



**Storm Water Quality Measures:
Construction & Land-Disturbing Activities**

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INTRODUCTION TO STORM WATER QUALITY MEASURES: CONSTRUCTION & LAND-DISTURBING ACTIVITIES

As an area undergoes land use changes it generally requires storm water control measures to prevent or at the very least minimize the introduction of pollutants into storm water runoff. This is true for both construction and post-construction phases of a project. Sediment is the most common pollutant associated with storm water runoff from construction sites. In fact, it has been shown that sediment is the number one pollutant, by volume, of surface waters of the United States. Sediment is also the primary pollutant that is addressed by state and local officials when they regulate construction projects. However, there are several other pollutants associated with construction activities. Some of these pollutants include but are not limited to solid wastes, nutrients, pesticides, petroleum products, and chemicals. This section of the manual lists several storm water quality measures that have been designed to control erosion and prevent or minimize the introduction of sediment into storm water runoff and surface waters.

Construction projects generally require a variety of storm water quality measures to properly manage and minimize the introduction of pollutants into surface water runoff. It is important to note that as a project moves through the various stages of construction, it will be necessary to modify, change, and properly maintain existing storm water quality measures as well as install new measures. The storm water quality measures in this section of the manual have been grouped into categories which attempt to address particular areas of concern on an active construction site.

It is important to recognize that selecting specific storm water quality measures will require thorough site assessment and design. Many of the measures can be applied and/or installed based on general criteria. However, there are measures contained within this manual that will require selection and design that is based on sound engineering principles. These measures include but are not limited to sediment basins, grassed and riprap-lined channels. These measures should be evaluated for feasibility and designed by a qualified individual. All structural measures should be designed by a professional engineer.

Some of the measures illustrated in Chapter 7 are only a representation of storm water quality/runoff control measures. Other alternatives may be available through design, field modification, or commercially available products.

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SITE ACCESS & PREPARATION

Prior to initiating land-disturbing activities on any construction site, it is important to properly prepare the site to minimize the potential for erosion and off-site sedimentation, preserve valuable vegetation, and protect unique/sensitive areas. This section of the manual contains measures that should be implemented on a construction site prior to initiating any land disturbance. It is also important to understand that every site is unique and has its own set of challenges. Therefore, not all measures contained in this section will be applicable to every site. Measures should be chosen to fit the project's specific site conditions.

Another important point to remember is that in most cases use of a single measure will not be sufficient to control erosion and sedimentation throughout all stages of construction activity. Therefore, measures included in other sections of this manual will need to be implemented during the site preparation phase. In particular, perimeter sediment control measures should be installed downstream of all proposed land-disturbing activities before actual disturbance begins in each area. Again, measures should be chosen to fit the project's specific site conditions. For example, on some sites perimeter measures may be as simple as leaving grassy vegetation in place to act as a filter strip. Other sites may require the use of properly installed silt fence. When more severe conditions are encountered it may be necessary to use temporary or permanent diversions to divert surface water runoff to temporary sediment traps and temporary sediment basins where the sediment-laden water can be treated.

Most measures illustrated in this section are associated with proper site management. Two measures within this section specifically address construction vehicle ingress and egress. It should be noted that there are products available commercially that, when installed according to the manufacturer's specifications, perform well and are designed to reduce vehicle tracking. These products include, but are not limited to, interlocking modules or plates and specially designed high-strength double walled fabric.

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SITE ACCESS & PREPARATION

Preservation & Utilization of Existing Cover



*Refer to **Preservation & Protection – Natural Site Design** on page 5 of Chapter 4, **Planning Principles & Design Considerations**.*

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SITE ACCESS & PREPARATION

Clearing & Grubbing

To be released at a later time

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SITE ACCESS & PREPARATION

Tree Preservation & Protection



Tree preservation and protection methods are used to preserve and protect desirable trees from damage during project development.

Purpose

To protect and insure survival of desirable existing trees from the effects of construction activities.

Specifications

Tree Selection and Planning

- Gather information from soil and topographic maps, aerial photos, and professional foresters to better understand the site, desirable trees, and how to save them.
- Walk the site to map out potential specimen trees, special features, and sensitive areas.
- Clearly identify and delineate on the construction plans all trees to be protected.
- Plan roads, sidewalks, and other infrastructure to save specimen trees and green space areas.
- Plan underground utilities so they can be combined in the same trench away from trees and potential planting sites. (If near trees, tunnel under the roots.)

Tree Protection

- Protect trees from equipment damage. (Wounds provide entry for insects and disease and reduce transport of sap.)
- If trees are damaged, repair immediately. (Repair of wounded areas allows trees to heal quickly, thus reducing insect and disease problems.)

Materials

- Fencing (orange safety fencing for increased visibility), snow fence and support posts.
- Signage.
- Wood mulch, chips, etc.
- Specialized equipment (brush cutter, rotary axe, hand tools).

Application

Tree Protection

1. Walk the site with plan and site map to verify location of specimen trees, special features, and sensitive areas.
2. If necessary, adjust the planned layout of roads, sidewalks, utilities, etc. to save specimen trees and green space areas.
3. Flag or mark all trees to be protected. Designate trees having high aesthetic value based on condition, spacing, and species. (More desirable species include beech, dogwood, sweetgum, sycamore, sugar maple, locust, hawthorn, oak, and hackberry. Less desirable species include aspen, elm, cherry, silver maple, willow, box elder, sassafras, cottonwood, and poplar.)
4. Mark for removal all undesirable or hazardous trees in the construction area. Thinning a stand ahead of time lets the remaining trees adjust to a more open environment.
5. If underground utilities must pass near or under tree rooting systems, tunnel under the roots.
6. Create traffic patterns to keep soil compaction to a minimum. (Compaction reduces the amount of air and water available to tree roots.)
7. Consider planting and/or transplanting. Small trees of desirable species can sometimes be transplanted from areas to be cleared. Property buffers, wind-breaks, or green space areas can be economically established with these trees.

Avoid Compaction

1. Install fencing around a specimen tree(s) as far out as its crown to keep equipment off the rooting area.
2. If a fence cannot be erected, cushion the rooting area with six inches of wood chips, wood, or brick paths.
3. Create traffic patterns to keep soil compaction to a minimum.
4. Store supplies and equipment away from specimen tree areas.
5. Designate sites well away from trees for burning debris and washing out concrete trucks.

Reduce Damage from Grading

1. When clearing, use equipment such as a brush cutter or rotary axe, or cut by hand.
2. Where root areas must be graded, cut large roots instead of tearing them with equipment.
3. Minimize changes in the drainage pattern. (Existing trees are acclimated to the current pattern; creating a new one could injure them.)
4. Where applicable, construct retaining walls to minimize root damage from grading operations. Removal or disturbance of soil may damage the root system of the tree.
5. Avoid putting fill over the root system. Adding soil material reduces water and air availability required for the root system and tree.

Avoid Wounding Trees

1. Protect trees from equipment damage by creating some type of barrier, fencing them off, or wrapping individual trees with snow fencing.
2. Prune low-hanging limbs that could otherwise be broken off by equipment.
3. Where feasible, leave trees in groups. Trees growing in wooded areas are used to shade from the surrounding trees, so when they are suddenly exposed to open areas they become susceptible to sun scald, frost cracks, excessive branching, and wind throw.

Repair Tree Damage

(Utilize the services of a consulting forester)

1. Properly prune all damaged limbs. Avoid leaving stubs.
2. Aerate soil where compaction has been excessive.
3. Fertilize to improve tree growth, vigor, and appearance.
4. Water during dry periods to help offset soil compaction and root damage.

Maintenance

- Inspect at least once every seven calendar days.
- Repair perimeter barriers if damaged.
- Inspect for damage from construction equipment, etc. Repair wounds simply by removing damaged bark and wood tissue. **Do not use tree paint.**
- Cable and brace any trunk splits, weak forks, and large limbs.

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SITE ACCESS & PREPARATION

Temporary Construction Ingress/Egress Pad (Large Sites – Two Acres or Larger)



A temporary construction ingress/egress pad is a sediment control measure consisting of a stabilized aggregate pad with geotextile underlayment that is used at any point where construction traffic will be traversing between a large construction site and adjoining public right-of-way, street, alley, sidewalk, or parking areas.

Purpose

To provide ingress/egress to a construction site and minimize tracking of mud and sediment onto public roadways.

Specifications

Location

- Avoid locating on steep slopes or at curves in public roads.

Dimensions

- Width – 20 feet minimum or full width of entrance/exit roadway, whichever is greater.
- Length – 150 feet minimum (length can be shorter for small sites).
- Thickness – eight inches minimum.

Washing Facility (optional)

- Level area with three inch, or larger, washed aggregate or install a commercial wash rack.
- Divert waste water to a sediment trap or basin.

TEMPORARY CONSTRUCTION INGRESS/EGRESS PAD (LARGE SITES—TWO ACRES OR LARGER)

Materials

- One to two and one-half inch diameter washed aggregate [Indiana Department of Transportation Course Aggregate No. 2 (see Appendix D)].
- One-half to one and one-half inch diameter washed aggregate [INDOT CA No. 53 (see Appendix D)].
- Geotextile fabric underlayment (see Appendix C) (used as a separation layer to prevent intermixing of aggregate and the underlying soil material and to provide greater bearing strength when encountering wet conditions or soils with a seasonal high water table limitation).

Installation

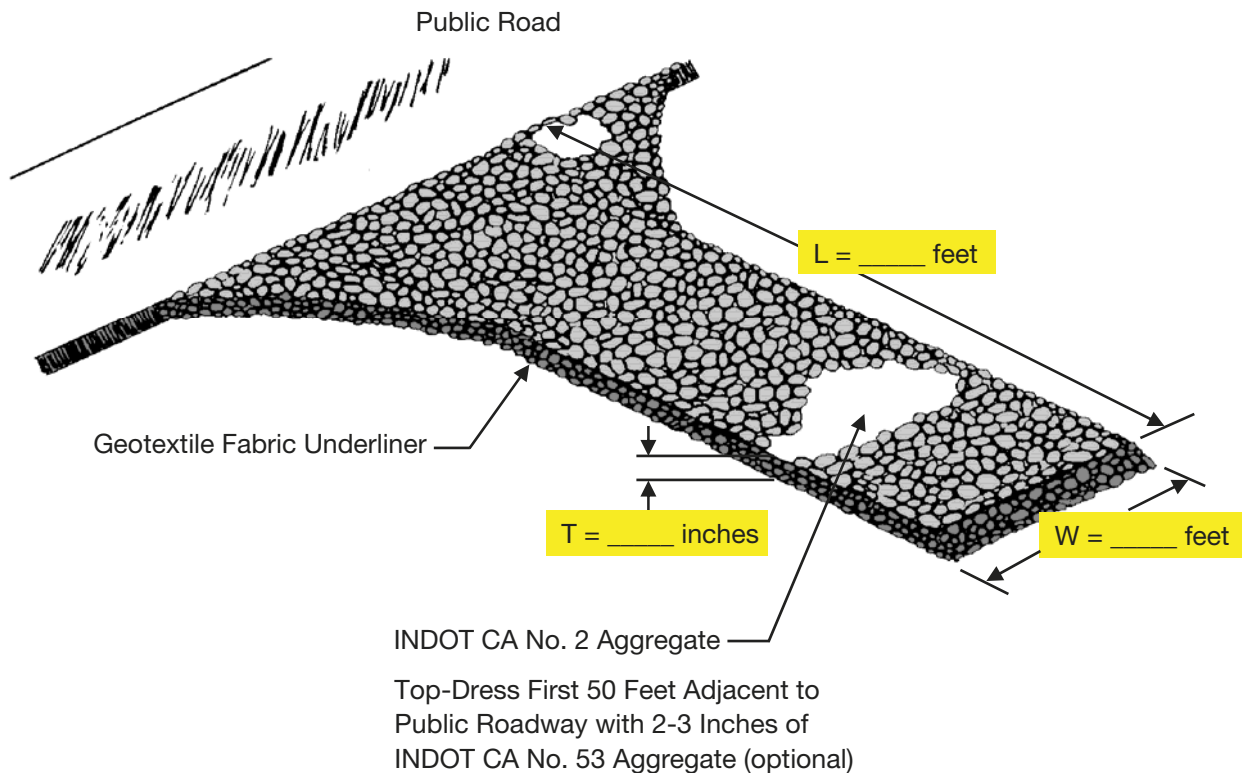
1. Remove all vegetation and other objectionable material from the foundation area.
2. Grade foundation and crown for positive drainage. If the slope of the construction entrance is toward a public road and exceeds two percent, construct an eight inch high diversion ridge with a ratio of 3-to-1 side slopes across the foundation area about 15 feet from the entrance to divert runoff away from the road (see Temporary Construction Ingress/Egress Pad Cross-Section View Worksheet).
3. Install a culvert pipe under the pad if needed to maintain proper public road drainage.
4. If wet conditions are anticipated, place geotextile fabric on the graded foundation to improve stability.
5. Place aggregate (INDOT CA No. 2) to the dimensions and grade shown in the construction plans, leaving the surface smooth and sloped for drainage.
6. Top-dress the first 50 feet adjacent to the public roadway with two to three inches of washed aggregate (INDOT CA No. 53) [optional, used primarily where the purpose of the pad is to keep soil from adhering to vehicle tires].
7. Where possible, divert all storm water runoff and drainage from the ingress/egress pad to a sediment trap or basin.

Maintenance

- Inspect daily.
- Reshape pad as needed for drainage and runoff control.
- Top dress with clean aggregate as needed.
- Immediately remove mud and sediment tracked or washed onto public roads.
- Flushing should only be used if the water can be conveyed into a sediment trap or basin.

TEMPORARY CONSTRUCTION INGRESS/EGRESS PAD (LARGE SITES—TWO ACRES OR LARGER)

Temporary Construction Ingress/Egress Pad Plan View Worksheet (large sites—two acres or larger)



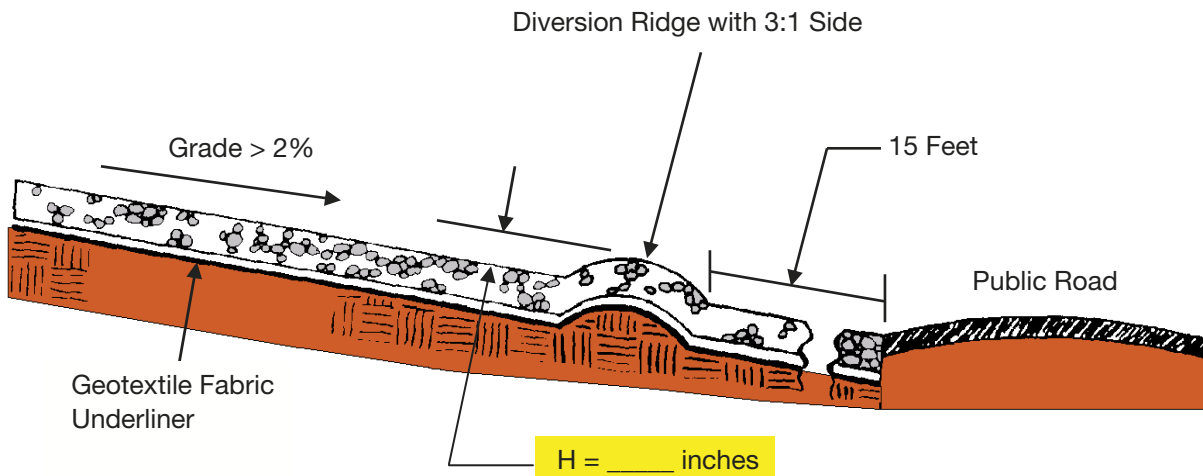
L = Ingress/Egress Pad Length
W = Ingress/Egress Pad Width
T = Aggregate Thickness

(Note: For minimum dimensions, see the
“Specifications” section of this measure.)

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

TEMPORARY CONSTRUCTION INGRESS/EGRESS PAD (LARGE SITES—TWO ACRES OR LARGER)

Temporary Construction Ingress/Egress Pad Cross-Section View Worksheet (large sites two acres or larger)



H = Height of Diversion Ridge

(Note: 8 inches minimum)

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

SITE ACCESS & PREPARATION

Temporary Construction Ingress/Egress Pad (Small Sites—Less Than Two Acres)



A temporary construction ingress/egress pad is a sediment control measure, consisting of a stabilized aggregate pad with geotextile underlayment, used at any point where construction traffic will be traversing between a small construction site and the adjoining public right-of-way or street.

Purpose

- To provide stable entrance/exit conditions from an individual lot or building site.
- To keep mud and sediment off of public roadways.

Specifications

Location

- Avoid locating on steep slopes or at curves in public roads.

Dimensions

- Width – 12 feet minimum or full width of entrance/exit drive, whichever is greater.
- Length – 50 feet minimum or full length of drive, whichever is greater.
- Thickness – six inches minimum.

Materials

- One to two and one-half inch diameter washed aggregate [INDOT CA No. 2 (see Appendix D)].
- One-half to one and one-half inch washed aggregate [INDOT CA No. 53 (see Appendix D); optional, used primarily where the purpose of the pad is to keep soil from adhering to vehicle tires].

TEMPORARY CONSTRUCTION INGRESS/EGRESS PAD (SMALL SITES—LESS THAN TWO ACRES)

- Geotextile fabric underlayment (see Appendix C) (used as a separation layer to prevent intermixing of aggregate and the underlying soil material and to provide greater bearing strength when encountering wet conditions or soils with a seasonal high water table limitation).

Installation

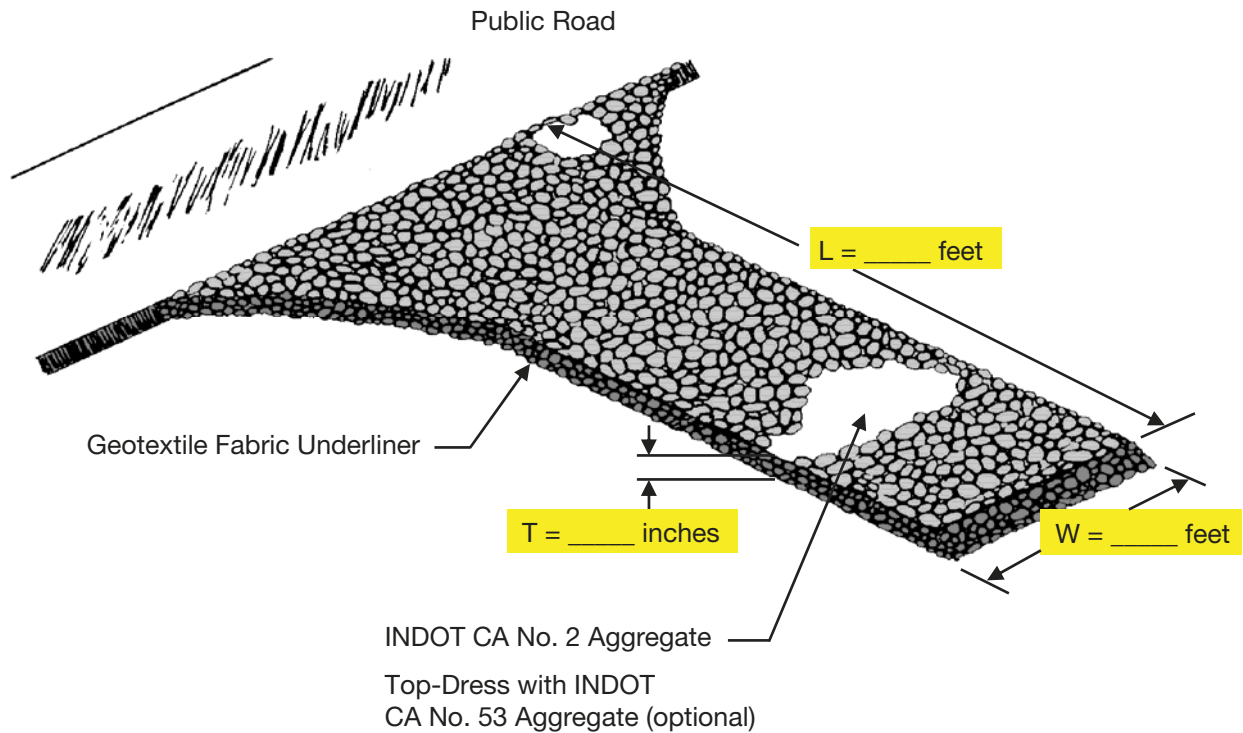
1. Remove all vegetation and other objectionable material from the foundation area.
2. Grade the foundation and crown for positive drainage.
3. Install a culvert pipe under the pad if needed to maintain proper public road drainage.
4. If wet conditions are anticipated, place geotextile fabric on the graded foundation to improve stability.
5. Place aggregate (INDOT CA No. 2) to the dimensions and grade shown in the construction plans, leaving the surface smooth and sloped for drainage.
6. Top-dress the drive with washed aggregate (INDOT CA No.53).
7. Where possible, divert all storm water runoff and drainage from the temporary construction ingress/egress pad to a sediment trap or basin.

Maintenance

- Inspect daily.
- Reshape pad as needed for drainage and runoff control.
- Top-dress with clean aggregate as needed.
- Immediately remove mud and sediment tracked or washed onto public roads.
- Flushing should only be used if the water from the construction drive can be conveyed into a sediment trap or basin.

TEMPORARY CONSTRUCTION INGRESS/EGRESS PAD (SMALL SITES—LESS THAN TWO ACRES)

Temporary Construction Ingress/Egress Pad Plan View Worksheet (small sites less than two acres)



L = Ingress/Egress Pad Length

W = Ingress/Egress Pad Width

T = Aggregate Thickness

(Note: For minimum dimensions, see the
"Specifications" section of this measure.)

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

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SITE ACCESS & PREPARATION

Topsoil Salvage & Utilization



Topsoil salvage and utilization involves the preservation and use of topsoil to enhance final site stabilization with vegetation.

Purpose

- To provide a method of preserving topsoil for use in establishing vegetation to achieve final site stabilization.
- To provide a suitable soil medium for vegetative growth on areas with poor moisture, low nutrient levels, undesirable pH, and/or the presence of other materials that would inhibit establishment of vegetation.

Specifications

Material

Typically the darker, friable, loamy surface layer of soil found immediately below vegetation. (Topsoil is the surface layer of the soil profile, generally characterized as darker than the underlying subsoil due to enrichment with organic matter. It is the major zone of root development and biological activity. Microorganisms that enhance plant growth thrive in this layer. Topsoil can usually be differentiated from subsoil by texture as well as color. Clay content usually increases in the subsoil. The depth of natural topsoil may be quite variable. On severely eroded sites it may be gone entirely.)

Storage Area

- Free of stumps, rock, and construction debris.
- Stockpile covered with vegetation or a tarp.
- Surrounded by a sediment barrier or sediment filter.
- Stockpile outside rooting zone of trees to be protected.

Removal/Storage/Respreading Plan

Needed to assure these operations will be compatible with overall construction activities at the site.

Application

Salvaging and Stockpiling Topsoil

1. Determine depth and suitability of topsoil at site. For help, contact your local soil and water conservation district office to obtain a county soil survey report or utilize the services of a consulting soil scientist.
2. Prior to stripping topsoil, install any site-specific down slope measures needed to control storm water runoff and sedimentation.
3. Remove soil material no deeper than the “surface soil” (e.g., A or Ap horizon).
4. Stockpile the material in accessible locations that will not interfere with other construction activities or block drainage. Several small stockpiles around the construction site are usually more efficient and easier to contain than one large stockpile.
5. Stockpiled soil should be temporarily seeded or covered with a tarp and/or surrounded by a sediment control measure.

Spreading Topsoil

1. Prior to applying topsoil, grade the subsoil and roughen the top three to four inches by disking. (This helps the topsoil bond with the subsoil. If the topsoil and existing soil surface are not properly bonded, water will not infiltrate evenly and it will be difficult to establish vegetation.)
2. Apply topsoil evenly to a depth of at least four inches, then compact slightly to improve contact with the subsoil.
 - a. Depths of four inches or greater are recommended if the underlying material is bedrock, fine-textured clayey soils, loose sand, rock fragments, aggregate, or other unsuitable soil material.
 - b. Do not apply topsoil when the site is wet, muddy, or frozen because it makes spreading difficult, inhibits bonding, can cause compaction problems, and forms a cloddy seedbed. Whenever possible avoid applying topsoil to the existing soil surface if the two layers have contrasting textures. Clayey topsoil over sandy subsoil is a particularly poor combination, as water creeps along the junction between the two soil layers and may cause the topsoil to slough.

TOPSOIL SALVAGE & UTILIZATION

- c. Applying topsoil on slopes with a ratio of 2:1 or greater may result in soil slippage and may require additional measures to provide good bonding of the soil material.
3. After spreading the topsoil, grade and stabilize the site.

Maintenance

- Inspect daily.
- Check for damage to perimeter barrier; repair immediately.
- Check for erosion or damage to newly spread topsoil; repair immediately and revegetate.

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SURFACE STABILIZATION

Surface stabilization is one of the most important principles of erosion and sediment control. Reducing erosion at the source is much more effective and efficient than trying to trap suspended sediment in surface water runoff. Therefore, the measures contained in this section are probably the most important management measures in the manual.

Minimizing the amount of land disturbance and length of time unvegetated areas are exposed to erosive forces can greatly reduce the potential for erosion and off-site sediment damage. Temporary seeding and/or mulching of even relatively small, idle, disturbed areas can make a significant difference in the quantity of suspended sediment. This reduction in sediment load can have a profound effect on the frequency and expense of maintenance operations.

The surface stabilization measures listed in this section of the manual have been designed to facilitate vegetative establishment on unvegetated areas or provide a soil cover that will minimize the exposure of soil to the erosive forces of wind and water. It is important to note that these measures require frequent monitoring and maintenance to ensure that the soil surface is adequately protected.

Surface stabilization will typically not require detailed site investigations and design. However, the stabilization of steep slopes and conveyance systems, and the utilization of materials such as riprap, will require site assessment and the application of sound engineering principles. A professional experienced in structural design may need to be consulted in these situations.

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SURFACE STABILIZATION

Temporary Seeding



Temporary seeding involves the establishment of rapid growing annual grasses or small grains to stabilize disturbed areas until such time as a permanent, nonerosive cover can be established.

Purpose

- To provide vegetative cover where permanent seeding is not desirable or practical.
- To reduce erosion and sedimentation damage by stabilizing disturbed areas.
- To reduce problems associated with mud or dust from unvegetated soil surfaces during construction.
- To reduce sediment-laden storm water runoff from being transported to downstream areas.
- To improve visual aesthetics of construction areas.

Specifications

Seedbed Preparation

Grade and apply soil amendments.

Seeding Frequency

Seed rough graded areas daily while soil is still loose and moist.

Density of Vegetative Cover

Eighty percent or greater over the soil surface.

TEMPORARY SEEDING

Materials

- Soil Amendments – Select materials and rates as determined by a soil test (contact your county soil and water conservation district or cooperative extension office for assistance and soil information, including available soil testing services) or 400 to 600 pounds of 12-12-12 analysis fertilizer, or equivalent. Consider the use of reduced phosphorus application where soil tests indicate adequate phosphorous levels in the soil profile.
- Seed – Select appropriate plant species seed or seed mixtures on the basis of quick germination, growth, and time of year to be seeded (see Table 1).
- Mulch –
 - Straw, hay, wood fiber, etc. (to protect seedbed, retain moisture, and encourage plant growth).
 - Anchored to prevent removal by wind or water or covered with manufactured erosion control blankets.

Table 1. Temporary Seeding Specifications

Seed Species ¹	Rate per Acre	Planting Depth	Optimum Dates ²
Wheat or Rye	150 lbs.	1 to 1½ inches	Sept. 15 – Oct. 30
Spring Oats	100 lbs.	1 inch	March 1 – April 15
Annual Ryegrass	40 lbs.	¼ inch	March 1 – May 1 Aug. 1 – Sept. 1
German Millet	40 lbs.	1 to 2 inches	May 1 – June 1
Sudangrass	35 lbs.	1 to 2 inches	May 1 – July 30
Buckwheat	60 lbs.	1 to 2 inches	April 15 – June 1
Corn (<i>broadcast</i>)	300 lbs.	1 to 2 inches	May 11 – Aug. 10
Sorghum	35 lbs.	1 to 2 inches	May 1 – July 15

¹Perennial species may be used as a temporary cover, especially if the area to be seeded will remain idle for more than one year (see **Permanent Seeding** on page 35).

²Seeding done outside the optimum seeding dates increases the chances of seeding failure. Dates may be extended or shortened based on the location of the project site within the state.

Notes:

Mulch alone is an acceptable temporary cover and may be used in lieu of temporary seeding, provided that it is appropriately anchored.

A high potential for fertilizer, seed, and mulch to wash exists on steep banks, cuts, and in channels and areas of concentrated flow.

TEMPORARY SEEDING

Application

Seedbed Preparation

1. Test soil to determine pH and nutrient levels.
2. Apply soil amendments as recommended by the soil test. If testing is not done, apply 400 to 600 pounds per acre of 12-12-12 analysis fertilizer, or equivalent.
3. Work the soil amendments into the upper two to four inches of the soil with a disk or rake operated across the slope.

Seeding

1. Select a seed species or an appropriate seed mixture and application rate from Table 1.
2. Apply seed uniformly with a drill or cultipacker seeder or by broadcasting. Plant or cover seed to the depth shown in Table 1.

Notes:

1. If drilling or broadcasting the seed, ensure good seed-to-soil contact by firming the seedbed with a roller or cultipacker after completing seeding operations.
 2. Daily seeding when the soil is moist is usually most effective.
 3. If seeding is done with a hydroseeder, fertilizer and mulch can be applied with the seed in a slurry mixture.
3. Apply mulch (see **Mulching** on page 55 or **Compost Mulching** on page 59) and anchor it in place.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Check for erosion or movement of mulch and repair immediately.
- Monitor for erosion damage and adequate cover (80 percent density); reseed, fertilize, and apply mulch where necessary.
- If nitrogen deficiency is apparent, top-dress fall seeded wheat or rye seeding with 50 pounds per acre of nitrogen in February or March.

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SURFACE STABILIZATION

Permanent Seeding



Permanent seeding involves the establishment of a permanent vegetative cover to protect soils from erosive forces.

Purpose

- To provide permanent vegetative cover and improve visual aesthetics of a project site.
- To reduce erosion and sedimentation damage by stabilizing disturbed areas.
- To reduce problems associated with mud or dust from unvegetated soil surfaces.
- To reduce sediment-laden storm water runoff from being transported to downstream areas.

Specifications

Seedbed Preparation

Grade and apply soil amendments.

Seeding Frequency

Seed final graded areas daily while soil is still loose and moist.

Density of Vegetative Cover

Ninety percent or greater over the soil surface.

Materials

- Soil Amendments – Select materials and rates as determined by a soil test (contact your county soil and water conservation district or cooperative extension office for assistance and soil information, including available soil testing services) or 400 to 600 pounds of 12-12-12 analysis fertilizer, or equivalent. Consider the use of reduced phosphorus application where soil tests indicate adequate phosphorous levels in the soil profile.
- Seed – Select an appropriate plant species seed or seed mixture on the basis of soil type, soil pH, region of the state, time of year, and intended land use of the area to be seeded (see Table 1).
- Mulch –
 - Straw, hay, wood fiber, etc. (to protect seedbed, retain moisture, and encourage plant growth).
 - Anchored to prevent removal by wind or water or covered with premanufactured erosion control blankets.

Application

Site Preparation

1. Grade the site to achieve positive drainage.
2. Add topsoil (see **Topsoil Salvage and Utilization** on page 25) or compost mulch (see **Compost Mulching** on page 59) to achieve needed depth for establishment of vegetation. (Compost material may be added to improve soil moisture holding capacity, soil friability, and nutrient availability.)

Seedbed Preparation

1. Test soil to determine pH and nutrient levels.
2. Apply soil amendments as recommended by the soil test and work into the upper two to four inches of soil. If testing is not done, apply 400 to 600 pounds per acre of 12-12-12 analysis fertilizer, or equivalent.
3. Till the soil to obtain a uniform seedbed. Use a disk or rake, operated across the slope, to work the soil amendments into the upper two to four inches of the soil.

Seeding

Optimum seeding dates are March 1 to May 10 and August 10 to September 30. Permanent seeding done between May 10 and August 10 may need to be irrigated. Seeding outside or beyond optimum seeding dates is still possible with the understanding that reseeding or overseeding may be required if adequate surface

PERMANENT SEEDING

cover is not achieved. Reseeding or overseeding can be easily accomplished if the soil surface remains well protected with mulch.

1. Select a seeding mixture and rate from Table 1. Select seed mixture based on site conditions, soil pH, intended land use, and expected level of maintenance.
2. Apply seed uniformly with a drill or cultipacker seeder (see Figure 1) or by broadcasting (see Figure 2). Plant or cover the seed to a depth of one-fourth to one-half inch. If drilling or broadcasting the seed, ensure good seed-to-soil contact by firming the seedbed with a roller or cultipacker after completing seeding operations. (If seeding is done with a hydroseeder (see Figure 3), fertilizer and mulch can be applied with the seed in a slurry mixture.)
3. Mulch all seeded areas (see **Mulching** on page 55 and **Compost Mulching** on page 59) and use appropriate methods to anchor the mulch in place. Consider using erosion control blankets on sloping areas and conveyance channels (see **Erosion Control Blanket** on page 63).

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days until the vegetation is successfully established.
- Characteristics of a successful stand include vigorous dark green or bluish-green seedlings with a uniform vegetative cover density of 90 percent or more.
- Check for erosion or movement of mulch.
- Repair damaged, bare, gullied, or sparsely vegetated areas and then fertilize, reseed, and apply and anchor mulch.
- If plant cover is sparse or patchy, evaluate the plant materials chosen, soil fertility, moisture condition, and mulch application; repair affected areas either by overseeding or preparing a new seedbed and reseeding. Apply and anchor mulch on the newly seeded areas.
- If vegetation fails to grow, consider soil testing to determine soil pH or nutrient deficiency problems. (Contact your soil and water conservation district or cooperative extension office for assistance.)
- If additional fertilization is needed to get a satisfactory stand, do so according to soil test recommendations.
- Add fertilizer the following growing season. Fertilize according to soil test recommendations.
- Fertilize turf areas annually. Apply fertilizer in a split application. For cool-season grasses, apply one-half of the fertilizer in late spring and one-half in early fall. For warm-season grasses, apply one-third in early spring, one-third in late spring, and the remaining one-third in middle summer.

PERMANENT SEEDING

Table 1. Permanent Seeding Recommendations

This table provides several seed mixture options. Additional seed mixtures are available commercially. When selecting a mixture, consider intended land use and site conditions, including soil properties (e.g., soil pH and drainage), slope aspect, and the tolerance of each species to shade and drought.

