from the 2-year storm, with the water surface at the emergency spillway crest elevation.

Sediment cleanout elevation- Show the distance from the top of the riser to the pool level when the basin is 50 percent full. This elevation should also be marked in the field with a permanent stake set at this ground elevation (not the top of the stake).

Crest elevation- Keep the crest elevation of the riser a minimum of 1 foot below the crest elevation of the emergency spillway.

Riser and Barrel- Keep the minimum barrel size at 15 inches for corrugated metal pipe or 12 inches for smooth wall pipe to facilitate installation and reduce potential for failure from blockage. Ensure that the pipe is capable of withstanding the maximum external loading without yielding, buckling or cracking. To improve the efficiency of the principal spillway system, make the cross-sectional area of the riser at least 1.5 times that of the barrel. The riser should be sized to minimize the range of stages when orifice flow will occur.

Pipe Connections- Ensure that all conduit connections are watertight. Rod and lug type connector bands with gaskets are preferred for corrugated metal pipe to assure watertightness under maximum loading and internal pressure. Do not use dimple (universal) connectors under any circumstances.

- **Trash guard**- It is important that a suitable trash guard be installed to prevent the riser and barrel pipes from becoming clogged. Install a trash guard on the top of the riser to prevent trash and other debris from clogging the conduit. A combination anti-vortex device and trash guard improves the efficiency of the principal spillway and protects against trash intake.

- **Protection against piping-** Install at least one watertight anti-seep collar with a minimum projection of 1.5 feet around the barrel of principal spillway conduits, 8 inches or larger in diameter. Locate the anti-seep collar slightly downstream from the dam center line. A properly designed drainage diaphragm installed around the barrel may be used instead of an anti-seep collar when it is appropriate.
- **Protection against flotation-** Secure the riser by an anchor with buoyant weight greater than 1.1 times the water displaced by the riser.
- **Outlet-** Protect the outlet of barrel against erosion.

Discharge velocities must be within allowable limits for the receiving stream (*References: Outlet Protection*).

Basin dewatering- The basin should be provided with a mechanism to dewater the basin from the water surface. Previously sediment basins were dewatered with a perforated riser. These were designed to dewater relatively quickly and draw water from the entire water column. Dewatering from the surface provides greater trapping efficiency. Two common methods are a skimmer and flashboard riser.

- Skimmer- A floating skimmer should be attached to the base of the riser. The orifice in the skimmer will control the rate of dewatering. The skimmer should be sized to dewater the basin in 2-5 days. A chart to determine the appropriate skimmer and orifice size is included on page 6.64.3. See Practice 6.64, *Skimmer Basins* for details on the installation of skimmers.

Figure 6.61b Sediment basin with skimmer attached to riser for dewatering.
Photo Credit: Town of Apex

- Flashboard Riser- A different approach is to use a flashboard riser, which forces the basin to fill to a given level before the water tops the riser. In this way it is similar to a solid riser, but with the option of being able to lower the water level in the basin when accumulated sediment must be removed. Flashboard risers are usually fabricated as a box or as a riser pipe cut in half. The open face has slots on each side into which boards or "stop logs" are placed, forcing the water up and over them. This device should be sized the same way as a typical riser.

  Forcing the water to exit the sediment basin from the top of the water column has the same advantages in sediment capture as the skimmer. A flashboard riser basin will have an adjustable, permanent pool which also improves basin efficiency. This method is a disadvantage when the sediment needs to be removed because the operator may need to remove the boards down to the sediment level to drain the basin. Flashboard risers are a good option for stilling basins for pump discharges, or when sandy soil conditions will allow dewatering of the basin through infiltration. They should not be selected when the basin will have to be cleaned frequently, or when located in clay soils.

Figure 6.61c Flashboard Riser installation example.
Photo credit: NC State University

Emergency spillway- Construct the entire flow area of the emergency spillway in undisturbed soil (not fill). Make the cross section trapezoidal with side slopes of 3:1 or flatter. Make the control section of the spillway straight and at least 20 feet long. The inlet portion of the spillway may be curved to improve alignment, but ensure that the outlet section is straight due to supercritical flow in this portion.

- Capacity- The minimum design capacity of the emergency spillway must be the peak rate of runoff from the 10-year storm, less any reduction due to flow in the principal spillway. In no case should freeboard of the emergency spillway be less than 1 foot above the design depth of flow.
- Velocity- Ensure that the velocity of flow discharged from the basin is non-erosive for the existing conditions. When velocities exceed that allowable for the receiving areas, provide outlet protection (*References: Outlet Protection*).

Embankment-

- Cut-off trench- Excavate a trench at the center line of the embankment. Ensure that the trench is in undisturbed soil and extends through the length of the embankment to the elevation of the riser crest at each end. A minimum of depth of 2 feet is recommended.
- Top width- The minimum top width of the dam is shown in Table 6.61a.
- Freeboard- Ensure that the minimum difference between the design water elevation in the emergency spillway and the top of the settled embankment is 1 foot.
- Side slopes- Make the side slopes of the impoundment structure 2.5:1 or flatter (Figure 6.61d).
- Allowance for settlement- Increase the constructed height of the fill at least 10 percent above the design height to allow for settlement.
- Erosion protection- Stabilize all areas disturbed by construction (except the lower ½ of the sediment pool) by suitable means immediately after completing the basin (*References: Surface Stabilization*).

Design information included in the Appendices may be used to develop final plans for sediment basins (*References: Appendices*).

Trap efficiency- Improve sediment basin trapping efficiency by employing the following considerations in the basin design:

- Surface area- In the design of the settling pond, allow the largest surface area possible. Studies of Barfield and Clar (1986) indicate that surface area (in acres) should be larger than 0.01 times the peak inflow rate in cfs, or 435 sq. ft. per cfs of peak flow.
- Length- The length to width ratio should be between 2:1 to 6:1.

Table 6.61a
Acceptable Dimensions for Basin Embankment

Fill Height	Minimum Top Width
less than 10 ft	8.0 ft
10 ft to 15 ft	10.0 ft

- Baffles- Provides a minimum of three porous baffles to evenly distribute flow across the basin and reduces turbulence. Basins less than 20 feet in length may use 2 baffles .
- Inlets- Locate the sediment inlets to the basin the greatest distance from the principal spillway.
- Dewatering- Allow the maximum reasonable detention period before the basin is completely dewatered-at least 48 hours.
- Inflow rate- Reduce the inflow velocity and divert all sediment-free runoff.

Construction Specifications

1. Site preparations- Clear, grub, and strip topsoil from areas under the embankment to remove trees, vegetation, roots, and other objectionable material. Delay clearing the pool area until the dam is complete and then remove brush, trees, and other objectionable materials to facilitate sediment cleanout. Stockpile all topsoil or soil containing organic matter for use on the outer shell of the embankment to facilitate vegetative establishment. Place temporary sediment control measures below the basin as needed.

2. Cut-off trench- Excavate a cut-off trench along the center line of the earth fill embankment. Cut the trench to stable soil material, but in no case make it less than 2 feet deep. The cut-off trench must extend into both abutments to at least the elevation of the riser crest. Make the minimum bottom width wide enough to permit operation of excavation and compaction equipment, but in no case less than 2 feet. Make side slopes of the trench no steeper than 1:1. Compaction requirements are the same as those for the embankment. Keep the trench dry during backfilling and compaction operations.

3. Embankment- Take fill material from the approved areas shown on the plans. It should be clean mineral soil, free of roots, woody vegetation, rocks, and other objectionable material. Scarify areas on which fill is to be placed before placing fill. The fill material must contain sufficient moisture so it can be formed by hand into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. Place fill material in 6 to 8 inch continuous layers over the entire length of the fill area and compact it. Compaction may be obtained by routing the construction hauling equipment over the fill so that the entire surface of each layer is traversed by at least one wheel or tread track of heavy equipment, or a compactor may be used. Construct the embankment to an elevation 10 percent higher than the design height to allow for settling.

4. Conduit spillways- Securely attach the riser to the barrel or barrel stub to make a watertight structural connection. Secure all connections between barrel sections by approved watertight assemblies. Place the barrel and riser on a firm, smooth foundation of impervious soil. Do not use pervious material such as sand, gravel, or crushed stone as backfill around the pipe or anti-seep collars. Place the fill material around the pipe spillway in 4-inch layers, and compact it under and around the pipe to at least the same density as the adjacent embankment. **Care must be taken not to raise the pipe from firm contact with its foundation when compacting under the pipe haunches.**

Place a minimum depth of 2 feet of compacted backfill over the pipe spillway before crossing it with construction equipment. Anchor the riser in place by concrete or other satisfactory means to prevent flotation. In no case should the pipe conduit be installed by cutting a trench through the dam after the embankment is complete.

5. Emergency spillway- Install the emergency spillway in undisturbed soil. The achievement of planned elevations, grade, design width, and entrance and exit channel slopes are critical to the successful operation of the emergency spillway.

6. Inlets- Discharge water into the basin in a manner to prevent erosion. Use diversions with outlet protection to divert sediment-laden water to the upper end of the pool area to improve basin trap efficiency (*References: Runoff Control Measures and Outlet Protection*).

7. Erosion control- Construct the structure so that the disturbed area is minimized. Divert surface water away from bare areas. Complete the embankment before the area is cleared. Stabilize the emergency spillway embankment and all other disturbed areas above the crest of the principal spillway immediately after construction (*References: Surface Stabilization*).

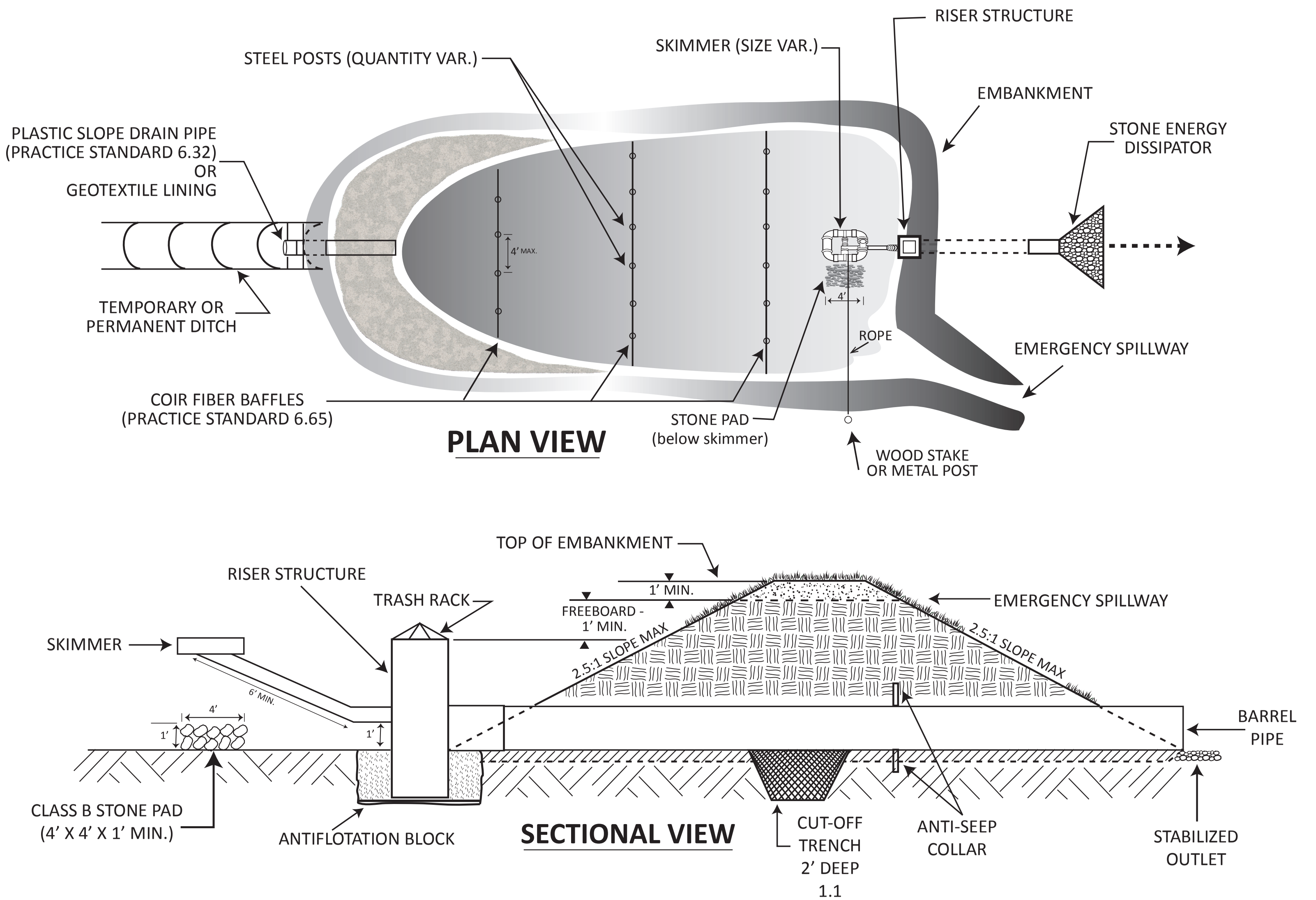
8. Install porous baffles as specified in Practice 6.65, Porous Baffles.

9. Safety- Sediment basins may attract children and can be dangerous. Avoid steep side slopes, and fence and mark basins with warning signs if trespassing is likely. **Follow all state and local requirements.**

Maintenance

Inspect temporary sediment basins at least weekly and after each significant (1/2 inch or greater) rainfall event and repair immediately. Remove sediment and restore the basin to its original dimensions when it accumulates to one-half the design depth. Place removed sediment in an area with sediment controls.

Check the embankment, spillways, and outlet for erosion damage, and inspect the embankment for piping and settlement. Make all necessary repairs immediately. Remove all trash and other debris from the riser and pool area.



NOTES
1. SEED AND PLACE MATTING FOR EROSION CONTROL ON INTERIOR AND EXTERIOR SIDESLOPES.
2. INSTALL A MINIMUM OF 3 COIR FIBER BAFFLES IN ACCORDANCE WITH PRACTICE STANDARD 6.65.
3. INSTALL SKIMMER AND COUPLING TO RISER STRUCTURE OR DIRECTLY INTO EMBANKMENT 1 FT. FROM BOTTOM OF BASIN.
4. THE ARM PIPE SHALL HAVE A MINIMUM LENGTH OF 6 FT. BETWEEN THE SKIMMER AND COUPLING.