Open Low-Maintenance Areas (remaining idle more than six months)

Seed Mixtures	Rate per Acre Pure Live Seed	Optimum Soil pH
1. Perennial ryegrass - white clover ¹	70 lbs. 2 lbs.	5.6 to 7.0
2. Perennial ryegrass - tall fescue ²	70 lbs. 50 lbs.	5.6 to 7.0
3. Tall fescue ² - white clover ¹	70 lbs. 2 lbs.	5.5 to 7.5

Steep Banks and Cuts, Low-Maintenance Areas (not mowed)

Seed Mixtures	Rate per Acre Pure Live Seed	Optimum Soil pH
1. Smooth brome grass - red clover ¹	35 lbs. 20 lbs.	5.5 to 7.0
2. Tall fescue ² - white clover ¹	50 lbs. 2 lbs.	5.5 to 7.5
3. Tall fescue ² - red clover ¹	50 lbs. 20 lbs.	5.5 to 7.5
4. Orchard grass - red clover ¹ - white clover ¹	30 lbs. 20 lbs. 2 lbs.	5.6 to 7.0
5. Crownvetch ¹ - tall fescue ²	12 lbs. 30 lbs.	5.6 to 7.0

Lawns and High-Maintenance Areas

Seed Mixtures	Rate per Acre Pure Live Seed	Optimum Soil pH
1. Bluegrass	140 lbs.	5.5 to 7.0
2. Perennial ryegrass (turf type)	60 lbs. 90 lbs.	5.6 to 7.0
3. Tall fescue (turf type) ² - bluegrass	170 lbs. 30 lbs.	5.6 to 7.5

PERMANENT SEEDING

Channels and Areas of Concentrated Flow

Seed Mixtures	Rate per Acre Pure Live Seed	Optimum Soil pH
1. Perennial ryegrass - white ¹	150 lbs. 2 lbs.	5.5 to 7.0
2. Kentucky bluegrass - smooth bromegrass - switchgrass - timothy - perennial ryegrass - white clover ²	20 lbs. 10 lbs. 3 lbs. 4 lbs. 10 lbs. 2 lbs.	5.5 to 7.5
3. Tall fescue ¹ - white clover ²	150 lbs. 2 lbs.	5.5 to 7.5
4. Tall fescue ² - perennial ryegrass - Kentucky bluegrass	150 lbs. 20 lbs. 20 lbs.	5.5 to 7.5

¹ For best results: (a) legume seed should be inoculated; (b) seeding mixtures containing legumes should preferably be spring-seeded, although the grass may be fall-seeded and the legume frost-seeded (see **Dormant Seeding and Frost Seeding** on page 41); and (c) if legumes are fall-seeded, do so in early fall.

² Tall fescue provides little cover for, and may be toxic to some species of wildlife. The Indiana Department of Natural Resources recognizes the need for additional research on alternatives such as buffalograss, orchardgrass, smooth bromegrass, and switchgrass. This research, in conjunction with demonstration areas, should focus on erosion control characteristics, wildlife toxicity, turf durability, and drought resistance.

Notes:

1. An oat or wheat companion or nurse crop may be used with any of the above permanent seeding mixtures, at the following rates:
 - (a) spring oats – one-fourth to three-fourths bushel per acre
 - (b) wheat – no more than one-half bushel per acre
2. A high potential for fertilizer, seed, and mulch to wash exists on steep banks, cuts, and in channels and areas of concentrated flow.

PERMANENT SEEDING

Figure 1: Cultipacker Seeder



Figure 2: Broadcast Seeding



Figure 3: Hydroseeding



SURFACE STABILIZATION

Dormant Seeding & Frost Seeding



Dormant seeding is a temporary or permanent seeding application at a time when soil temperatures are too low for germination to occur (less than 50°F).

Frost seeding is a temporary or permanent seeding application in late winter when soils are in the freeze-thaw stage. (This measure can be used to repair or enhance areas having thin or declining vegetative cover or to revegetate an area.)

Purpose

- To provide early germination and soil stabilization in the spring.
- To reduce sediment-laden storm water runoff from being transported to downstream areas.
- To improve the visual aesthetics of the construction area.
- To repair or enhance previous seeding.

Specifications

Seedbed Preparation

Grade and apply soil amendments as recommended by a soil test (incorporate soil amendments into soil prior to soil freezing).

Density of Vegetative Cover

Eighty percent or greater over the soil surface.

Materials

- Soil Amendments – Select materials and rates as determined by a soil test (contact your county soil and water conservation district or cooperative extension office for assistance and soil information, including available soil testing services) or 200 to 300 pounds of 12-12-12 analysis fertilizer, or equivalent. Consider the use of reduced phosphorus application where soil tests indicate adequate phosphorous levels in the soil profile.

DORMANT SEEDING & FROST SEEDING

- Seed – Select an appropriate plant species seed or seed mixture on the basis of soil type, soil pH, region of the state, time of year, and intended land use of the area to be seeded (see Table 1 or Table 2).
- Mulch –
 - Straw, hay, wood fiber, compost, etc. (to protect seedbed, retain moisture, and encourage plant growth).
 - Anchored to prevent removal by wind or water or covered with premanufactured erosion control blankets.

Application

(see Tables 1 and 2)

Site Preparation

1. Grade the site to achieve positive drainage.
2. Add topsoil (see **Topsoil Salvage and Utilization** on page 25) to achieve needed depth for establishment of vegetation.

Dormant Seeding

Site preparation, seedbed preparation and mulching can be done months ahead of actual seeding or if the existing ground cover is adequate, seeding can be done directly into it.

1. Test soil to determine pH and nutrient levels.
2. Broadcast soil amendments as recommended by a soil test and work into the upper two to four inches of soil. If testing was not done, apply 200 to 300 pounds per acre of 12-12-12 analysis fertilizer, or equivalent.
3. Apply and anchor mulch (see **Mulching** on page 55 and **Compost Mulching** on page 59) immediately after completion of grading and addition of soil amendments.
4. Select an appropriate seed species or mixture from Table 1 for temporary seeding or Table 2 for permanent seeding. Broadcast the seed on top of the mulch and/or into existing ground cover at the rate shown. (Seed areas when soil temperatures are below 50° F but the soil is not frozen.)

Frost Seeding

Seed is broadcast over the prepared seedbed and incorporated into the soil by natural freeze-thaw action.

1. Test soil to determine pH and nutrient levels.

DORMANT SEEDING & FROST SEEDING

2. Broadcast soil amendments as recommended by a soil test and work into the upper two to four inches of soil before it freezes. If testing was not done, apply 200 to 300 pounds per acre of 12-12-12 analysis fertilizer, or equivalent.
3. Select an appropriate seed species or mixture from Table 1 for temporary seeding or Table 2 for permanent seeding. Broadcast the seed on the seedbed or into the existing ground cover at the rate shown. (Seed areas when the soil is frozen. Do not work the seed into the soil.)

Maintenance

- Inspect at least once every seven calendar days.
- Check for erosion or movement of mulch.
- Check for inadequate cover (less than 80 percent density over the soil surface); reseed and mulch in mid to late April if necessary. For best results, reseed within the recommended dates shown in Temporary Seeding on page 31 and Permanent Seeding on page 35.
- Apply 200 to 300 pounds per acre of 12-12-12 analysis fertilizer, or equivalent, between April 15 and May 10 or during periods of vigorous growth.
- Fertilize turf areas annually. Apply fertilizer in a split application. For cool-season grasses, apply one-half of the fertilizer in late spring and one-half in early fall. For warm-season grasses, apply one-third in early spring, one-third in late spring, and the remaining one-third in middle summer.

Table 1. Temporary Dormant or Frost Seeding Recommendations

Seed Species	Rate per Acre
Wheat or rye	150 lbs.
Spring oats	150 lbs.
Annual ryegrass	60 lbs.

Table 2 provides several seeding options. Additional seed mixtures are available commercially. When selecting a mixture, consider site conditions, including soil properties (e.g., soil pH and drainage), slope aspect, and the tolerance of each species to shade and drought.

DORMANT SEEDING & FROST SEEDING

Table 2. Permanent Dormant or Frost Seeding Recommendations

Open Low-Maintenance Areas (remaining idle more than six months)

Seed Mixtures	Rate per Acre Pure Live Seed	Optimum Soil pH
1. Perennial ryegrass - white clover ¹	75 lbs. 3 lbs.	5.6 to 7.0
2. Kentucky bluegrass - smooth brome - switchgrass - timothy - perennial ryegrass - white clover ¹	30 lbs. 15 lbs. 5 lbs. 6 lbs. 15 lbs. 3 lbs.	5.6 to 7.5
3. Perennial ryegrass - tall fescue ²	45 lbs. 45 lbs.	5.6 to 7.0
4. Tall fescue ² - white clover ¹	75 lbs. 3 lbs.	5.5 to 7.5

Steep Banks and Cuts, Low-Maintenance Areas (not mowed)

Seed Mixtures	Rate per Acre Pure Live Seed	Optimum Soil pH
1. Smooth brome - red clover ¹	50 lbs. 30 lbs.	5.5 to 7.5
2. Tall fescue ² - white clover ¹	75 lbs. 3 lbs.	5.5 to 7.5
3. Tall fescue ² - red clover	75 lbs. 30 lbs.	5.5 to 7.5
4. Orchardgrass - red clover ¹ - white clover ¹	45 lbs. 30 lbs. 3 lbs.	5.6 to 7.0
5. Crownvetch ¹ - tall fescue	18 lbs. 45 lbs.	5.6 to 7.0

Lawns and High-Maintenance Areas

Seed Mixtures	Rate per Acre Pure Live Seed	Optimum Soil pH
1. Bluegrass	210 lbs.	5.5 to 7.0
2. Perennial ryegrass (turf type) - bluegrass	90 lbs. 135 lbs.	5.6 to 7.0
3. Tall fescue (turf type) ² - bluegrass	250 lbs. 45 lbs.	5.6 to 7.5

DORMANT SEEDING & FROST SEEDING

Channels and Areas of Concentrated Flow

Seed Mixtures	Rate per Acre Pure Live Seed	Optimum Soil pH
1. Perennial ryegrass - white clover ¹	225 lbs. 3 lbs.	5.6 to 7.0
2. Kentucky bluegrass - smooth brome - switchgrass - timothy - perennial ryegrass - white clover ¹	30 lbs. 15 lbs. 5 lbs. 6 lbs. 15 lbs. 3 lbs.	5.5 to 7.5
3. Tall fescue ² - white clover ¹	225 lbs. 3 lbs.	5.5 to 7.5
4. Tall fescue ² - perennial ryegrass - Kentucky bluegrass	225 lbs. 30 lbs. 30 lbs.	5.5 to 7.5

¹ For best results: (a) legume seed should be inoculated; (b) seeding mixtures containing legumes should preferably be spring-seeded, although the grass may be fall-seeded and the legume frost-seeded; and (c) if legumes are fall-seeded, do so in early fall.

² Tall fescue provides little cover for, and may be toxic to some species of wildlife. The Indiana Department of Natural Resources recognizes the need for additional research on alternatives such as buffalograss, orchardgrass, smooth brome, and switchgrass. This research, in conjunction with demonstration areas, should focus on erosion control characteristics, wildlife toxicity, turf durability, and drought resistance.

Notes:

1. If using mixtures other than those listed in this table, increase seeding rates by 50 percent over the conventional seeding rates.
2. A high potential for fertilizer, seed, and mulch to wash exists on steep banks, cuts, and in channels and areas of concentrated flow.

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SURFACE STABILIZATION

Sod



The soil surface is stabilized by laying a continuous cover of grass sod over soil exposed to erosive forces.

Purpose

- To provide immediate vegetative cover on critically sloping areas, channels, and sediment control structures.
- To prevent erosion and damage from sedimentation.
- To reduce problems associated with mud or dust from unvegetated soil surfaces.

Specifications

Site Preparation

- Grade the site to achieve positive drainage.
- Prepare a smooth, firm soil surface and apply soil amendments.

Irrigation

Irrigate as needed to ensure rooting of sod.

Materials

- Soil Amendments – Select materials and rates as determined by a soil test (contact your county soil and water conservation district or cooperative extension office for assistance and soil information, including available soil testing services.) or 400 to 600 pounds of 12-12-12 analysis fertilizer, or equivalent.
- Sod – Select a high quality, healthy, vigorous variety well adapted to the region and compatible with the intended use. (Selection of varieties is usually much more limited than when establishing vegetation from seed.)

Installation

Sod should not be installed during hot weather, on dry soil, frozen soil, compacted clay, loose sand or gravelly substrate soils, aggregate, or pesticide-treated soil. The ideal time to lay sod is May 1 to June 1 or September 1 to September 30, although it can be installed as early as March 15 if available or June 1 to September 1 if irrigated.

Site Preparation

1. Apply topsoil (see **Topsoil Salvage and Utilization** on page 25) if existing soil conditions are unsuitable for establishing vegetation.
2. Grade the site to achieve positive drainage and create a smooth, firm soil surface.
3. Where applicable, use a chisel plow, disk, harrow, or rake to break up compacted soils and create a favorable rooting depth of six to eight inches.

Sod Bed Preparation

1. Test soil to determine pH and nutrient levels.
2. If soil pH is too acidic for the grass sod to be installed, apply lime according to soil test results or at the rate recommended by the sod supplier.
3. Apply fertilizer as recommended by the soil test. If testing was not done, apply 400 to 600 pounds per acre of 12-12-12 analysis fertilizer, or equivalent.
4. Work the soil amendments into the upper two to four inches of soil with a disk or rake operated across the slope.
5. Rake or harrow the area to achieve a smooth final grade and then roll or cultipack the soil surface to create a firm surface on which to lay the sod.

Laying the Sod

1. Install sod within thirty-six hours of its cutting.
2. Store the sod in a shaded location during installation.
3. Immediately before laying the sod, rake the soil surface to break any crust. (If the weather is hot, lightly irrigate the soil surface prior to laying the sod.)
4. Lay sod strips in a brick-like pattern (see Exhibit 1).
5. Butt all joints tightly against each other (do not stretch or overlap them), using a knife or mason's trowel to trim and fit sod into irregularly shaped areas.
6. Roll the sod lightly after installation to ensure firm contact between the sod and soil.

7. Irrigate newly sodded areas until the underlying soil is wet to a depth of four inches, and then keep moist until the grass takes root.

Slope Application

1. Install the sod strips with the longest dimension perpendicular to the slope.
2. Where slopes exceed a ratio of 3:1, staple or stake each strip at the corners and in the middle.

Channel Application

(Sodding provides quicker protection than seeding and may reduce the risk of early washout.)

1. Excavate the channel, allowing for the full thickness of the sod.
2. Lay the sod strips with the longest dimension perpendicular to channel flow.
3. Staple or stake each strip of sod at the corners and in the middle.
4. Staple jute or biodegradable polypropylene netting over the sodded area to minimize the potential for washout during establishment.

Maintenance

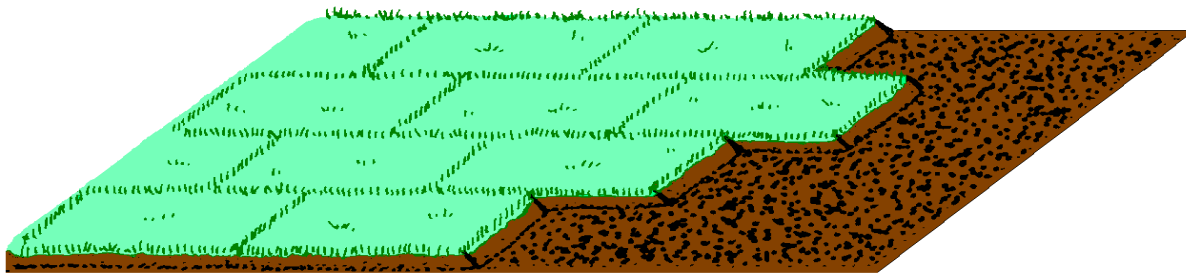
- Inspect within 24 hours of each rain event and at least once every seven calendar days until sod is well rooted.
- Keep sod moist until fully rooted.
- After sod is well-rooted (two to three weeks), maintain a plant height of two to three inches.
- Time mowing to avoid ruts in turf.
- Fertilize turf areas annually. Apply fertilizer in a split application. For cool-season grasses, apply one-half of the fertilizer in late spring and one-half in early fall. For warm-season grasses, apply one-third in early spring, one-third in late spring and one-third in mid-summer.

Exhibit 1

Cross-Section View



Perspective View



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

SURFACE STABILIZATION

Native & Warm Season Grasses

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SURFACE STABILIZATION

Stabilization of Dune Areas



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SURFACE STABILIZATION

Mulching



Mulching is the application of plant residues/materials to enhance and protect vegetative establishment and minimize erosion potential.

Purpose

- To prevent erosion by protecting the soil from wind and water impact.
- To provide temporary surface stabilization.
- To prevent soil from crusting.
- To conserve soil moisture, moderate soil temperature, and promote seed germination and seedling growth.

Note: This measure should not be used in storm water runoff channels or areas where concentrated flow is attempted.

Specifications

Materials

Table 1. Mulch Specifications

Material ¹	Rate per Acre	Comments
Straw or hay	2 tons	Should be dry, free of undesirable seeds. Spread by hand or machine. Must be crimped or anchored (see Table 2).
Wood fiber or cellulose	1 ton	Apply with a hydraulic mulch machine and use with tacking agent.

¹ Mulching is not recommended in concentrated flows. Consider erosion control blankets or other stabilization methods.

Coverage

The mulch should have a uniform density of at least 75 percent over the soil surface.

Anchoring

Table 2. Mulch Anchoring Methods

Anchoring Method ¹	How to Apply
Mulch anchoring tool or farm disk (dull, serrated, and blades set straight)	Crimp or punch the straw or hay two to four inches into the soil. Operate machinery on the contour of the slope.
Cleating with dozer tracks	Operate dozer up and down slope to prevent formation of rills by dozer cleats.
Wood hydromulch fibers	Apply according to manufacturer's recommendations.
Synthetic tackifiers, binders, or soil stabilizers	Apply according to manufacturer's recommendations.
Netting (synthetic or biodegradable material)	Install netting immediately after applying mulch. Anchor netting with staples. Edges of netting strips should overlap with each up-slope strip overlapping four to six inches over the adjacent down-slope strip. Best suited to slope applications. In most instances, installation details are site specific, so manufacturer's recommendations should be followed.

¹ All forms of mulch must be anchored to prevent displacement by wind and/or water.

Application

1. Apply mulch at the recommended rate shown in Table 1.
2. Spread the mulch material uniformly by hand, hayfork, mulch blower, or hydraulic mulch machine. After spreading, no more than 25 percent of the ground should be visible.
3. Anchor straw or hay mulch immediately after application. The mulch can be anchored using one of the methods listed below:
 - a. Crimp with a mulch anchoring tool, a weighted farm disk with dull serrated blades set straight, or track cleats of a bulldozer,
 - b. Apply hydraulic mulch with short cellulose fibers,
 - c. Apply a liquid tackifier, or
 - d. Cover with netting secured by staples.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Check for erosion or movement of mulch; repair damaged areas, reseed, apply new mulch and anchor the mulch in place.
- Continue inspections until vegetation is firmly established.
- If erosion is severe or recurring, use erosion control blankets or other more substantial stabilization methods to protect the area.

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SURFACE STABILIZATION

Compost Mulching



Compost mulching is the application of composted materials to enhance vegetative establishment and minimize erosion potential.

Source: U.S. Dept. of Agriculture, Natural Resources Conservation Service, Iowa, Lynn Betts

Purpose

- To protect exposed soil from the erosive forces of wind and water.
- To provide temporary surface stabilization.
- To prevent soil from crusting.
- To conserve soil moisture and promote seed germination and seedling growth.

Note: This measure should not be used in storm water runoff channels or anywhere that concentrated flow is anticipated.

Specifications

Compost Specifications

- Feedstocks may include but are not limited to well-composted vegetable matter, leaves, yard trimmings, food scraps, composted manures, paper fiber, wood bark, Class A biosolids (as defined in Title 40 of the Code of Federal Regulations at 40 CFR Part 503), or any combination thereof.
- Compost shall be produced using an aerobic composting process meeting 40 CFR Part 503 regulations, including time and temperature data indicating effective weed seed, pathogen, and insect larvae kill.
- Compost shall be well decomposed, stable, and weed free.

COMPOST MULCHING

- Refuse free (less than one percent by weight).
- Free of any contaminants and materials toxic to plant growth.
- Inert materials not to exceed one percent by dry weight pH of 5.5 to 8.0.
- Carbon-nitrogen ratio not to exceed 100.
- Moisture content not to exceed 45 percent by dry weight.
- Variable particle size with maximum dimensions of three inches in length, one-half inch in width and one-half inch in depth.

Table 1. Compost Particle Size

Percent Passing Sieve Size			
2-Inch Sieve	1-Inch Sieve	¾-Inch Sieve	> ¼-Inch Sieve
100%	99%	90%	25%

Bonding Agents (optional)

Tackifiers, flocculants, or microbial additives may be used to remove sediment and/or additional pollutants from storm water runoff. (All additives combined with compost materials should be tested for physical results at a certified erosion and sediment control laboratory and biologically tested for elevated beneficial microorganisms at a United States Compost Council, Seal of Testing Assurance, approved testing laboratory.)

Soil Material (optional)

Five percent to ten percent sandy loam (as classified by the U.S. Department of Agriculture soil classification system).

Cover Density

Ninety percent or greater over the soil surface.

Anchoring Method

- Moisten compost/mulch blanket for a minimum of 60 days.
- Erosion control netting (optional).

Cover Thickness

Table 2. Compost Blanket Thickness

Slope		Thickness of Compost Blanket	Thickness of Compost Blanket with Erosion Control Netting
< 25%	< 4:1	1 to 2 inches	Not Applicable
25% to 50%	4:1 to 2:1	1 to 2 inches	2 inches
> 50%	> 2:1	2 to 3 inches	3 inches

Application

1. Remove existing vegetation, large soil clods, rocks, stumps, large roots, and debris in areas where compost mulch is to be applied and dispose of in designated areas.
2. Scarify sloping areas.
3. Aerate areas to be covered with compost/mulch blanket. (Proper aeration will require a minimum of two passes oriented in opposite directions.)
4. Broadcast a minimum of one pound of nitrogen (N), one-half pound of phosphorous (P_2O_5), and one-half pound of potash (K_2O) per 1,000 square feet or 300 to 400 pounds per acre of 12-12-12 analysis fertilizer, or equivalent, per acre.
5. Apply compost mulch blanket with a pneumatic blower or per manufacturer's directions.
 - a. Apply within three days of completing aeration operations.
 - b. Overlap top of slope shoulder by five to ten feet.
 - c. Seed may be applied at time of installation. (Seed must be evenly blended into the compost if applied with a pneumatic blower or applied with a calibrated seeder attachment prior to installation of the compost blanket.)
6. Water compost mulch blanket for a period of 60 days following application. (On steeper slopes, it may be necessary to install erosion control netting over the compost blanket.)
 - a. Mist blanket for first seven days and then every three days throughout the remainder of the 60-day period.
 - b. Maintain a constant moisture content of 40 percent to 60 percent.

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Repair eroded areas.
- Reseed, if applicable.
- Monitor vegetation and apply appropriate soil amendments (if needed) per a soil test.

SURFACE STABILIZATION

Erosion Control Blanket



An erosion control blanket is a biodegradable, organic or synthetic mulch incorporated with a biodegradable, photodegradable, or permanent polypropylene, natural fiber, or similar netting material. It is an alternative to mulch and normally used on slopes and in concentrated flow channels.

Purpose

- To prevent erosion by protecting the soil from rainfall impact, overland water flow, concentrated runoff, or wind.
- To provide temporary surface stabilization.
- To anchor mulch in critical areas, including slopes and concentrated flow conveying systems.
- To reduce soil crusting.
- To conserve soil moisture and increase seed germination and seedling growth.

Specifications

Effective Life

The functional life of an erosion control blanket is dependent on the materials used.

Anchoring

Staples, pins or stakes used to prevent movement or displacement of blanket. (Follow manufacturer's recommendations for specific applications.)

Materials

- Organic (straw, excelsior, woven paper, coconut fiber, etc.) or synthetic mulch incorporated with a polypropylene, natural fiber or similar netting material. (The netting may be biodegradable, photodegradable or permanent.)

EROSION CONTROL BLANKET

Note: Some erosion control blanket nettings may pose a threat to certain species of wildlife if they become entangled in the netting matrix.

- Six to 12-inch staples, pins, or stakes.

Installation

1. Select the type and weight of erosion control blanket to fit the site conditions (e.g., slope, channel, flow velocity) per the manufacturer's specifications.
2. Prepare the seedbed, add soil amendments, and permanently seed (see **Permanent Seeding** on page 35) the area immediately following seedbed preparation.
3. Lay erosion control blankets on the seeded area so that they are in continuous contact with the soil with each up-slope or up-stream blanket overlapping the down-slope or down-stream blanket by at least eight inches, or follow manufacturer's recommendations.
4. Tuck the uppermost edge of the upper blankets into a check slot (slit trench), backfill with soil and tamp down. In certain applications, the manufacturer may require additional check slots at specific locations down slope from the uppermost edge of the upper blankets.
5. Anchor the blankets in place by driving staples, pins, or stakes through the blanket and into the underlying soil. Follow an anchoring pattern appropriate for the site conditions and as recommended by the manufacturer.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Check for erosion or displacement of the blanket.
- If any area shows erosion, pull back that portion of the blanket covering the eroded area, add soil and tamp, reseed the area, replace and staple the blanket.

SURFACE STABILIZATION

Turf Reinforcement Mat



A turf reinforcement mat is a three-dimensional matrix of polypropylene, nylon, or other material typically used in channel applications or on slopes to reinforce plant rooting systems and the underlying soil material.

Purpose

- To provide reinforcement to vegetation in areas of concentrated flow or steep slopes where other types of stabilization, such as riprap, are not feasible or desired.
- To provide surface stabilization.
- To provide reinforcement for plant roots as vegetation is being established.

Specifications

Effective Life

The functional life of turf reinforcement mat is dependent on the materials used.

Anchoring

Staples, pins, or stakes used to prevent movement or displacement of mat. (Follow manufacturer's recommendations for specific applications.)

Materials

- Turf reinforcement mat (typically consists of a three-dimensional matrix of polypropylene, nylon, or other material).
- Six to 12-inch staples, pins, or stakes.

TURF REINFORCEMENT MAT

Installation

1. Select a turf reinforcement mat appropriate for the site conditions (e.g., slope, channel, flow velocity) per the manufacturer's specifications.
2. Grade and prepare the soil foundation for mat installation.
3. Install the mat according to the manufacturer's instructions, including burying the edges in check slots or slit trenches.
4. Anchor the mat in place by driving staples, pins, or stakes through the mat and into the underlying soil. Follow an anchoring pattern appropriate for the site conditions and as recommended by the manufacturer.
5. Backfill the mat with topsoil, filling to the top of the mat.
6. Seed the area after the mat has been installed and backfilled with soil.
7. Install erosion control blankets over the seeded turf reinforcement mat to stabilize the surface.

Note: Some products may not require backfill of topsoil or the application of erosion control blankets. Consult manufacturer's literature for proper installation guidance.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Check for erosion or displacement/exposure of the mat.
- If a specific area shows erosion, add soil and restabilize.

SURFACE STABILIZATION

Soil Stabilizers

To be released at a later time

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SURFACE STABILIZATION

Riprap Slope Protection



Riprap slope protection is an erosion control measure consisting of geotextile fabric and stone riprap that is placed on an unvegetated slope to protect the soil from erosive forces.

Purpose

To protect slopes or similar areas subject to erosion by water.

Specifications

Slope

A ratio of 2:1 or flatter (designed by a qualified individual/professional engineer; slopes exceeding 2:1 may require additional design considerations).

Minimum Thickness

Two times the designed d_{50} (see Appendix A – Glossary) stone diameter plus the depth of the bedding material.

Materials

- Riprap
 - Hard, angular, and weather resistant.
 - Specific gravity of at least 2.5.
 - Size and gradation that will withstand velocities of storm water discharge flow design.
 - Well-graded mixture of stone with 50 percent of the stone pieces, by weight, larger than the designed d_{50} size.
 - Largest pieces should not exceed two times the designed d_{50} and no more than 15 percent of the pieces (by weight) should be less than three inches.

RIPRAP SLOPE PROTECTION

- Bedding Material – Geotextile fabric, sand, or crushed aggregate [Indiana Department of Transportation CA No. 9, 11, or 12 (see Appendix D)].

Installation

Subgrade Preparation

1. Remove brush, trees, stumps, and other debris and dispose of in designated areas.
2. Excavate foundation subgrade below design elevation to allow for thickness of the bedding material and riprap.
3. Compact any fill material to the density of the surrounding undisturbed soil.
4. Cut a keyway in stable material at the slope base to reinforce the toe; keyway depth should be one and one-half times the design thickness of the stone and should extend a horizontal distance equal to the design thickness (see Riprap Slope Protection Worksheet).
5. Smooth the graded foundation.

Placement of Bedding Material

1. If using geotextile fabric, place on the smoothed foundation, overlap the edges at least 12 inches and secure with anchor pins spaced every three feet along the overlap. (For large riprap, consider a four inch layer of sand to protect the fabric.)
2. If using sand or aggregate bedding material, spread the well-graded bedding material in a uniform layer to the required thickness (six inches minimum). If two or more layers are specified, place the layer of the smaller gradation first and avoid mixing the layers.

Note: Omission of the bedding material or damage to it may result in erosion and/or piping beneath the riprap or movement of the underlying soil through the voids in the riprap.

Riprap Placement

1. Immediately after installing the bedding material, add riprap to the lines and elevations shown in the construction plans. Place the riprap in one operation, taking care not to damage the bedding material. (Do not dump through chutes or use any method that causes segregation of stone sizes or that will dislodge or damage the underlying bedding material.)
2. If geotextile fabric tears when placing riprap, repair immediately by laying and stapling a piece of fabric over the damaged area, overlapping the undamaged areas by at least 12 inches.

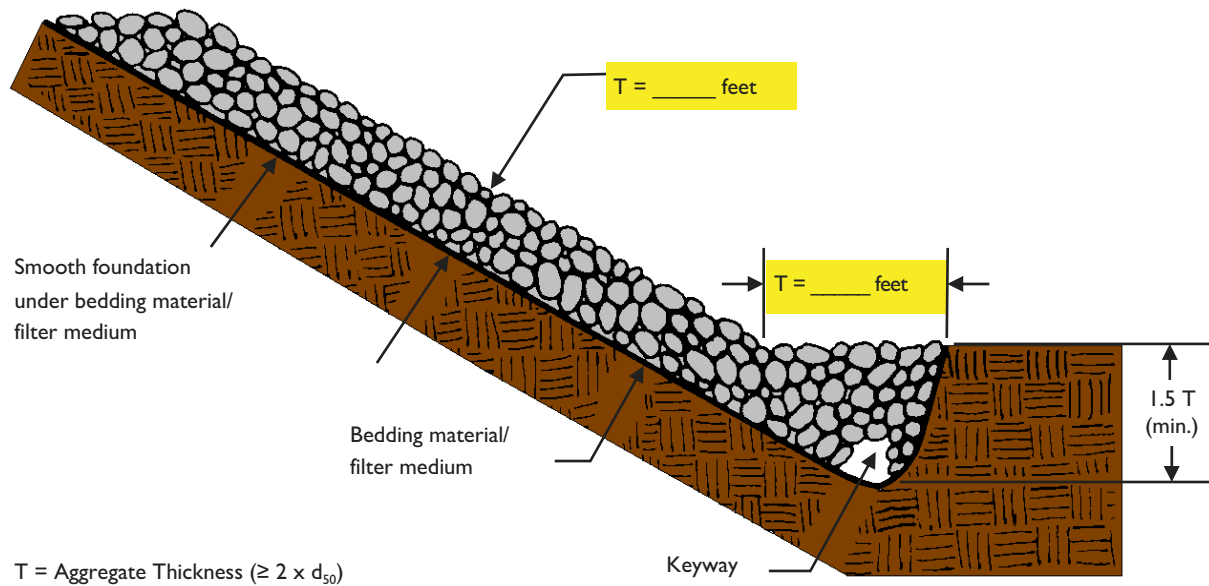
RIPRAP SLOPE PROTECTION

3. Place smaller stone in voids to form a dense, uniform, well-graded riprap mass. (Selective loading at the quarry and some hand placement may be needed to ensure an even distribution of stone material.)
4. Blend the riprap surface smoothly with the surrounding area to eliminate protrusions or overfalls.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Check for displacement of riprap material, slumping, and erosion along the edges, especially on the down-slope side. (Properly designed and installed riprap usually requires very little maintenance.)

Riprap Slope Protection Worksheet



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

RUNOFF CONTROL

Runoff controls are important in effectively controlling and managing storm water runoff. Measures included in this section of the manual are designed to reduce the velocity of storm water runoff by reducing slope lengths (e.g., diversions and water bars); carry concentrated runoff down slopes and channels without causing erosion (e.g., temporary slope drains, grade breaks, and check dams); and collect storm water runoff (e.g., temporary and permanent diversions) and transport it to sediment control devices such as sediment traps and basins. Depending on the situation, several of the measures included in this section may also provide for some additional sediment trapping.

Many of the measures in this section can also be used to divert surface water runoff away from unvegetated work areas. Diversion of runoff away from work areas generally results in less water flowing across the work site which means lower erosion potential. Lower quantities of runoff will also allow for the installation of smaller sediment treatment devices.

Designs for runoff control measures can be complex and generally require detailed site investigations and the application of sound engineering principles. A professional knowledgeable of the principles of storm water management and experienced in structural design should be consulted when using runoff control measures.

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RUNOFF CONTROL

Temporary Diversion



A temporary diversion is a storm water control measure consisting of a temporary ridge, excavated channel, or combination of a channel and supporting ridge constructed on a predetermined grade across a slope to collect storm water runoff and divert it to a treatment device or stable outlet.

Purpose

- To temporarily direct storm water runoff in a controlled manner to a desired location.
- To protect work areas from storm water runoff.
- To manipulate watershed areas for sizing of sediment controls/measures.

Specifications

Contributing Drainage Area

Three acres maximum. (Larger drainage areas may be accommodated, but may require additional design considerations.)

Capacity

Peak runoff from a two-year frequency, 24-hour duration storm event.

Ridge

- Side slope – A ratio of 2:1 or flatter (3:1 or flatter if mowed).
- Top width – two feet minimum.
- Freeboard – six inches minimum.
- Settlement – 10 percent of fill height.
- Stabilized if in place more than 15 working days.

TEMPORARY DIVERSION

Channel

- Shape – parabolic, trapezoidal, or V-shaped.
- Side slopes – ratio of 2:1 or flatter (3:1 or flatter if mowed).
- Depth – 18 inches minimum.
- Grade – positive towards outlet, but not exceeding one percent.
- Stabilized for design flow.

Outlet

Stable, with sediment-laden water diverted to a sediment trap or basin.

Installation

1. Lay out the diversion by setting grade and alignment to fit site needs and topography, maintaining a stable, positive channel grade towards the outlet.
2. Remove and properly dispose of brush, trees, and other debris from the foundation area.
3. Construct the diversion to dimensions and grades shown in the construction plans.
4. Construct the diversion ridge in six to eight-inch lifts. Compact each lift by driving wheels of construction equipment along the ridge. Overfill and compact the ridge to design height plus 10 percent to allow for settlement. (The compacted ridge must be at or above design grade at all points, while the channel must be at design grade. Leave sufficient area along the diversion to permit cleanout and regrading.)
5. Stabilize outlets prior to or during construction of the diversion, diverting sediment-laden storm water flow to a temporary sediment trap (see **Temporary Sediment Trap** on page 183) or a temporary dry sediment basin (see **Temporary Dry Sediment Basin** on page 191).

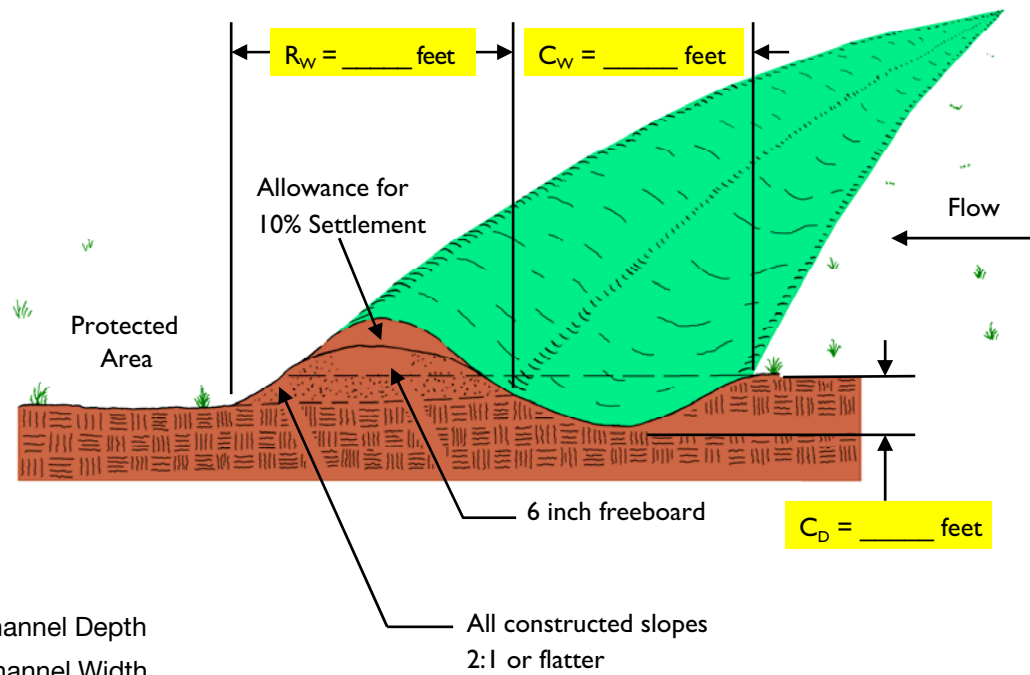
Note: Temporary diversions are also used in conjunction with temporary slope drains (see **Temporary Slope Drain** on page 103) or other appropriate sediment control measures.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Remove sediment from channel to maintain positive grade.
- Check outlets and make necessary repairs immediately.
- Adjust ridge height to prevent overtopping.

TEMPORARY DIVERSION

Temporary Diversion Worksheet



$C_D = \text{Channel Depth}$
 $C_W = \text{Channel Width}$
 $R_W = \text{Ridge Width}$

All constructed slopes
2:1 or flatter

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RUNOFF CONTROL

Permanent Diversion



A permanent diversion is a storm water control measure consisting of a permanent channel and supporting ridge constructed on a predetermined grade across a slope to collect storm water runoff and divert it to a treatment device or stable outlet.

Purpose

To divert storm water runoff to a location where it can be stored, used, or released without causing erosion or flood damage.

Specifications

Contributing Drainage Area

50 acres maximum. (Designed by a qualified individual/professional engineer. Larger drainage areas may be accommodated but may require additional design considerations.)

Capacity

Peak runoff from 25-year frequency, 24-hour duration storm event (or higher capacity where safety is a concern or flood damage cannot be tolerated).

Ridge

- Side slope – ratio of 2:1 or flatter (3:1 or flatter if mowed).
- Top width – four feet minimum.
- Freeboard – six inches minimum.
- Settlement – 10 percent of fill height.
- Stabilized with vegetation.

Channel

- Shape – parabolic.
- Side slopes – ratio of 2:1 or flatter (3:1 or flatter if mowed).
- Depth – 18 inches minimum.
- Grade – positive towards outlet, but not exceeding two percent.
- Stabilized with vegetation or appropriate armor based on design flow.

Outlet

Stable, with sediment-laden water diverted to a sediment trap or basin.

Subsurface Drain (optional)

- Installed off to the side of the channel bottom (to eliminate seepage from channel side slopes).
- Perforated drain tile.
- Depth – two feet minimum.

Installation

1. Lay out the diversion by setting grade and alignment to fit site needs and topography, maintaining a stable, positive channel grade towards the outlet.
2. Remove and properly dispose of brush, trees, and other debris from the foundation area.
3. Disk ridge base before placing fill to allow bonding of soil materials.
4. Excavate the channel and fill/shape the diversion ridge to alignment, grade and cross-section shown in the construction plans.
Note: Install subsurface tile drain where a seasonal high water table exists.
5. Construct the ridge in six to eight-inch lifts, compacting each lift as it is placed. Build the diversion ridge higher than design elevation, allowing for 10 percent settlement. (Compaction of the ridge may be achieved by driving wheeled equipment along the ridge as soil lifts are added. The compacted ridge must be at or above design grade at all points, while the channel must be at design grade. Shape the ridge and channel to blend with the surrounding landscape and leave sufficient area along the diversion to permit cleanout and regrading.)
6. Stabilize outlets prior to or during construction of the diversion diverting sediment-laden storm water flow to a temporary sediment trap (see **Tempo-**

PERMANENT DIVERSION

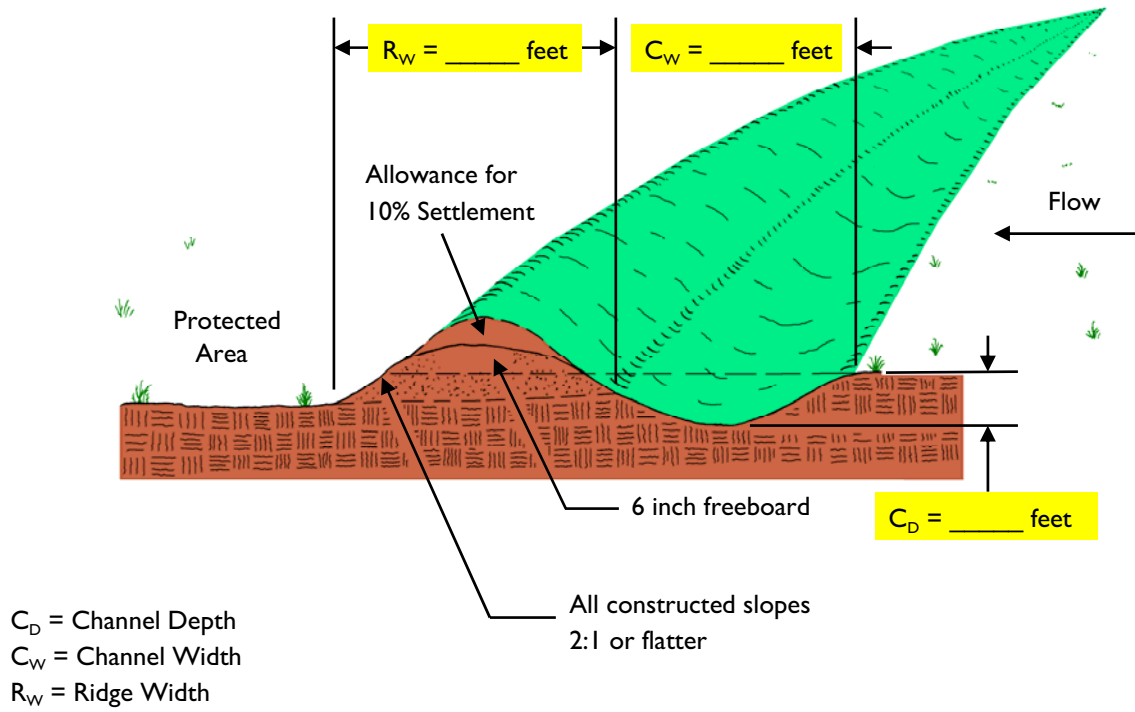
rary **Sediment Trap** on page 183) or a temporary dry sediment basin (see **Temporary Dry Sediment Basin** on page 191) or other appropriate sediment control measures.

7. Stabilize diversions immediately after construction using vegetation and/or other suitable linings (e.g., riprap). If vegetation is used (see **Permanent Seeding** on page 35), protect newly seeded areas with properly anchored mulch (see **Mulching** on page 55), erosion control blankets (see **Erosion Control Blanket** on page 63), or by installing sod (see **Sod** on page 47).

Maintenance

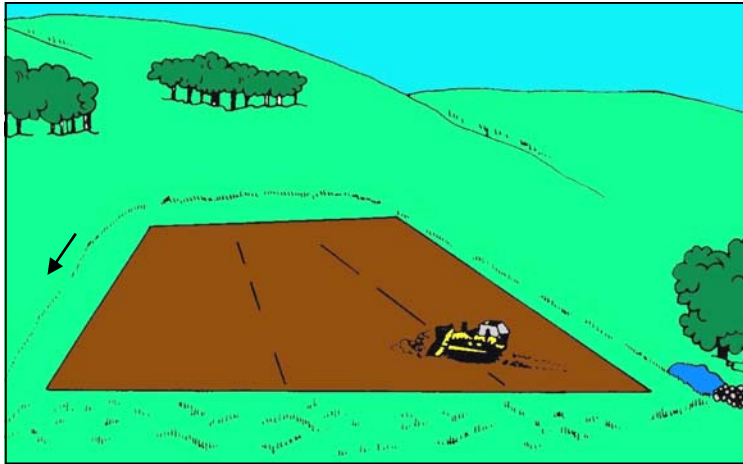
- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Remove sediment from channel to maintain positive grade.
- Check outlets and make necessary repairs immediately.
- Adjust ridge height to prevent overtopping.

Permanent Diversion Worksheet



RUNOFF CONTROL

Perimeter Diversion Dike



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

A perimeter diversion dike is a storm water control measure, consisting of a dike or dike and channel, constructed along the up-slope perimeter of an unvegetated construction site to control storm water runoff from undisturbed areas and divert it around the construction zone.

Purpose

To prevent storm water runoff from entering a construction site thereby reducing erosion potential and the volume of storm water runoff that will require treatment for sediment capture.

Specifications

Contributing Drainage Area

- Five acres maximum. (Designed by a qualified individual/professional engineer. Larger drainage areas may be accommodated but may require additional design considerations.)

Capacity

- Peak runoff from a two-year frequency, 24-hour duration storm event.

Ridge

- Side slope – ratio of 2:1 or flatter (3:1 or flatter if mowed).
- Top width – two feet minimum.
- Height – one and one-half feet minimum from channel bottom.
- Freeboard – six inches minimum.
- Settlement – 10 percent of fill height.
- Stabilized immediately after construction.

PERIMETER DIVERSION DIKE

Channel

- Shape – parabolic, trapezoidal, or V-shaped.
- Side slopes – ratio of 2:1 or flatter.
- Depth – 18 inches minimum.
- Grade – positive towards outlet, but not exceeding two percent.
- Stabilized for design flow.

Outlet

- Stable, with sediment-laden water diverted to a sediment trap or basin and storm water runoff from undisturbed areas diverted to a stable natural outlet or outlet stabilization structure.

Installation

1. Lay out the diversion by setting grade and alignment to fit site needs and topography, maintaining a stable, positive channel grade towards the outlet.
Caution: Water diverted from the construction site must not damage adjacent property.
2. Remove and properly dispose of brush, trees, and other debris from the foundation area.
3. Fill and compact all ditches and gullies to be crossed.
4. Remove topsoil and scarify the subsoil. Prepare ridge foundation so its elevation is at or above surrounding ground elevation.
5. Construct the diversion dike and channel to dimensions and grades shown in the construction plans.
6. Construct the diversion dike ridge in six to eight-inch lifts. Compact each lift by driving wheels of construction equipment along the ridge. Overfill and compact the ridge to design height plus 10 percent to allow for settlement. (The compacted ridge must be at or above design grade at all points, while the channel must be at design grade. Shape the ridge and channel to blend with the surrounding landscape and leave sufficient area along the diversion to permit cleanout and regrading.)
7. Install outlet protection and sediment traps and basins where appropriate as part of the diversion dike. All outlets must be stable.
8. Establish vegetation (see **Temporary Seeding** on page 31; **Permanent Seeding** on page 35; **Sod** on page 47; and **Mulching** on page 55) on dike immediately following construction and stabilize the diversion channel with an erosion resistant lining (e.g., riprap).

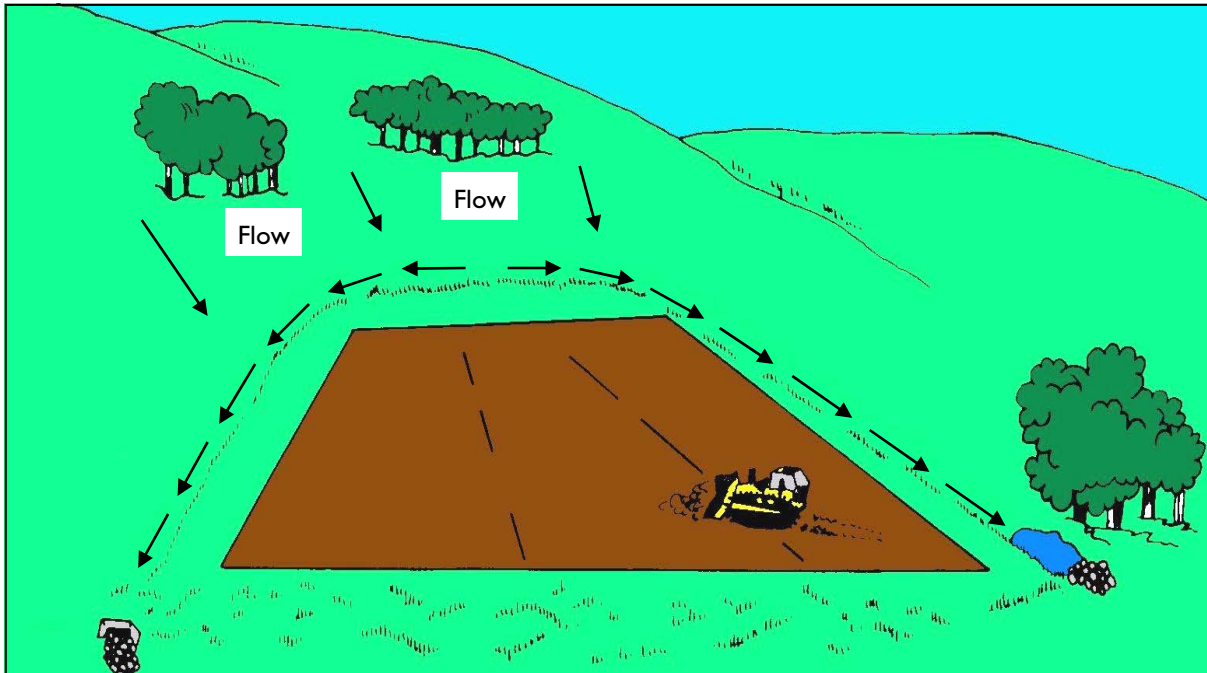
PERIMETER DIVERSION DIKE

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Remove sediment and debris from channel to maintain positive grade.
- Repair dike to its original height.
- Check outlets and make necessary repairs to prevent gully formation.
- Once the work area has been stabilized, remove diversion ridge, fill and compact channel to blend with surrounding area, and stabilize with vegetation.

PERIMETER DIVERSION DIKE

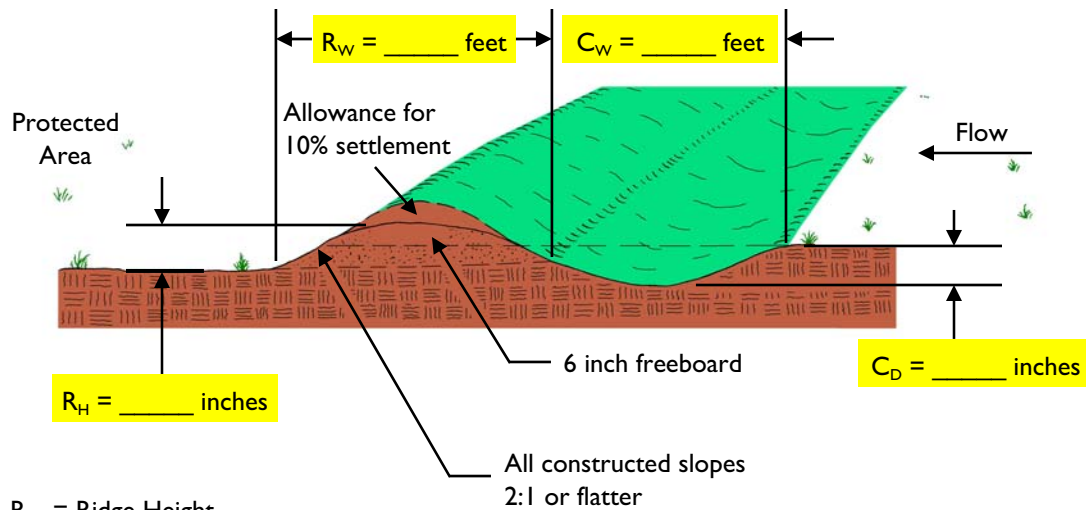
Exhibit 1



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

PERIMETER DIVERSION DIKE

Perimeter Diversion Dike Worksheet



R_H = Ridge Height

R_W = Ridge Base Width

C_D = Channel Depth

C_W = Channel Top Width

Note: Drainage channel is optional.

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RUNOFF CONTROL

Water Bar



*A **water bar** is a series of small ridges or ridges and channels used to intercept and divert storm water runoff from long, narrow corridors and discharge it into a stabilized area or sediment treatment device.*

Purpose

To temporarily reduce erosion on narrow, long, sloping corridors by diverting storm water runoff at selected intervals.

Specifications

Corridor Width

100 feet maximum.

Water Bars

- Spacing – as shown in Table 1.
- Ridge
 - Height – nine inches minimum from down-slope ground level to top of settled ridge.
 - Base width – six feet minimum.
- Side slope – ratio of 2:1 or flatter.
- Alignment – stable, positive grade towards outlet, but not exceeding two percent.
- Settlement – 10 percent of fill height.

Outlet

- Water bar must cross full corridor width and extend to a stable outlet.
- Diversion grade near outlet should be reduced to one percent or less to slow storm water discharge velocities at outlet.

Table 1. Water Bar Spacing

Slope		Spacing
< 5%	< 20:1	125 feet
5% to 10%	20:1 to 10:1	100 feet
10% to 20%	10:1 to 5:1	75 feet
20% to 33%	5:1 to 3:1	50 feet
>33%	> 3:1	25 feet

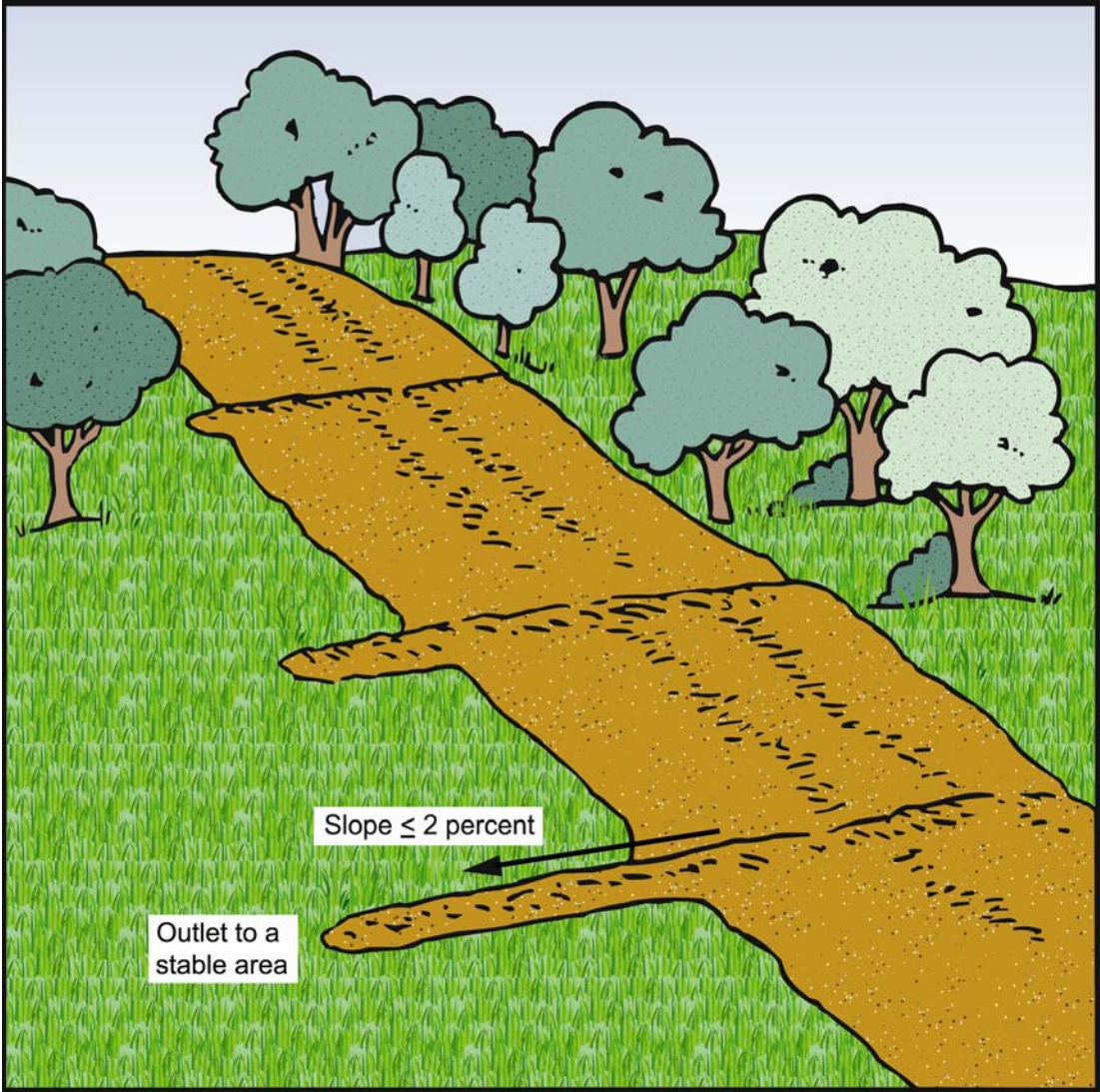
Installation

1. Remove and properly dispose of brush, trees, and other debris from the corridor.
2. Lay out (set) the water bars to the lines and dimensions shown in the construction plans, locating the first water bar at the required distance from the slope crest depending on steepness of the corridor slope.
3. Mark the locations and widths of the remaining water bars. If necessary, adjust length and/or spacing between water bars to prevent runoff from up-slope water bars converging with outlets of down-slope water bars.
4. Lay out the direction of the water bars to utilize the most stable outlet locations. Set water bar crossing angles to maintain a positive grade of less than two percent towards the outlet.
5. Construct sediment traps or outlet stabilization structures as needed.
6. Clear and grade the foundation for the water bars.
7. Disk the entire length of the water bar foundation.
8. Construct the water bar ridge in six to eight-inch lifts. Compact each lift by driving wheels of construction equipment along the ridge. Overfill and compact the ridge to design height plus 10 percent to allow for settlement.
9. Establish vegetation (see **Temporary Seeding** on page 31; **Permanent Seeding** on page 35; **Sod** on page 47; and **Mulching** on page 55) on water bar ridges immediately following construction or stabilize with a nonerosive cover.

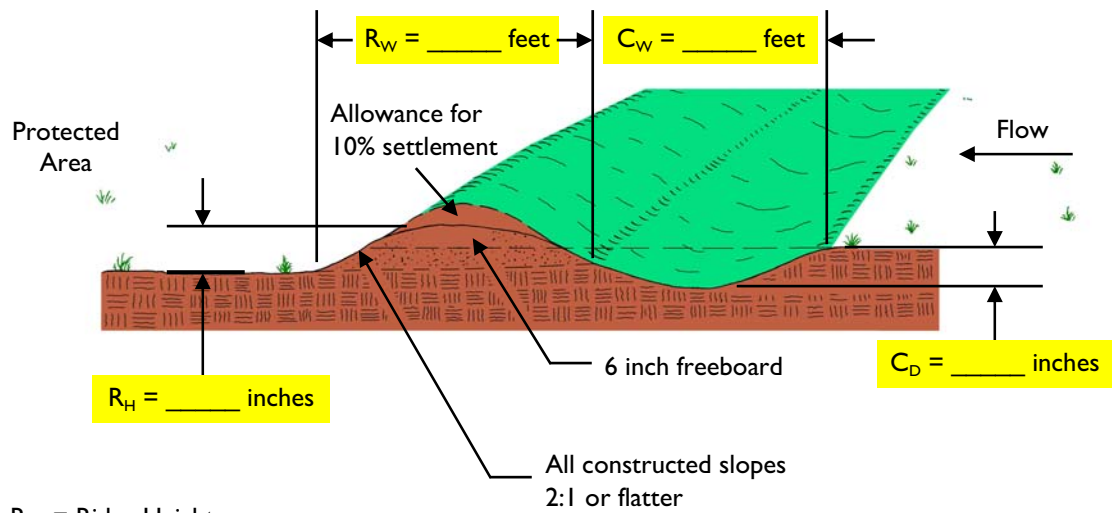
Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days. Frequency of equipment action may require daily inspection.
- Inspect for erosion and sediment deposition; remove debris and sediment from channels and sediment traps or basins.
- Repair ridges to grade and design height.
- Inspect for vehicular wear; add aggregate at vehicle crossing areas when necessary.
- Inspect outlets and stabilize as needed.
- Repair and stabilize water bars immediately after installation of utilities in right-of-way.
- To remove temporary water bars, grade ridge and channel to blend with natural ground, compact channel fill and stabilize disturbed areas. Do not remove water bars until all disturbed areas draining into them are stabilized.

Exhibit 1



Water Bar Worksheet



R_H = Ridge Height

R_W = Ridge Base Width

C_D = Channel Depth

C_W = Channel Top Width

Note: Drainage channel is optional.

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RUNOFF CONTROL

Grade Breaks

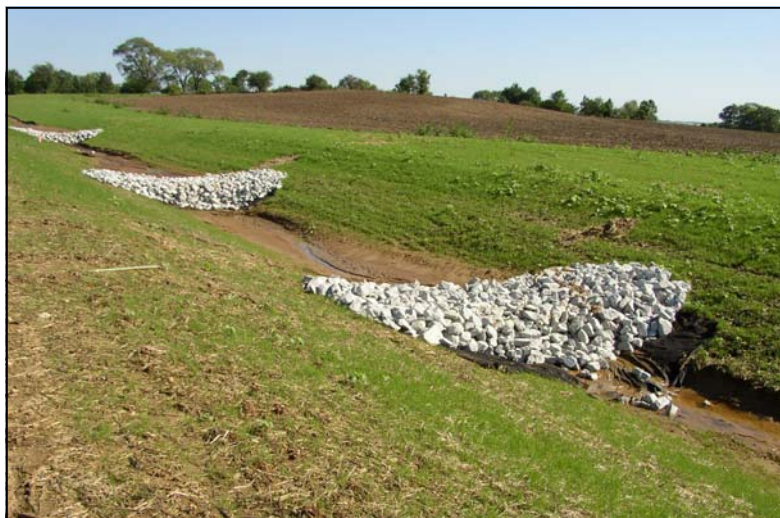


To be released at a later date

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RUNOFF CONTROL

Rock Check Dam



A rock check dam is a series of runoff control structures, consisting of geotextile fabric and aggregate, placed across drainage channels to slow storm water runoff. This measure may also provide limited effectiveness as a sediment control measure.

Purpose

- To reduce erosion in a drainage channel by slowing velocity of flow. (Check dams are commonly used (a) in channels that are eroding, but where permanent stabilization is impractical due to their short period of usefulness, and (b) in eroding channels where construction delays or weather conditions prevent timely installation of erosion-resistant linings.)
- To reduce flow velocities in a drainage channel.

Note: Do not use check dams in perennial streams.

Specifications

Contributing Drainage Area

Two acres maximum.

Riprap Check Dam

- Dam height.
 - Two feet maximum.
 - center of the dam at least nine inches lower than the points of contact between the uppermost points of the riprap dam and channel banks.
- Side slope – ratio of 2:1 or flatter.
- Spacing – toe of the upstream dam at same elevation as overflow weir of the downstream dam.

Overflow Areas

Stabilized to reduce scour/erosion along sides and below the dam.

Filter Medium

- Placed on up-slope side of dam.
- Height – to base of overflow weir notch.

Materials

- Geotextile fabric (8 ounce or heavier; nonwoven).
- Indiana Department of Transportation Revetment riprap (see Appendix D) for dam.
- INDOT CA No. 5 aggregate (see Appendix D) for use as filter medium (Aggregate must be well-graded).

Note: INDOT CA No. 8 aggregate is acceptable if No. 5 aggregate is not available. The use of No. 8 aggregate may result in more frequent overtopping of the structure and will increase the frequency of structure maintenance.

Installation

1. Lay out the location of the check dam.
2. Excavate a cutoff trench into the channel bottom and ditch banks, extending it a minimum of 18 inches beyond the top of the ditch bank.
3. Install and anchor filter fabric in the channel and cutoff trench.
4. Place riprap in the cutoff trench and channel to the lines and dimensions shown in the construction plans. The center of each dam must be at least nine inches lower than the uppermost points of contact between the riprap dam and channel banks (see Rock Check Dam Worksheet on page 101).
5. Extend the riprap at least 18 inches beyond the top of the channel banks to keep overflow water from eroding areas adjacent to the channel banks before it re-enters the channel.
6. Place filter medium (INDOT CA No. 5 aggregate) on the up-slope side of the dam. Place filter medium over the entire face of the dam up to the base of the overflow weir notch.
7. Stabilize the channel above the uppermost dam.
8. Install an erosion-resistant lining in the channel below the lowermost dam. The lining should extend a minimum distance of six feet below the dam.

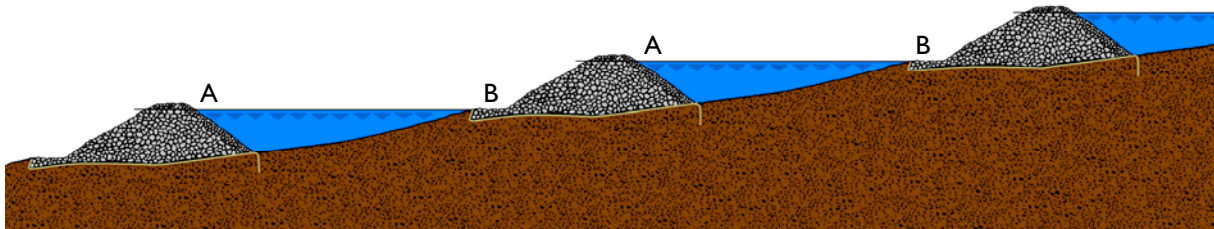
ROCK CHECK DAM

9. Additional sediment storage can be provided by excavating a small sediment trap on the upstream side of the check dam.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- If significant erosion occurs between dams, install an erosion-resistant liner in that portion of the channel.
- Remove accumulated sediment when it reaches one-half the height of the dam to maintain channel capacity, allow drainage through the dam, and prevent large flow from displacing sediment.
- Add riprap and aggregate as needed to maintain design height and cross section of the dams.
- When dams are no longer needed, remove the riprap and aggregate and stabilize the channel, using an erosion-resistant lining if necessary. (Riprap and aggregate from the dam may be removed or utilized to stabilize the channel.)

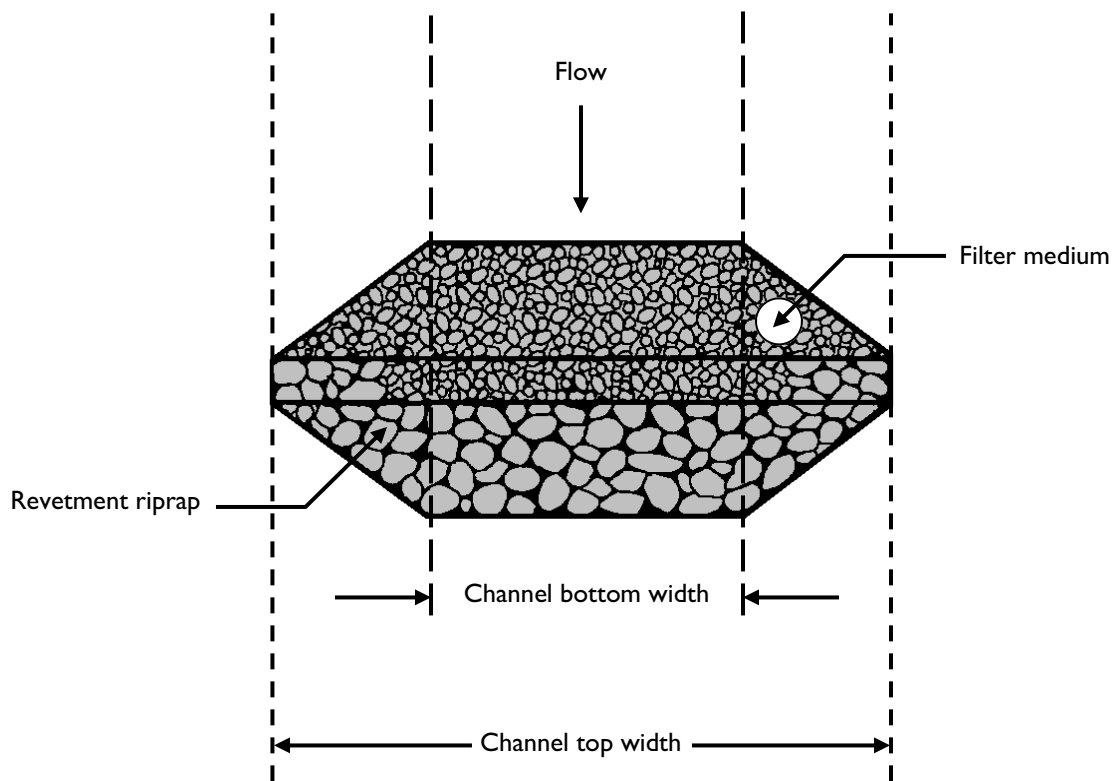
Exhibit 1



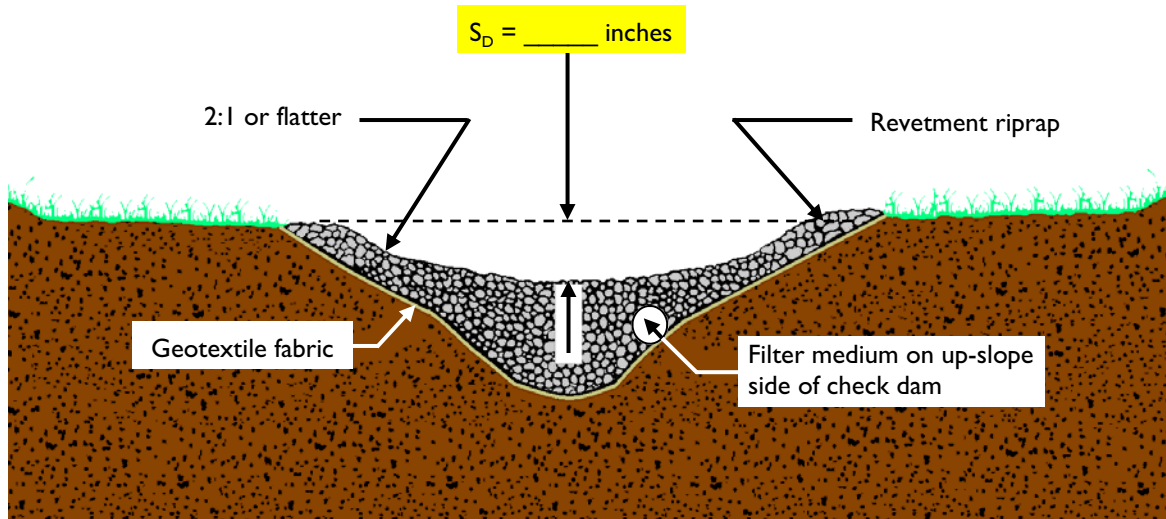
A = Crest of Dam

B = Toe of Dam

Exhibit 2

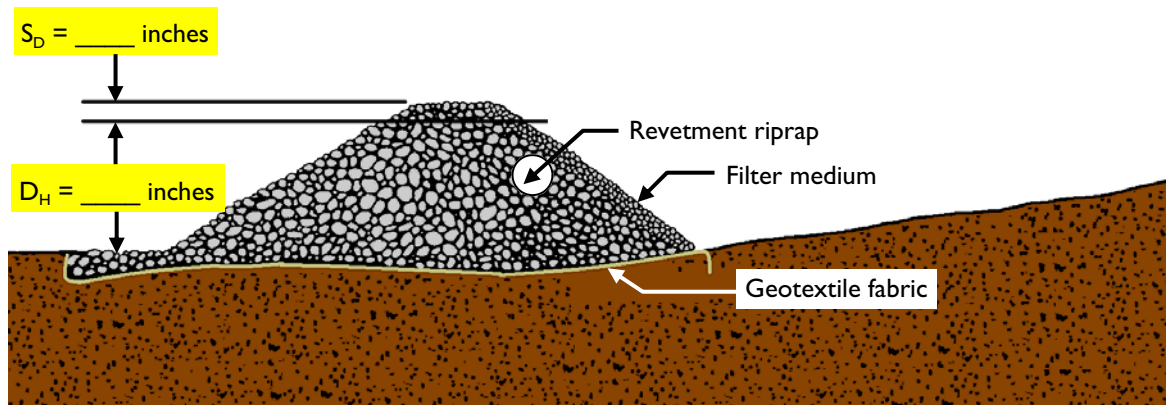


Rock Check Dam Worksheet



S_D = Spillway Depth

NOTE: For minimum dimensions see the "Specifications" section of this measure.