NOT TO SCALE

Figure 6.61d Sediment Basin (with Riser Barrel Pipe)

References

Surface Stabilization
- 6.10, Temporary Seeding
- 6.11, Permanent Seeding
- 6.12, Sodding
- 6.13, Trees, Shrubs, Vines, and Ground Covers

Runoff Control Measures
- 6.20, Temporary Diversions
- 6.21, Permanent Diversions
- 6.22, Perimeter Dike

Outlet Protection
- 6.40, Level Spreader
- 6.41, Outlet Stabilization Structure

Sediment Traps and Barriers
- 6.64, Skimmer Sediment Basin
- 6.65, Porous Baffles

Appendices
- 8.01, Soil Information
- 8.02, Vegetation Tables
- 8.03, Estimating Runoff
- 8.04, Estimating Roughness Coefficients
- 8.05, Design of Stable Channels and Diversions
- 8.06, Design of Riprap Outlet Protection
- 8.07, Sediment Basin Design
- 8.08, The Sediment Control Law

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

6.62

SEDIMENT FENCE

Definition

A temporary sediment control measure consisting of fabric buried at the bottom, stretched, and supported by posts.

Purpose

To retain sediment from small disturbed areas by reducing the velocity of sheet flows to allow sediment deposition.

Conditions Where Practice Applies

Below small-disturbed areas that are less then ¼ acre per 100 feet of fence.

Where runoff can be stored behind the sediment fence without damaging the fence or the submerged area behind the fence.

Do not install sediment fences across streams, ditches, or waterways, or other areas of concentrated flow.

Sediment fence should be placed along topographic elevation contours, where it can intercept stormwater runoff that is in dispersed sheet flow. Sediment fence should not be used alone below graded slopes greater than 10 feet in height.

Planning Considerations

A sediment fence is a system to retain sediment on the construction site. The fence retains sediment primarily by retarding flow and promoting deposition. In operation, generally the fence becomes clogged with fine particles, which reduce the flow rate. This causes a pond to develop behind the fence. The designer should anticipate ponding and provide sufficient storage areas and overflow outlets to prevent flows from overtopping the fence. Since sediment fences are not designed to withstand high water levels, locate them so that only shallow pools can form. Tie the ends of a sediment fence into higher ground to prevent flow around the end of the fence before the pool reaches design level. Curling each end of the fence uphill in a “J” pattern may be appropriate to prevent end flow. Provide stabilized outlets to protect the fence system and release storm flows that exceed the design storm.

Deposition occurs as the storage pool forms behind the fence. The designer can direct flows to specified deposition areas through appropriate positioning of the fence or by providing an excavated area behind the fence. Plan deposition areas at accessible points to promote routine cleanout and maintenance. Show deposition areas in the erosion and sedimentation control plan. A sediment fence acts as a diversion if placed slightly off the contour. A maximum slope of 2 percent is recommended. This technique may be used to control shallow, uniform flows from small disturbed areas and to deliver sediment-laden water to deposition areas. The anchoring of the toe of the fence should be reinforced with 12 inches of NC DOT #5 or #57 washed stone when flow will run parallel to the toe of the fence.

Sediment fences serve no function along ridges or near drainage divides where there is little movement of water. Confining or diverting runoff unnecessarily with a sediment fence may create erosion and sedimentation problems that would not otherwise occur.

Straw barriers have only a 0-20% trapping efficiency and are inadequate. Straw bales may not be used in place of sediment fence. Prefabricated sediment fence with the fabric already stapled to thin wooden posts does not meet minimum standards specified later in this section.

Anchoring of sediment fence is critical. The toe of the fabric must be anchored in a trench backfilled with compacted earth. Mechanical compaction must be provided in order for the fence to effectively pond runoff.

Design Criteria

Ensure that drainage area is no greater than ¼ acre per 100 feet of fence. This is the maximum drainage area when the slope is less than 2 percent. Where all runoff is to be stored behind the fence, ensure that the maximum slope length behind a sediment fence does not exceed the specifications shown in Table 6.62a. The shorter slope length allowed for steeper slopes will greatly reduce the maximum drainage area. For example, a 10–20 % slope may have a maximum slope length of 25 feet. For a 100-foot length of sediment fence, the drainage area would be 25ft X 100ft = 2500sq.ft., or 0.06 acres.

Table 6.62a Maximum Slope Length and Slope for which Sediment Fence is Applicable

Slope	Slope Length (ft)	Maximum Area (ft^2)
<2%	100	10,000
2 to 5%	75	7,500
5 to 10%	50	5,000
10 to 20%	25	2,500
>20%	15	1,500

Make the fence stable for the 10-year peak storm runoff.

Ensure that the depth of impounded water does not exceed 1.5 feet at any point along the fence.

If non-erosive outlets are provided, slope length may be increased beyond that shown in Table 6.62a, but runoff from the area should be determined and bypass capacity and erosion potential along the fence must be checked. The velocity of the flow at the outlet or along the fence should be in keeping with Table 8.05d, Appendix 8.05.

Provide a riprap splash pad or other outlet protection device for any point where flow may overtop the sediment fence, such as natural depressions or swales. Ensure that the maximum height of the fence at a protected, reinforced outlet does not exceed 2 feet and that support post spacing does not exceed 4 feet.

The design life of a synthetic sediment fence should be 6 months.

Construction Specifications

MATERIALS

1. Use a synthetic filter fabric of at least 95% by weight of polyolefins or polyester, which is certified by the manufacturer or supplier as conforming to the requirements in ASTM D 6461, which is shown in part in Table 6.62b.

Synthetic filter fabric should contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 to 120º F.

2. Ensure that posts for sediment fences are 1.25 lb/linear ft minimum steel with a minimum length of 5 feet. Make sure that steel posts have projections to facilitate fastening the fabric.

3. For reinforcement of standard strength filter fabric, use wire fence with a minimum 14 gauge and a maximum mesh spacing of 6 inches.

Table 6.62b Specifications For Sediment Fence Fabric

Temporary Silt Fence Material Property Requirements					
	Test Material	Units	Supported[1] Silt Fence	Un-Supported[1] Silt Fence	Type of Value
Grab Strength	ASTM D 4632	N (lbs)			
Machine Direction			400	550	MARV
			(90)	(90)	
X-Machine Direction			400	450	MARV
			(90)	(90)	
Permittivity[2]	ASTM D 4491	sec-1	0.05	0.05	MARV
Apparent Opening Size[2]	ASTM D 4751	mm	0.60	0.60	Max. ARV[3]
		(US Sieve #)	(30)	(30)	
Ultraviolet Stability	ASTM D 4355	% Retained Strength	70% after 500h of exposure	70% after 500h of exposure	Typical

[1] Silt Fence support shall consist of 14 gage steel wire with a mesh spacing of 150 mm (6 inches), or prefabricated poylmer mesh of equivalent strength.
[2] These default values are based on empirical evidence with a variety of sediment. For environmentally sensitive areas, a review of previous experience and/or site or regionally specific geotextile tests in accordance with Test Method D 5141 should be performed by the agency to confirm suitability of these requirements.
[3] As measured in accordance with Test Method D 4632.

CONSTRUCTION

1. Construct the sediment barrier of standard strength or extra strength synthetic filter fabrics.

2. Ensure that the height of the sediment fence does not exceed 24 inches above the ground surface. (Higher fences may impound volumes of water sufficient to cause failure of the structure.)

3. Construct the filter fabric from a continuous roll cut to the length of the barrier to avoid joints. When joints are necessary, securely fasten the filter cloth only at a support post with 4 feet minimum overlap to the next post.

4. Support standard strength filter fabric by wire mesh fastened securely to the **upslope** side of the posts. Extend the wire mesh support to the bottom of the trench. Fasten the wire reinforcement, then fabric on the upslope side of the fence post. Wire or plastic zip ties should have minimum 50 pound tensile strength.

5. When a wire mesh support fence is used, space posts a maximum of 8 feet apart. Support posts should be driven securely into the ground a minimum of 24 inches.

6. Extra strength filter fabric with 6 feet post spacing does not require wire mesh support fence. Securely fasten the filter fabric directly to posts. Wire or plastic zip ties should have minimum 50 pound tensile strength.

7. Excavate a trench approximately 4 inches wide and 8 inches deep along the proposed line of posts and upslope from the barrier (Figure 6.62a).

8. Place 12 inches of the fabric along the bottom and side of the trench.

9. Backfill the trench with soil placed over the filter fabric and compact. Thorough compaction of the backfill is critical to silt fence performance.

10. Do not attach filter fabric to existing trees.

SEDIMENT FENCE INSTALLATION USING THE SLICING METHOD

Instead of excavating a trench, placing fabric and then backfilling trench, sediment fence may be installed using specially designed equipment that inserts the fabric into a cut sliced in the ground with a disc (Figure 6.62b).

Installation Specifications

1. The base of both end posts should be at least one foot higher than the middle of the fence. Check with a level if necessary.

2. Install posts 4 feet apart in critical areas and 6 feet apart on standard applications.

3. Install posts 2 feet deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.

4. Install posts with the nipples facing away from the silt fabric.

5. Attach the fabric to each post with three ties, all spaced within the top 8 inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1 inch vertically apart. Also, each tie should be positioned to hang on a post nipple when tightened to prevent sagging.

6. Wrap approximately 6 inches of fabric around the end posts and secure with 3 ties.

7. No more than 24 inches of a 36 inch fabric is allowed above ground level.

8. The installation should be checked and corrected for any deviations before compaction.

9. Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence fabric with the front wheel of the tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first, and then each side twice for a total of 4 trips.

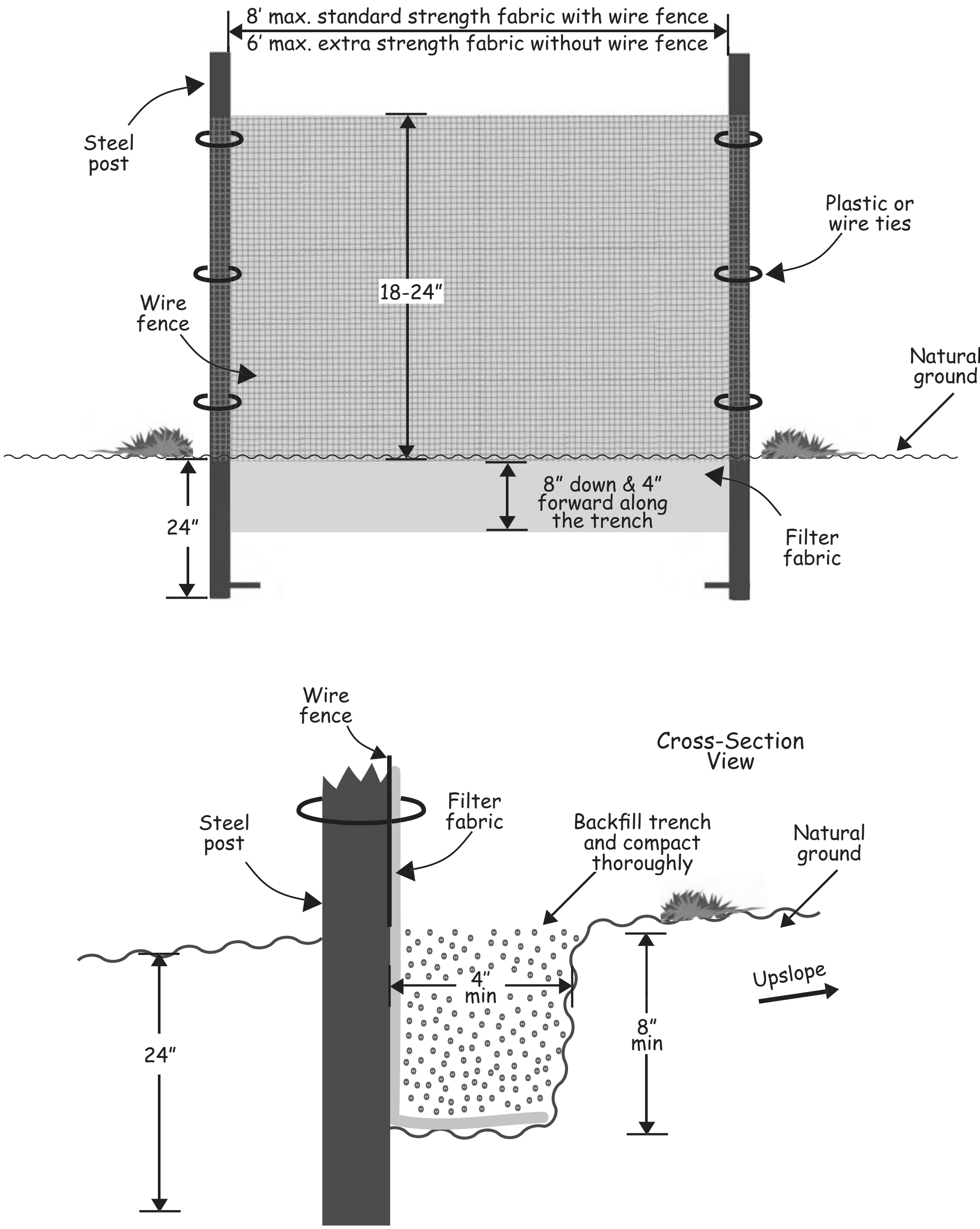


Figure 6.62a Installation detail of a sediment fence.