D_H = Dam Height
 S_D = Spillway Depth

NOTE: For minimum dimensions see the "Specifications" section of this measure.

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

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RUNOFF CONTROL

Temporary Slope Drain



A temporary slope drain is a temporary storm water control measure consisting of flexible or rigid tubing or conduit placed and anchored on an unvegetated slope to convey storm water runoff from the top of the slope to the bottom of the slope without causing erosion of the slope surface.

Purpose

To temporarily convey storm water runoff down the face of a slope without causing erosion.

Specifications

Capacity

Peak runoff from two-year frequency, 24-hour duration storm event.

Pipe Size

Based on drainage area as shown in Table 1.

Table 1. Pipe Size Selection

Maximum Drainage Area per Pipe	Minimum Pipe Diameter
0.50 acre	8 inch
0.75 acre	10 inch
1.00 acre	12 inch
> 1.00 acre	Individually designed

Inlet Section

- Standard “T” or flared-end section (see Figure 1).
- Compacted fill over pipe
 - Depth – one and one-half feet minimum.
 - Width – four feet minimum.
 - Height – six inches higher than the diversion ridge.

TEMPORARY SLOPE DRAIN

Figure 1: Temporary Slope Drain with Flared-End Section



Outlet

- Pipe extended beyond the toe of the slope.
- Pipe terminated on a stable, four-foot long (minimum), level section.

Materials

- Pipe – Strong, flexible pipe, such as heavy-duty, non-perforated, corrugated plastic.
- “T” or flared-end section.
- Wooden stakes or rebar.

Installation

1. Lay the pipe down the slope face and anchor it in place with stakes no more than 10 feet apart (see Temporary Slope Drain Worksheet on page 107).
Note: Place temporary slope drains on undisturbed soil or well-compacted fill.
2. Extend the pipe beyond the toe of the slope to a stable grade and terminate the pipe on a four-foot level section to protect the outlet from erosion.
3. Install a sediment trap or basin to capture sediment-laden water discharged from the pipe.
4. Set the slope drain inlet section at the bottom of the diversion channel.
5. Connect the pipe to the inlet section.

TEMPORARY SLOPE DRAIN

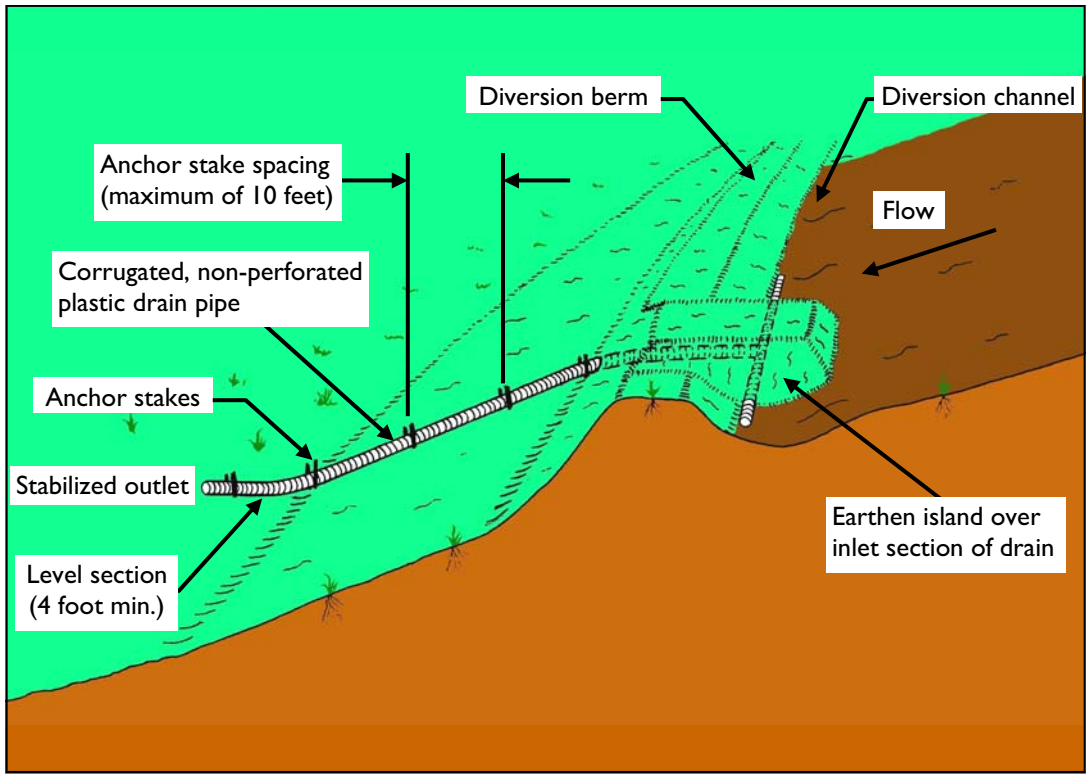
6. Construct a ridge over the inlet section of pipe by placing fill over the pipe in six-inch lifts.
7. Compact each lift by hand tamping under and around the inlet and along the pipe. **Caution: Compacting with heavy equipment may displace or collapse the pipe.**
8. Repeat steps 6 and 7 until the minimum depth, width, and side slope dimensions shown in the construction plans are reached. Making the top of the fill six inches higher than the adjoining diversion ridge creates an island over the pipe to prevent overtopping (see Temporary Slope Drain Worksheet).
9. Make all pipe connections watertight and secure so that joints will not separate in use.
10. Construct a temporary diversion channel (see **Temporary Diversion** on page 75) towards the temporary slope drain. The diversion must have a stable, positive grade not exceeding two percent.
11. Following installation, stabilize all areas down slope of the diversion and where practical, all disturbed areas.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Check the inlet for sediment or trash accumulation; clear and restore to proper entrance condition.
- Check the fill over the pipe for settlement, cracking, or piping holes; repair immediately.
- Check pipe for evidence of leaks or inadequate anchoring; repair immediately.
- Check the outlet for erosion or sedimentation; clean and repair, or extend if necessary.
- Once slopes have been stabilized, remove temporary diversions and slope drains, and stabilize all disturbed areas.

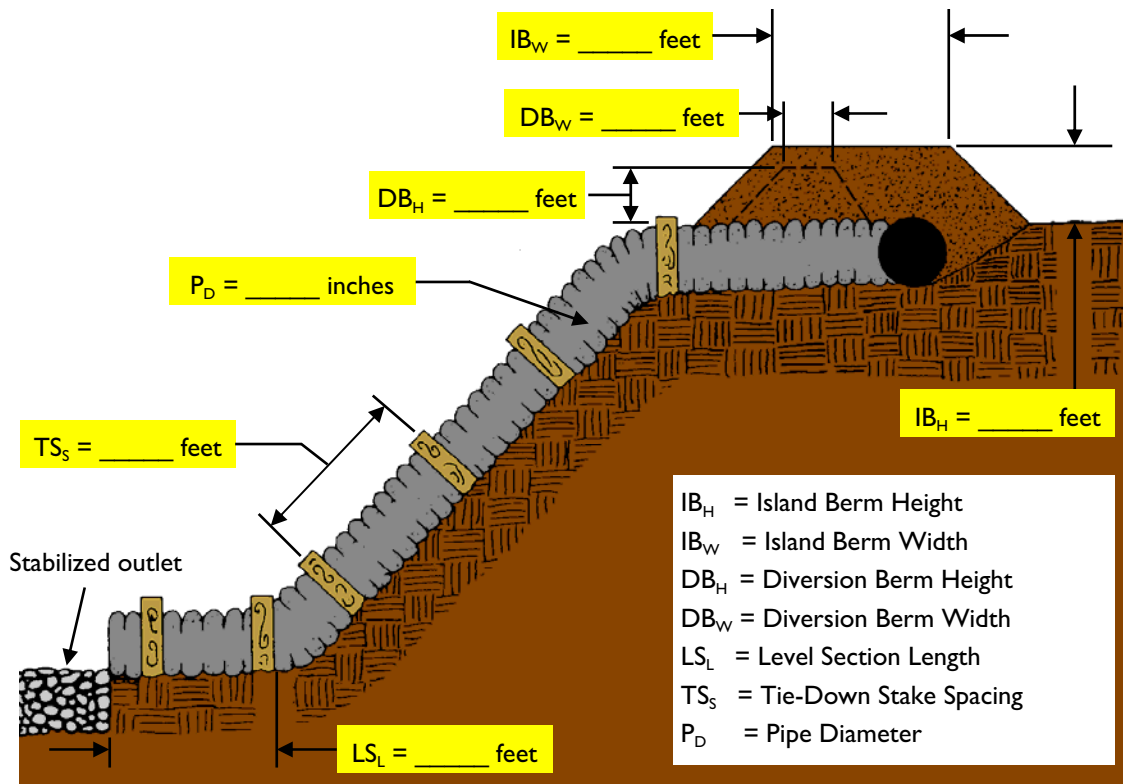
TEMPORARY SLOPE DRAIN

Exhibit 1



TEMPORARY SLOPE DRAIN

Temporary Slope Drain Worksheet



Note: For minimum and maximum dimensions see the "Specifications" section of this measure.)

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

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RUNOFF CONVEYANCE SYSTEMS

Runoff conveyance systems are measures that have been designed to carry concentrated runoff from small areas to a stable outlet without causing erosion in the conveyance system and erosion/damage at the outlet. Measures in this section primarily include channels and swales. These conveyance systems are usually stabilized with vegetation or some type of hard armor. Conveyance systems should be constructed and stabilized prior to becoming functional. Every effort should be made to prevent sediment from entering the conveyance system, especially after it becomes functional.

Designs for runoff control measures can be complex and generally require detailed site investigations and the application of sound engineering principles. A professional knowledgeable of the principles of storm water management and experienced in structural design should be consulted when using runoff control measures.

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RUNOFF CONVEYANCE SYSTEMS

Grass-Lined Channel



A grass-lined channel is a storm water conveyance measure consisting of a natural channel or constructed channel, shaped, and graded to required dimensions, stabilized with suitable vegetation, and used to convey water in a non-erosive manner.

Purpose

To carry concentrated storm water runoff from a small watershed area to a stable outlet without damage from erosion.

Specifications

Minimum Capacity

Peak runoff from 10-year frequency, 24-hour duration storm event.

Channel

Design based on contributing drainage area.

- Size – as specified in the construction plans (a 3:1 ratio of bottom width to depth is recommended for maximum storm water pollutant removal).
- Grade – as specified in the construction plans (generally restricted to a gradient of five percent or less).
- Cross Section – parabolic or trapezoidal.
- Side Slopes – 3:1 ratio or flatter to establish and maintain vegetation and facilitate mowing.

Channel Stabilization

Stabilize channel with one or more of the following measures; select based on field conditions and channel velocity.

GRASS-LINED CHANNEL

- Erosion control blankets.
- Turf reinforcement mats.
- Sod.

Outlet

Stable.

Materials

- Erosion control blankets, turf reinforcement mats, or sod (optional).
- Drainage tile – used in areas with a seasonal high water table or seepage problems.
 - Offset from center of channel.
 - Minimum of two feet of soil cover over the tile.
 - Animal guard placed on pipe outlet section (as needed).

Installation

1. Remove and properly dispose of brush, trees, and other debris from the foundation area.
2. Excavate and shape the channel to lines and dimensions shown on construction plans, removing and properly disposing of excess soil so that surface water can enter the channel freely.
3. If soils have a seasonal high water table, install subsurface drainage tile. Offset the drainage tile to one side of the channel (do not place in the center of the channel). Utility lines should not be installed near the channel bottom. Protect all concentrated inflow points along the channel with erosion-resistant linings such as riprap or with other appropriate measures.
4. Add topsoil where soils exposed during excavation would be unsuitable for establishment of vegetation.
5. Seed (see **Permanent Seeding** on page 35) channel immediately after grading and protect with erosion control blankets (see **Erosion Control Blanket** on page 63), turf reinforcement mats (see **Turf Reinforcement Mat** on page 65), or install sod (see **Sod** on page 47).
6. Stabilize outlets during channel installation (see the **Outlet Protection and Grade Stabilization** measures on pages 119–142).

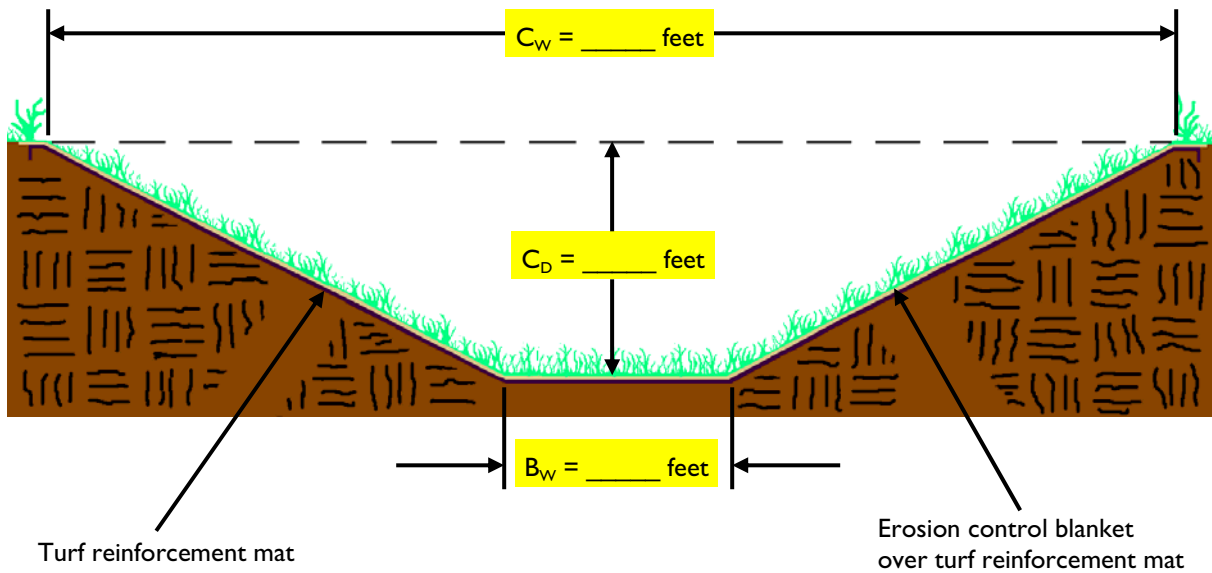
GRASS-LINED CHANNEL

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- Check channel outlet and road crossings for blockage, sediment, bank instability, and piping or scour holes; remove any blockage, and make repairs immediately.
- Remove significant sediment and debris from channel to maintain design cross section and channel grade and to prevent spot erosion.

GRASS-LINED CHANNEL

Grass-Lined Channel Worksheet



B_w = Designed Bottom Width of Channel

C_w = Designed Top Width of Channel

C_d = Designed Depth of Channel

RUNOFF CONVEYANCE SYSTEMS

Riprap-Lined Chanel



A riprap-lined channel is a storm water conveyance measure consisting of a natural channel or constructed channel, shaped, and graded to required dimensions, stabilized with riprap, and used to convey water in a non-erosive manner.

Purpose

To carry concentrated storm water runoff from a small watershed area to a stable outlet without damage from erosion.

Specifications

Note: Designed by a qualified individual/professional engineer. Additional design considerations will be required when discharge velocities are very high or tailwater conditions are very low.

Minimum capacity

Peak runoff from 10-year frequency, 24-hour duration storm event.

Foundation

Stable, relatively homogeneous, mineral soil with low piping potential.

Channel

Design based on contributing drainage area.

- Size – as specified in the construction plans.
- Grade – as specified in the construction plans (generally restricted to a gradient of five percent or less).
- Cross Section – parabolic or trapezoidal.
- Side Slopes – 2:1 ratio or flatter.

RIPRAP-LINED CHANNEL

Thickness of Riprap Layer

Two times designed d_{50} (see Appendix A – Glossary of Terms) stone diameter or 12 inches, whichever is greater.

Outlet

Stable.

Materials

- Riprap
 - Hard, angular, highly weather resistant.
 - Specific gravity of at least 2.5.
 - Size and gradation that will withstand velocities of channel flow design. (Do not use broken concrete.)
 - Well-graded mixture of stone with 50 percent of the stone pieces, by weight, larger than the designed d_{50} size.
 - No more than 15 percent of the pieces, by weight, should be less than three inches.
- Geotextile fabric or well-graded aggregate [INDOT CA No. 9, 11, or 12 (see Appendix D)].
- Concrete grout (optional).
- Drainage tile
 - Used in areas with a seasonal high water table or seepage problems.
 - Offset from center of channel.
 - Minimum of two feet of soil cover over the tile.
 - Animal guard placed on pipe outlet section (as needed).

Installation

1. Remove and properly dispose of brush, trees, and other debris from the foundation area.
2. Excavate foundation subgrades below design elevation to allow for thickness of the filter medium (geotextile fabric or well-graded aggregate) and riprap (see Riprap-Lined Channel Worksheet on page 118).

Note: This overcut significantly increases excavation and spoil disposal. For instance, for the channel on the Riprap-Lined Channel Worksheet, excavation doubles from 1.1 cubic yards per foot of

RIPRAP-LINED CHANNEL

channel to 2.2 cubic yards per foot. An aggregate filter medium would require even more excavation and disposal.

3. Smooth the subgrade enough to protect geotextile fabric from tearing.
4. Place geotextile fabric or aggregate filter medium (for stabilization and filtration) on the compacted and smoothed foundation. If more than one piece of geotextile fabric is needed, the upstream piece should overlap the downstream piece by at least 12 inches.
5. Install riprap to the lines and elevations shown in the construction plans. If the channel is poorly defined, the final cross section should be nearly level with the middle slightly depressed or lower than the outer edges. If the channel is well defined, the filter medium and riprap should extend to the top of the channel banks. The riprap should form a dense, uniform, and well-graded mass with few voids. Selective loading at the quarry and some hand placement may be necessary to obtain good distribution of stone sizes.
6. If geotextile fabric tears when placing riprap, repair immediately by laying and stapling a piece of fabric over damaged area, overlapping the undamaged areas by at least 12 inches.
7. Blend riprap smoothly to surrounding grade, avoiding overfill or channel constriction.

Note: Grass-lined channels with riprap bottoms must have a smooth transition between the riprap and vegetation.

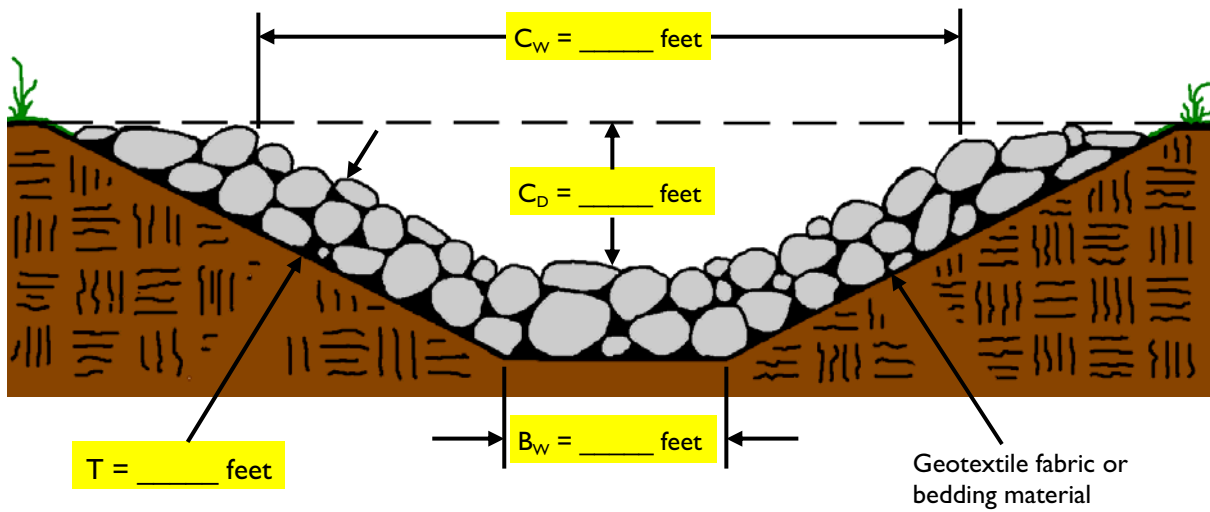
8. Stabilize channel inlet points and install needed outlet protection during channel stabilization.

Maintenance

- Inspect within 24 hours of each rain event and at least once every seven calendar days.
- When stones have been displaced, remove debris and replace stones in such a way as to not restrict the flow area.
- If filter fabric is damaged, remove the riprap and repair by adding another layer of fabric, overlapping adjacent, undamaged areas by 12 inches. Secure fabric with anchor pins spaced every three feet, then replace riprap.
- Give special attention to outlets and points where concentrated flow enters the channel, and repair eroded areas promptly.
- Check for sediment accumulation, piping, bank instability, and scour holes; repair promptly.

RIPRAP-LINED CHANNEL

Riprap-Lined Channel Worksheet



B_w = Designed Bottom Width of Channel

C_w = Designed Top Width of Channel

C_d = Designed Depth of Channel

T = Thickness of Riprap

OUTLET PROTECTION & GRADE STABILIZATION

When concentrated runoff is carried through a storm water conveyance system and discharged, it is necessary to provide a stable outlet. Outlet protection measures listed in this section are designed to prevent scouring at the point of discharge and provide energy dissipation to reduce erosion downstream of the discharge.

The measures listed in this section are designed to:

- Establish a stable grade and prevent erosion and head cutting at the outlet of a conveyance channel; or
- Establish an in-channel, stable grade transition and provide for flatter channel grade in the upper and lower reaches of the conveyance channel, thereby reducing flow velocity and reducing potential for in-channel erosion and head cutting at the point of transition.

Designs for outlet protection and grade stabilization structures can be complex and generally require detailed site investigations and the application of sound engineering principles. A professional knowledgeable of the principles of storm water management and experienced in structural design should be consulted when using these structures.

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OUTLET PROTECTION & GRADE STABILIZATION

Energy Dissipater (Outlet Protection)



An energy dissipater (outlet protection) is an erosion control measure consisting of riprap placed at the outlet end of culverts, conduits, channels, etc.

Purpose

To prevent erosion at the outlet of a channel or conduit by reducing the velocity of storm water flow and dissipating its energy.

Specifications

Note: Designed by a qualified individual/professional engineer. Additional design considerations will be required when discharge velocities are very high or tailwater conditions are very low.

Capacity:

Peak runoff from a 10-year frequency, 24-hour storm event or the design discharge of the water conveyance structure, whichever is greater.

Maximum Velocity

Ten feet per second.

Tailwater Depth

- Determined immediately below the structure outlet.
- Based on design discharge plus other contributing flows.

Apron

- Length and width determined according to tailwater conditions.

ENERGY DISSIPATER (OUTLET PROTECTION)

- Aligned straight with channel flow. If a curve is necessary to align the apron with the receiving stream, locate the curve in the upstream section of the apron.
- Plunge pool (used with higher velocity flows).
- Thickness
 - 1.2 times the maximum stone diameter for a d_{50} stone size of 15 inches or larger.
 - 1.5 times the maximum stone diameter for a d_{50} stone size of 15 inches or less.

Table 1. Sizing for Flow Dissipaters at Culvert Pipe Outlets¹

Pipe Size	Average Riprap Diameter	Apron Width ²	Apron Length ³
8 in.	3 in.	2 to 3 ft.	5 to 7 ft.
12 in.	5 in.	3 to 4 ft.	6 to 12 ft.
18 in.	8 in.	4 to 6 ft.	8 to 18 ft.
24 in.	10 in.	6 to 8 ft.	12 to 22 ft.
30 in.	12 in.	8 to 10 ft.	14 to 28 ft.
36 in.	14 in.	10 to 12 ft.	16 to 32 ft.

¹ For larger or higher flows consult a registered engineer.

² Apron width at the narrow end of apron (pipe or channel outlet).

³ Select length taking into consideration the low flow (no pressure head) or high flow (pressure head) conditions of the culvert pipe.

Materials

- Riprap
 - Hard, angular, highly weather resistant.
 - Specific gravity of at least 2.5.
 - Size and gradation that will withstand velocities of storm water discharge flow design.
 - Well-graded mixture of stone with 50 percent of the stone pieces, by weight, larger than the d_{50} size and the diameter of the largest stone equal to 1.5 times the d_{50} size.

Note: Concrete, gabion baskets, grouted riprap, interlocking concrete blocks, cabled concrete, and turf reinforcement products are alternative options to riprap.

- Geotextile fabric or well-graded aggregate [INDOT CA No. 9, 11, or 12 (see Appendix D)].

ENERGY DISSIPATER (OUTLET PROTECTION)

Installation

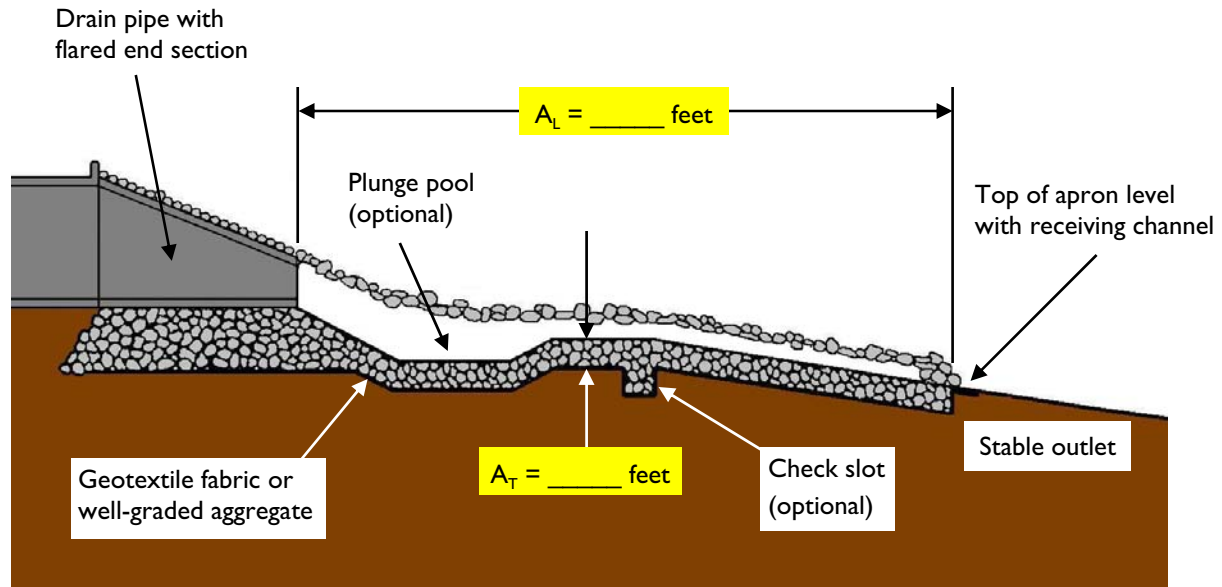
1. Divert surface water runoff around the structure during construction so that the site can be properly dewatered for foundation preparation.
2. Excavate foundation and apron area subgrades below design elevation to allow for thickness of the filter medium and riprap.
3. Compact any fill used in subgrade preparation to the density of surrounding undisturbed soil material.
4. Smooth subgrade enough to protect geotextile fabric from tearing.
5. Place geotextile fabric or aggregate bedding material (for stabilization and filtration) on the compacted and smoothed foundation.
6. Install riprap to the lines and elevations shown in the construction plans. Blend riprap smoothly to surrounding grade. If the channel is well defined, extend the apron across the channel bottom and up the channel banks to an elevation of six inches above the maximum tailwater depth or to the top of the bank, whichever is less.
7. If geotextile fabric tears when placing riprap, repair immediately by laying and stapling a piece of fabric over damaged area, overlapping the undamaged areas by at least 12 inches.
8. Construct a small plunge pool within the outlet apron. (Riprap aprons must be level with or slightly lower than the receiving channel and should not produce an overfall or restrict flow of the water conveyance structure.)

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Inspect for stone displacement; replace stones ensuring placement at finished grade.
- Check for erosion or scouring around sides of the apron; repair immediately.
- Check for piping or undercutting; repair immediately.

ENERGY DISSIPATER (OUTLET PROTECTION)

Energy Dissipater Worksheet 1

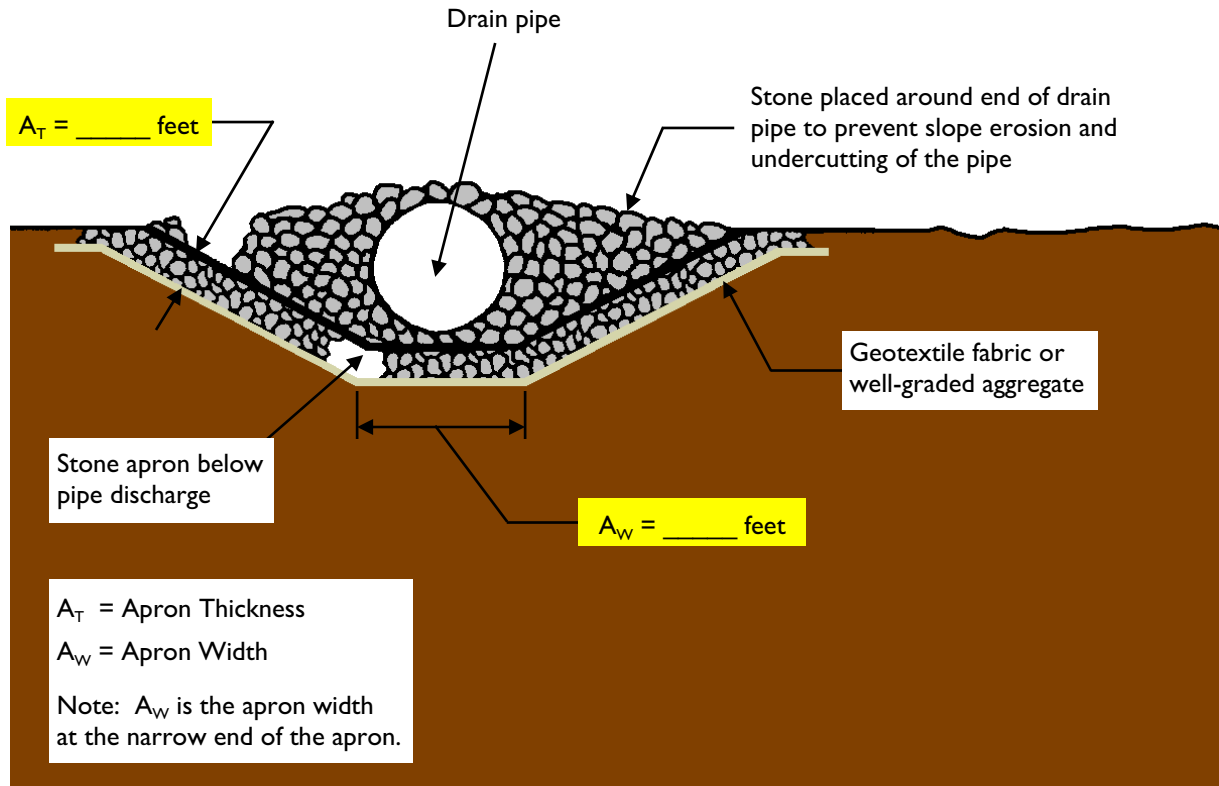


A_L = Apron Length

A_T = Apron Thickness

ENERGY DISSIPATER (OUTLET PROTECTION)

Energy Dissipater Worksheet 2



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OUTLET PROTECTION & GRADE STABILIZATION

Rock-Lined Chute



A rock-lined chute is a storm water conveyance measure, consisting of a defined channel lined with riprap, that is used to convey water down a steep grade in a non-erosive manner.

Purpose

- To establish a stable grade and prevent erosion and head cutting at the outlet of a conveyance channel.
- To establish an in-channel, stable grade transition and provide for flatter channel grade in the upper and lower reaches of the conveyance channel, thereby reducing flow velocity and reducing potential for in-channel erosion and head cutting at the point of transition.

Specifications

Contributing Drainage Area

50 acres maximum (designed by a qualified individual/professional engineer; larger watersheds may be accommodated but may require additional design considerations).

Capacity

Peak runoff from 10-year frequency, 24-hour storm event.

Foundation

Stable, relatively homogeneous, mineral soil with low piping potential.

Diversion Ridge

- Designed and constructed to channel surface water runoff into the concrete block chute.

ROCK-LINED CHUTE

- Side slopes – 2:1 ratio or flatter.
- Top width – four foot minimum.

Inlet and Outlet Aprons

- Excavated below design elevation to allow for thickness of filter medium and riprap.
- Aligned straight with channel flow.
- Set at zero grade.
- Transition section consisting of properly sized riprap at the toe of the structure to prevent erosion of the outlet and the channel bed.
- Plunge pool constructed in the outlet apron.

Thickness of Riprap Layer

Two times the d_{50} stone diameter or 12 inches, whichever is greater.

Materials

- Riprap
 - Hard, angular, highly weather resistant.
 - Specific gravity of at least 2.5.
 - Size and gradation that will withstand velocities of channel flow design.
 - Well-graded mixture of stone with 50 percent of the stone pieces, by weight, larger than the d_{50} size and the diameter of the largest stone equal to 1.5 times the d_{50} size.
- Geotextile fabric or well-graded aggregate [INDOT CA No. 9, 11, or 12 (see Appendix D)].
- Concrete grout (optional).
- Drainage tile
 - To prevent seepage of up-slope groundwater.
 - Offset from center of channel.
 - Minimum of two feet of soil cover over the tile.
 - Animal guard placed on pipe outlet section (as needed).