The Slicing Method

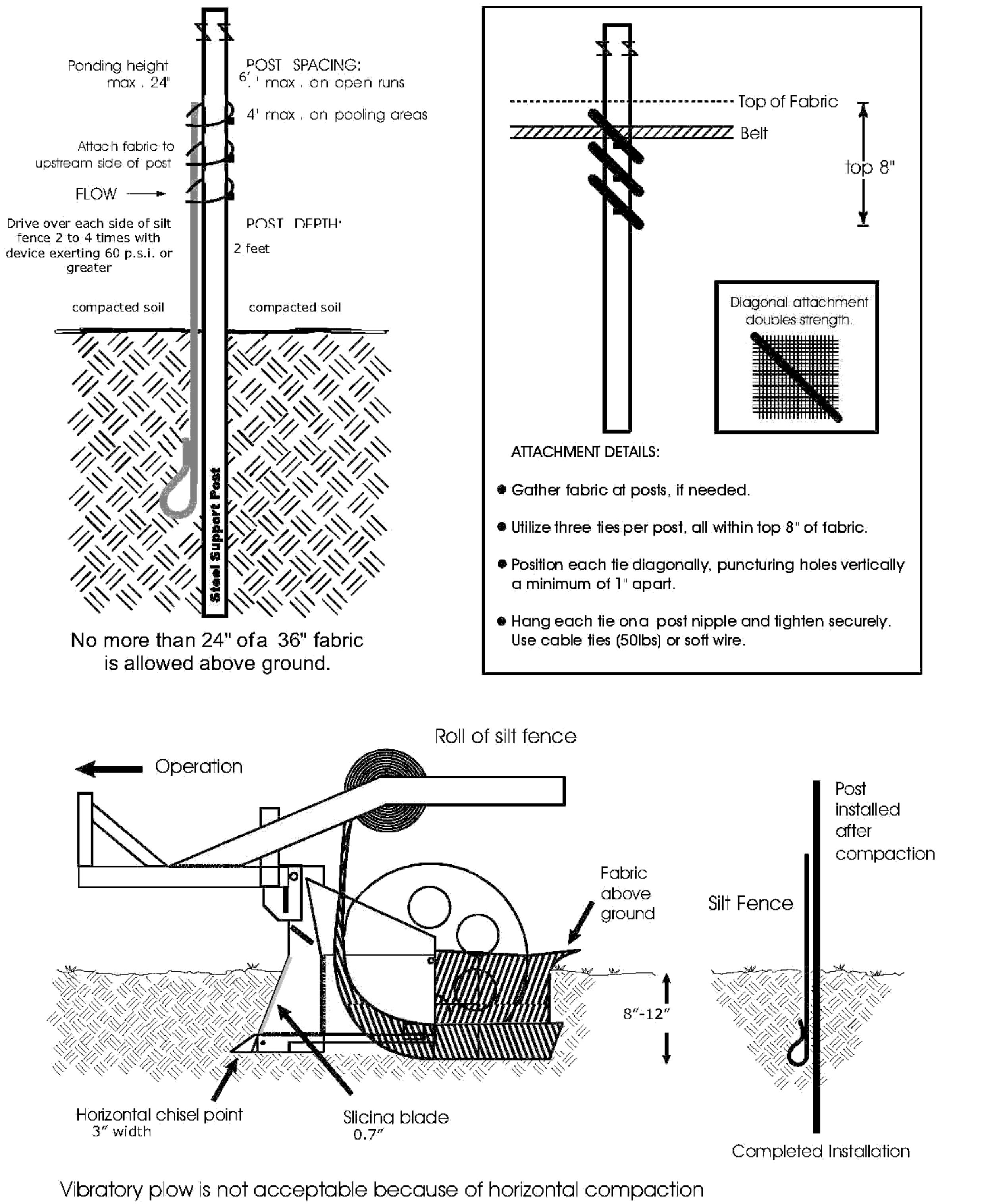


Figure 6.62b Schematics for using the slicing method to install a sediment fence. Adapted from *Silt Fence that Works*

Maintenance

Inspect sediment fences at least once a week and after each rainfall. Make any required repairs immediately.

Should the fabric of a sediment fence collapse, tear, decompose or become ineffective, replace it promptly.

Remove sediment deposits as necessary to provide adequate storage volume for the next rain and to reduce pressure on the fence. Take care to avoid undermining the fence during cleanout.

Remove all fencing materials and unstable sediment deposits and bring the area to grade and stabilize it after the contributing drainage area has been properly stabilized.

References

ASTM D 6461 – 99. "Standard Specification for Silt Fence Materials" ASTM International. For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

ASTM D 6462 – 03. "Standard Practice for Silt Fence Installation" ASTM International. For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

C. Joel Sprague, PE, Silt Fence Performance Limits and Installation Requirements. Sprague and Sprague Consulting Engineers and TRI/ Environmental, Inc.

Carpenter Erosion Control. http://www.tommy-sfm.com/

Kentucky Erosion Prevention and Sediment Control Field Manual, 2004.

Runoff Control Measures
6.20, Temporary Diversions

Outlet Protection
6.41, Outlet Stabilization Structure

Appendix
8.03, Estimating Runoff

6.64

SKIMMER SEDIMENT BASIN

Definition

An earthen embankment suitably located to capture runoff, with a trapezoidal spillway lined with an impermeable geotextile or laminated plastic membrane, and equipped with a floating skimmer for dewatering.

Purpose

Sediment basins are designed to provide an area for runoff to pool and settle out a portion of the sediment carried down gradient. Past designs used a perforated riser for dewatering, which allowed water to leave the basin from all depths. One way to improve the sediment capture rate is to have an outlet which dewaters the basin from the top of the water column where the water is cleanest. A skimmer is probably the most common method to dewater a sediment basin from the surface. The basic concept is that the skimmer does not dewater the basin as fast as runoff enters it, but instead allows the basin to fill and then slowly drain over hours or days. This process has two effects. First, the sediment in the runoff has more time to settle out prior to discharge. Second, a pool of water forms early in a storm event and this further increases sedimentation rates in the basin. Many of the storms will produce more volume than the typical sediment basin capacity and flow rates in excess of the skimmer capability, resulting in flow over the emergency spillway. This water is also coming from the top of the water column and has thereby been "treated" to remove sediment as much as possible. (Adapted from SoilFacts: Dewatering Sediment Basins Using Surface Outlets. N. C. State University, Soil Science Department.)

Conditions Where Practice Applies

Skimmer sediment basins are needed where drainage areas are too large for temporary sediment traps. Do not locate the skimmer sediment basin in intermittent or perennial streams.

Planning Considerations

Select locations for skimmer basins during initial site evaluation. Install skimmer sediment basins before any site grading takes place within the drainage area.

Select skimmer sediment basin sites to capture sediment from all areas that are not treated adequately by other sediment control measures. Always consider access for cleanout and disposal of the trapped sediment. Locations where a pond can be formed by constructing a low dam across a natural swale are generally preferred to sites that require excavation. Where practical, divert sediment-free runoff away from the basin.

A skimmer is a sedimentation basin dewatering control device that withdraws water from the basin's water surface, thus removing the highest quality water for delivery to the uncontrolled environment. A skimmer is shown in Figure 6.64a. By properly sizing the skimmer's control orifice, the skimmer can be made to dewater a design hydrologic event in a prescribed period. Because the spillway is actually used relatively frequently, it should be carefully stabilized using geotextiles, or rock if necessary, that can withstand the expected flows. The spillway should be placed as far from the inlet of the basin as possible to maximize sedimentation before discharge. The spillway should be located in natural groundcover to the greatest extent possible

The costs of using a skimmer system are similar, or occasionally less, than a conventional rock outlet or perforated riser. However, the basin is more efficient in removing sediment. Another advantage of the skimmer is that it can be reused on future projects. The main disadvantage of the skimmer is that it does require frequent maintenance, primarily in removing debris from the inlet.

A skimmer must dewater the basin from the top of the water surface. The rate of dewatering must be controlled. A dewatering time of 2-5 days is required. **Any skimmer design that dewaters from the surface at a controlled rate is acceptable.**

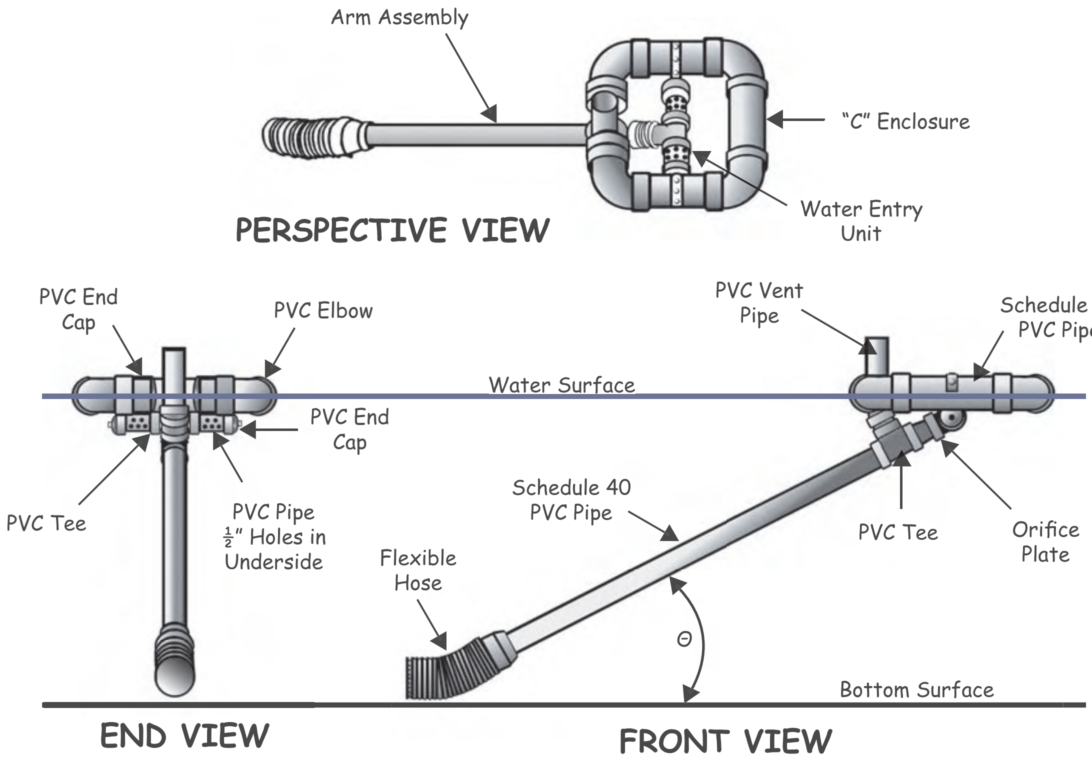


Figure 6.64a Schematic of a skimmer, from Pennsylvania Erosion and Sediment Pollution Control Manual, March, 2000.

SKIMMER ORIFICE DIAMETER

The orifice of a skimmer should be selected in order to achieve the desired dewatering time. **Three days** is probably the optimal length of time for temporary sediment controls. It allows longer settling time for suspended solids remaining in the basin after a storm event, while dewatering the basin in less time than the average interval between rainfall events. Design criteria for permanent stormwater detention basins in the Division of Water Quality Stormwater BMP Manual require 2-5 days for dewatering.

Procedure

First determine the desired dewatering time in days (t_d) and the volume (V) of water to be released in that time period. Dividing the volume in cubic feet by the dewatering time in days gives a flow rate Q_d in cubic feet per day.

$$Q_d = V / t_d \ \ (\text{ft}^3/\text{day})$$

Next determine the head on the skimmer orifice. Table 6.64a has the values for various sizes of the Faircloth skimmer.

Table 6.64a Head on orifice of various skimmer sizes

Skimmer Size (in.)	Head on Orifice (ft.)
1.5	0.125
2	0.167
2.5	0.208
3	0.25
4	0.333
5	0.333
6	0.417
8	0.5

The desired orifice diameter (D) in inches can now be calculated using the equation

$$D = \sqrt{Q_d /(2310 * \sqrt{H})} \quad \text{(inches)}$$

Example: Select a skimmer that will dewater a 20,000 ft^3 skimmer basin in 3 days.

1. $Q_d = V / t_d$ (ft^3/day) = 20,000 ft^3 / 3 days = 6670 (ft^3/day).

2. Try a 4 inch skimmer, with H = 0.333 ft. (Table 6.64a)

3. $D = \sqrt{Q_d /(2310 * \sqrt{H})}$ (in.) $= \sqrt{6670 \ \text{ft}^3/\text{day} /(2310 * \sqrt{0.333 \ \text{ft.}})}$ (in.)

   = 2.24 inches (Use 2 ¼ inches)

The desired dewatering time can also be achieved by adjusting the skimmer size and orifice diameter using the spreadsheet entitled "Sediment Control Measures", which is available at http://portal.ncdenr.org/web/lr/links

Figure 6.64b Example Excel Spreadsheet

4	Skimmer Size (inches)
0.333	Head on Skimmer (feet)
2.25	Orifice Size (1/4 in increment)
2.96	Dewatering Time (days)

Skimmer Size (Inches)	Head on Skimmer (Feet)
1.5	0.125
2	0.167
2.5	0.208
3	0.25
4	0.333
5	0.333
6	0.417
8	0.5

Adapted from training materials developed by Albert R. Jarrett, Ph.D. for Erosion and Sediment Control/Stormwater Certification for NC DOT Projects Level IIIA and IIIB, N.C. State University, Department of Biological and Agricultural Engineering, 2007.

Design Criteria

Summary:	**Skimmer Sediment Basin**
Primary Spillway:	Trapezoidal spillway with impermeable membrane
Maximum Drainage Area:	10 acres
Minimum Volume:	1800 cubic feet per acre of disturbed area
Minimum Surface Area:	325 square feet per cfs of Q_{10} peak inflow
Minimum L/W Ratio:	2:1
Maximum L/W Ratio:	6:1
Minimum Depth:	2 feet
Dewatering Mechanism:	Skimmer
Minimum Dewatering Time:	2 days
Baffles Required:	3 baffles*
	(*Note: Basins less than 20 feet in length may use 2 baffles.)

Drainage areas—Limit drainage areas to 10 acres.

Design basin life—Ensure a design basin life of 3 years or less.

Dam height—Limit dam height to 5 feet.

Basin locations—Select areas that:

- Provide capacity for storage of sediment from as much of the planned disturbed area as practical;
- Exclude runoff from undisturbed areas where practical;
- Provide access for sediment removal throughout the life of the project;
- Interfere minimally with construction activities.

Basin shape—Ensure that the flow length to basin width ratio is at least 2:1 to improve trapping efficiency. Length is measured at the elevation of the principal spillway.

Storage volume—Ensure that the sediment storage volume of the basin, as measured to the elevation of the crest of the principal spillway, is at least 1,800 cubic feet per acre for the disturbed area draining into the basin (1,800 cubic feet is equivalent to half an inch of sediment per acre of basin disturbed area).

Remove sediment from the basin when approximately one-half of the storage volume has been filled.

Spillway capacity—The spillway system must carry the peak runoff from the 10-year storm with a minimum 1 foot of freeboard in the spillway. Base runoff computations on the disturbed soil cover conditions expected during the effective life of the structure.

Sediment cleanout elevation—Determine the elevation at which the invert of the basin would be half-full. This elevation should also be marked in the field with a permanent stake set at this ground elevation (not the top of the stake).

Basin dewatering—The basin should be provided with a surface outlet. A floating skimmer should be attached to a Schedule 40 PVC barrel pipe of the same diameter as the skimmer arm. The orifice in the skimmer will control the rate of dewatering. The skimmer should be sized to dewater the basin in 2-5 days).

Outlet Protection—Discharge velocities must be within allowable limits for the receiving stream (References: *Outlet Protection*).

Basin spillway—Construct the entire flow area of the spillway in undisturbed soil if possible. Make the cross section trapezoidal with side slopes of 3:1 or flatter.

- Capacity—The minimum design capacity of the spillway must be the peak rate of runoff from the 10-year storm. Maximum depth of flow during the peak runoff should be 6 inches. In no case should the freeboard of the spillway be less than 1 foot above the design depth of flow.
- Velocity—Ensure that the velocity of flow discharged from the basin is nonerosive for the existing conditions. When velocities exceed that allowable for the receiving areas, provide outlet protection (References: *Outlet Protection*).

Embankment—Ensure that embankments for skimmer sediment basins do not exceed 5 feet in height (measured at the center line from the original ground surface to the top of the embankment). Keep the crest of the spillway outlet a minimum of 1.5 feet below the top of the embankment. Additional freeboard may be added to the embankment height which allows flow through a designated bypass location. Construct embankments with a minimum top width of 5 feet and side slopes of 2:1 or flatter. Machine compact the embankments.

Excavation—Where sediment pools are formed or enlarged by excavation, keep side slopes at 2:1 or flatter for safety.

Erosion protection—Stabilize all areas disturbed by construction (except the lower half of the sediment pool) by suitable means immediately after completing the basin (References: *Surface Stabilization*).

Trap efficiency—Improve sediment basin trapping efficiency by employing the following considerations in the basin design:

- Surface area—In the design of the settling pond, allow the largest surface area possible.
- Length—Maximize the length-to-width ratio of the basin to prevent short circuiting, and ensure use of the entire design settling area.
- Baffles—Provide a minimum of three porous baffles to evenly distribute flow across the basin and reduce turbulence.
- Inlets—Area between the sediment inlets and the basin should be stabilized by geotextile material, with or without rocks (Figure 6.64c shows the area with rocks). The inlet to basin should be located the greatest distance possible from the principal spillway.

• Dewatering—Allow the maximum reasonable detention period before the basin is completely dewatered (at least 48 hours).

• Inflow rate—Reduce the inflow velocity and divert all sediment-free runoff.

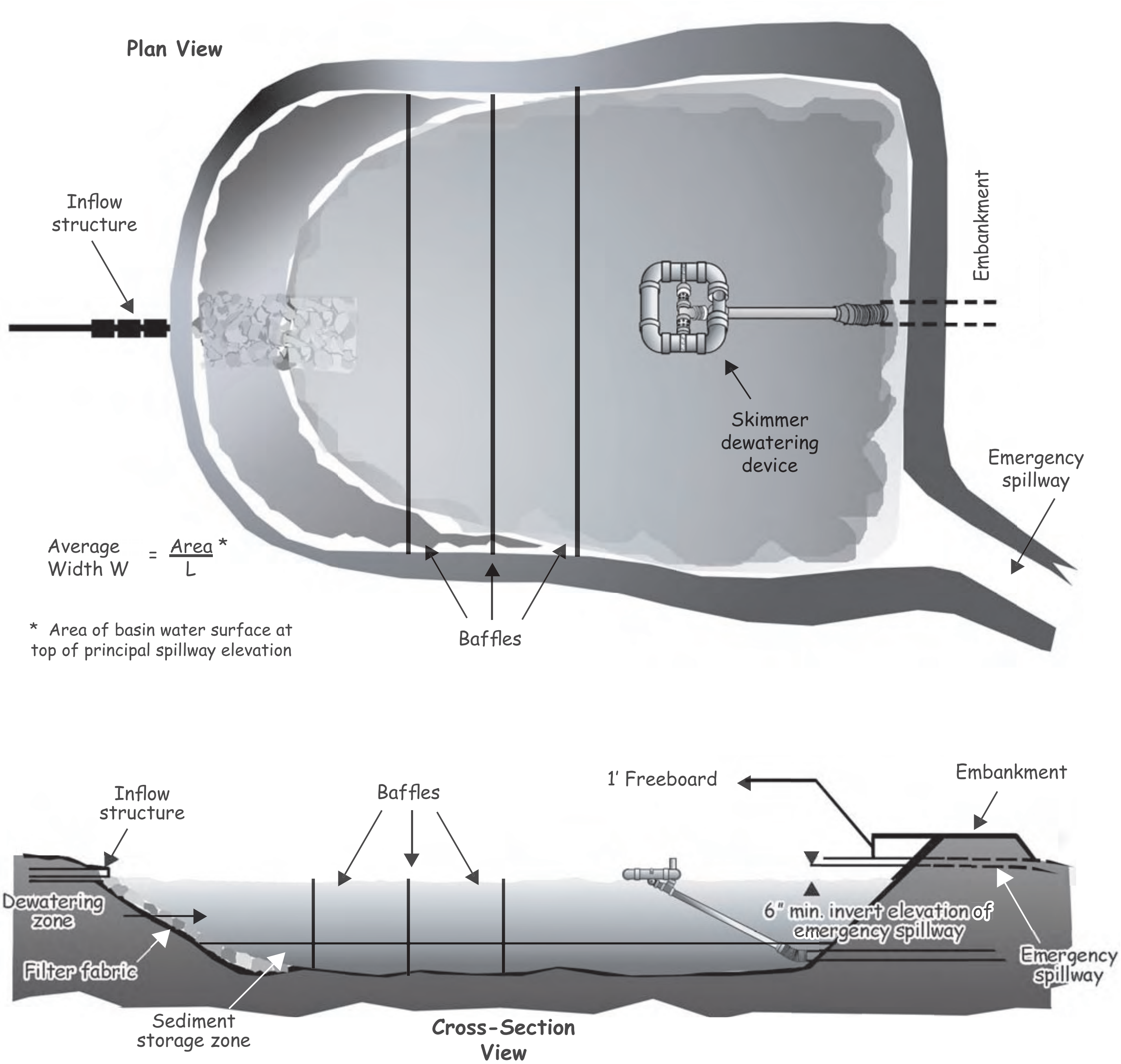


Figure 6.64c Example of a sediment basin with a skimmer outlet and emergency spillway. From Pennsylvania Erosion and Sediment Pollution Control Manual, March, 2000.

Construction Specifications

1. Clear, grub, and strip the area under the embankment of all vegetation and root mat. Remove all surface soil containing high amounts of organic matter and stockpile or dispose of it properly. Haul all objectionable material to the designated disposal area. Place temporary sediment control measures below basin as needed

2. Ensure that fill material for the embankment is free of roots, woody vegetation, organic matter, and other objectionable material. Place the fill in lifts not to exceed 9 inches, and machine compact it. Over fill the embankment 6 inches to allow for settlement.

3. Shape the basin to the specified dimensions. Prevent the skimming device from settling into the mud by excavating a shallow pit under the skimmer or providing a low support under the skimmer of stone or timber.

4. Place the barrel (typically 4-inch Schedule 40 PVC pipe) on a firm, smooth foundation of impervious soil. Do not use pervious material such as sand, gravel, or crushed stone as backfill around the pipe. Place the fill material around the pipe spillway in 4-inch layers and compact it under and around the pipe to at least the same density as the adjacent embankment. Care must be taken not to raise the pipe from the firm contact with its foundation when compacting under the pipe haunches.

Place a minimum depth of 2 feet of compacted backfill over the pipe spillway before crossing it with construction equipment. In no case should the pipe conduit be installed by cutting a trench through the dam after the embankment is complete.

5. Assemble the skimmer following the manufacturers instructions, or as designed.

6. Lay the assembled skimmer on the bottom of the basin with the flexible joint at the inlet of the barrel pipe. Attach the flexible joint to the barrel pipe and position the skimmer over the excavated pit or support. Be sure to attach a rope to the skimmer and anchor it to the side of the basin. This will be used to pull the skimmer to the side for maintenance.

7. Earthen spillways—Install the spillway in undisturbed soil to the greatest extent possible. The achievement of planned elevations, grade, design width, and entrance and exit channel slopes are critical to the successful operation of the spillway. The spillway should be lined with laminated plastic or impermeable geotextile fabric. The fabric must be wide and long enough to cover the bottom and sides and extend onto the top of the dam for anchoring in a trench. The edges may be secured with 8-inch staples or pins. The fabric must be long enough to extend down the slope and exit onto stable ground. The width of the fabric must be one piece, not joined or spliced; otherwise water can get under the fabric. If the length of the fabric is insufficient for the entire length of the spillway, multiple sections, spanning the complete width, may be used. The upper section(s) should overlap the lower section(s) so that water cannot flow under the fabric. Secure the upper edge and sides of the fabric in a trench with staples or pins. (Adapted from "A Manual for Designing, Installing and Maintaining Skimmer Sediment Basins." February, 1999. J. W. Faircloth & Son.).

8. Inlets—Discharge water into the basin in a manner to prevent erosion. Use temporary slope drains or diversions with outlet protection to divert sediment-laden water to the upper end of the pool area to improve basin trap efficiency (References: *Runoff Control Measures and Outlet Protection*).

9. Erosion control—Construct the structure so that the disturbed area is minimized. Divert surface water away from bare areas. Complete the embankment before the area is cleared. Stabilize the emergency spillway embankment and all other disturbed areas above the crest of the principal spillway immediately after construction (References: *Surface Stabilization*).

10. Install porous baffles as specified in Practice 6.65, *Porous Baffles*.

11. After all the sediment-producing areas have been permanently stabilized, remove the structure and all the unstable sediment. Smooth the area to blend with the adjoining areas and stabilize properly (References: *Surface Stabilization*).

Maintenance

Inspect skimmer sediment basins at least weekly and after each significant (one-half inch or greater) rainfall event and repair immediately. Remove sediment and restore the basin to its original dimensions when sediment accumulates to one-half the height of the first baffle. Pull the skimmer to one side so that the sediment underneath it can be excavated. Excavate the sediment from the entire basin, not just around the skimmer or the first cell. Make sure vegetation growing in the bottom of the basin does not hold down the skimmer.

Repair the baffles if they are damaged. Re-anchor the baffles if water is flowing underneath or around them.

If the skimmer is clogged with trash and there is water in the basin, usually jerking on the rope will make the skimmer bob up and down and dislodge the debris and restore flow. If this does not work, pull the skimmer over to the side of the basin and remove the debris. Also check the orifice inside the skimmer to see if it is clogged; if so remove the debris.

If the skimmer arm or barrel pipe is clogged, the orifice can be removed and the obstruction cleared with a plumber's snake or by flushing with water. Be sure and replace the orifice before repositioning the skimmer.

Check the fabric lined spillway for damage and make any required repairs with fabric that spans the full width of the spillway. Check the embankment, spillways, and outlet for erosion damage, and inspect the embankment for piping and settlement. Make all necessary repairs immediately. Remove all trash and other debris from the skimmer and pool areas.

Freezing weather can result in ice forming in the basin. Some special precautions should be taken in the winter to prevent the skimmer from plugging with ice.

Reference

Jarrett, A. R. Proper Sizing of the Control Orifice for the Faircloth Skimmer. Pennsylvania State University Department of Agricultural and Biological Engineering Fact Sheet #252. http://www.age.psu.edu/extension/factsheets/f/F252.pdf

Jarrett, A. R. Controlling the Dewatering of Sedimentation Basins. Pennsylvania State University Department of Agricultural and Biological Engineering Fact Sheet #253. http://www.age.psu.edu/extension/factsheets/f/F253.pdf

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McLaughlin, Richard. SoilFacts: Dewatering Sediment Basins Using Surface Outlets. N. C. State University, Soil Science Department.

A Manual for Designing, Installing and Maintaining Skimmer Sediment Basins. February, 1999. J. W. Faircloth & Son.

Surface Stabilization
6.10, Temporary Seeding
6.11, Permanent Seeding
6.12, Sodding
6.13, Trees, Shrubs, Vines, and Ground Covers

Runoff Control Measures
6.20, Temporary Diversions
6.21, Permanent Diversions
6.22, Perimeter Dike

Outlet Protection
6.41, Outlet Stabilization Structure

Sediment Traps and Barriers
6.65, Porous Baffles

Appendices
8.03, Estimating Runoff
8.07, Sediment Basin Design

6.65 POROUS BAFFLES

Definition

Porous barriers installed inside a temporary sediment trap, skimmer basin, or sediment basin to reduce the velocity and turbulence of the water flowing through the measure, and to facilitate the settling of sediment from the water before discharge.

Purpose

Sediment traps and basins are designed to temporarily pool runoff water to allow sediment to settle before the water is discharged. Unfortunately, they are usually not very efficient due to high turbulence and "short-circuiting" flows which take runoff quickly to the outlet with little interaction with most of the basin. Porous baffles improve the rate of sediment retention by distributing the flow and reducing turbulence. This process can improve sediment retention.

Conditions Where Practice Applies

This practice should be used in any temporary sediment trap, skimmer basin, or temporary sediment basin.

Planning Considerations

Porous baffles effectively spread the flow across the entire width of a sediment basin or trap. Water flows through the baffle material, but is slowed sufficiently to back up the flow, causing it to spread across the entire width of the baffle (Figure 6.65a).