Installation

1. Divert surface water runoff around the structure during construction so that the site can be properly dewatered for foundation preparation, construction of headwalls, apron drains, and other structural appurtenances.

ROCK-LINED CHUTE

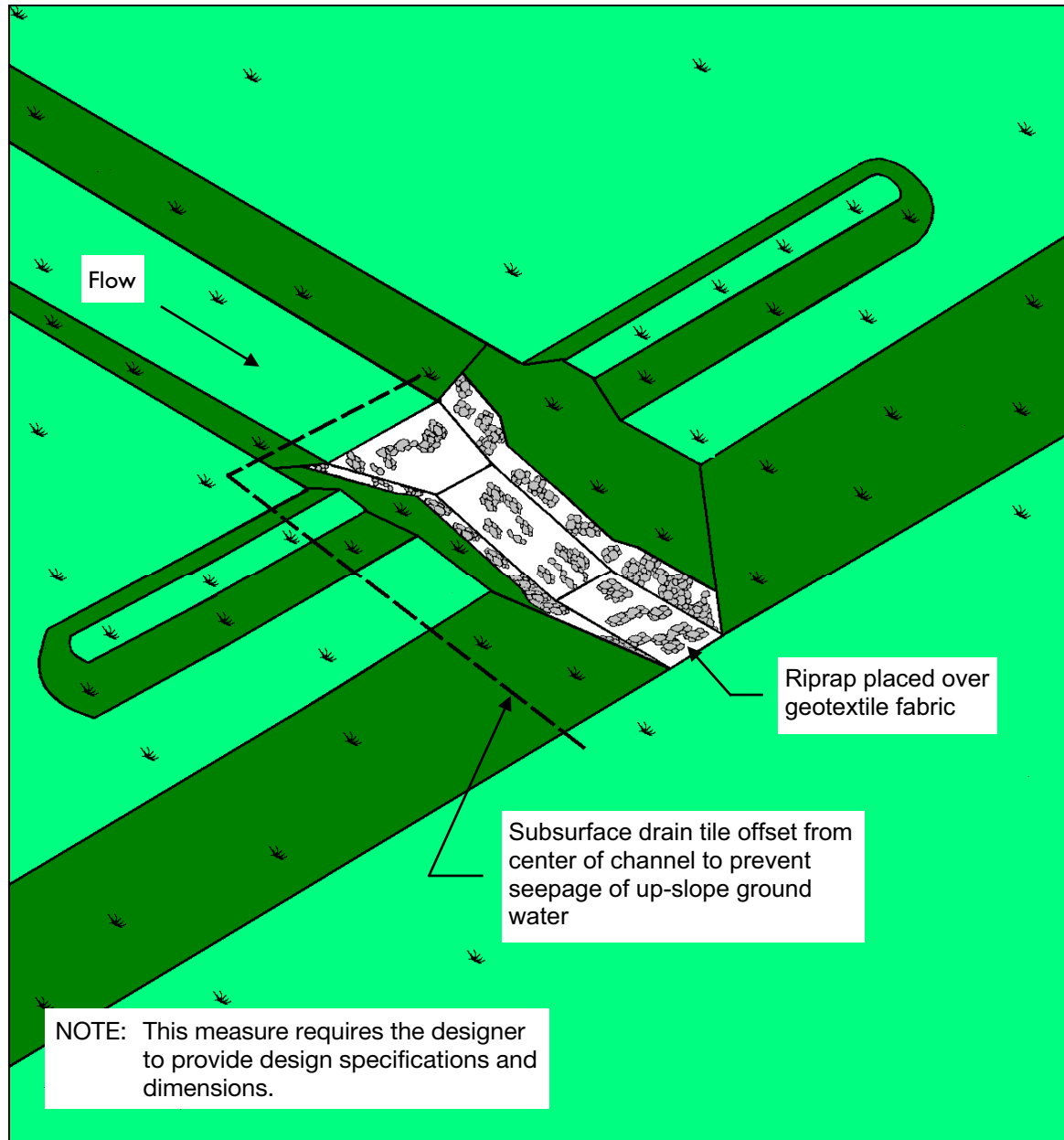
2. Excavate foundation and apron subgrades below design elevation to allow for thickness of the filter medium and riprap.
3. Compact any fill used in subgrade preparation to the density of the surrounding undisturbed soil material.
4. Smooth the subgrade enough to protect geotextile fabric from tearing.
5. Place geotextile fabric or aggregate bedding material (for stabilization and filtration) on the compacted and smoothed foundation. If more than one piece of geotextile fabric is needed, the upstream piece should overlap the downstream piece by at least 12 inches.
6. Install riprap to the lines and elevations shown in the construction plans. If the channel is poorly defined, the final cross section should be nearly level with the middle, slightly depressed or lower than the outer edges of the chute. If the channel is well defined, the filter medium and riprap should extend to the top of the channel banks.
7. If the geotextile fabric tears when placing the riprap, repair immediately by laying and stapling a piece of fabric over the damaged area, overlapping the undamaged areas by at least 12 inches.
8. Blend riprap smoothly to the surrounding grade.
9. Construct a small plunge pool within the outlet apron. Riprap aprons must be level with or slightly lower than the channel grade and should not restrict channel flow or produce an overfall.
10. Construct a permanent diversion ridge (see **Permanent Diversion** on page 79), according to design capacity, on each side of the riprap-lined chute to collect storm water runoff and direct its flow into the chute.

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Inspect riprap-lined chutes for stone displacement, erosion along sides of chute, scouring around aprons, and piping or undercutting; make needed repairs immediately, using appropriate size stone and ensuring placement at finished grade.

ROCK-LINED CHUTE

Exhibit 1



Source: Adapted from U.S. Department of Agriculture, Natural Resources Conservation Service

OUTLET PROTECTION & GRADE STABILIZATION

Concrete Block Chute



A concrete block chute is a storm water conveyance measure, consisting of a defined channel lined with standard concrete blocks, that is used to convey water down a steep grade in a non-erosive manner.

Purpose

- To establish a stable grade and prevent erosion and head cutting at the outlet of a conveyance channel.
- To establish an in-channel, stable grade transition and provide for flatter channel grade in the upper and lower reaches of the conveyance channel, thereby reducing flow velocity and reducing potential for in-channel erosion and head cutting at the point of transition.

Specifications

Contributing Drainage Area

50 acres maximum (designed by a qualified individual/professional engineer; larger drainage areas may be accommodated, but may require additional design considerations).

Capacity

Runoff from a 10-year frequency, 24-hour storm event.

Maximum Overfall

Ten feet.

Diversion Ridge:

- Designed and constructed to channel surface water runoff into the concrete block chute.

CONCRETE BLOCK CHUTE

- Side slopes – 2:1 ratio or flatter.
- Top width – four foot minimum.

Chute Foundation:

- Chute-bottom and side-slope subgrade excavated and/or filled and compacted to approximately 10 inches below finished grade.
- Subgrade overlain with plastic sheeting or geotextile fabric, covered with two inches of bedding aggregate (INDOT CA No. 9, 11, or 12), and finally covered with geotextile fabric.

Inlet and Outlet Aprons:

- Excavated 10 inches below finished grade.
- Aligned straight with channel flow.
- Set at zero grade

Materials:

- Standard eight-inch concrete blocks.
- INDOT CA No. 9, 11, or 12 aggregate (see Appendix D).
- Plastic sheeting (4 mm or thicker).
- Geotextile fabric (for stabilization and filtration).
- Drainage tile
 - To prevent seepage of up-slope groundwater.
 - Offset from center of channel.
 - Minimum of two feet of soil cover over the tile.
 - Animal guard placed on pipe outlet section (as needed).

Installation

1. Divert surface water runoff around the structure during construction so that the site can be properly dewatered for foundation preparation, construction of headwalls, apron drains, and other structural appurtenances.
2. Excavate foundation subgrade for the chute and inlet and outlet aprons to about 10 inches below finished grade elevations (to allow for thickness of bedding materials and the concrete blocks). Align the aprons with channel flow and install them on zero grade.
3. Compact any fill used in the subgrade to the density of the surrounding undisturbed soil material.
4. Smooth subgrade enough to protect plastic sheeting and geotextile fabric from tearing.

CONCRETE BLOCK CHUTE

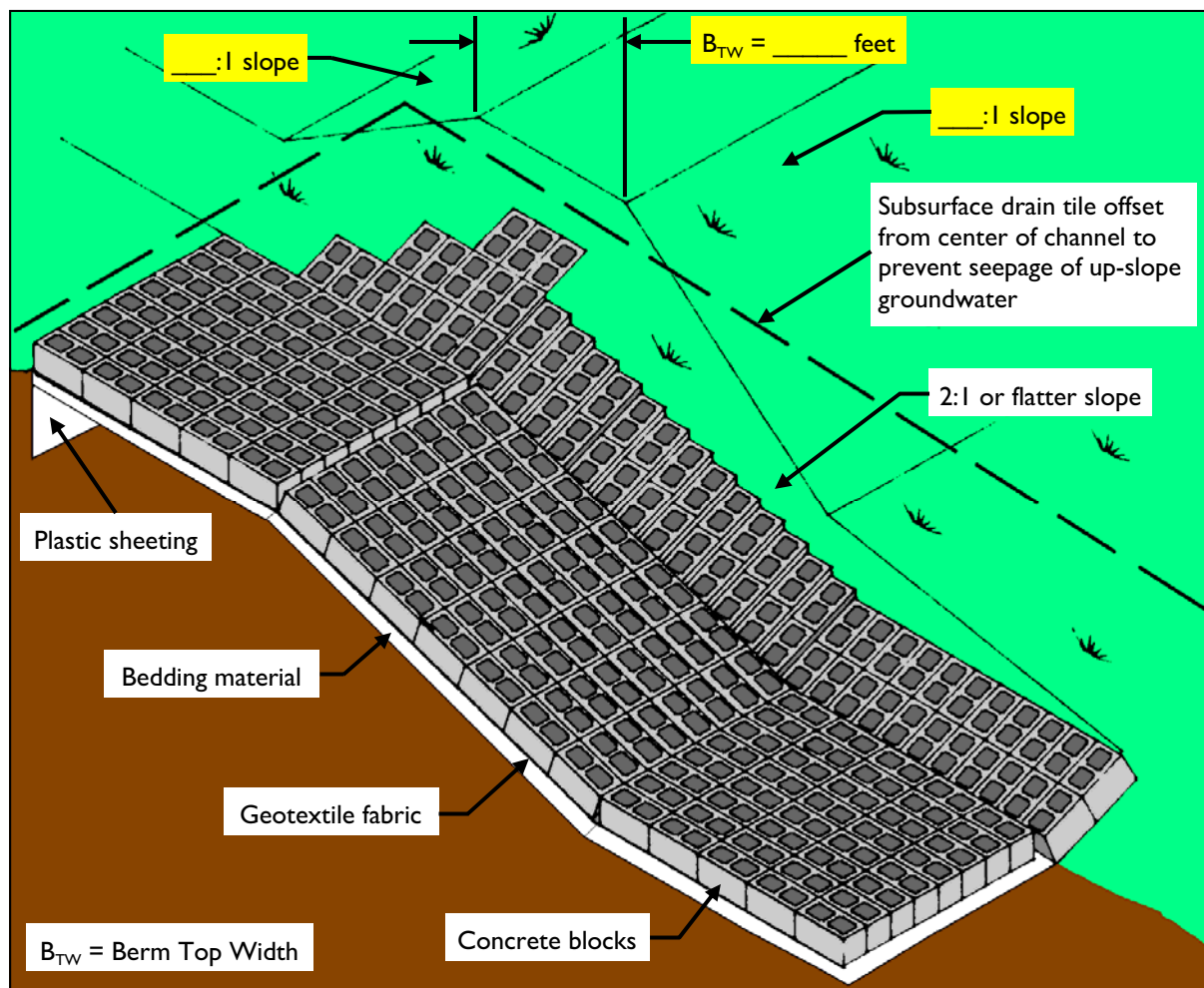
5. Excavate a 12-inch to 18-inch deep trench around the perimeter of the structure (e.g., edges of inlet and outlet aprons and top of the chute and chute side slopes) to entrench and secure the plastic sheeting/geotextile fabric and minimize potential for piping and undercutting.
6. Install plastic sheeting or geotextile fabric over the smoothed subgrade. If more than one sheet of plastic or geotextile fabric is needed, the upstream piece should overlap the downstream piece by at least 12 inches.
7. Place two inches of bedding aggregate over the plastic sheeting/geotextile fabric.
8. Cover the aggregate with a layer of geotextile fabric. As noted in step seven, upstream pieces of the fabric should overlap downstream pieces by at least 12 inches.
9. Construct a permanent diversion ridge (see **Permanent Diversion** on page 79), according to design capacity, on each side of the concrete block chute to collect storm water runoff and direct its flow into the chute.
10. Lay the edges of the plastic sheeting and geotextile fabric in the excavated trench so that the edges extend to the bottom of the trench with approximately four inches laying flat in the trench bottom. Using six inch or longer metal or wooden staples, anchor the sheeting and fabric in the trench, back-fill with soil material, and compact.
11. Lay concrete blocks (holes facing up) on the geotextile fabric as shown in Exhibit 1, taking care not to damage the fabric. If fabric is torn when placing the blocks, repair immediately by laying and stapling a piece of fabric over the damaged area, overlapping undamaged areas by 12 inches.
12. Fill the holes in the blocks with soil and seed immediately.

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Inspect for scouring, piping and undercutting; make needed repairs immediately.
- Keep inlet and outlet areas free of any debris or other obstructions.
- Do not drive equipment or vehicles on the structure.

CONCRETE BLOCK CHUTE

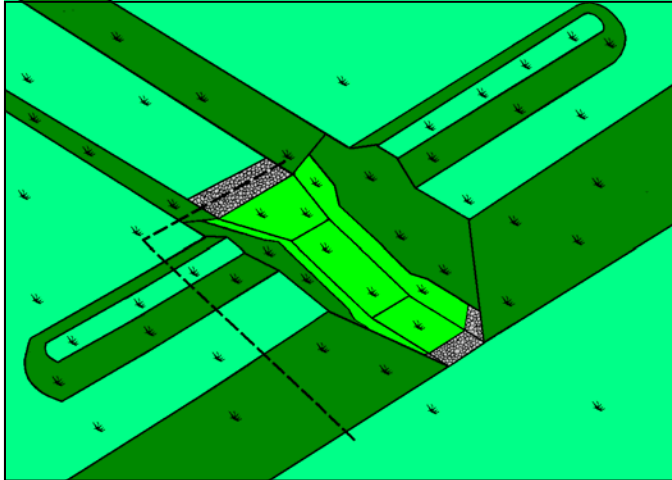
Concrete Block Chute Worksheet



Source: Adapted from USDA, Natural Resources Conservation Service

OUTLET PROTECTION & GRADE STABILIZATION

Reinforced Vegetated Chute



Source: Adapted from USDA, Natural Resources Conservation Service

A reinforced vegetated chute is a storm water conveyance measure consisting of a defined channel lined with a three-dimensional matrix that has been filled with soil material and stabilized with vegetation. It is used to convey water down a steep grade in a nonerosive manner.

Purpose

- To establish a stable grade and prevent erosion and head cutting at the outlet of a conveyance channel.
- To establish an in-channel, stable grade transition and provide for flatter channel grade in the upper and lower reaches of the conveyance channel, thereby reducing flow velocity and reducing potential for in-channel erosion and head cutting at the point of transition.

Specifications

Contributing Drainage Area

20 acres maximum with no base flow (designed by a qualified individual/professional engineer; larger drainage areas may be accommodated, but may require additional design considerations).

Capacity

Runoff from a two-year frequency, 24-hour storm event.

Maximum Overfall

Seven feet.

Diversion Ridge

- Designed and constructed to channel surface water runoff into the concrete block chute.
- Side slopes – 2:1 ratio or flatter.
- Top width – four foot minimum.

REINFORCED VEGETATED CHUTE

Materials

- Erosion control blankets.
- Turf reinforcement mats.
- Indiana Department of Transportation CA No. 5 aggregate (see Appendix D).

Note: INDOT CA No. 8 aggregate is acceptable if No. 5 aggregate is not available.

- Drainage tile
 - To prevent seepage of up-slope groundwater.
 - Offset from center of channel.
 - Minimum of two feet of soil cover over the tile.
 - Animal guard placed on pipe outlet section (as needed).

Installation

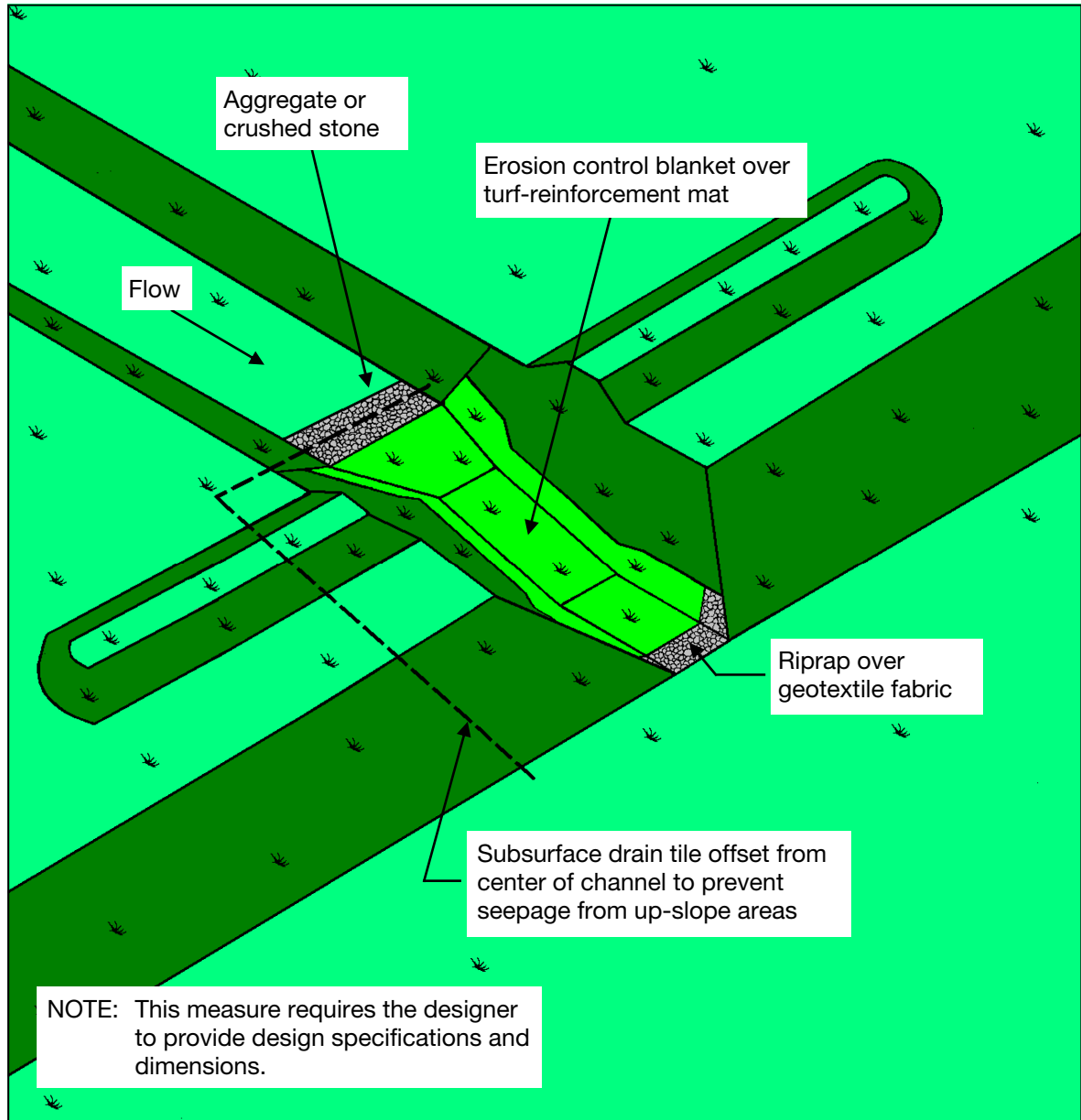
1. Excavate and/or fill and compact the chute foundation and slopes to finished grade. Excavate and/or fill and compact the apron foundations below design elevation to allow for thickness of the filter medium and aggregate. Ensure that the aprons and chute are straight and aligned with the receiving channel.
2. If needed, lay drain tile outside the chute area as shown in Exhibit 1, including outlet pipe section and animal guard.
3. Place INDOT CA No. 5 aggregate such that the inlet and outlet aprons are at zero grade. Construct a small plunge pool in the outlet apron.
4. Install and anchor the turf reinforcement mat according to manufacturer's directions and cover with soil.
5. Immediately following mat installation, permanently seed, fertilize, and install erosion control blankets (see **Erosion Control Blanket** on page 63) according to the manufacturer's directions.
6. Construct a permanent diversion ridge (see **Permanent Diversion** on page 79), according to design capacity, on each side of the reinforced vegetated chute to collect storm water runoff and direct its flow into the chute.

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- During vegetation establishment, inspect for blockage, sediment accumulation and scour holes.
- Remove accumulated sediment and make other repairs as necessary.

REINFORCED VEGETATED CHUTE

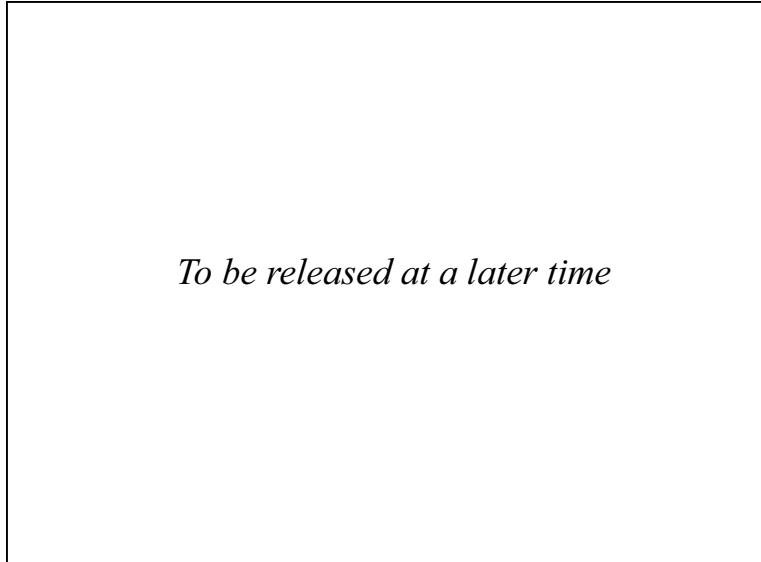
Exhibit 1



Source: Adapted from USDA, Natural Resources Conservation Service

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Pipe Drop Structure



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OUTLET PROTECTION & GRADE STABILIZATION

Toe Wall Structure



To be released at a later time

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TEMPORARY DROP INLET PROTECTION

Urban storm water management systems are efficient carriers of storm water runoff. As such, they are also efficient conduits for carrying sediment and other contaminants suspended in storm water runoff. If proper steps are not taken during the construction phase(s) of a project, these storm water management systems can carry significant amounts of sediment which can lead to siltation of the storm drain system and/or off-site sediment damage. In the worst case scenario, the storm drain system can become plugged with sediment. Cleaning the storm drain system can be extremely difficult and expensive. Therefore it is critical to keep sediment out of the storm drain system.

As was noted in the Surface Stabilization section, reducing erosion at the source is much more effective and efficient than trying to trap suspended sediment in surface water runoff. Timely installation of temporary and permanent soil stabilization measures, such as those listed in the Surface Stabilization section, can greatly reduce erosion and sediment loads and reduce frequency of maintenance operations. Unfortunately this is not always practical or possible.

When erosion cannot be controlled at the source it becomes necessary to implement sediment control measures designed to reduce the amount of sediment entering the storm drain system. The principal behind all sediment control measures is relatively simple. Slow or pond the sediment-laden surface water runoff for a sufficient length of time to allow the suspended soil particles to settle out.

Inlet protection measures should not be the only level of sediment control. It is not the intent of these measures to accommodate or be effective where sediment loading is high. It is important that appropriate sediment control measures are installed in the drainage area above the storm sewer system to reduce excessive sediment loading. The temporary drop inlet protection measures in this section are designed to reduce the amount of sediment entering a storm sewer system. It is extremely important to note that these measures require intensive maintenance and require frequent monitoring, cleanout, repair and/or replacement.

The selection of any type of inlet protection device should be selected on the principal that the storm drain inlet continues to function and carry runoff. Blocking the inlet may result in excessive or prolonged ponding/flooding. Blocking flow may also result in bypass of the storm sewer system that may redirect water to an area that results in erosion or damage to private property.

The measures illustrated in this section are a small representation of drop inlet protection devices that are available. Field modification by contractors of these measures is not uncommon and have proven to be innovative and effective. In addition, there are many types of drop inlet protection available commercially. When selecting or modifying a device it is important that the device used will allow the storm drain to function and carry runoff in the event it plugs or if an excessive storm event occurs.

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TEMPORARY DROP INLET PROTECTION

Excavated Drop Inlet Protection



Excavated drop inlet protection is a temporary sediment control measure consisting of an excavated area around a storm drain drop inlet.

Purpose

To capture sediment at the approach to a storm drain inlet, allowing full use of the storm drain system during the construction period.

Specifications

Contributing Drainage Area

One acre maximum.

Capacity

Runoff from a two-year frequency, 24-hour storm event entering a storm drain without bypass flow.

Pool Area

- Less than one percent slope.
- Side slopes – 2:1 ratio or flatter.
- Excavated Depth – One to two feet measured from the top of the storm drain inlet.
- Storm Water/Sediment Storage Volume (excavated volume) – Minimum of 950 cubic feet.

Dewatering System

- Weep holes in the drop inlet structure.

EXCAVATED DROP INLET PROTECTION

- Geotextile fabric or hardware cloth wrapped around the sides of the drop inlet structure.
- Filter aggregate placed around the drop inlet structure.

Materials

- Geotextile fabric or hardware cloth.
- INDOT CA No. 5 aggregate (see Appendix D).

Note: INDOT CA No. 8 aggregate is acceptable if No. 5 aggregate is not available. The use of No. 8 aggregate may result in more frequent overtopping of the structure and will increase the frequency of structure maintenance.

Installation

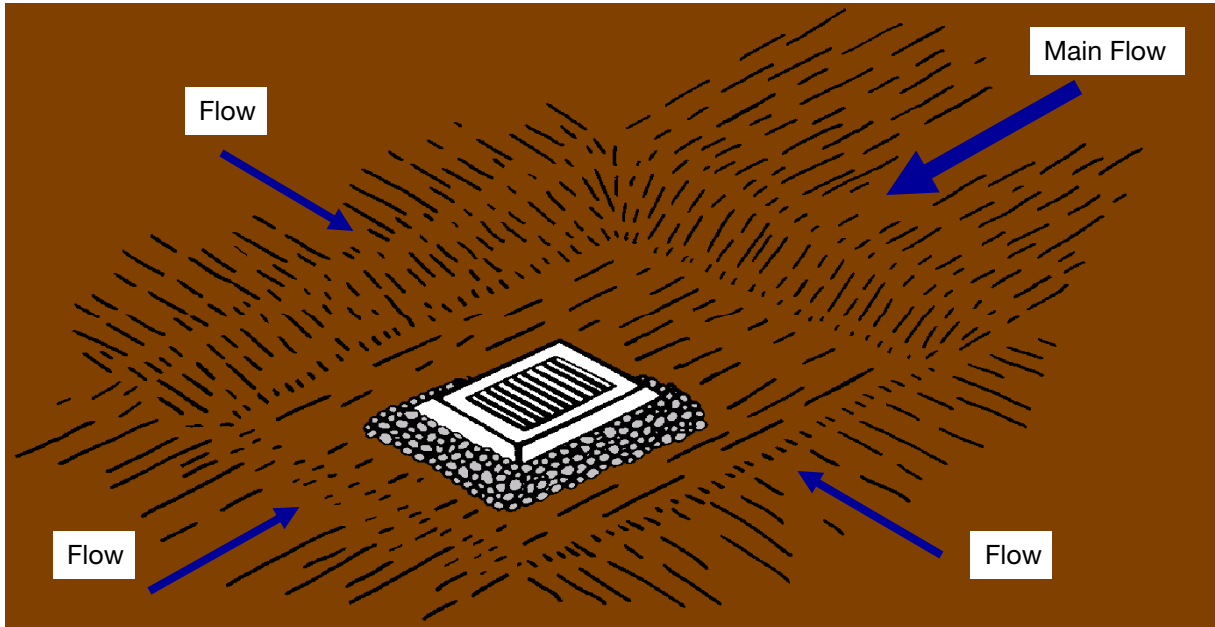
1. Clear the area of all debris.
2. Excavate the pool area with a one to two-foot depth and 2:1 side slopes or flatter. Orient the longest dimension toward the largest inflow (see Exhibit 1).
3. Stockpile or spread excavated soil so it will not block storm water flow or wash back into the excavation. If necessary, spoil may be placed to form a dike on the down-slope side of the excavation to prevent by-pass flow. The dike should be at least six inches higher than the top elevation of the storm drain inlet grate.
4. Install weep holes in the drop inlet structure so the pool drains slowly.
5. Cover the weep holes with geotextile fabric or hardware cloth and at least 12 inches of aggregate (INDOT CA No. 5) to retain the sediment (see Excavated Drop Inlet Protection Worksheet).

Maintenance

- Inspect daily.
- Remove sediment when pool area is approximately one-half full of sediment.
- Remove and replace aggregate if sediment hinders drainage.
- Once contributing drainage area has been permanently stabilized, remove sediment, seal weep holes, fill basin with soil, compact and grade to finished elevation, and stabilize.

EXCAVATED DROP INLET PROTECTION

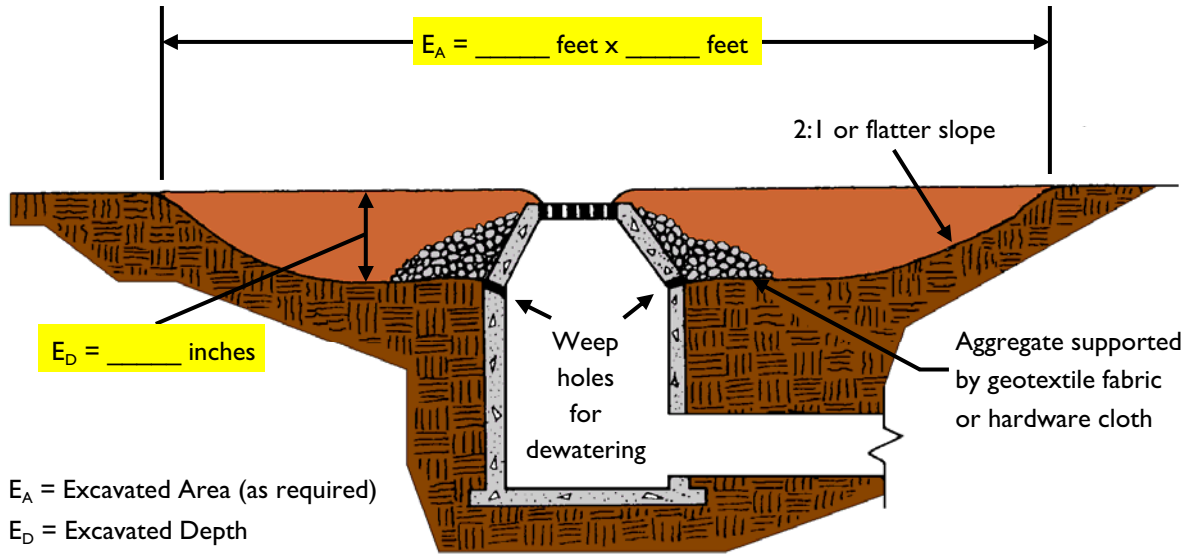
Exhibit 1



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

EXCAVATED DROP INLET PROTECTION

Excavated Drop Inlet Protection Worksheet



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

TEMPORARY DROP INLET PROTECTION

Gravel Donut Drop Inlet Protection



Gravel donut drop inlet protection is a temporary sediment control measure consisting of an aggregate filter barrier placed around a storm drain drop inlet.

Purpose

To trap sediment at the approach to a storm drain inlet, allowing full use of the storm drain system during the construction period.

Specifications

Contributing Drainage Area

One acre maximum.

Capacity

Runoff from a two-year frequency, 24-hour storm event entering a storm drain without bypass flow.

Aggregate Donut (see Exhibits 1 and 2)

- Side Slopes
 - 2:1 ratio or flatter on outside of aggregate donut.
 - 3:1 ratio or flatter on inside of aggregate donut.
- Height – 12 to 24 inches above the top of the storm drain inlet.

Materials

- INDOT uniform B riprap. (see Appendix D).
- INDOT CA No. 5 aggregate. (see Appendix D).

GRAVEL DONUT DROP INLET PROTECTION

Note: INDOT CA No. 8 aggregate is acceptable if No. 5 aggregate is not available. The use of No. 8 aggregate may result in more frequent overtopping of the structure and will increase the frequency of structure maintenance.

Installation

1. Around the outer perimeter of the excavated area, lay a ring of riprap (INDOT uniform B riprap) to a height of 12 to 24 inches above the top of the storm drain inlet. Construct the aggregate donut such that it has a 2:1 or flatter outside slope and a 3:1 or flatter inside slope.
2. Cover the outside face of the aggregate donut with at least a 12-inch thick layer of INDOT CA No. 5 aggregate (for filtration). Maintain a 2:1 or flatter slope.