Spreading the flow in this manner utilizes the full cross section of the basin, which in turn reduces flow rates or velocity as much as possible. In addition, the turbulence is also greatly reduced. This combination increases sediment deposition and retention and also decreases the particle size of sediment captured.

The installation should be similar to a sediment fence (Figure 6.65b). The fabric should be 700 g/m^2 coir erosion blanket (Figure 6.65c) or equal. A support wire across the top will help prevent excessive sagging if the material is attached to it with appropriate ties.

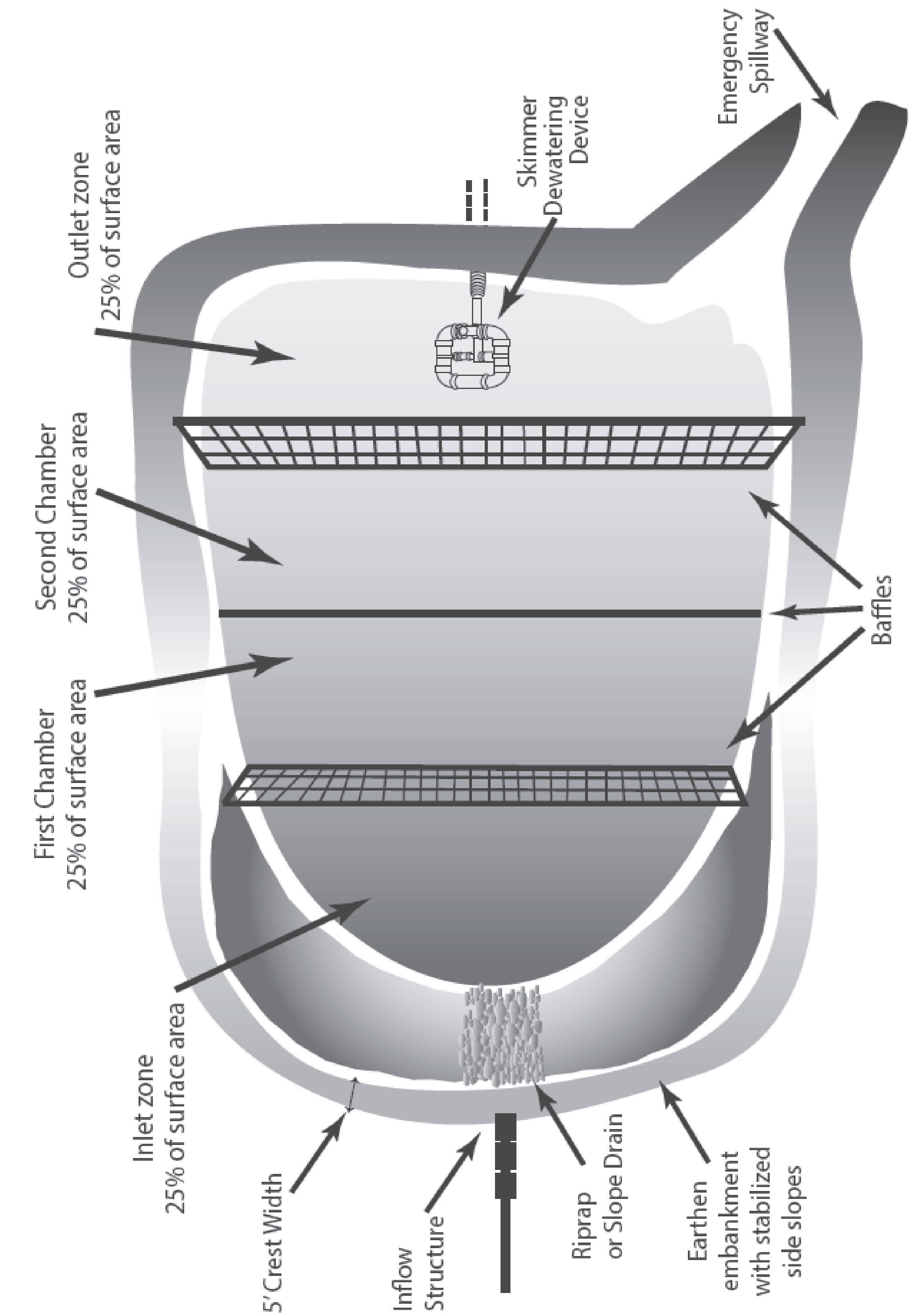

Figure 6.65a Porous baffles in a sediment basin. The flow is distributed evenly across the basin to reduce flow rates and turbulence, resulting in greater sediment retention.

Baffles need to be installed correctly in order to fully provide their benefits. Refer to Figure 6.65b and the following key points:

- The baffle material needs to be secured at the bottom and sides using staples.
- Most of the sediment will accumulate in the first bay, so this should be readily accessible for maintenance.

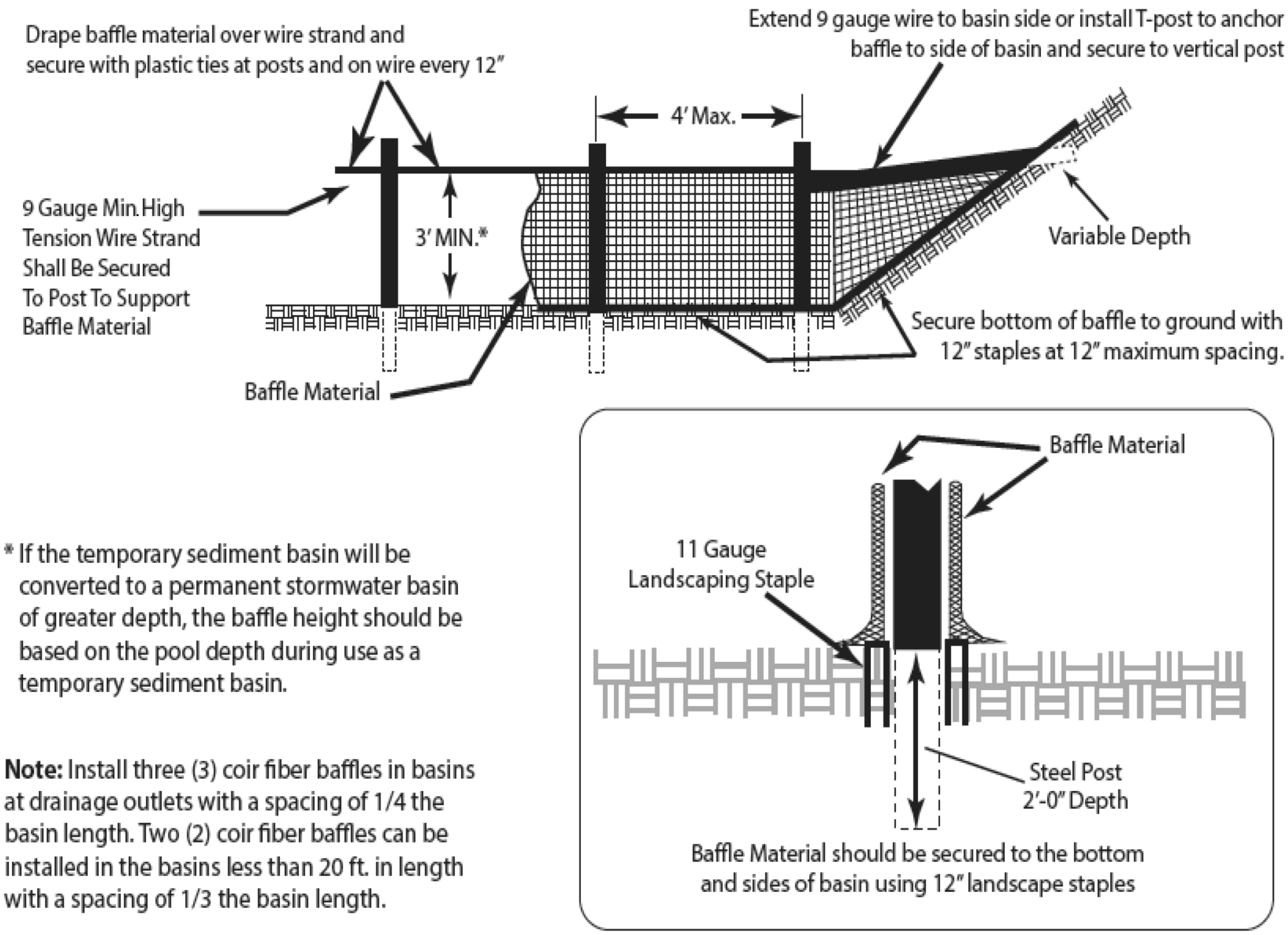

Figure 6.65b Coir Fiber Baffle Detail
Cross section of a porous baffle in a sediment basin.

Figure 6.65c Example of porous baffles made of 700 g/m^2 coir erosion blanket as viewed from the outlet.

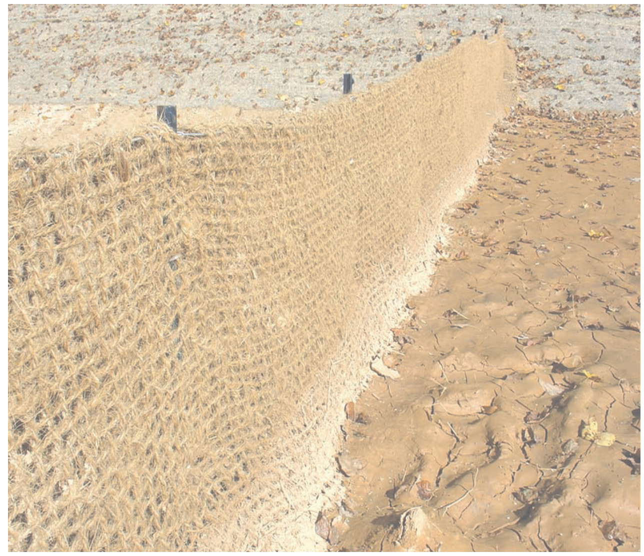

Figure 6.65d Close-up of a porous baffle.

Design Criteria

The temporary sediment trap or temporary sediment basin should be sized using the appropriate design criteria.

The percent of surface area for each section of the baffle is as follows:

- inlet zone: 25%
- first cell: 25%
- second cell: 25%
- outlet zone: 25%

Baffle spacing in future permanent stormwater basins is beyond forebay.

Be sure to construct baffles up the sides of the trap or basin banks so water does not flow around the structures. Most of the sediment will be captured in the inlet zone. Smaller particle size sediments are captured in the latter cells. Be sure to maintain access to the trap for maintenance and sediment removal.

The design life of the fabric is 6-12 months, but may need to be replaced more often if damaged or clogged.

Construction Specifications

MATERIALS

1. Use matting made of 100% coconut fiber (coir) twine woven into high strength matrix with the properties shown in Table 6.65a.

2. Staples should be made of 0.125 inch diameter new steel wire formed into a 'U' shape not less than 12 inches in length with a throat of 1 inch in width. The staples anchor the porous baffles into the sides and bottom of the basin.

3. Ensure that steel posts for porous baffles are of a sufficient height to support baffles at desired height. Posts should be approximately 1-3/8" wide measured parallel to the fence, and have a minimum weight of 1.25 lb/linear ft. The posts must be equipped with an anchor plate having a minimum area of 14.0 square inches and be of the self-fastener angle steel type to have a means of retaining wire and coir fiber mat in the desired position without displacement.

4. Use 9-gauge high tension wire for support wire.

Table 6.65a Specifications for Porous Baffle Material

Coir Fiber Baffle Material Property Requirements	
Thickness	0.30 in. minimum
Tensile Strength (Wet)	900 x 680 lb/ft minimum
Elongation (Wet)	69% x 34% maximum
Flow Velocity	10-12 ft/sec
Weight	20 oz/SY (680 g/m^2) minimum
Minimum Width	6.5 feet
Open Area	50% maximum

CONSTRUCTION

1. Grade the basin so that the bottom is level front to back and side to side.

2. Install the coir fiber baffles immediately upon excavation of the basins.

3. Install posts across the width of the sediment trap (Practice 6.62, *Sediment Fence*).

4. Steel posts should be driven to a depth of 24 inches and spaced a maximum of 4 feet apart. The top of the fabric should be a minimum of 6 inches higher than the invert of the spillway. Tops of baffles should be a minimum of 2 inches lower than the top of the earthen embankment.

5. Install at least three rows of baffles between the inlet and outlet discharge point. Basins less than 20 feet in length may use 2 baffles.

6. Attach a 9 gauge high tension wire strand to the steel posts at a height of 6 inches above the spillway elevation with plastic ties or wire fasteners to prevent sagging. If the temporary sediment basin will be converted to a permanent stormwater basin of a greater depth, the baffle height should be based on the pool depth during use as a temporary sediment basin.

7. Extend 9 gauge minimum high tension wire strand to side of basin or install steel T-posts to anchor baffle to side of basin and secure to vertical end posts as shown in Figure 6.65b.

8. Drape the coir fiber mat over the wire strand mounted at a height of 6 inches above the spillway elevation. Secure the coir fiber mat to the wire strand with plastic ties or wire fasteners. Anchor the matting to the sides and floor of the basin with 12 inch wire staples, approximately 1 ft apart, along the bottom and side slopes of the basin.

9. Do not splice the fabric, but use a continuous piece across the basin

10. Adjustments may be required in the stapling requirements to fit individual site conditions.

Maintenance

Inspect baffles at least once a week and after each rainfall. Make any required repairs immediately.

Be sure to maintain access to the baffles. Should the fabric of a baffle collapse, tear, decompose, or become ineffective, replace it promptly.

Remove sediment deposits when it reaches half full, to provide adequate storage volume for the next rain and to reduce pressure on the baffles.
Take care to avoid damaging the baffles during cleanout, and replace if damaged during cleanout operations. Sediment depth should never exceed half the designed storage depth.

After the contributing drainage area has been properly stabilized, remove all baffle materials and unstable sediment deposits, bring the area to grade, and stabilize it.

References

Sediment Traps and Barriers
6.60, Temporary Sediment Trap
6.61, Sediment Basins
6.62, Sediment Fence
6.64, Skimmer Sediment Basin

McLaughlin, Richard, "Soil Facts: Baffles to Improve Sediment Basins." N.C. State University Cooperative Extension Service Fact Sheet AGW-439-59, 2005.

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Sullivan, Brian. City of High Point Erosion Control Specifications.

Thaxton, C. S., J. Calantoni, and R. A. McLaughlin. 2004. Hydrodynamic assessment of various types of baffles in a sediment detention pond. Transactions of the ASAE. Vol. 47(3): 741-749.

6.66 COMPOST SOCK

C SOCK

Definition

A compost sock is a three-dimensional tubular sediment control and storm water runoff device typically used for perimeter control of sediment and soluble pollutants (such as phosphorous and petroleum hydrocarbon), on and around construction activities. Compost socks trap sediment and other pollutants in runoff water as it passes through the matrix of the sock and by allowing water to temporarily pond behind the sock, allowing deposition of suspended solids. Compost socks are also used to reduce runoff flow velocities on sloped surfaces.

Compost products acceptable for this application should meet the chemical, physical and biological properties specified for Practice 6.18, *Compost Blankets.*

Figure 6.66a – Compost Sock
Photo Credit – Filtrexx International

Conditions Where Practice Applies

Compost socks are to be installed down slope of disturbed areas requiring erosion and sediment control. Compost socks are effective when installed perpendicular to sheet flow, in areas where sediment accumulation of less than six inches is anticipated. Acceptable applications include (Fifield, 2001):

- Site perimeters
- Below disturbed areas subject to sheet runoff, with minor sheet or rill erosion. Compost socks should not be used alone below graded slopes greater than 10 feet in height.
- Above graded slopes to serve as a diversion berm.

- Check dams
- Along the toe of stream and channel banks
- Around area drains or inlets located in a storm drain system
- Around sensitive trees where trenching of silt fence is not beneficial for tree survival or may unnecessarily disturb established vegetation.
- On paved surfaces where trenching of silt fence is impossible.

A compost sock can be applied to areas of sheet runoff, on slopes up to a 2:1 grade with a maximum height of 10 feet, around inlets, and in other disturbed areas of construction sites requiring sediment control. Compost socks may also be used in sensitive environmental areas, or where trenching may damage roots.

The weight of a filled sock (40 lbs / linear ft. for 8” diameter) effectively prevents sediment migration beneath the sock. It is possible to drive over a compost sock during construction (although not recommended); however, these areas should be immediately repaired by manually moving the sock back into place, if disturbed. Continued heavy construction traffic may destroy the fabric mesh, reduce the dimensions, and reduce the effectiveness of the compost sock. Vegetating the compost sock should be considered.

Planning Considerations

Compost socks shall either be made on site or delivered to the jobsite assembled. The sock shall be produced from a 5 mil thick continuous HDPE or polypropylene, woven into a tubular mesh netting material, with openings in the knitted mesh of ⅛" - ⅜" (3-10mm). This shall then be filled with compost meeting the specifications outlined in Practice 6.18*, Compost Blankets,* with the exception of particle size, to the diameter of the sock. Compost sock netting materials are also available in biodegradable plastics for areas where removal and disposal are not desired (i.e., when using pre-seeded socks). Compost socks contain the compost, maintaining its density and shape.

Compost socks should be installed parallel to the base of the slope or other affected area, perpendicular to sheet flow. The sock should be installed a minimum of 10 feet beyond the top of graded slopes. When runoff flows onto the disturbed area from a land above the work zone, a second sock may be constructed at the top of the slope in order to dissipate flows.

On locations where greater than a 200-foot long section of ground is to be treated with a compost sock, the sock lengths should be sleeved. After one sock section (200 feet) is filled and tied off (knotted) or zip tied, the second sock section shall be pulled over the first 1-2 feet and 'sleeved' creating an overlap. Once overlapped, the second section is filled with compost starting at the sleeved area to create a seamless appearance. The socks may be staked at the overlapped area (where the sleeve is) to keep the sections together. Sleeving at the joints is necessary because it reduces the opportunity for water to penetrate the joints when installed in the field.

Compost Sock BMP	Conventional Application	Product Description	Example
Silt Socks	Silt Fence (on smaller areas)	A 3-dimensional sediment control measure used for sediment removal	
Inlet Socks	Inlet Protection	Designed to allow stormwater to enter inlets while removing sediment and protecting inlets from clogging	
Ditch Check	Rock Check Dams	Contours to ditch shape and eliminates gullies	

Table 6.66a Compost Sock BMPs as Replacements for Current Erosion Control Practices
Photo credits: Filtrexx International

After filling, the compost sock must be staked in place. Oak or other durable hardwood stakes 2"x 2" in cross section should be driven vertically plumb, through the center of the compost sock. Stakes should be placed at a maximum interval of 4 feet, or a maximum interval of 8 feet if the sock is placed in a 4 inch trench. See Figure 6.66b. The stakes should be driven to a minimum depth of 12 inches, with a minimum of 3 inches protruding above the compost sock.

If the compost sock is to be left as part of the natural landscape, it may be seeded at time of installation for establishment of permanent vegetation using the seeding specification in the erosion and sedimentation control plan. A maximum life of 2 years for photodegradable netting and 6 months for biodegradable netting should be used for planning purposes.

Compost socks may be used as check dams in ditches not exceeding 3 feet in depth. Normally, 8 to 12 inch diameter socks should be used. Be sure to stake the sock perpendicular to the slope of the ditch. When used as check dams, installation should be similar to that of natural fiber wattles. The ends and middle of the sock should be staked, and additional stakes placed at a 2-foot maximum interval. See Table 6.66b for spacing.

Design Criteria

The sediment and pollutant removal process characteristic to a compost sock allows deposition of settling solids. Ponding occurs when water flowing to the sock accumulates faster than the hydraulic flow through rate of the sock. Typically, initial hydraulic flow-through rates for a compost sock are 50% greater than geotextile fabric (silt fence). However, installation and maintenance is especially important for proper function and performance. Design consideration should be given to the duration of the project, total area of disturbance, rainfall/runoff potential, soil erosion potential, and sediment loading when specifying a compost sock.

Runoff Flow:

The depth of runoff ponded above the compost sock should not exceed the height of the compost sock. If overflow of the device is a possibility, a larger diameter sock should be constructed, other sediment control devices may be used, or management practices to reduce runoff should be installed. Alternatively, a second sock may be constructed or used in combination with Practice 6.17, *Rolled Erosion Control Products* or Practice 6.18, *Compost Blankets* to slow runoff and reduce erosion.

Level Contour:

The compost sock should be placed on level contours to assist in dissipating low concentrated flow into sheet flow and reducing runoff flow velocity. Do not construct compost socks to concentrate runoff or channel water. Sheet flow of water should be perpendicular to the sock at impact and un-concentrated. Placing compost socks on undisturbed soil will reduce the potential for undermining by concentrated runoff flows.

Runoff and Sediment Accumulation:

The compost sock should be placed at a 10 foot minimum distance away from the toe of the slope to allow for proper runoff accumulation for sediment deposition and to allow for maximum sediment storage capacity behind the device. On flat areas, the sock should be placed at the edge of the land-disturbance.

End Around Flow:

In order to prevent water flowing around the ends of the compost sock, the ends of the sock must be constructed pointing upslope so the ends are at a higher elevation. A minimum of 10 linear feet at each end placed at a 30 degree angle is recommended.

Vegetated Compost Sock:

For permanent areas the compost sock can be directly seeded to allow vegetation established directly on the device. Vegetation on and around the compost sock will assist in slowing runoff velocity for increased deposition of pollutants. The option of adding vegetation should be shown on the erosion and sedimentation control plan. No additional soil amendments or fertilizer are required for vegetation establishment in the vegetated compost sock.

Slope Spacing & Drainage Area:

Maximum drainage area to and spacing between the compost socks is dependent on rainfall intensity and duration used for specific design/plan, slope steepness, and width of area draining to the sock.

A compost sock across the full length of the slope is normally used to ensure that stormwater does not break through at the intersection of socks placed end-to-end. Ends are jointed together by sleeving one sock end into the other. The diameter of the compost sock used will vary depending upon the steepness and length of the slope; example slopes and slope lengths used with different diameter compost socks are presented in Table 6.66b.

Table 6.66b - Compost Sock Spacing versus Channel Slope

Channel Slope (%)	Spacing Between Socks (feet)	
	8-inch Diameter Sock	12-inch Diameter Sock
1	67	100
2	33	50
3	22	33
4	17	25
5	13	20

Source: B. Faucette – 2010

Material:

The compost media shall be derived from well-decomposed organic matter source produced by controlled aerobic (biological) decomposition that has been sanitized through the generation of heat and stabilized to the point that it is appropriate for this particular application. Compost material shall be processed through proper thermophilic composting, meeting the US Environmental Protection Agency's definition for a 'Process to Further Reduce Pathogens' (PFRP), as defined at 40 CFR Part 503. The compost portion shall meet the chemical, physical and biological properties specified in Practice 6.18, *Compost Blankets* Table 6.18a, with the exception of particle size. Slightly more coarse compost is recommended for the socks, as follows:

Particle Size Distribution

Sieve Size	Percent Passing Selected Sieve Mesh Size, Dry Weight Basis
2"	99 % (3" Maximum Particle Size)
3/8"	30-50 %

See Practice 6.18, *Compost Blankets* for complete information on compost parameters and tests. Installer should provide documentation to support compliance of testing required in the compost specification.

This specification covers compost produced from various organic by-products, for use as an erosion and sediment control measure on sloped areas. The product's parameters will vary based on whether vegetation will be established on the treated slope. Only compost products that meet all applicable state and federal regulations pertaining to its production and distribution may be used in this application. Approved compost products must meet related state and federal chemical contaminant (e.g., heavy metals, pesticides, etc.) and pathogen limit standards pertaining to the feedstocks (source materials) in which it are derived.

In regions subjected to higher rates of precipitation and/or greater rainfall intensity, larger compost socks should be used. In these particular regions, coarser compost products are preferred as the compost sock must allow for an improved water percolation rate. The designer should check the flow rate per foot of sock in order to ensure drainage rate of the compost sock being used is adequate. The required flow rates are outlined in Table 6.66c.

Table 6.66c – Compost Sock Initial Flow Rates

Compost Sock Design Diameter	**8 inch (200mm)**	**12 inch (300mm)**	**18 inch (450mm)**	**24 inch (600mm)**	**32 inch (800mm)**
Maximum Slope Length (<2%)	**600 ft (183m)**	**750 ft (229m)**	**1,000 ft (305m)**	**1,300 ft (396m)**	**1,650 ft (500m)**
Hydraulic Flow Through Rate	**7.5 gpm/ft (94 l/m/m)**	**11.3 gpm/ft (141 l/m/m)**	**15.0 gpm/ft (188 l/m/m)**	**22.5gpm/ft (281 l/m/m)**	**30.0 gpm/ft (374 l/m/m)**

Source: B. Faucette-2010

Construction Specifications

INSTALLATION

1. Materials used in the compost sock must meet the specifications outlined above and in Practice 6.18, Compost Blankets.

2. Compost socks should be located as shown on the erosion and sedimentation control plan.

3. Prior to installation, clear all obstructions including rocks, clods, and other debris greater than one inch that may interfere with proper function of the compost sock.

4. Compost socks should be installed parallel to the toe of a graded slope, a minimum of 10 feet beyond the toe of the slope. Socks located below flat areas should be located at the edge of the land-disturbance. The ends of the socks should be turned slightly up slope to prevent runoff from going around the end of the socks.

5. Fill sock netting uniformly with compost to the desired length such that logs do not deform.

6. Oak or other durable hardwood stakes 2" X 2" in cross section should be driven vertically plumb, through the center of the compost sock. Stakes should be placed at a maximum interval of 4 feet, or a maximum interval of 8 feet if the sock is placed in a 4 inch trench. See Figure 6.66b. The stakes

should be driven to a minimum depth of 12 inches, with a minimum of 3 inches protruding above the compost sock.

7. In the event staking is not possible (i.e., when socks are used on pavement) heavy concrete blocks shall be used behind the sock to hold it in place during runoff events.

8. If the compost sock is to be left as part of the natural landscape, it may be seeded at time of installation for establishment of permanent vegetation using the seeding specification in the erosion and sedimentation control plan.