Note: In situations where storm water may bypass the structure, either:

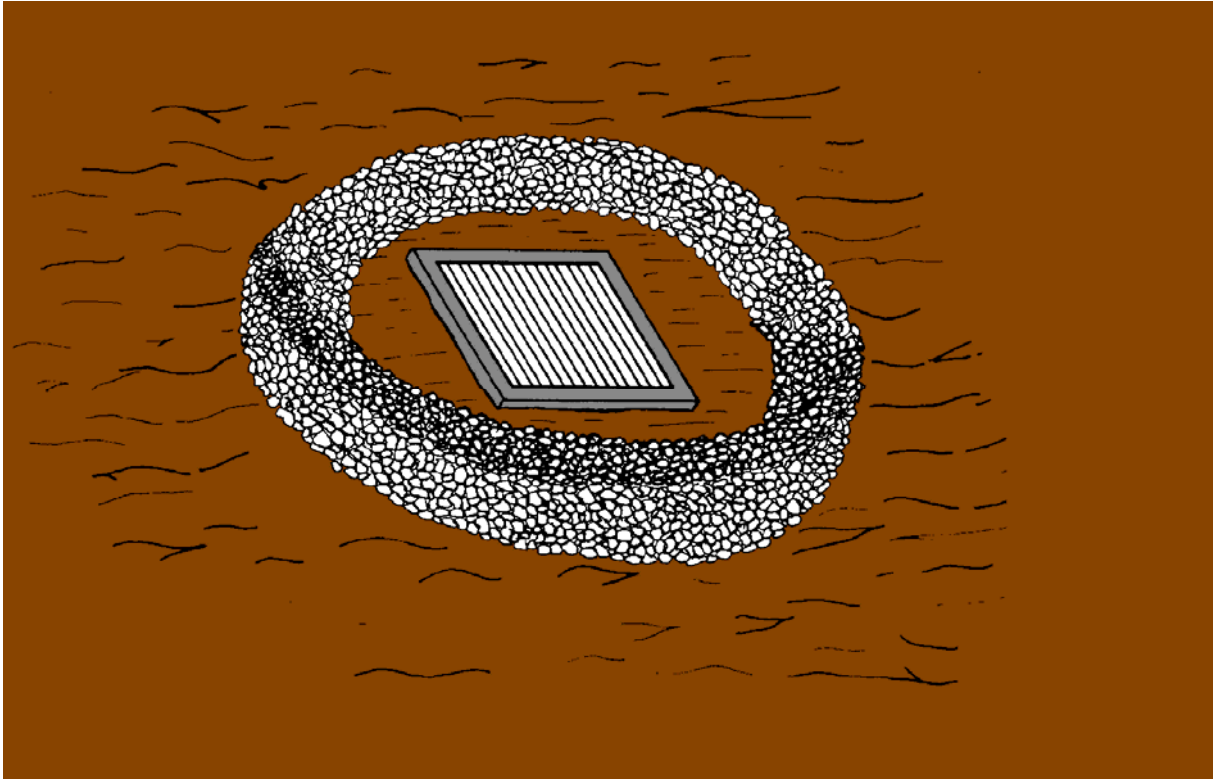
- Set the top of the aggregate donut at least six inches lower than the ground elevation on the down-slope side of the storm drain inlet,
- Build a temporary dike, compacted to six inches higher than the aggregate donut, on the down-slope side of the storm drain inlet, AND/OR
- Use in conjunction with excavated drop inlet protection (see **Excavated Drop Inlet Protection** on page 145).

Maintenance

- Inspect daily.
- Make needed repairs immediately.
- When the contributing drainage area has been stabilized, remove and properly dispose of all sediment and construction material and restabilize.

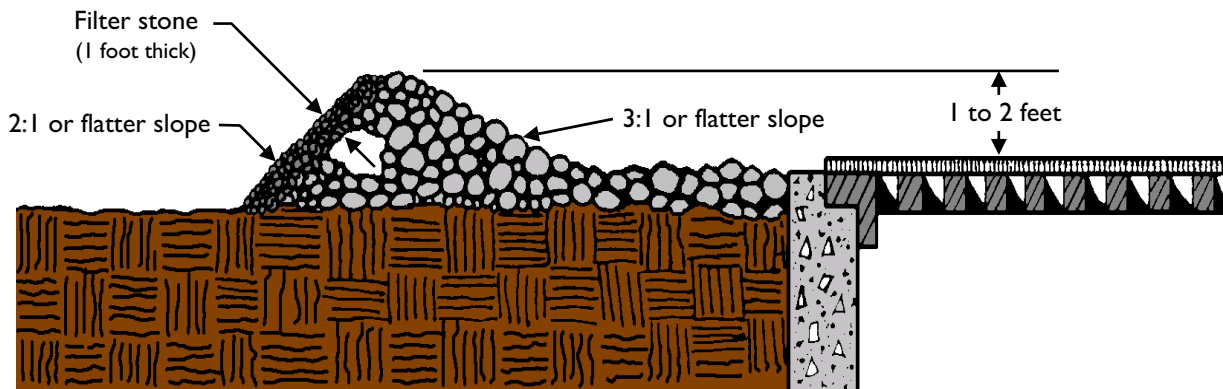
GRAVEL DONUT DROP INLET PROTECTION

Exhibit 1



GRAVEL DONUT DROP INLET PROTECTION

Exhibit 2



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

TEMPORARY DROP INLET PROTECTION

Geotextile Fabric Drop Inlet Protection



Geotextile fabric drop inlet protection is a temporary sediment control measure consisting of a temporary geotextile fabric barrier placed around a storm drain drop inlet.

Purpose

To capture sediment at the entrance to a storm drain inlet, allowing full use of the storm drain system during the construction period.

Note: This measure is not recommended for paved surfaces due to inability to entrench the fabric and lack of an anchoring system.

Specifications

Note: Alternative support systems may be substituted for hardwood posts and cross braces.

Contributing Drainage Area

One acre maximum.

Effective Life

Six months (maximum).

Capacity

Runoff from a two-year frequency, 24-hour storm event entering a storm drain without bypass flow.

Geotextile Structure

- Height – 12 to 18 inches, measured from top of storm drain inlet.
- Post spacing – 36-inch maximum spacing between posts.
- Frame support – bracing to strengthen integrity of the structure. (Structure must withstand 1½-foot head of water and sediment without collapsing or undercutting.)

GEOTEXTILE FABRIC DROP INLET PROTECTION

Materials

- Support posts
 - 2 x 2 inch or 2 x 4 inch hardwood posts.
 - Three feet length, minimum.
- 1 x 2 inch or 1 x 3 inch hardwood cross bracing lumber.
- Lathe.
- Staples or nails.
- Geotextile fabric

Table 1. Geotextile Fabric Specifications

Physical Property	Woven	Non-Woven
Filtering Efficiency	85%	85%
UV Resistance (Inhibitors and stabilizers to ensure six month minimum life at temperatures of 0° to 120° F)	70%	85%
Tensile Strength at 20% Elongation: Standard Strength Extra Strength	30 lbs./linear inch 50 lbs./linear inch	50 lbs./linear inch 70 lbs./linear inch
Slurry Flow Rate	0.3 gal./min./sq. ft.	4.5 gal./min./sq. ft.
Water Flow Rate	15 gal./min./sq. ft.	220 gal./min./sq. ft.

Installation

(see Exhibits 1 and 2)

1. Dig an eight-inch deep, four-inch wide trench around the perimeter of the inlet.
2. If using pre-assembled geotextile fabric and posts, drive the posts into the soil, tightly stretching the geotextile fabric between posts as each is driven. (Posts must be placed on the inlet side of the anchor trench with the geotextile fabric on the side of the trench farthest from the inlet.)

Note: If assembling the geotextile fabric and posts on-site, drive the posts into the soil and then secure the geotextile fabric to the posts by placing a piece of lathe over the fabric and fastening it to the post (stretching the fabric between posts as it is fastened).

GEOTEXTILE FABRIC DROP INLET PROTECTION

3. Use the wrap join method when joining posts (see **Silt Fence** on page 215).
4. Place the bottom 12 inches of geotextile fabric into the eight-inch deep trench, laying the remaining four inches in the bottom of the trench and extending away from the inlet.
5. Backfill the trench with soil material and compact it in place.
6. Brace the posts by nailing braces into each corner post or utilize rigid panels to support fabric.

Note: In situations where storm water may bypass the structure, either:

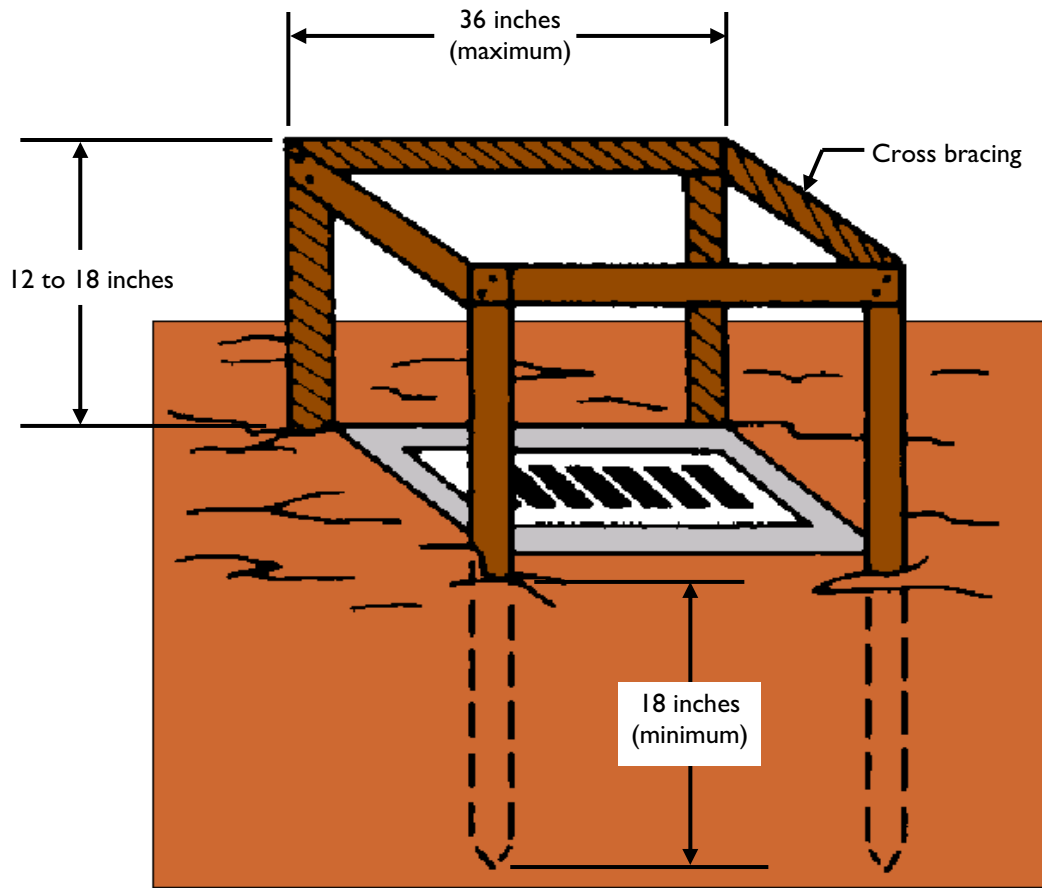
- Set the top of the geotextile fabric filter at least six inches lower than the ground elevation on the down-slope side of the storm drain inlet,
- Build a temporary dike, compacted to six inches higher than the fabric, on the down-slope side of the storm drain inlet, AND/OR
- Use in conjunction with excavated drop inlet protection (see **Excavated Drop Inlet Protection** on page 145).

Maintenance

- Inspect daily.
- Inspect geotextile fabric and make needed repairs immediately.
- Remove sediment from pool area to provide storage for the next storm event. Avoid damaging or undercutting fabric during sediment removal.
- When contributing drainage area has been stabilized, remove sediment, properly dispose of all construction material, grade area to the elevation of the storm drain inlet top, then stabilize immediately.

GEOTEXTILE FABRIC DROP INLET PROTECTION

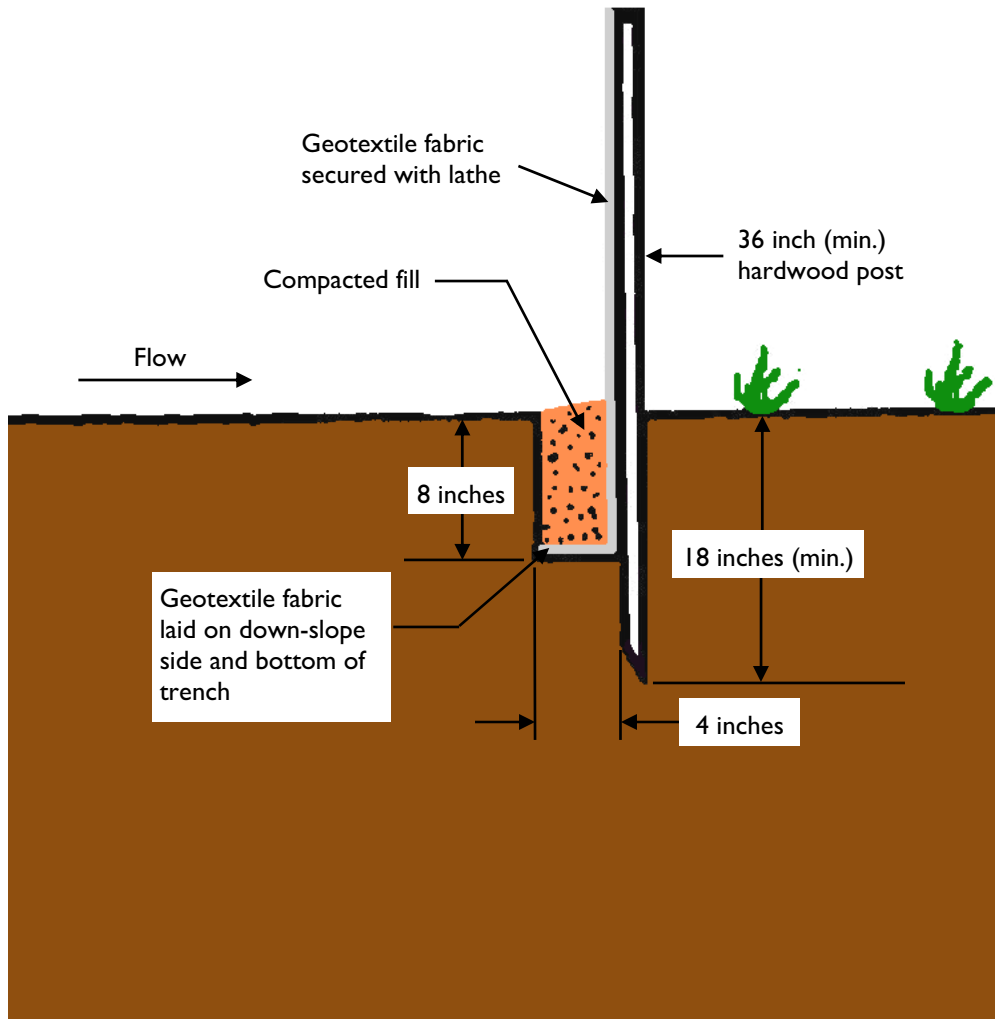
Exhibit 1



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

GEOTEXTILE FABRIC DROP INLET PROTECTION

Exhibit 2



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TEMPORARY DROP INLET PROTECTION

Straw Bale Drop Inlet Protection



Straw bale drop inlet protection is a temporary sediment control measure consisting of straw bales placed around a storm drain drop inlet.

Purpose

To capture sediment at the inlet to a storm drain, allowing full use of the drain system during the construction period.

Note: This measure is not recommended for paved surfaces due to inability to entrench the bales and lack of an anchoring system.

Specifications

Contributing Drainage Area

One acre maximum.

Effective Life

Less than three months.

Capacity

Runoff from a two-year frequency, 24-hour storm event entering a storm drain without bypass flow.

Barrier Height

Fourteen inches above top elevation of the storm drain inlet.

STRAW BALE DROP INLET PROTECTION

Materials

- Straw or hay bales approximately 14 inches by 18 inches by 36 inches.
- Thirty-six inch long (minimum) steel rebar or 2 x 2 inch hardwood stakes.

Installation

(see Exhibits 1 and 2)

1. Excavate a trench at least four inches deep and a bale's width around the inlet.
2. Place bales lengthwise in the trench so the bindings are oriented around the sides, rather than top and bottom, to minimize deterioration of the bindings.
3. Allow bales to overlap at the corners, and **abut them tightly against each other** (see Exhibit 1).
4. Anchor the bales in place by driving two 36-inch long steel rebar or 2 x 2 inch hardwood stakes through each bale until nearly flush with the top. Drive the first stake at an angle towards the previously laid bale to force the bales together (see Exhibits 1 and 2).
5. Chink (tightly wedge) straw into any gaps between bales to prevent sediment-laden water from flowing between the bales and directly into the inlet.
6. Backfill excavated soil material, four inches high, against the outside perimeter of the straw bale barrier and compact in place.

Note: In situations where storm water may bypass the structure, either:

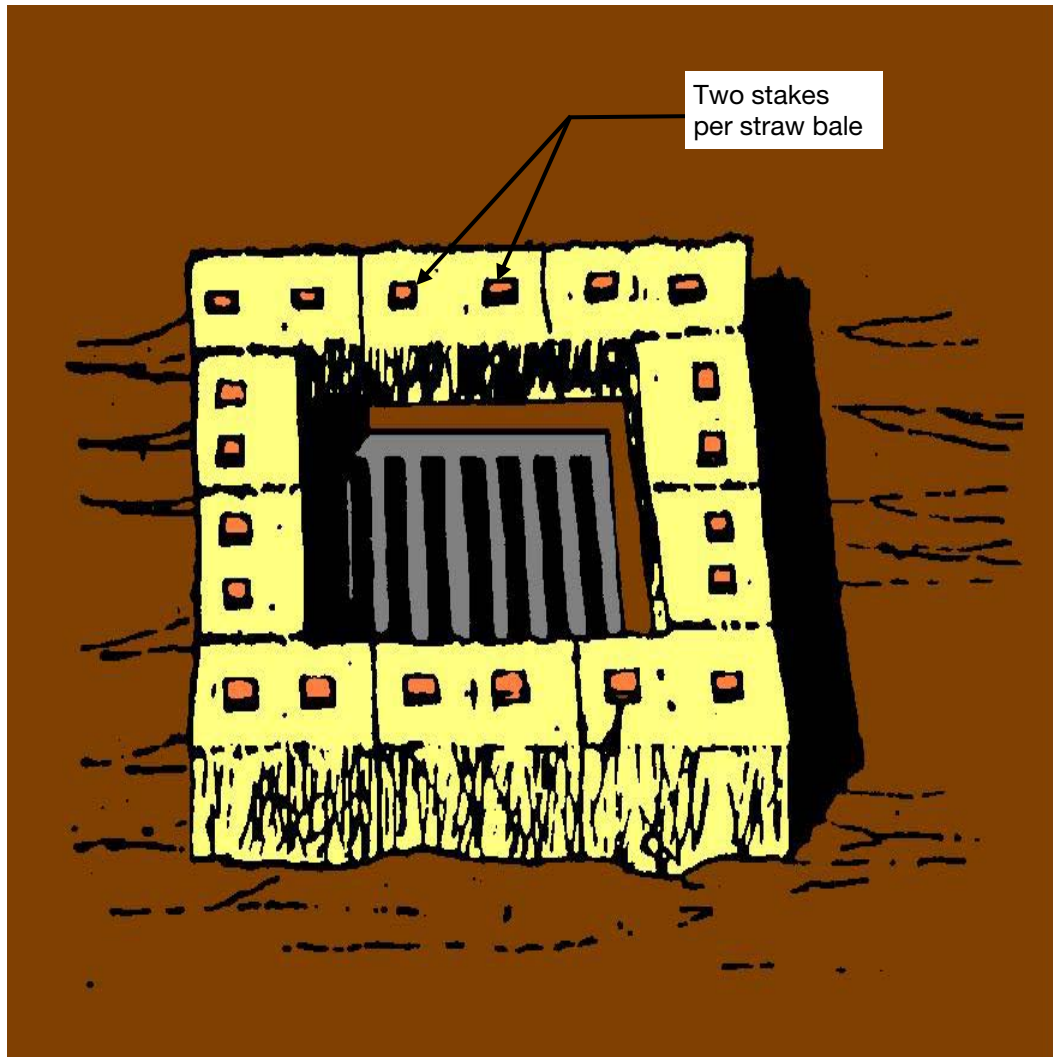
- Set the top of the straw/hay bales at least six inches lower than the ground elevation on the down-slope side of the storm drain inlet,
- Build a temporary dike, compacted to six inches higher than the straw/hay bales, on the down-slope side of the storm drain inlet, AND/OR
- Use in conjunction with excavated drop inlet protection (see **Excavated Drop Inlet Protection** on page 145).

Maintenance

- Inspect daily.
- Remove sediment and debris from the pool area to ensure adequate storm water runoff storage from the next rain, taking care to not damage or undercut the bales.
- When the contributing drainage area has been stabilized, remove and properly dispose of accumulated sediment, all bales, and construction materials. Grade the disturbed area to the elevation of the top of the storm drain inlet and stabilize.

STRAW BALE DROP INLET PROTECTION

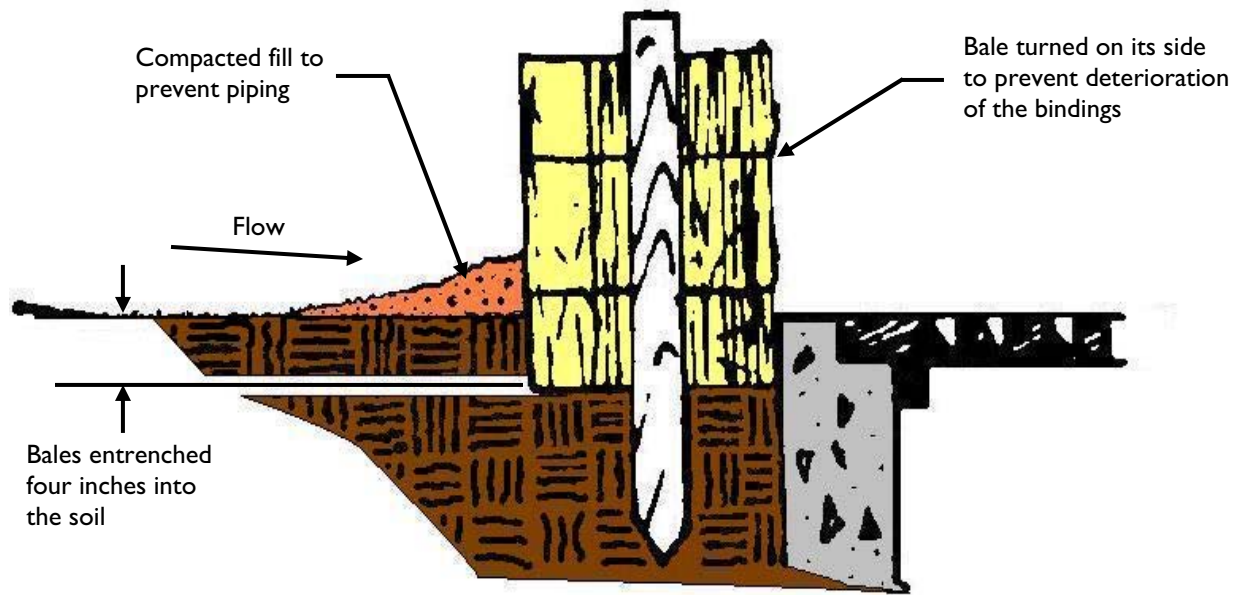
Exhibit 1



Source: Adapted from Michigan Soil Erosion and Sedimentation Control Guidebook, 1975

STRAW BALE DROP INLET PROTECTION

Exhibit 2



Source: Adapted from Michigan Soil Erosion and Sedimentation Control Guidebook, 1975

TEMPORARY DROP INLET PROTECTION

Block & Gravel Drop Inlet Protection



Block and gravel drop inlet protection is a temporary sediment control measure consisting of standard concrete blocks and aggregate placed around a storm drain drop inlet.

Purpose

To trap sediment at the approach to a storm drain inlet, allowing full use of the storm drain system during the construction period.

Specifications

Contributing Drainage Area

One acre maximum.

Capacity

Runoff from a two-year frequency, 24-hour storm event entering a storm drain without bypass flow.

Barrier Height

Two standard eight-inch concrete blocks.

Aggregate Blanket

- Side slopes – 2:1 ratio or flatter.

Sediment Dewatering Structure

- One or more concrete blocks in the bottom row placed with openings horizontal to ground surface.
- Covered with hardware cloth and aggregate to control drainage rate.

BLOCK & GRAVEL DROP INLET PROTECTION

Materials

- Standard eight-inch concrete blocks.
- INDOT CA No. 5 aggregate (see Appendix D).

Note: INDOT CA No. 8 aggregate is acceptable if No. 5 aggregate is not available. The use of No. 8 aggregate may result in more frequent overtopping of the structure and will increase the frequency of structure maintenance.

- Hardware cloth.

Installation

1. Excavate the foundation for the concrete blocks on level grade and at least two inches below the top of the storm drain inlet.
2. Place the bottom row of concrete blocks around the perimeter of the storm drain. Lay blocks with openings facing up, abutting the blocks firmly together and overlapping the corners (see Exhibit 1).
3. If necessary, support the blocks by driving sharpened 2 x 4 inch wood studs or rebar (not mortar) through the block openings and into the underlying soil.
4. On each side of the bottom row, turn one concrete block with its openings facing horizontally to allow for dewatering.
5. Place hardware cloth over the openings to hold the aggregate in place (see Exhibit 2).
6. Place the filter medium (INDOT CA No. 5 aggregate) around the outside of the concrete blocks to control drainage rate; limit filter medium side slopes to 2:1 ratio or flatter.

Note: In situations where storm water may bypass the structure, either:

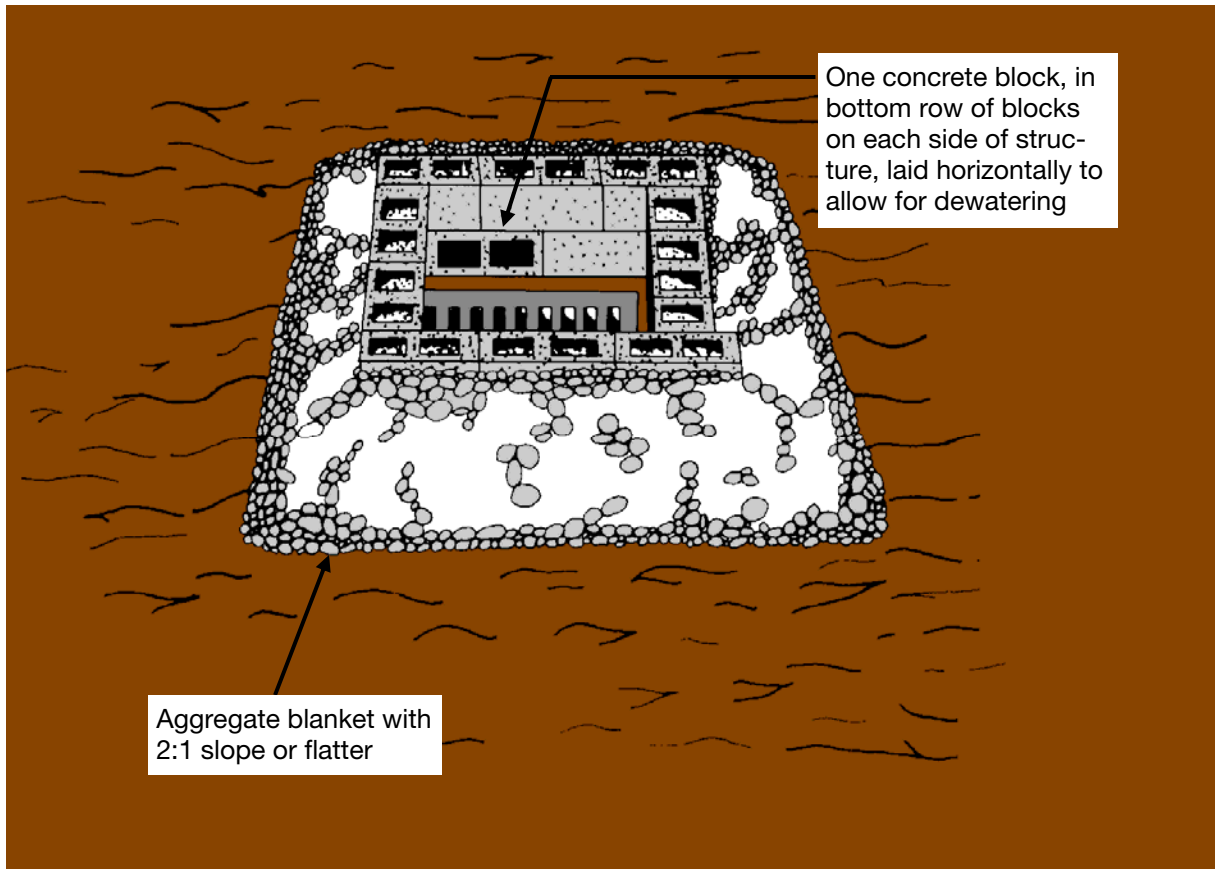
- Set the top of the concrete blocks at least six inches lower than the ground elevation on the down-slope side of the storm drain inlet,
- Build a temporary dike, compacted to six inches higher than the concrete blocks, on the down-slope side of the storm drain inlet, AND/OR
- Use in conjunction with excavated drop inlet protection (see **Excavated Drop Inlet Protection** on page 145).

Maintenance

- Inspect daily.
- Remove sediment and debris and make needed repairs immediately.
- When the contributing drainage area has been stabilized, remove and properly dispose of all construction material and sediment, then stabilize.

BLOCK & GRAVEL DROP INLET PROTECTION

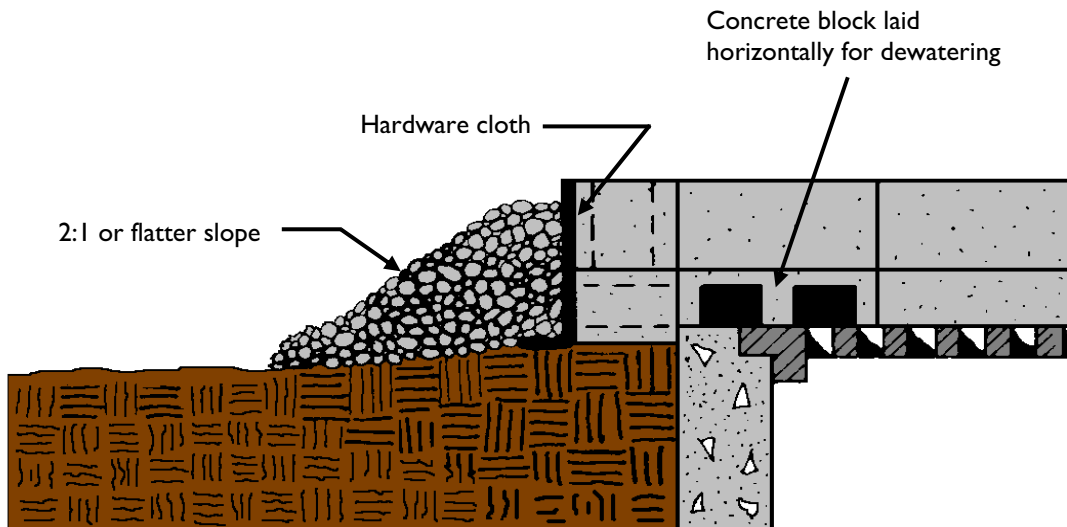
Exhibit 1



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

BLOCK & GRAVEL DROP INLET PROTECTION

Exhibit 1



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

TEMPORARY CURB & PAVED AREA INLET PROTECTION

Storm water management systems are efficient carriers of storm water runoff. As such, they are also efficient conduits for carrying sediment and other contaminants suspended in storm water runoff. If proper steps are not taken during the construction phase(s) of a project, these storm water management systems can carry significant amounts of sediment which can lead to siltation of the storm drain system and/or off-site sediment damage. In the worst case scenario, the storm drain system can become plugged with sediment. Cleaning the storm drain system can be extremely difficult and expensive. Therefore it is critical to keep sediment out of the system.

Reducing erosion at the source is much more effective and efficient than trying to trap suspended sediment in surface water runoff. Timely installation of temporary and permanent soil stabilization measures, such as those listed in Surface Stabilization section on pages 29–72, can greatly reduce erosion and sediment loads and reduce frequency of maintenance operations. Unfortunately, this is not always practical or possible.

When erosion cannot be controlled at the source it becomes necessary to implement sediment control measures designed to reduce the amount of sediment entering paved areas and the storm drain system. The principal behind all sediment control measures is relatively simple. Slow or pond the sediment-laden surface water runoff for a sufficient length of time to allow the suspended soil particles to settle out.

The measures in this section have been designed to reduce the amount of sediment entering a storm sewer system. These measures are intended to trap residual sediments that are either tracked or inadvertently deposited in paved areas. It is not the intent of these measures to accommodate or be effective where sediment loading is high. Every effort should be made to prevent or at the very least minimize the amount of sediment entering the paved area, either via sediment-laden surface water runoff or tracking from vehicles. Preventing sediment from entering paved areas will require the installation of many other measures listed in other subsections of Chapter 7.

It is extremely important to note that these measures require intensive maintenance and require frequent monitoring, cleanout, repair and/or replacement. Where applicable, traffic barricades should also be installed around curb and paved area inlet protection measures to prevent vehicles from hitting the protection devices.

The selection of any type of inlet protection should be based on the principal that the storm drain inlet continue to function and to carry runoff. Blocking the inlet may result in excessive or prolonged ponding/flooding. Blocking flow may also result in bypass of the storm sewer system that may redirect water to an area that results in erosion or damage to private property.

The measures illustrated in this section are a small representation of inlet protection devices that are available for use in curb and paved areas. Field modification by contractors of these measures is not uncommon and have proven to be innovative and effective. In addition, there are many types of curb/paved inlet protection devices available commercially. When selecting or modifying a device it is important that the device used will allow the storm drain to function and carry runoff in the event it plugs or an excessive storm event occurs.

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TEMPORARY CURB & PAVED AREA INLET PROTECTION

Stone Bag Curb Inlet Protection



Stone bag curb inlet protection is a temporary sediment control measure consisting of bags filled with gravel or aggregate and placed around a storm drain curb inlet.

Purpose

- To minimize sediment from entering storm sewer curb inlets while allowing full use of the storm drainage system during construction activities.
- To trap sediment on paved streets that receive relatively small runoff flows.

Note: This measure should be used in conjunction with other sediment control measures.

Specifications

Contributing Drainage Area

One acre maximum.

Capacity

Runoff from a two-year frequency, 24-hour storm event entering a storm drain without bypass flow.

Location

- At curb inlets on paved roads where ponding is likely to occur without bypass flow.
- Down grade from construction activities (e.g., individual home sites).
- Up-slope side of storm drain inlets.
- Around storm drain inlets in sump (depressional) areas.

STONE BAG CURB INLET PROTECTION

Barrier

- Height – One to three layers of bags (as necessary).
- Length – Three feet minimum (or as needed to intercept runoff).

Materials

- Bags – UV-stabilized geotextile fabric.
- Traffic Barricades – As needed, to prevent vehicles from hitting the barrier.
- Gravel or INDOT CA No. 5 washed aggregate.

Note: Gravel or aggregate must be larger than storm sewer grate openings to prevent it from falling into the storm sewer in the event a bag breaks.

Installation

1. Fill bags approximately one-half full with washed gravel or aggregate.
2. For inlets located on a slope gradient (see Exhibit 1):
 - a. At a position(s) up slope of the inlet, lay bags tightly in a row curving up slope from the inlet and away from the curb.
 - b. Overlap bags onto the curb and extend a minimum of three feet into the street, keeping bags tightly abutted together.
 - c. For additional layers of bags, overlap the bags with the row beneath and leave a one-bag gap (at or below curb height) in the middle of the top row to serve as a spillway. If the spillway height is higher than the top of the curb, place additional bags along the curb to prevent bypass flow.
 - d. For additional storage capacity, construct a series of stone bag barriers along the curb so each one traps small amounts of sediment.
3. For inlets located in a depressional (sump) position (see Exhibit 2):
 - a. Place bags in an arc around the curb inlet.
 - b. Overlap bags onto the curb, keeping bags tightly abutted together.
 - c. For additional layers of bags, overlap the bags with the row beneath and leave a one-bag gap (at or below curb height) in the middle of the top row to serve as a spillway. If the spillway height is higher than the top of the curb, place additional bags along the curb to prevent bypass flow.
4. Place a traffic barricade at each installed measure for safety and to protect measure integrity.

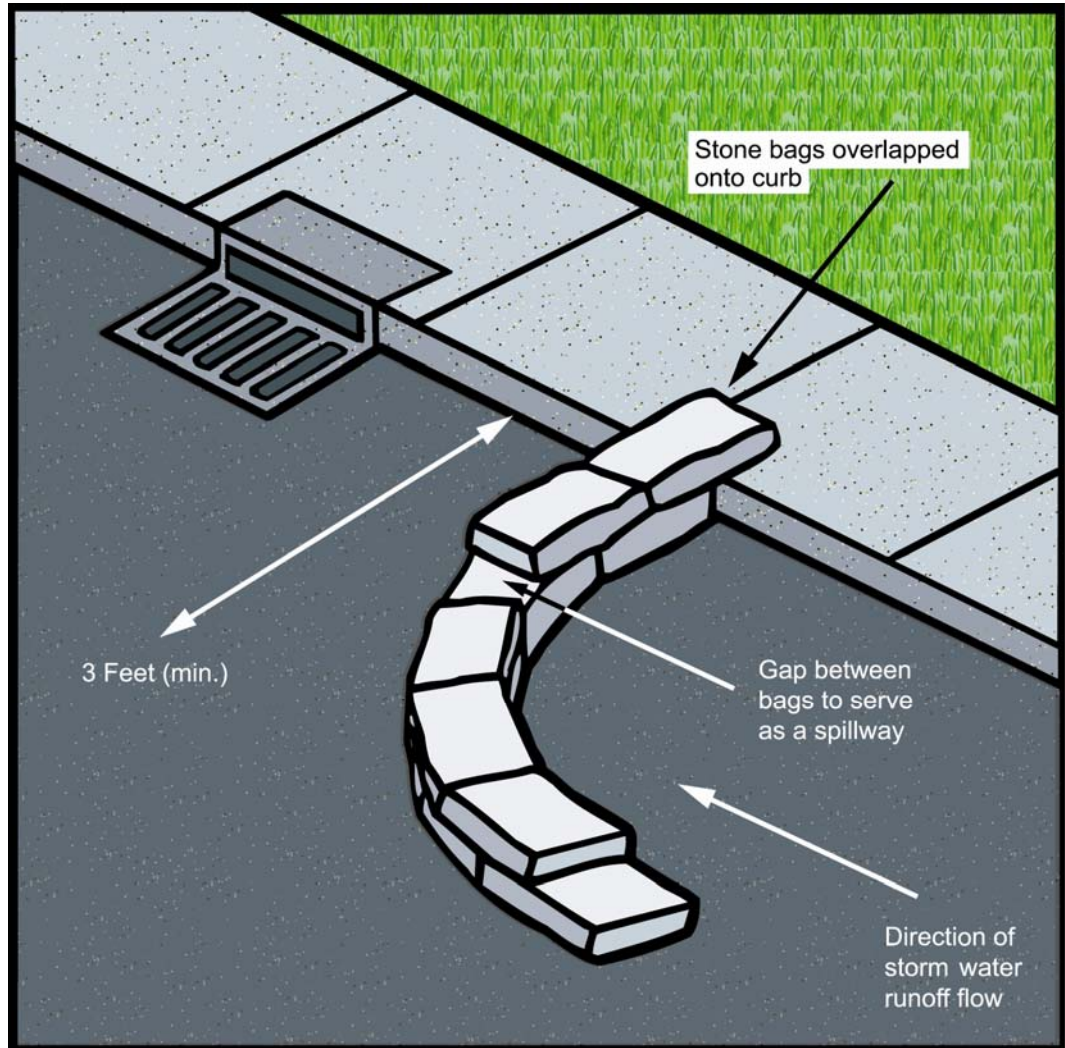
Maintenance

- Inspect daily.
- Remove accumulated sediment from paved area (**do not flush with water**) after each storm event. Deposit sediment in an area where it will not re-enter the paved area or storm drains.

STONE BAG CURB INLET PROTECTION

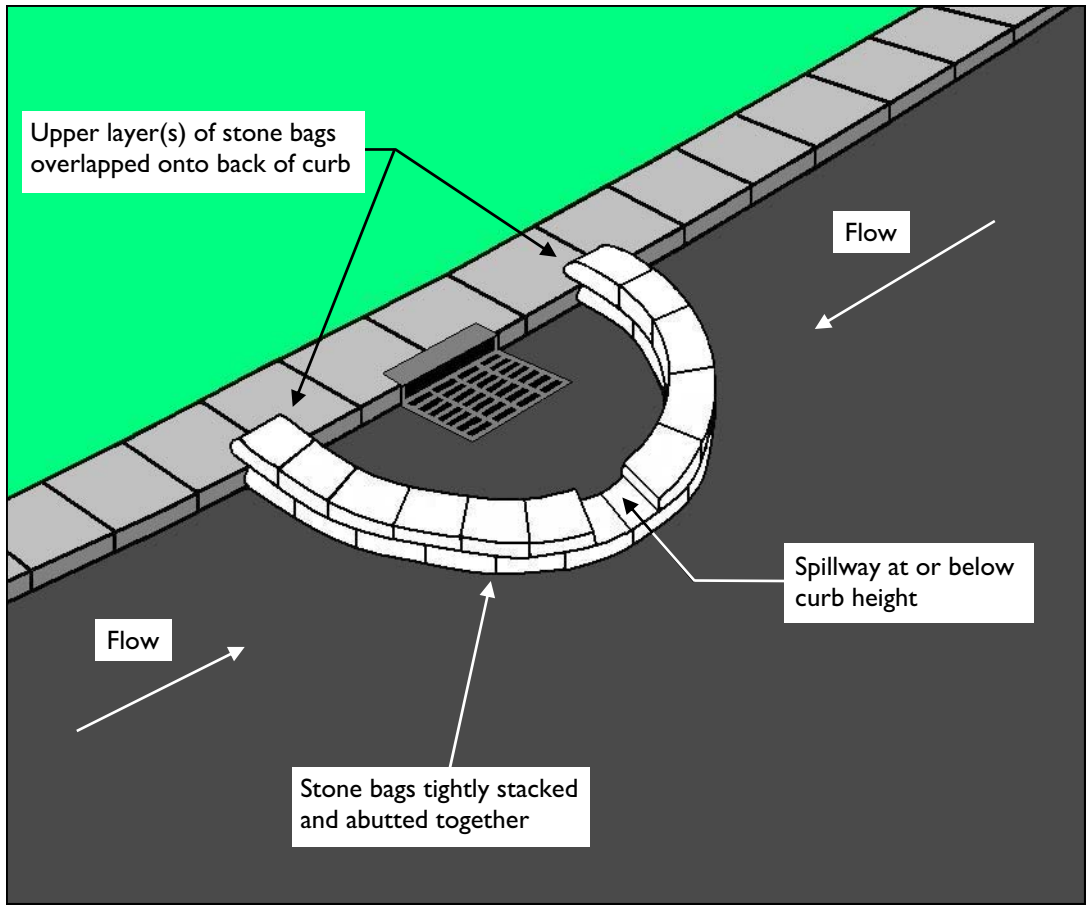
- Inspect for damage by vehicular traffic and repair if needed.
- When the contributing drainage areas have been stabilized, remove inlet protection.

Exhibit 1



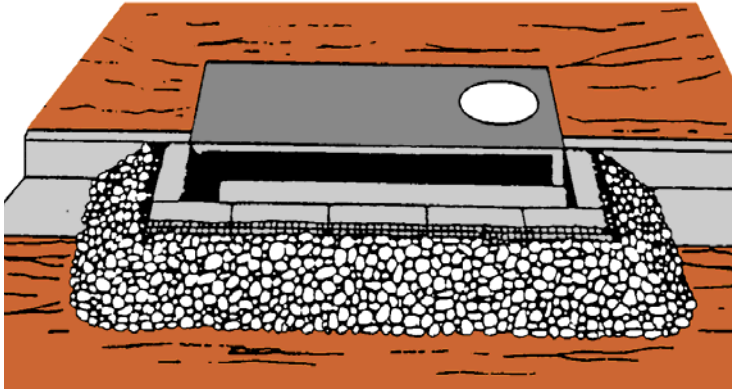
STONE BAG CURB INLET PROTECTION

Exhibit 2



TEMPORARY CURB & PAVED AREA INLET PROTECTION

Block & Gravel Curb Inlet Protection



Block and gravel curb inlet protection is a temporary sediment control measure consisting of concrete blocks and aggregate placed around a storm drain curb inlet.

Source: Adapted from Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation

Purpose

- To minimize sediment from entering storm sewer curb inlets while allowing full use of the storm drainage system during construction activities.
- To minimize ponding at an inlet.

Note: Use this measure only where traffic would not be adversely affected.

Specifications

Contributing Drainage Area

One acre maximum.

Capacity

Runoff from a two-year frequency, 24-hour storm event entering a storm drain without bypass flow.

Location

At curb inlets on paved roads where ponding is likely to occur without bypass flow.

Materials

- Standard eight-inch concrete blocks.
- Hardware cloth with ½-inch openings.
- INDOT CA No. 5 aggregate (see Appendix D).

BLOCK & GRAVEL CURB INLET PROTECTION

Note: INDOT CA No. 8 aggregate is acceptable if No. 5 aggregate is not available. The use of No. 8 aggregate may result in more frequent overtopping of the structure and will increase the frequency of structure maintenance.

- Traffic Barricades – as needed, to prevent vehicles from hitting the barrier.

Installation

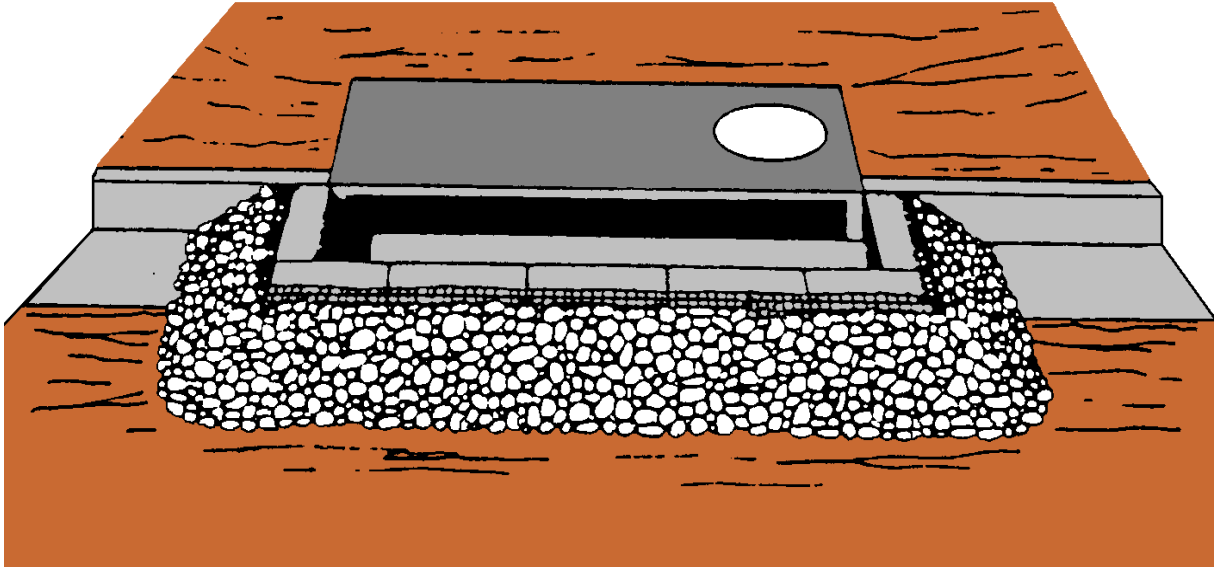
1. At each side of the storm drain inlet, place a concrete block (to serve as a spacer block) lengthwise out from the curb with block openings parallel to the street surface.
2. Place a row of concrete blocks (openings parallel to the street surface) across the front of the inlet and abutting the spacer blocks.
3. Cut a 2 x 4 inch wood stud equal to the length of the inlet plus spacer blocks. Insert the wood stud through the street-side opening of the spacers to keep the row of blocks ahead of it from being pushed back toward the inlet (see Exhibit 2).
4. Run hardware cloth from the top of the blocks, down the outside vertical face and extend to about 12 inches into the street (see Exhibit 2).
5. Place INDOT CA No. 5 aggregate (for filtration) over the hardware cloth on the outside face of the concrete block barrier, covering it to the top of the blocks. If the top of the curb is rounded over, use extra hardware cloth and aggregate to fill in the space between the spacer blocks and the curb.
6. Place a traffic barricade at each installed measure for safety and to protect measure integrity.

Maintenance

- Inspect daily.
- Remove accumulated sediment and replace aggregate as needed to maintain flow.
- Remove accumulated sediment from paved area (**do not flush with water**) after each storm event.
- Deposit sediment in an area where it will not re-enter the paved area or storm drains. When the contributing drainage area has been stabilized, remove and properly dispose of accumulated sediment, aggregate, hardware cloth, and concrete blocks.

BLOCK & GRAVEL CURB INLET PROTECTION

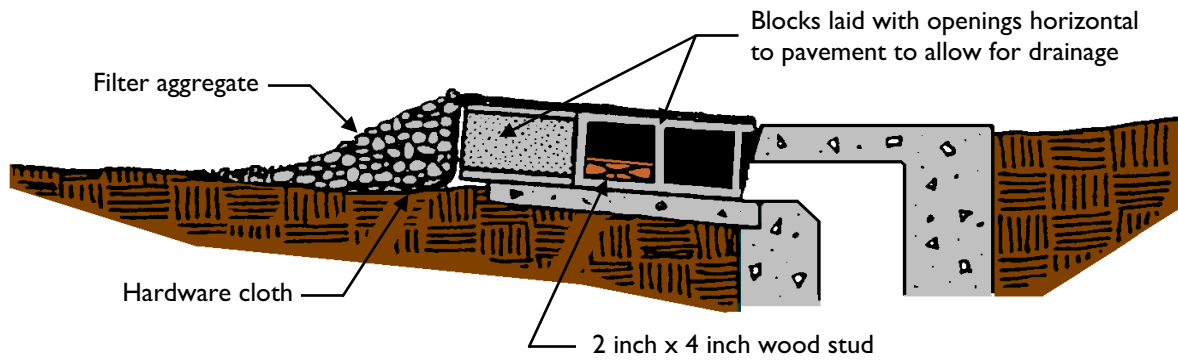
Exhibit 1



Source: Adapted from Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation

BLOCK & GRAVEL CURB INLET PROTECTION

Exhibit 2



TEMPORARY CURB & PAVED AREA INLET PROTECTION

Insert (Basket) Curb Inlet Protection

Insert (basket) curb inlet protection is a temporary sediment control measure consisting of a metal frame or basket that is used to support a geotextile fabric. The system is installed under the storm sewer grate.



Purpose

To minimize sediment from entering the storm sewer system while allowing runoff to enter the storm sewer system in the event of excessive storm events. This measure traps sediment associated with small storm events below the grade of the paved area. This measure does not place an obstruction in the street to trap sediment and is especially conducive to stages of construction when the public has access to the project site.

Note: This measure should be used in conjunction with other sediment control measures.

Specifications

Contributing Drainage Area:

One-quarter acre maximum.

Capacity

Runoff from a two-year frequency, 24-hour storm event entering a storm drain without bypass flow.

INSERT (BASKET) CURB INLET PROTECTION

Location

- At curb inlets on paved roads and parking lots.
- Down grade from construction activities (e.g., individual home sites).

Materials

- Metal frame or basket with a top width and length such that the frame fits into the inlet. (The frame is supported by the structural integrity of the storm sewer.)
- The metal frame or geotextile should be designed with a bypass to allow storm water to flow into the storm sewer system during excessive storm events.
- The system should be designed for ease of maintenance.
- Geotextile fabric.

Table 1. Geotextile Fabric Specifications

Physical Property	Woven	Non-Woven
Filtering Efficiency	85%	85%
UV Resistance (Inhibitors and stabilizers to ensure six month minimum life at temperatures of 0° F to 120° F)	70%	85%
Tensile Strength at 20% Elongation: Standard Strength Extra Strength	30 lbs./linear inch 50 lbs./linear inch	50 lbs./linear inch 70 lbs./linear inch
Slurry Flow Rate	0.3 gal./min./sq. ft.	4.5 gal./min./sq. ft.
Water Flow Rate	15 gal./min./sq. ft.	220 gal./min./sq. ft.

Installation

1. Remove the storm sewer grate and place the frame into the grate opening.
2. Place geotextile fabric into the frame and secure according to the manufacturer's recommendations.
3. Replace the storm sewer grate.

INSERT (BASKET) CURB INLET PROTECTION

Maintenance

- Inspect daily.
- Remove accumulated sediment and debris after each storm event. Deposit sediment in an area where it will not re-enter the paved area or storm drains.
- Replace or clean geotextile fabric as needed.
- When the contributing drainage area has been stabilized, remove inlet protection.

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SEDIMENT TRAPS & BASINS

Reducing erosion at the source is much more effective and efficient than trying to trap suspended sediment in surface water runoff. Timely installation of temporary and permanent soil stabilization measures, such as those listed in the Surface Stabilization section on pages 29–72, can greatly reduce erosion and sediment loads and reduce frequency of maintenance operations. However, this is not always practical or possible.

When erosion cannot be controlled at the source it becomes necessary to implement sediment control measures designed to collect, control, and treat the resultant sediment-laden surface water runoff. The principal behind all sediment control measures is relatively simple. Slow or pond the sediment-laden surface water runoff for a sufficient length of time to allow the suspended soil particles to settle out.

The measures in this section have been designed specifically to collect and temporarily retain sediment-laden surface water runoff for a specified time to allow suspended soil particles to settle out. These systems do not provide efficiency levels to remove all soil particles that are contained in runoff. The overall effectiveness of these measures can be improved by utilizing additional erosion and sediment control measures within the same drainage area.

These measures are intended for use on large areas and where there are concentrated flows. Often, other measures such as temporary and permanent diversions (designed to collect and channel surface water runoff) must be used in conjunction with these measures.

Designs for sediment traps and basins can be complex and in many cases may require detailed site investigations and the application of sound engineering principles. A professional knowledgeable of the principles of storm water management and experienced in structural design should be consulted when using these measures.

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SEDIMENT TRAPS & BASINS

Temporary Sediment Trap



A temporary sediment trap is a sediment control measure consisting of a small, temporary settling basin formed by construction of an embankment and/or excavated basin with an outlet control structure.

Purpose

- To minimize sediment release from construction areas by pooling (retaining) storm water runoff and allowing sufficient retention time for settling of suspended soil particles.
- To minimize offsite sedimentation by trapping sediment at designated locations accessible for cleanout.

Specifications

Drainage Area

Five acres maximum (designed by a qualified individual/professional engineer; larger drainage areas may be accommodated but may require additional design considerations).

Structure Life

Typically two years.

Pool Area

- Sediment Storage Volume – minimum of 1,800 cubic feet per acre of watershed's **total** contributing drainage area.
- Surface Area – variable (the larger the surface area, the greater the trapping efficiency).
- Side Slopes – 2:1 ratio or flatter.

TEMPORARY SEDIMENT TRAP

- Bring storm drain pipe and channel discharges into the sediment trap at a low velocity.
- Shape – length to width ratio of 2:1 or greater.
- Flow Path Length – locate concentrated storm water inflow(s) as far away from the sediment trap outlet as possible (provides for maximum flow path length, detention time, and pollutant removal).
- Dewatering – pond should completely drain within 48 to 72 hours of a storm water runoff event.

Embankment

- Fill Material
 - Stable mineral soil.
 - Machine compacted in six to eight-inch lifts while the earth fill is still moist.
- Height – five feet maximum.
- Top width – five feet minimum.
- Side slopes – 2:1 ratio or flatter.

Outlet

- Capacity – routed two-year frequency, 24-hour duration storm event.
- Spillway
 - Depth – minimum of 1½ feet below top of settled embankment.
 - Bottom Width – based on drainage area as shown in Table 1.
 - Side Slopes – 2:1 ratio or flatter.
 - Inside face lined with a 12-inch thick layer of INDOT CA No. 5 aggregate.
 - Protection From Piping – Cut-off trench between stone spillway outlet section and compacted embankment with geotextile fabric for separation.

Table 1. Temporary Sediment Trap Spillway Design Specifications

Drainage Area	Minimum Bottom Width
1 acre	4 feet
2 acres	6 feet
3 acres	8 feet
4 acres	10 feet
5 acres	12 feet

TEMPORARY SEDIMENT TRAP

- Apron
 - Grade – level, where feasible, with filter fabric foundation to ensure exit velocity is nonerosive.
 - Length – based on outlet size, location, and grade [see **Energy Dissipater (Outlet Protection)** on page 121] but no shorter than five feet.
 - Plunge pool (optional) – used to reduce discharge velocities.

Materials

- INDOT revetment riprap (see Appendix D).
- INDOT CA No. 5 aggregate (see Appendix D).

Note: INDOT CA No. 8 aggregate is acceptable if No. 5 aggregate is not available. The use of No. 8 aggregate may result in more frequent overtopping of the structure and will increase the frequency of structure maintenance.

- Geotextile fabric.
- Cleanout reference stake(s).

Installation

Location and Layout

1. Locate the sediment trap as near to the sediment source as topography allows.
2. Lay out the location and shape of the sediment trap allowing for a length to width ratio of 2:1 or greater.
3. Locate concentrated storm water inflows as far away from the sediment trap outlet as possible.
4. Where applicable, divert runoff from adjoining, undisturbed areas away from the sediment trap and install downstream sediment control measures to prevent off-site damages during construction of the sediment trap.

Embankment

1. Clear, grub, and strip all vegetation and root mat from the embankment area.
2. Construct the embankment in six to eight-inch lifts, compacting each lift as it is placed. Construct the embankment with 2:1 or flatter side slopes. (Material used to construct the embankment must be a stable mineral soil that is free of rocks, brush, roots, and other debris. The soil material must be wet enough to form a ball without crumbling, yet not so wet that water can be squeezed out of it. Place the most permeable soil material in the downstream toe of the embankment and the least permeable material in the center and on the up slope

TEMPORARY SEDIMENT TRAP

side of the embankment. To improve stability of the stone spillway, 3:1 side slopes are recommended for the embankment back slope.)

3. Construct the embankment six inches above design elevation to allow for settling.

Outlet

1. Excavate a trapezoidal outlet section in the compacted embankment. Excavate the outlet section to the base of the pool area.
2. Install geotextile fabric in the trapezoidal outlet section, extending the fabric up the sides of the outlet section to the top of the embankment.
3. Place INDOT revetment riprap to the lines and grades shown in the construction plans, working smaller stones into voids to achieve a dense mass. The spillway crest must be level with a minimum depth of 1½ feet, measured from the highest stones in the spillway weir notch to the top of the dam.
4. Cover the upstream face of the riprap outlet section with a 12-inch thick layer of INDOT CA No. 5 aggregate (for filtration).
5. On the downstream side of the spillway, construct an outlet apron at the toe of the embankment. Construct the apron to the lines and grade shown in the construction plans.

Note: Outlet apron length must extend to a stable area of the stream channel.

6. Place geotextile fabric or aggregate bedding material on the compacted and smoothed foundation and install riprap to the lines and elevations shown in the construction plans.
7. Construct a small plunge pool within the outlet apron. (Riprap aprons must be level with or slightly lower than the receiving channel and should not produce an overfall or restrict flow of the water conveyance structure.)
8. Stabilize the embankment and other disturbed areas with seed and mulch (anchored in place) or another suitable erosion resistant cover.
9. Place a sediment cleanout reference stake at the 50 percent design volume elevation of the sediment trap.

Maintenance

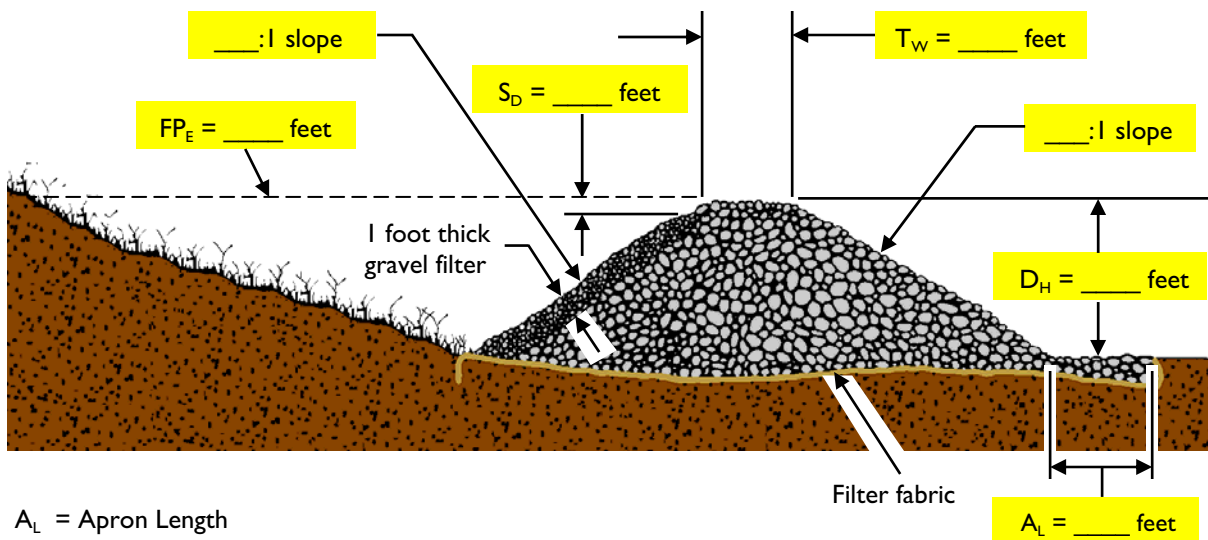
- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Check the embankment for erosion and piping holes; repair immediately.
- Check pool area side slopes for erosion, repair immediately.
- Remove sediment when it has accumulated to one-half the design volume.

TEMPORARY SEDIMENT TRAP

- Replace spillway aggregate facing if the sediment pool does not dewater (drain) within 48 to 72 hours following a storm water runoff event.
- Inspect vegetation; reseed if necessary.
- Check spillway depth periodically to ensure a minimum depth of 1½ feet from the lowest point of the settled embankment to the highest point of the spillway crest; fill any low areas to maintain design elevation.
- Promptly replace any displaced riprap, being careful that no stones in spillway are above design grade.
- After all disturbed areas have been stabilized, remove accumulated sediment and the embankment structure, smooth the site to blend with adjoining areas, and stabilize with seed and mulch or another appropriate nonerosive cover.

TEMPORARY SEDIMENT TRAP

Temporary Sediment Trap Rock Dam Worksheet

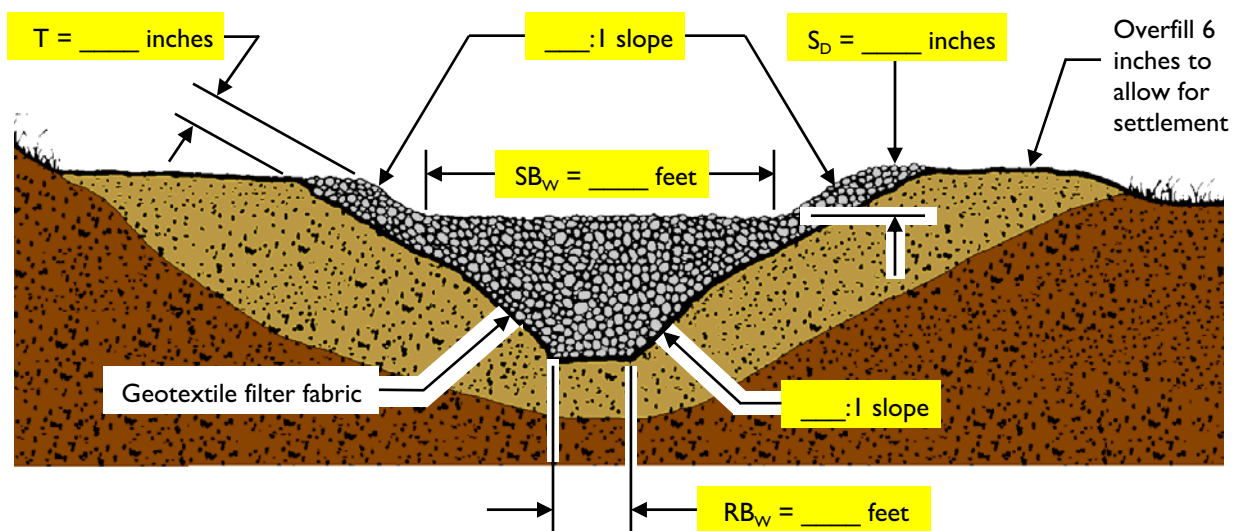


- A_L = Apron Length
- D_H = Dam Height
- FP_E = Flood Pool Elevation
- S_D = Spillway Depth
- T_W = Top Width

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

TEMPORARY SEDIMENT TRAP

Temporary Sediment Trap Outlet Worksheet



RB_w = Rock Dam Bottom Width

S_D = Spillway Depth

SB_w = Spillway Bottom Width

T = Spillway Side-Slope Armament Thickness

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

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SEDIMENT TRAPS & BASINS

Temporary Dry Sediment Basin



A temporary dry sediment basin is a sediment control measure consisting of a temporary settling basin formed by construction of an embankment and/or excavated basin. Temporary dry sediment basins are typically designed with

a principle spillway, emergency spillway and dewatering structure to control water levels and maximize sediment trapping efficiency.

Purpose

- To minimize sediment release from construction areas by pooling (retaining) storm water runoff and allowing sufficient retention time for settling of suspended soil particles.
- To minimize off-site sedimentation by trapping sediment at designated locations accessible for cleanout.

Notes:

1. **This measure may be used where failure of the embankment would not endanger life; damage homes, commercial or industrial buildings, main highways, or railroads; or disrupt public utility services.**
2. **This measure is designed specifically for temporary control of storm water runoff and sediment from large areas where sediment traps or other sediment control measures are not appropriate. Permanent storm water management ponds may be used as temporary sediment basins provided that they meet the requirements of this section and that the construction sequence addresses converting the temporary sediment basin to the permanent storm water management pond.**

TEMPORARY DRY SEDIMENT BASIN

Specifications

Contributing Drainage Area

30 acres maximum (designed by a qualified individual/professional engineer; larger drainage areas may be accommodated but may require additional design considerations.)

Structure Life

Typically three years.

Siting

- Avoid steep slopes; slopes should be 2:1 or flatter.
- Locate as close to sediment sources as possible.
- Consider soil type, pool area, embankment length, spillway conditions, accessibility, and ease of cleanout.

Pool Area

- Design volume (storm water storage volume)
 - Provide a minimum storage volume below the crest of the emergency spillway to contain the runoff from a 10-year frequency, 24-hour duration storm event. (Assume zero discharge through the principle spillway and perforated riser when calculating design storage volume.)
 - Measured one foot below the spillway crest.
- Sediment Storage Volume – minimum of 1,800 cubic feet per acre of disturbed drainage area.
- Surface Area – variable (the larger the surface area, the greater the trapping efficiency).
- Side Slopes – 2:1 or flatter.
- Bring storm drain pipe and channel discharges into the sediment basin at a low velocity.
- Flow Path Length
 - Locate concentrated storm water inflow(s) as far away from the sediment basin outlet as possible (provides for maximum flow path length, detention time, and pollutant removal).
 - Flow path length to basin effective width ratio must be 2:1 or greater. [This is calculated by taking the total distance from the concentrated in-

TEMPORARY DRY SEDIMENT BASIN

flow point to the outlet riser and dividing it by the basin effective width. This value should be equal to or greater than two. (Note: Basin effective width is calculated by dividing the surface area of the 10-year, 24-hour duration storm event pool elevation by the distance between the inflow point and the outflow point at the outlet control structure in the basin.)]

- Baffle
 - Used to increase flow path length between concentrated storm water inflow(s) into the basin and the basin outflow (outlet).
 - May consist of baffle boards or an earthen embankment.
- Dewatering – pond should completely drain within 48 to 72 hours of a storm water runoff event.
- Accessibility – provide accessibility for mechanical cleanout and maintenance of the pool area.

Dam/Embankment

- Height – 10 feet maximum or as per design.
- Top Width – six feet minimum.
- Side Slopes – 2.5:1 or flatter.
- Settlement Allowance – 10 percent of design height.
- Fill Material – stable mineral soil compacted in six to eight-inch lifts while the earth fill is still moist.
- Cut-off Trench
 - Depth – two feet minimum.
 - Width – two feet minimum.
 - Side slopes – 1:1.
 - Along the center line of the embankment.
 - Backfilled with highly impermeable soil material.

Outlet

- Principal spillway
 - Capacity – runoff from a 10-year frequency, 24-hour duration storm event without discharging through the emergency spillway.

TEMPORARY DRY SEDIMENT BASIN

- Barrel
 - ◆ Must be able to withstand maximum external loading without yielding, buckling or cracking.
 - ◆ Anti-seep collar – watertight collar, with a 1½ foot minimum projection, placed around the barrel of the outlet pipe (used on pipes with an eight-inch diameter or larger).
- Riser
 - ◆ Must be able to withstand maximum external loading without yielding, buckling or cracking.
 - ◆ Height – at a minimum, the crest elevation of the riser pipe must be set at the five-year frequency, 24-hour duration storm event pool elevation and at least one foot below the elevation of the crest or control section of the emergency spillway.
 - ◆ Perforated (one-half inch holes spaced three inches apart or use a premanufactured perforated riser pipe) for dewatering and wrapped with hardware cloth or suitable wire mesh to a height above the perforations to prevent stones from the aggregate filter pack from plugging the perforations.
 - ◆ Wrapped with an aggregate filter pack consisting of INDOT Uniform A or B riprap or INDOT CA No. 2 aggregate covered with a minimum of 12 inches of INDOT CA No. 5 aggregate for filtration. (INDOT CA No. 8 aggregate is acceptable if No. 5 aggregate is not available. The use of No. 8 aggregate may result in more frequent overtopping of the structure and will increase the frequency of structure maintenance.)
 - ◆ Aggregate filter pack must be a minimum of 12 inches thick over all riser perforations.
 - ◆ Trash guard and anti-vortex baffle at top of riser pipe.
- Apron
 - ◆ Riprap outlet apron needed unless foundation is rock.
 - ◆ Stable and sized for design of pipe discharge.
 - ◆ Length – based on outlet size, location, and grade but no shorter than five feet.
 - ◆ Grade – level, where feasible, with filter fabric foundation to ensure exit velocity is nonerosive.
 - ◆ Filter fabric placed over apron foundation.
 - ◆ Plunge pool (optional) – used to reduce discharge velocities.
- Anti-flotation block – an anchor having a buoyant weight greater than 1.1 times that of water displaced by the riser and any exposed portion of the barrel.
- Emergency Spillway
 - Capacity – routed peak flow from a 25-year frequency, 24-hour duration storm event **plus** one foot of freeboard.

TEMPORARY DRY SEDIMENT BASIN

- Location – constructed in undisturbed soil.
- Cross Section – trapezoidal with side slopes 3:1 or flatter.
- Control Section – level, straight, at least 20 feet long.
- Approach Channel
 - ◆ Two percent slope, minimum.
 - ◆ Width – 1½ times the width of the emergency spillway base through the control section.
- Stabilized with erosion control blankets, riprap, or another suitable non-erosive material.
- Apron
 - ◆ Riprap outlet apron needed unless foundation is rock.