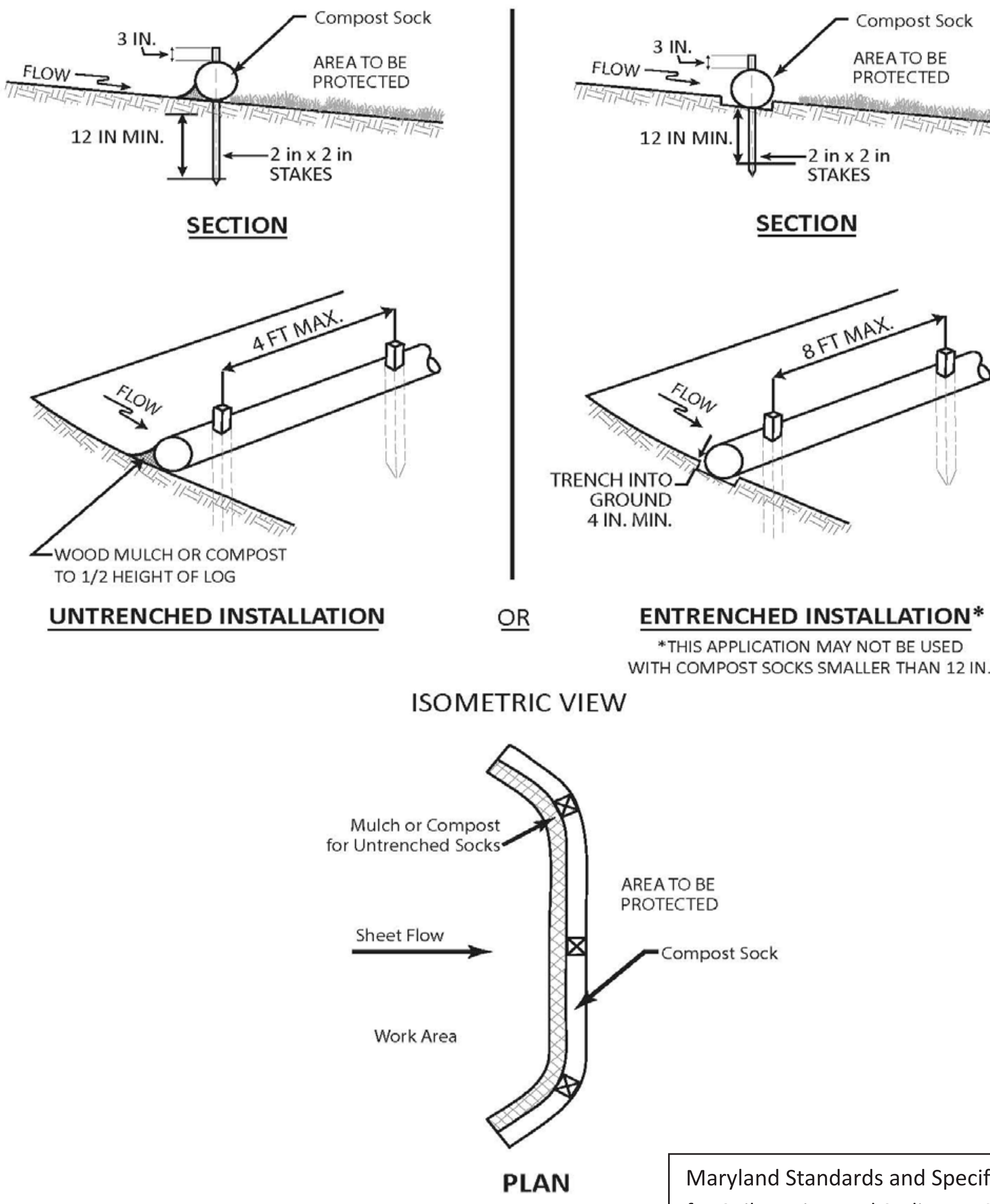
9. Compost socks are not to be used in perennial or intermittent streams.

Maintenance

Inspect compost socks weekly and after each significant rainfall event (1/2 inch or greater). Remove accumulated sediment and any debris. The compost sock must be replaced if clogged or torn. If ponding becomes excessive, the sock may need to be replaced with a larger diameter or a different measure. The sock needs to be reinstalled if undermined or dislodged. The compost sock shall be inspected until land disturbance is complete and the area above the measure has been permanently stabilized.

DISPOSAL/RECYCLING

Compost media is a composted organic product recycled and manufactured from locally generated organic, natural, and biologically based materials. Once all soil has been stabilized and construction activity has been completed, the compost media may be dispersed with a loader, rake, bulldozer or similar device and may be incorporated into the soil as an amendment or left on the soil surface to aid in permanent seeding or landscaping. Leaving the compost media on site reduces removal and disposal costs compared to other sediment control devices. The mesh netting material will be extracted from the media and disposed of properly. The photodegradable mesh netting material will degrade in 2 to 5 years if left on site. Biodegradable mesh netting material is available and does not need to be extracted and disposed of, as it will completely decompose in approximately 6 to 12 months. Using biodegradable compost socks completely eliminates the need and cost of removal and disposal.



Maryland Standards and Specifications for Soil Erosion and Sediment Control, 2011, Maryland Department of Environment, Water Management Administration

Figure 6.66b Compost Sock Installation

References

Chapter 3 Vegetative Considerations
Chapter 6 Practice Standard and Site Specifications
6.10, Temporary Seeding
6.11, Permanent Seeding
6.17, Rolled Erosion Control Products
6.18, Compost Blankets

Tyler, R., A. Marks, B. Faucette. 2010. The Sustainable Site: Design Manual for Green Infrastructure and Low Impact Development Forester Press, Santa Barbara, CA.

Fifield, J. 2001. Designing for Effective Sediment and Erosion Control on Construction Sites. Forester Press, Santa Barbara, CA.

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APPENDICES

8.07

SEDIMENT BASIN DESIGN

The design of temporary sediment basins for construction sites should meet all minimum requirements contained in *Practice Standards and Specifications: 6.61, Sediment Basin*.

The following outline provides guidance in designing sediment basins to meet those requirements.

Size, Location, and Efficiency

Structures intended for more than 3 years of use should be designed as permanent structures. **Procedures outlined in this section do not apply to permanent structures.** All high hazard potential dams and structures taller than 25 feet and that also have a maximum storage capacity of 50 acre-feet or more are subject to the N.C. Dam Safety Law of 1967.

Basic requirements for design of a sediment basin are the following:

- drainage area less than 100 acres;
- design structure life less than 3 years;
- minimum design storm, 10-yr peak runoff with minimum 1 ft freeboard;
- In High Quality Water (HQW) Zones, minimum design storm, 25-yr peak runoff with minimum 1 foot freeboard. The sediment basin shall settle the 40-micron particle with a minimum efficiency of at least 70% during the 2-yr peak runoff event. See appendices beginning on pg. 8.07.13.
- hazard classification: sudden failure should not cause loss of life or serious property damage.

Basin location—Locate the basin so that a maximum amount of runoff from disturbed areas can be brought into the structure. It should be accessible for periodic cleanout and should not interfere with construction activities. When possible delay clearing the sediment impoundment area until the dam is in place. Keep the remaining temporary pool area undisturbed.

Basin volume—Minimum volume of the basin should be 1,800 ft^3/acre for the disturbed area draining into the basin. Volume is measured below the principal spillway crest. Where possible the entire drainage basin is used for this computation, rather than the disturbed area alone, to help ensure adequate trapping efficiency.

Trapping efficiency—For additional information see Appendices pg. 8.07.13-8.07.42) Maximize the trapping efficiency of the basin by:

- diverting runoff from undisturbed areas away from the basin;
- limiting drainage area to increase the ratio of basin surface area to peak inflow rate. This ratio should be 435 ft^2/cfs or greater to achieve more than 75% efficiency on most soils. Subdivide area with additional traps and barriers to limit inflow rate and improve efficiency;
- maximizing the length-to-width ratio of the basin. Length to width should be 2:1 to 6:1;
- locating sediment inflow points as far as possible from the principal spillway inlet;
- controlling flow at inlet points to maintain nonerosive velocities.

Basin cleanout—Plan to remove sediment when approximately one half of the basin volume has been filled. **The minimum volume requirement (1,800 ft^3/acre) must always be met.**

Spillway System Design

The spillway system, consisting of a principal spillway and an emergency spillway, should carry the peak runoff from a 10-year storm with a minimum 1 foot freeboard above the design water surface in the emergency spillway. Base runoff computations on the most severe soil cover conditions expected during the effective life of the structure (*Appendix 8.03*).

PRINCIPAL SPILLWAY

The principal spillway consists of a vertical pipe riser fastened to a horizontal pipe barrel with watertight connectors. The horizontal conduit must extend beyond the toe of the dam and must be stabilized, usually by riprap.

Minimum capacity—2-year peak runoff, computed for water surface at the emergency spillway elevation.

Crest elevation of the riser may be set no lower than the elevation of the sediment detention pool as a minimum.

Barrel conduit and riser—The minimum barrel conduit size allowable is 15 inches for corrugated pipe and 12 inches for smooth-walled pipe. Limit the maximum barrel diameter to 30 inches. The riser should have a cross-sectional area at least 1.5 times that of the barrel. Rod and lug type connector bands with gaskets are recommended for corrugated pipe to provide positive watertight connections.

Basin dewatering should be from the water surface, using a floating surface intake or by operating a flash board riser.

The minimum dewatering time is 48 hours, and not more than 1 foot of stage draw-down per day.

Trash guard—Install a trash guard on top of the riser. A fabricated cone of steel rods, spaced 2 inches apart, fastened to the top of the riser is recommended.

Protection against piping—Secure at least one watertight antiseep collar with a minimum projecting of 1.5 feet around 12-inch or larger conduits. Locate the collar just downstream from the centerline of the dam. A properly designed drainage diaphragm installed around the barrel may be substituted for an antiseep collar.

Protection against flotation—Anchor the riser with a mass with a buoyant weight greater than 1.1 times the weight of water displaced by the riser.

Stabilize the outlet below the barrel against erosion (*Appendix 8.06*).

EMERGENCY SPILLWAY
Construct the entire flow area of the emergency spillway in undisturbed soil. Cross section should be trapezoidal, with side slopes 3:1 or flatter. Select vegetated lining to meet flow requirements and site conditions (Figure 8.07a)

Capacity—Design the emergency spillway for runoff from the 10-year storm less any reduction due to flow in the principal spillway.

Inlet protection—Ensure that the approach section has a slope toward the impoundment area of not less than 2% and is flared at its entrance, gradually reducing to the design width of the control section.

The control section should be level and straight and at least 20 ft long. Determine the width and depth for the required capacity and site conditions. Wide, shallow spillways are preferred because they reduce outlet velocities.

The outlet section should be straight, aligned and sloped to assure supercritical flow with exit velocities not exceeding values acceptable for site conditions.

Outlet velocity—Ensure that the velocity of flow from the basin is nonerosive for existing site conditions. It may be necessary to stabilize the downstream areas or the receiving channels.

EMBANKMENT DESIGN
There should be a cutoff trench in stable soil material under the dam at the centerline, extending up the abutments to the elevation of the emergency spillway. The trench should be at least 2 feet deep with 1:1 side slopes, and sufficiently wide to allow compaction by machine.

Top width—Fill height 10 feet: minimum top width 8 feet
Fill height 10-15 feet: minimum top width 10 feet

Allowment for settlement—10% of fill height.

Side slope—2.5:1 or flatter

Freeboard—minimum 1 foot between the settled top of the dam and the design water level in the emergency spillway.

Embankment material should be a stable mineral soil, free of roots, woody vegetation, rocks or other objectionable materials, with adequate moisture for compaction. Place fill in 8-inch layers through the length of dam and compact by routing construction hauling equipment over it. Equipment must traverse the entire surface of each layer by at least one wheel width.

EROSION CONTROL
Construct the structure to minimize the area disturbed. Divert surface water away from disturbed areas. Complete the embankment before clearing the impoundment area. Stabilize the emergency spillway, embankment, and all other disturbed areas above the crest elevation of the principal spillway immediately after construction (*Practices 6.10-6.15, Surface Stabilization*).

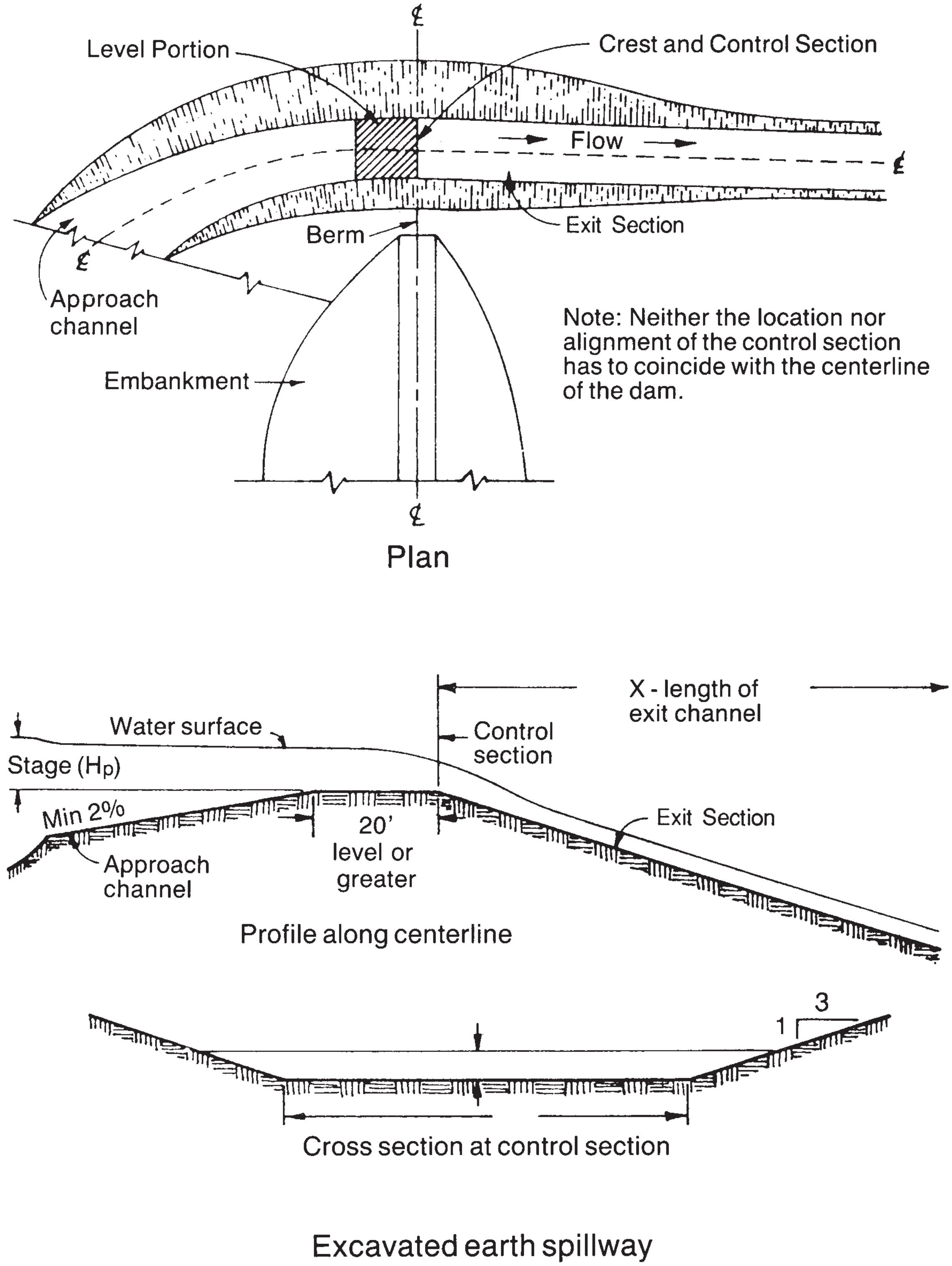

Figure 8.07a Design of excavated earthen spillway.

Safety—Avoid steep side slopes. Fence basins properly and mark them with warning signs if trespassing is likely. Follow all State and local safety requirements.

Design Procedure

Step 1. Determine peak flow, Q_{10}, for the basin drainage area (*Appendix 8.03*).

Step 2. Determine any site limitations for the sediment pool elevation, emergency spillway or top of the dam.

Step 3. Determine basin volumes:

- Compute minimum volume required (1800 ft^3/acre disturbed).
- Specify sediment cleanout level to be marked on riser (one-half the design volume referenced to the top of the riser) and sediment storage area to be cleared after the dam is built.

Step 4. Determine area and shape of basin:

- Check length/width ratio (should be 2:1 to 6:1).
- Compute the basin surface area at principal spillway elevation.
- Check the ratio of basin surface area to peak inflow rate (should be greater than or equal to 435 ft^2/cfs). Employ diversions with additional traps and basins to reduce area drained.

Determine barrel capacity required for site conditions (minimum capacity for Q_p is the 2-year peak runoff, Q_2.

Step 5. Determine the principal spillway discharge capacity.

- The combined capacities of the principal and emergency spillways must be at least the 10-year peak flow for the entire watershed of the basin.
- The principal spillway is analyzed for three possible limiting flow types: Weir flow, Orifice flow, and Pipe flow. The principal spillway discharge capacity is the smallest of these three flow rates. Discharges through a skimmer should be disregarded during this computation. Weir, orifice and pipe flow may be determined by the following equations:

1. Weir Flow: $Q = CLH^{1.5}$

where:
Q = discharge in cubic feet per second (cfs)
C = weir coefficient, use 3.1 for corrugated metal pipe risers.
L = circumference of the riser in feet
H = head above riser crest in feet

2. Orifice Flow: $Q = CA\,(2gH)^{0.5}$

where:
Q = discharge in cubic feet per second (cfs)
C = orifice coefficient, use C = 0.6 for corrugated metal pipe risers.
A = cross-sectional area of the riser pipe in square feet
g = acceleration due to gravity, 32.2 ft/sec^2
H = head above riser crest in feet

3. Pipe Flow: $Q = a \left[\frac{2gh}{1 + K_m + K_p L}\right]^{0.5}$

where:

Q = discharge in cubic feet per second (cfs)
a = cross-sectional area of the barrel in square feet
g = acceleration due to gravity, 32.2 ft/sec^2
h = head above the centerline of the outlet end of the barrel
K_m = coefficient of minor losses, can be assumed to be 1.0 for most principal spillway systems
L = barrel length in feet
K_p = pipe friction coefficient:

$$= \frac{5087n^2}{di^{4/3}}$$

(See Table 8.07c for K_p values for common size of pipe.)

n = Manning's coefficient of roughness, use n = 0.025 for corrugated metal pipe
n = 0.015 for reinforced concrete pipe
di = inside diameter of the barrel in inches

Select riser and barrel dimensions so that the riser has a cross-sectional area at least 1.5 times that of the barrel. Spillway hydraulics are improved by maximizing weir flow and minimizing orifice flow. See Table 8.07b for recommended riser/barrel proportions.

Table 8.07a K_p Values for Common Sizes of Pipe

Pipe Diameter (inches)	Flow Area (square feet)	Manning's Coefficient	
		0.015	0.025
6	0.196	0.1050	0.2916
8	0.349	0.0715	0.1987
10	0.545	0.0531	0.1476
12	.0785	0.0417	0.1157
14	1.069	0.0339	0.0942
15	1.23	0.0309	0.0859
16	1.40	0.0284	0.0789
18	1.77	0.0243	0.0674
21	2.41	0.0198	0.0549
24	3.14	0.0165	0.0459
27	3.98	0.0141	0.0393
30	4.91	0.0123	0.0341
36	7.07	0.0096	0.0267
42	9.62	0.0078	0.0218
48	12.57	0.0066	0.0182
54	15.90	0.0056	0.0156
60	19.64	0.0049	0.0135

RISER
Select trail riser and barrel dimensions. Use the weir, orifice and pipe flow equations to determine if the 2-year peak discharge is passed without activating the emergency spillway. Determine riser size from Table 8.07b. Check the head and stage requirements. If the design stage is too high, choose larger dimensions and recalculate. As a minimum, set the elevation of the riser at the same elevation as the top of the sediment pool. A riser height 2 to 5 times the barrel diameter is recommended. Select the type of trash guard.

Select a dewatering device. If a skimmer is used, refer to the manufacturers dewatering data, or Table 6.64.a.

Step 6. Design antiseep collar.
Ensure that antiseep collars are no closer than 2 ft from a pipe joint. Collar must project at least 1.5 ft from the pipe. Indicate watertight connections.

Step 7. Design antiflotation block.
Determine the weight of water displaced by the empty riser, and design a block with buoyant weight 1.1 times the weight of water displaced.

Step 8. Design outlet.
Determine discharge velocity from the barrel. Design outlet protection to assure stable conditions. Riprap placement is usually necessary (*Appendix 8.06*).

Step 9. Design emergency spillway.

- Determine the required capacity for the emergency spillway as

$$Q_e = Q_{10} - Q_p \ (Q_p \geq Q_2)$$

- From Table 8.07e or Table 8.07f, select the width and depth of the outlet, depending on soil conditions. In general, the wider bottom widths and lower slopes are preferred to minimize exit velocities at supercritical flow.

- An acceptable alternative is the use of the weir equation

$$Q = CLH^{1.5}$$

  Where this option is used, the maximum value of C should be 2.8. L is the bottom width of the spillway at the crest, and H is the depth of flow above the spillway crest in feet. Note: Manning's channel equation should not be used to size the spillway crest. However, it should be used to design the outlet channel below the spillway crest.

- The total of the emergency and principle spillway capacities must equal or exceed the required 10-year peak discharge.

- Set the elevation of the crest of the emergency spillway a minimum of 1 foot above the crest of the riser.

Step 10. Spillway approach section.
Adjust the spillway alignment so that the control section and outlet section are straight. The entrance width should be 1.5 times the width of the control section with a smooth transition to the width of the control section. Approach channel should slope toward the reservoir no less than 2%.

Table 8.07b Design chart for riser outlet

Inlet Proportions	
Pipe Conduit (D) - in	Pipe Riser (d) - in
8-12	18
15	21
18	24
21	30
24	30
30	36
36	48
42	54
48	60

Table 8.07c
Design Table for Vegetated Spillways Excavated in Erosion Resistant Soils
(side slopes-3 horizontal:1 vertical)

Discharge Q CFS	Slope Range		Bottom Width Feet	Stage Feet
	Minimum Percent	Maximum Percent		
15	3.3	12.2	8	.83
	3.5	18.2	12	.69
20	3.1	8.9	8	.97
	3.2	13.0	12	.81
	3.3	17.3	16	.70
25	2.9	7.1	8	1.09
	3.2	9.9	12	.91
	3.3	13.2	16	.79
	3.3	17.2	20	.70
30	2.9	6.0	8	1.20
	3.0	8.2	12	1.01
	3.0	10.7	16	.88
	3.3	13.8	20	.78
35	2.8	5.1	8	1.30
	2.9	6.9	12	1.10
	3.1	9.0	16	.94
	3.1	11.3	20	.85
	3.2	14.1	24	.77
40	2.7	4.5	8	1.40
	2.9	6.0	12	1.18
	2.9	7.6	16	1.03
	3.1	9.7	20	.91
	3.1	11.9	24	.83
45	2.6	4.1	8	1.49
	2.8	5.3	12	1.25
	2.9	6.7	16	1.09
	3.0	8.4	20	.98
	3.0	10.4	24	.89
50	2.7	3.7	8	1.57
	2.8	4.7	12	1.33
	2.8	6.0	16	1.16
	2.9	7.3	20	1.03
	3.1	9.0	24	.94
60	2.6	3.1	8	1.73
	2.7	3.9	12	1.47
	2.7	4.8	16	1.28
	2.9	5.9	20	1.15
	2.9	7.3	24	1.05
	3.0	8.6	28	.97
70	2.5	2.8	8	1.88
	2.6	3.3	12	1.60
	2.6	4.1	16	1.40
	2.7	5.0	20	1.26
	2.8	6.1	24	1.15
	2.9	7.0	28	1.05
80	2.5	2.9	12	1.72
	2.6	3.6	16	1.51
	2.7	4.3	20	1.35
80	2.8	5.2	24	1.24
	2.8	5.9	28	1.14
	2.9	7.0	32	1.06
90	2.5	2.6	12	1.84
	2.5	3.1	16	1.61
	2.6	3.8	20	1.45
	2.7	4.5	24	1.32
	2.8	5.3	28	1.22
	2.8	6.1	32	1.14
100	2.5	2.8	16	1.71
	2.6	3.3	20	1.54
	2.6	4.0	24	1.41
	2.7	4.8	28	1.30
	2.7	5.3	32	1.21
	2.8	6.1	36	1.13
120	2.5	2.8	20	1.71
	2.6	3.2	24	1.56
	2.7	3.8	28	1.44
	2.7	4.2	32	1.34
	2.7	4.8	36	1.26
140	2.5	2.7	24	1.71
	2.5	3.2	28	1.58
	2.6	3.6	32	1.47
	2.6	4.0	36	1.38
	2.7	4.5	40	1.30
160	2.5	2.7	28	1.70
	2.5	3.1	32	1.58
	2.6	3.4	36	1.49
	2.6	3.8	40	1.40
	2.7	4.3	44	1.33
180	2.4	2.7	32	1.72
	2.4	3.0	36	1.60
	2.5	3.4	40	1.51
	2.6	3.7	44	1.43
200	2.5	2.7	36	1.70
	2.5	2.9	40	1.60
	2.5	3.3	44	1.52
	2.6	3.6	48	1.45
220	2.4	2.6	40	1.70
	2.5	2.9	44	1.61
	2.5	3.2	48	1.53
240	2.5	2.6	44	1.70
	2.5	2.9	48	1.62
	2.6	3.2	52	1.54
260	2.4	2.6	48	1.70
	2.5	2.9	52	1.62
280	2.4	2.6	52	1.70
300	2.5	2.6	56	1.69

Example of Use

Given: Discharge, Q = 87 c.f.s. Spillway slope, Exit section (from profile) = 4%

Find: Bottom width and Stage in Spillway

Procedure: Enter table from left at 90 c.f.s. Note that Spillway slope (4%) falls within slope ranges corresponding to bottom widths of 24, 28, and 32 ft. Use bottom width, 32 ft, to minimize velocity. State in Spillway will be 1.14 ft.

Note: Computations based on: Roughness coefficient, n = 0.40. Maximum velocity 5.50 ft. per sec.

Table 8.07d
Design Table for Vegetated Spillways Excavated in Very Erodible Soils
(side slopes-3 horizontal:1 vertical)

Discharge Q CFS	Slope Range		Bottom Width Feet	Stage Feet
	Minimum Percent	Maximum Percent		
10	3.5	4.7	8	.68
15	3.4	4.4	12	.69
	3.4	5.9	16	.60
20	3.3	3.3	12	.80
	3.3	4.1	16	.70
	3.5	5.3	20	.62
25	3.3	3.3	16	.79
	3.3	4.0	20	.70
	3.5	4.9	24	.64
30	3.3	3.3	20	.78
	3.3	4.0	24	.71
	3.4	4.7	28	.65
	3.4	5.5	32	.61
35	3.2	3.2	24	.77
	3.3	3.9	28	.71
	3.5	4.6	32	.66
	3.5	5.2	36	.62
40	3.3	3.3	28	.76
	3.4	3.8	32	.71
	3.4	4.4	36	.67
	3.4	5.0	40	.64
45	3.3	3.3	32	.76
	3.4	3.8	36	.71
	3.4	4.3	40	.67
	3.4	4.8	44	.64
50	3.3	3.3	36	.75
	3.3	3.8	40	.71
	3.3	4.3	44	.68
60	3.2	3.2	44	.75
	3.2	3.7	48	.72
70	3.3	3.3	52	.75
80	3.1	3.1	56	.78

Example of Use

Given: Discharge, Q = 38 c.f.s. Spillway slope, Exit section (from profile) = 4%.

Find: Bottom width and Stage in Spillway.

Procedure: Enter table from left at 40 c.f.s. Note that Spillway slope (4.0%) falls within slope ranges corresponding to bottom widths of 36 and 40 ft. Use wider bottom width, 40 ft., to minimize velocity. Stage in Spillway will be 0.64 ft.

Note: Computations based on: Roughness coefficient, n = 0.40. Maximum velocity = 3.50 ft. per sec.

Step 11. Spillway control section

- Locate the control section in the spillway near where it intersects the extension of the centerline of the dam.
- Keep a level area to extend at least 20 ft upstream from the outlet end of the control section, to ensure a straight alignment.
- Side slopes should be 3:1.

Step 12. Design spillway exit section.

- Spillway exit should align with the control section and have the same bottom width and side slopes.
- Slope should be sufficient to maintain supercritical flow, but make sure it does not create erosive velocities for site conditions. (Stay within slope ranges in appropriate design tables.)
- Extend the exit channel to a point where the water may be released without damage.

Step 13. Size the embankment.

- Set the design elevation of the top of the dam a minimum of 1 ft above the water surface for the design flow in the emergency spillway.
- Constructed height should be 10% greater than the design to allow for settlement.
- Base top width on the design height.
- Set side slopes 2.5:1 or flatter.
- Determine depth of cutoff trench from site borings. It should extend to a stable, tight soil layer (a minimum of 2 ft deep).
- Select borrow site–the emergency spillway cut will provide a significant amount of fill.

Step 14. Erosion control

- Locate and design diversions to protect embankment and spillway (*Practice Standards and Specifications: 6.20, Temporary Diversions*).
- Select surface protection measures to control erosion (*Practice Standards and Specifications: 6.10, Temporary Seeding; 6.14, Mulching; and 6.15, Riprap*).
- Select groundcover for emergency spillway to provide protection for design flow velocity and site conditions. Riprap stone over geotextile fabric may be required in erodible soils or when the spillway is not in undisturbed soils.

Step 15. Safety.

- Construct a fence and install warning signs as needed.