Materials

- Riser and barrel pipes.
- Anti-seep collar.
- Anti-flotation block.
- Trash guard.
- Geotextile fabric.
- Hardware cloth or wire mesh.
- INDOT Uniform A or B riprap or INDOT CA No. 2 aggregate.
- INDOT CA No. 5 aggregate.
- Clean-out reference stake(s).
- Erosion control blankets or a nonerosive material (for stabilization of the emergency spillway).

Installation

Location and Layout

1. Locate the sediment basin as near to the sediment source as topography allows, taking into consideration the soil type, pool area, length of the dam, outlet location, spillway conditions, and accessibility for cleanout and maintenance of the basin/pool area.
2. Lay out the location and shape of the sediment basin, allowing for a length to width ratio of 2:1 or greater.
3. Locate concentrated storm water inflow(s) as far away from the basin outlet as possible. If the storm water inflow(s) cannot be located at or near the up-slope end of the basin, install a baffle(s) to achieve a minimum flow path length of 2:1 or greater.
4. Where applicable, divert runoff from adjoining, undisturbed areas away from the sediment basin and install downstream sediment control measures to prevent off-site damages during construction of the sediment basin.

Apron and Sub-Base Preparation

1. Clear, grub, and strip all vegetation and root mat from the area where the dam is to be located and from the pool area, properly disposing of all trees, logs, limbs, vegetative matter, rocks and other objectionable materials in pre-designated disposal areas.
2. Excavate the area for the outlet apron and embankment, stockpiling any surface soil material containing a high amount of organic matter.
3. Excavate a two-foot wide by two-foot deep, minimum, cut-off trench with 1:1 side slopes along the center line of the embankment, extending it all the way up the embankment side slopes.
4. Place highly impermeable soil material in the cut-off trench. Place material in six to eight-inch lifts, compacting each lift as it is placed.
5. Excavate the outlet apron, allowing for the thickness of the filter medium and riprap.
6. Line the apron excavation with the specified filter medium and place INDOT Uniform A or B riprap with a d_{50} of nine inches, or greater, to the lines and grade shown in the construction plans.

Principal Spillway

1. Install the spillway barrel (pipe) and riser on a firm, even foundation. Place at least one watertight anti-seep collar (1½ foot minimum projection) around the barrel if it is eight inches or larger in diameter.
2. Place a four-inch layer of moist, clayey, soil around the lower part of the barrel and compact it by hand to at least the density of the soil foundation, taking care **not to** raise the barrel from the foundation when compacting under the barrel haunches. (Do not use soil materials such as sand, aggregate or silt.)
3. Perforate the riser pipe with one-half inch holes spaced three inches apart or use a manufactured perforated riser pipe.
4. Connect the riser pipe to the barrel.
5. Embed the riser pipe in at least 12 inches of concrete (the concrete serves as an anti-flotation block).
6. Wrap the perforated riser with hardware cloth or wire mesh.
7. Place an aggregate filter pack around the perforated riser. [The filter pack should consist of 12 inches of INDOT Uniform A or B riprap or INDOT CA No. 2 aggregate placed around the riser and then covered with a minimum of 12 inches of INDOT CA No. 5 aggregate (for filtration)].
8. Install a trash guard (bars two to three inches apart) on the top of the riser pipe.

Embankment and Pool Area

1. Scarify the soil surface in the area of the embankment base location.
2. Using clean, stable mineral soil free of roots, woody vegetation, rocks and other debris, construct the embankment in continuous six to eight-inch lifts over the entire length of the embankment, compacting each lift as it is placed. (Material used to construct the embankment must be a stable mineral soil that is free of rocks, brush, roots, and other debris. The soil material must be wet enough to form a ball without crumbling, yet not so wet that water can be squeezed out of it. Place the most permeable soil material in the downstream toe of the embankment and the least permeable material in the center and on the upslope side of the embankment. Route construction equipment over the length of the dam so that all parts of each soil lift are traversed by at least one wheel of the equipment.
Note: Protect the spillway barrel with two feet of hand-compacted fill before crossing it with equipment.)
3. Construct and compact the embankment until it is 10 percent above design elevation to allow for settling.
4. Stabilize the embankment with seed and mulch (anchored in place) or another suitable erosion resistant cover.
5. Place a sediment cleanout reference stake at the 50 percent design volume elevation of the sediment basin.

Emergency Spillway

1. Site the emergency spillway at one end of the embankment. Locate it in undisturbed soil outside the construction limits of the embankment.
2. Locate the emergency spillway so that any flow will return to the receiving channel without damaging the embankment.
3. Excavate a trapezoidal channel with 3:1 or flatter side slopes as specified in the construction plans. Maintain a straight, level, 20-foot long, minimum, channel through the control section.
4. Permanent seed (see **Permanent Seeding** on page 35) and protect with erosion control blankets (see **Erosion Control Blanket** on page 63) as soon as grading is complete or, if vegetation is not used or suitable for the soil conditions and slope, install a nonerosive liner to finished grade.

Safety

1. Do not locate in areas where slopes are greater than 2:1.
2. Install a fence around the area and erect warning signs if trespassing is likely.
3. Dewater the basin between storm events.
4. Follow all state and local requirements for impoundment sites.

TEMPORARY DRY SEDIMENT BASIN

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Remove and properly dispose of sediment when it accumulates to one-half the design volume.
- Periodically check embankment, emergency spillway, and outlet for erosion damage, piping, settling, seepage, or slumping along the toe or around the barrel; repair immediately.
- Remove trash and other debris from riser, emergency spillway, and pool area.
- Clean or replace aggregate around the riser if the sediment pool does not dewater (drain) within 48 to 72 hours following a storm water runoff event.
- Remove basin after drainage area has been permanently stabilized, inspected, and approved. Do so by draining any water, removing sediment to a designated disposal area, smoothing the site to blend with the surrounding area, and then stabilizing with seed and mulch or another appropriate nonerosive cover.

TEMPORARY DRY SEDIMENT BASIN

Design Data Sheet

Computed by: _____ Date: _____

Project Name: _____ Basin #: _____

Location: _____

Total watershed area draining to basin: _____ acres

Total disturbed area draining to basin: _____ acres

Basin Volume Design

Design volume (minimum required volume for 10-yr. freq. storm event): _____ cubic feet

Sediment storage volume (minimum required volume): _____ cubic feet

Volume of basin below emergency spillway crest: _____ cubic feet

Volume of basin at riser crest elevation (5-year frequency storm event): _____ cubic feet

Design Elevations

Emergency Spillway Crest: _____ feet

Riser Crest: _____ feet

Top of Dam (settled): _____ feet

Bottom of Basin: _____ feet

Flow Path

Surface area of pool at riser crest elevation: _____ square feet

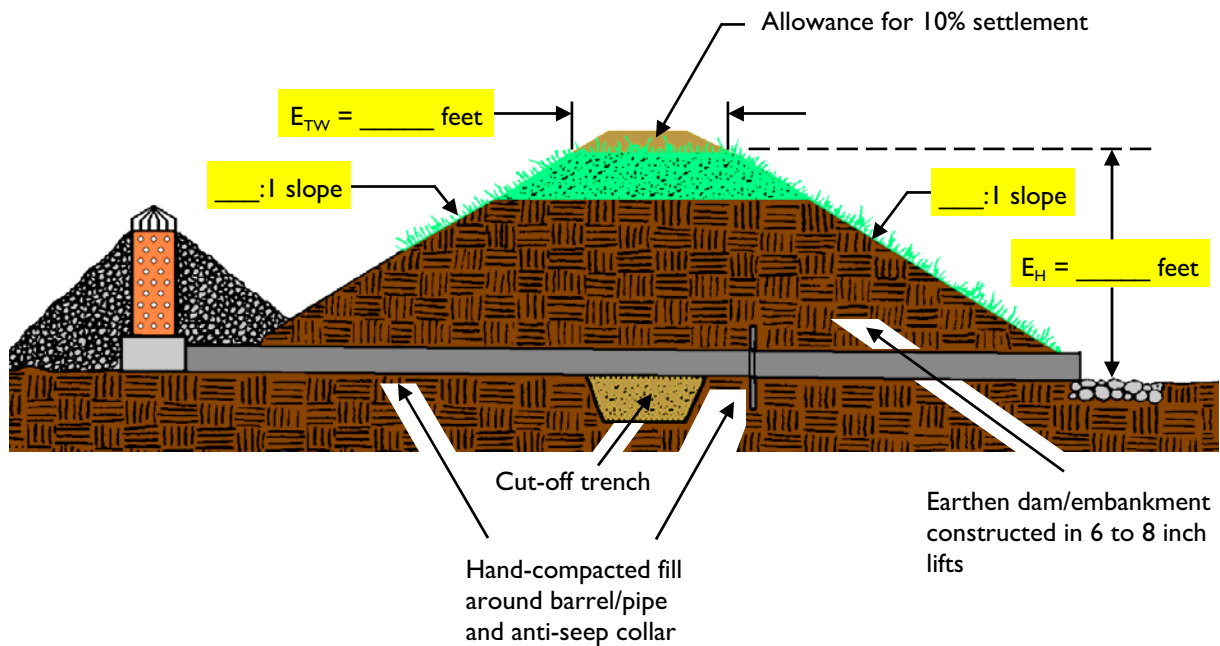
Number of concentrated flows into basin: _____

Note: The flow path length to basin effective width ratio must be 2:1 or greater. [This is calculated by taking the total distance from the concentrated inflow point to the outlet riser and dividing it by the basin effective width. This value should be equal to or greater than two. (Note: Basin effective width is calculated by dividing the area of the 10-year frequency, 24-hour duration storm event pool elevation by the distance between the inflow point and the outflow point at the outlet control structure in the basin.)]

Do all flow path lengths from concentrated inflows to the riser achieve the 2:1 minimum ratio? Yes: _____
No: _____

If NO, provide details for required baffle(s) to achieve the minimum 2:1 ratio for each concentrated inflow.

Temporary Dry Sediment Basin Earthen Dam/Embankment Worksheet



E_H = Earthen Dam/Embankment Height

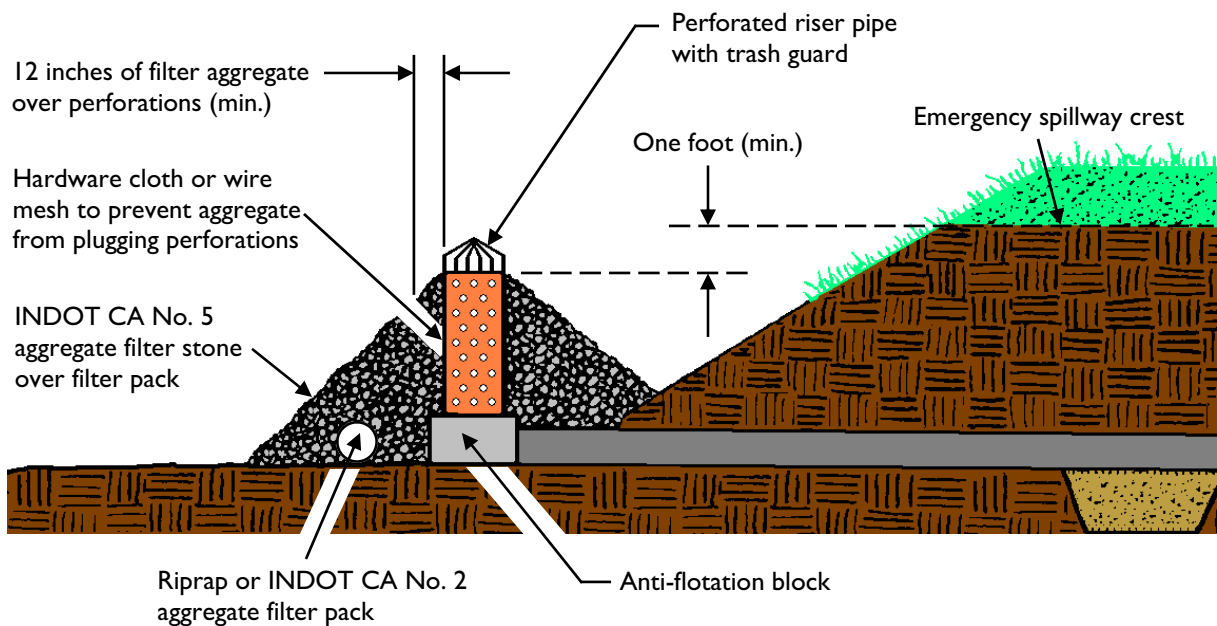
E_{TD} = Earthen Dam/Embankment Top Width

NOTE: For minimum dimensions see the
"Specifications" section of this measure.

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

Exhibit 1

Temporary Dry Sediment Basin Riser Pipe

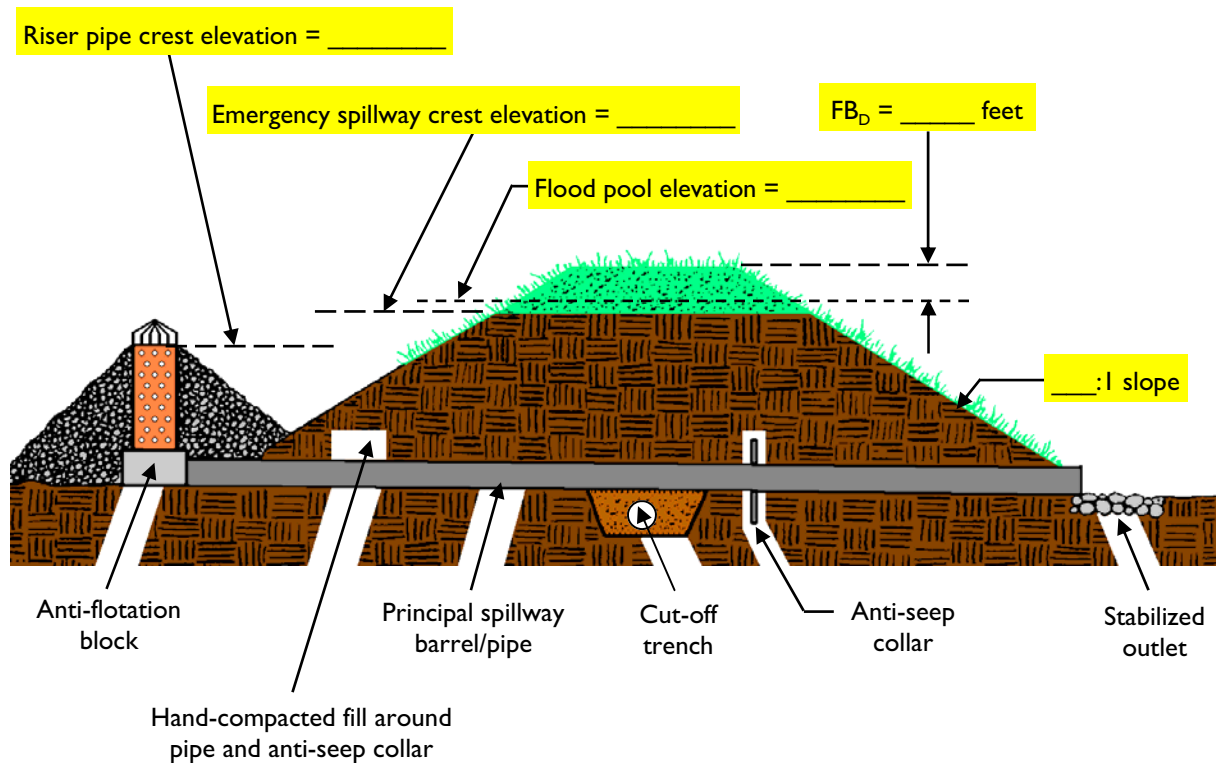


NOTE: For minimum dimensions see the "Specifications" section of this measure.

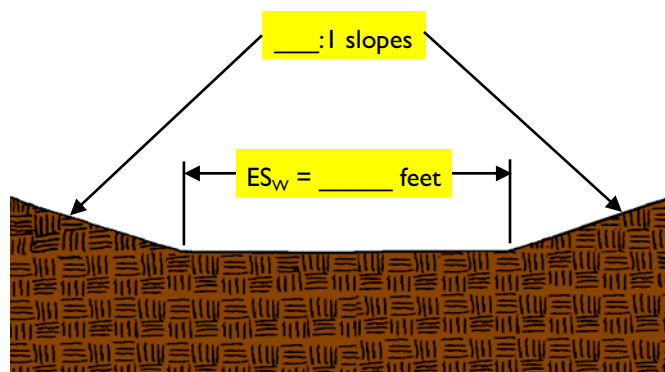
Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

TEMPORARY DRY SEDIMENT BASIN

Temporary Dry Sediment Basin Spillway Worksheet 1



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993



ES_w = Emergency Spillway Width

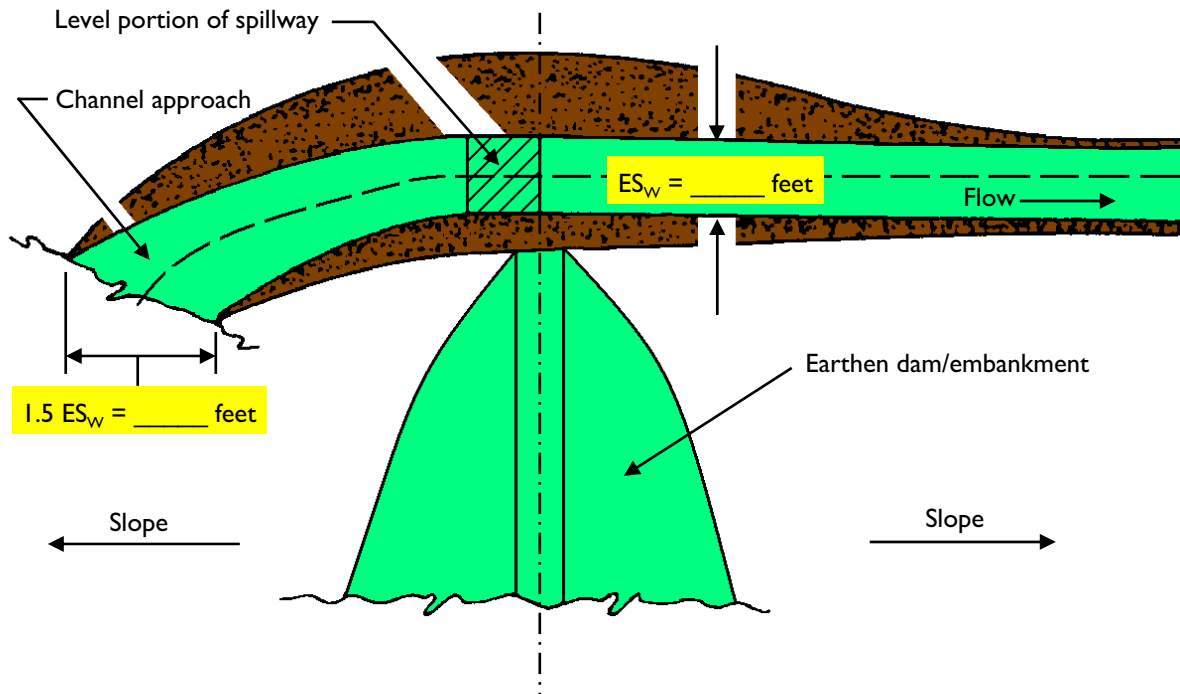
FB_D = Free Board Depth

NOTE: For minimum dimensions see the "Specifications" section of this measure.

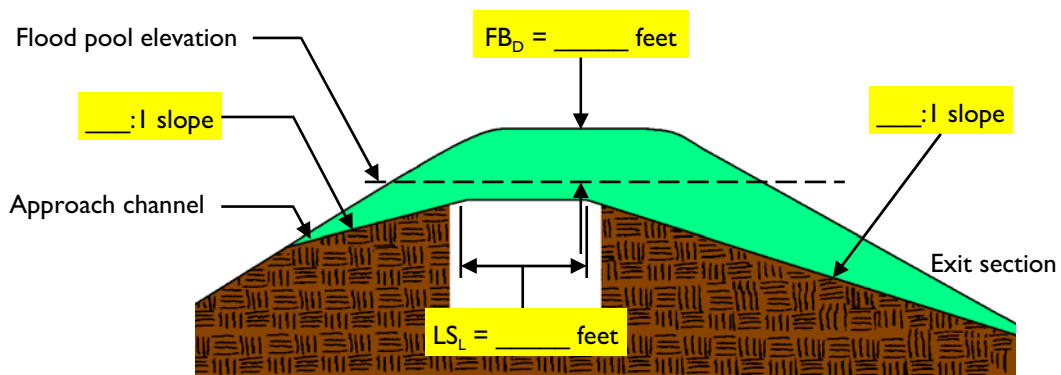
Source: Adapted from U.S. Department of Agriculture, Natural Resources Conservation Service

TEMPORARY DRY SEDIMENT BASIN

Temporary Dry Sediment Basin Spillway Worksheet 2



Source: Adapted from USDA, Natural Resources Conservation Service



ES_W = Emergency Spillway Width

FB_D = Free Board Depth

LS_L = Level Section Length

NOTE: For minimum dimensions see the
"Specifications" section of this measure.

Source: Adapted from USDA, Natural Resources Conservation Service

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SEDIMENT TRAPS & BASINS

Retrofitting Storm Water Retention/Detention Basins



To be released at a later time

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Portable Sediment Trap

To be released at a later time

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SEDIMENT BARRIERS & FILTERS

As has been stated several times in this manual, reducing erosion at the source is much more effective and efficient than trying to trap suspended sediment in surface water runoff. Timely installation of temporary and permanent soil stabilization measures, such as those listed in the Surface Stabilization section on pages 29–72, can greatly reduce erosion and sediment loads and reduce frequency of maintenance operations. Unfortunately, this is not always practical or possible.

When erosion cannot be controlled at the source it becomes necessary to implement sediment control measures designed to collect, control, and treat the resultant sediment-laden surface water runoff. The principal behind all sediment control measures is relatively simple. Slow or pond the sediment-laden surface water runoff for a sufficient length of time to allow the suspended soil particles to settle out.

The measures in this section have been designed specifically to either filter or pond sediment-laden surface water runoff for a limited time to allow suspended soil particles to settle out. The sediment removal efficiency of each measure will vary. The overall effectiveness of these measures can be improved by utilizing additional erosion and sediment control measures within the same drainage area. These measures are intended for use on relatively small, flat areas. They are not designed to withstand high or concentrated flows and excessive sediment loads.

It is important to note that these measures require intensive maintenance and require frequent monitoring, cleanout, repair and/or replacement, especially when sediment loads are high.

The measures illustrated in this section are a representation of sediment barriers and filters. While the measures in this section are representative, there are many variations of these measures that are available commercially. Prior to selecting a measure, it is important that each is evaluated and chosen based on field conditions.

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SEDIMENT BARRIERS & FILTERS

Vegetative Filter Strip



A vegetative filter strip is a sediment control measure consisting of an existing or newly planted and established vegetative strip located between a construction zone and down-slope site or water-course. This measure is used to filter sediment and other pollutants from storm water runoff discharges.

Purpose

- To trap sediment from small, disturbed areas by reducing velocity of sheet flow. Vegetative filter strips capture sediment by filtering storm water runoff and allowing sediment to settle out.
- To reduce damage associated with sedimentation.
- To improve water quality.

Note: Filter strip effectiveness is increased when used in conjunction with other measures, such as sediment barriers, inlet protection, and sediment traps and basins.

Specifications

Capacity

Depth of concentrated storm water sheet flow no greater than 2½ inches.

Filter Strip Type

- Existing Filter Strip
 - Used where sufficient vegetative cover is already present.
 - Established by stopping earth-disturbing activities at the up-slope edge of the intended filter strip, leaving existing vegetation in the filter strip area intact.

VEGETATIVE FILTER STRIP

- New Filter Strip
 - Used where site has little or no vegetative cover and lead time is sufficient (e.g., minimum of six weeks during the growing season) to establish four to six-inch high vegetation that covers 80 percent or more of the soil surface.
 - Seeded and established before the up-slope area is disturbed.
- Permanent Filter Strip
 - Used in areas where the filter strip will not be disturbed for at least one year.
- Temporary Filter Strip
 - Used in areas where the filter strip will be disturbed within less than one year or alternative vegetation is desired at a later date.

Filter Strip

- Location – down slope of sediment producing site.
- Width – based on slope of the contributing watershed (see Table 1).

Table 1. Filter Strip Width

Percent Slope Above Filter Strip		Maximum Slope Length Above Filter Strip	Minimum Width
< 5%	< 20:1	100 feet	20 feet
5% to 10%	20:1 to 10:1	75 feet	40 feet
10% to 20%	10:1 to 5:1	50 feet	60 feet
> 20%	> 5:1	Not Recommended	Not Recommended

- Height of Vegetation – maintain a height of four to six inches.
- Grade – one percent or greater, but less than six percent.
- Cover Density – vegetative cover of 80 percent or greater over the soil surface.

Materials

- Seed – Select species or mixture appropriate for soil and site conditions (see Tables 2 and 3).

VEGETATIVE FILTER STRIP

Table 2. Seed Species and Seeding Rates for Permanent Filter Strips¹

Seed Species ²	Rate per Acre
Moderately well and well drained soils	
1. Creeping red fescue (prefers shade) – annual ryegrass	20 lbs. 5 lbs.
2. Tall fescue ³ – annual ryegrass	50 lbs. 5 lbs.
Somewhat poorly, poorly and very poorly drained soils	
1. Tall fescue ³ – annual ryegrass	50 lbs. 5 lbs.

¹ Applies to filter strips that will be in place for one year or more.

² Species referenced in Table 3 is also suitable for establishment of filter strips.

³ Tall fescue provides little cover for and may be toxic to some species of wildlife. The Indiana Department of Natural Resources recognizes the need for additional research on alternatives, such as buffalograss, orchard grass, smooth bromegrass, and switchgrass. This research, in conjunction with demonstration areas, should focus on erosion control characteristics, wildlife toxicity, turf durability, and drought resistance.

Table 3. Seed Species and Seeding Rates for Temporary Filter Strips¹

Seed Species	Rate per Acre
Annual ryegrass	40 lbs.
Wheat or cereal rye	150 lbs.

¹ Applies to filter strips that will be in place for up to one year.

Installation

Determine the width of the filter strip, based on the slope of the contributing watershed (see Table 1).

Existing Filter Strip

1. Evaluate existing vegetation and determine if it is sufficient for a filter strip [i.e., Does the vegetative cover consist of grasses (weeds are not an acceptable vegetative filter) that are four to six inches high or higher and does it cover 80 percent or more of the soil surface?].
2. If existing vegetation is not adequate, and site conditions and seeding conditions are favorable, overseed the area using a no-till grain drill or

VEGETATIVE FILTER STRIP

fertilize the existing vegetation to enhance growth and density. Allow time for sufficient vegetative growth before discharging sediment-laden storm water runoff into the filter strip.

New Filter Strip

1. If existing vegetation is not adequate, and site conditions and lead time is sufficient (i.e., minimum of six weeks during the growing season) to establish four- to six-inch high vegetation that covers 80 percent or more of the soil surface, consider establishing a new filter strip.
2. To establish a new vegetative filter strip, temporarily divert storm water runoff away from the site wherever possible (see **Temporary Diversion** on page 75).
3. Prepare the seedbed and add soil amendments (see **Permanent Seeding** on page 35 and **Dormant Seeding and Frost Seeding** on page 41).
4. Plant vegetative species appropriate to the soil and site conditions as shown in Table 2 (Seed Species and Seeding Rates for Permanent Filter Strips) or Table 3 (Seed Species and Seeding Rates for Temporary Filter Strips).
5. Apply mulch (see **Mulching** on page 55 or **Compost Mulching** on page 59) or install erosion control blankets (see **Erosion Control Blanket** on page 63) to newly seeded areas.

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Promptly repair any small rills that form.
- Add fertilizer and lime as needed to maintain healthy vegetation.
- Mow as needed but not shorter than four inches.
- Where the filter strip has actively trapped sediment during construction, remove the accumulated sediment, regrade the area and reseed it when conditions are favorable for vegetative establishment.

SEDIMENT BARRIERS & FILTERS

Silt Fence



*A **silt fence** is a temporary barrier of entrenched geotextile fabric stretched across and attached to supporting posts and installed on the contour to intercept and treat sediment-laden storm water runoff from small, unvegetated drainage areas.*

Purpose

To trap sediment from small, disturbed areas by reducing the velocity of sheet flow. Silt fences capture sediment by ponding water to allow deposition, not by filtration.

Note: Silt fence is not recommended for use as a diversion and should not be used across a stream, channel, ditch, swale, or anywhere that concentrated flow is anticipated.

Specifications

Drainage Area

- Limited to one-quarter acre per 100 linear feet of fence.
- Further restricted by slope steepness (see Table 1).

Effective Life

Six months (maximum).

Location

- Installed parallel to the slope contour.
- Minimum of 10 feet beyond the toe of the slope to provide a broad, shallow sediment pool.
- Accessible for maintenance (removal of sediment and silt fence repair).

Spacing

Table 1. Slope Steepness Restrictions

Percent Slope		Maximum Distance
< 2%	< 50:1	100 feet
2% – 5%	50:1 to 20:1	75 feet
5% – 10% ¹	20:1 to 10:1	50 feet
10% – 20% ¹	10:1 to 5:1	25 feet
> 20% ¹	> 5:1	15 feet

¹ Consider other alternatives.

Note: Multiple rows of silt fence are not recommended on the same slope.

Trench

- Depth – eight inches minimum.
- Width – four inches minimum.
- After installing fence, backfill with soil material and compact (to bury and anchor the lower portion of the fence fabric).

Note: An alternative to trenching is to use mechanical equipment to plow in the silt fence.

Materials and Silt Fence Specifications

- Fabric – woven or non-woven geotextile fabric meeting specified minimums outlined in Table 2.

Table 2. Geotextile Fabric Specifications for Silt Fence (minimum)

Physical Property	Woven Geotextile Fabric	Non-Woven Geotextile Fabric
Filtering efficiency	85%	85%
Textile strength at 20% elongation Standard strength Extra strength	30 lbs. per linear inch 50 lbs. per linear inch	50 lbs. per linear inch 70 lbs. per linear inch
Slurry flow rate	0.3 gal./min./square feet	4.5 gal./min./square feet
Water flow rate	15 gal./min./square feet	220 gal./min./square feet
UV resistance	70%	85%
Post spacing	7 feet	5 feet

Note: Silt fences can be purchased commercially.

- Height – a minimum of 18 inches above ground level (30 inches maximum).
- Reinforcement – fabric securely fastened to posts with wood lathe.
- Support Posts
 - 2 x 2 inch hardwood posts. Steel fence posts may be substituted for hardwood posts (steel posts should have projections for fastening fabric).
 - Spacing
 - ◆ Eight feet maximum if fence is supported by wire mesh fencing.
 - ◆ Six feet maximum for extra-strength fabric without wire backing.

Installation

Prefabricated silt fence (see Exhibits 1, 2, and 3)

1. Lay out the location of the fence so that it is parallel to the contour of the slope and at least 10 feet beyond the toe of the slope to provide a sediment storage area. Turn the ends of the fence up slope such that the point of contact between the ground and the bottom of the fence end terminates at a higher elevation than the top of the fence at its lowest point (see Exhibit 1).
2. Excavate an eight-inch deep by four-inch wide trench along the entire length of the fence line (see Exhibit 2). Installation by plowing is also acceptable.
3. Install the silt fence with the filter fabric located on the up-slope side of the excavated trench and the support posts on the down-slope side of the trench.

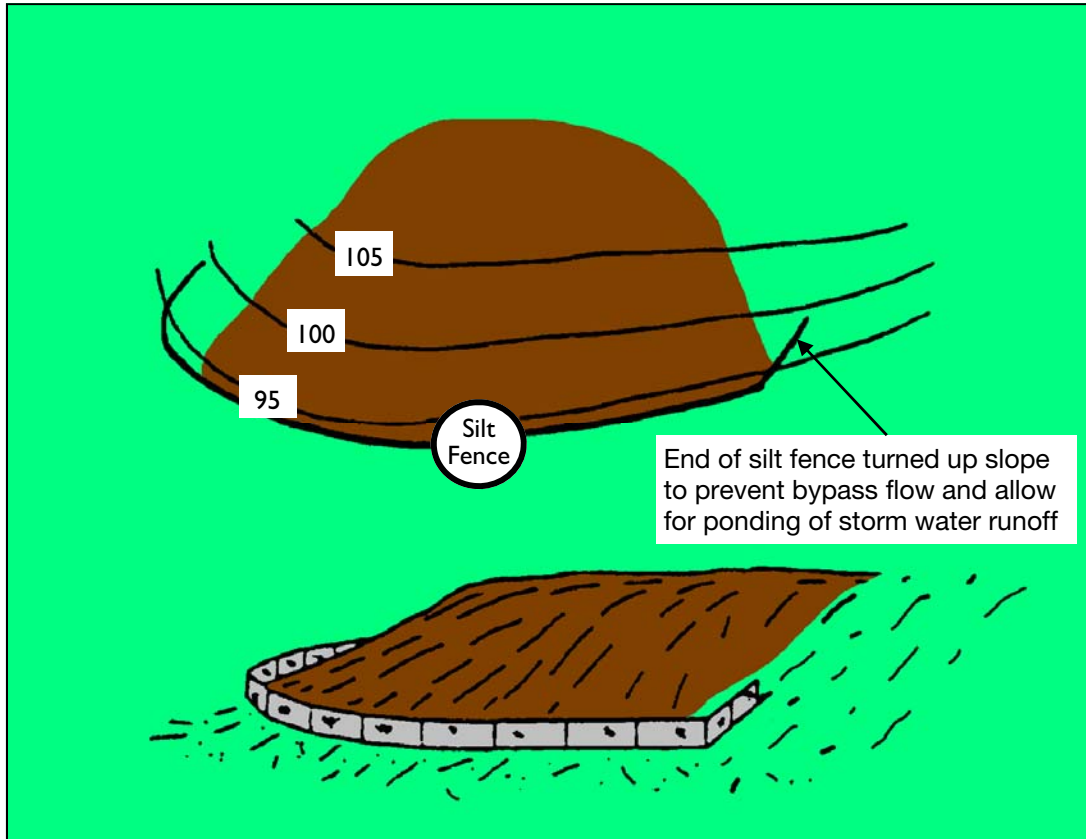
4. Drive the support posts at least 18 inches into the ground, tightly stretching the fabric between the posts as each is driven into the soil. A minimum of 12 inches of the filter fabric should extend into the trench. (If it is necessary to join the ends of two fences, use the wrap joint method shown in Exhibit 3.)
5. Lay the lower four inches of filter fabric on the bottom of the trench and extend it toward the up-slope side of the trench.
6. Backfill the trench with soil material and compact it in place.

Note: If the silt fence is being constructed on-site, attach the filter fabric to the support posts (refer to Tables 1 and 2 for spacing and geotextile specifications) and attach wooden lathe to secure the fabric to the posts. Allow for at least 12 inches of fabric below ground level. Complete the silt fence installation, following steps 1 through 6 above.

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- If fence fabric tears, starts to decompose, or in any way becomes ineffective, replace the affected portion immediately. **Note:** All repairs should meet specifications as outlined within this measure.
- Remove deposited sediment when it is causing the filter fabric to bulge or when it reaches one-half the height of the fence at its lowest point. When contributing drainage area has been stabilized, remove the fence and sediment deposits, grade the site to blend with the surrounding area, and stabilize.

Exhibit 1



Source: Adapted from Commonwealth of Pennsylvania Erosion and Sediment Pollution Control Manual, 1990

Exhibit 2

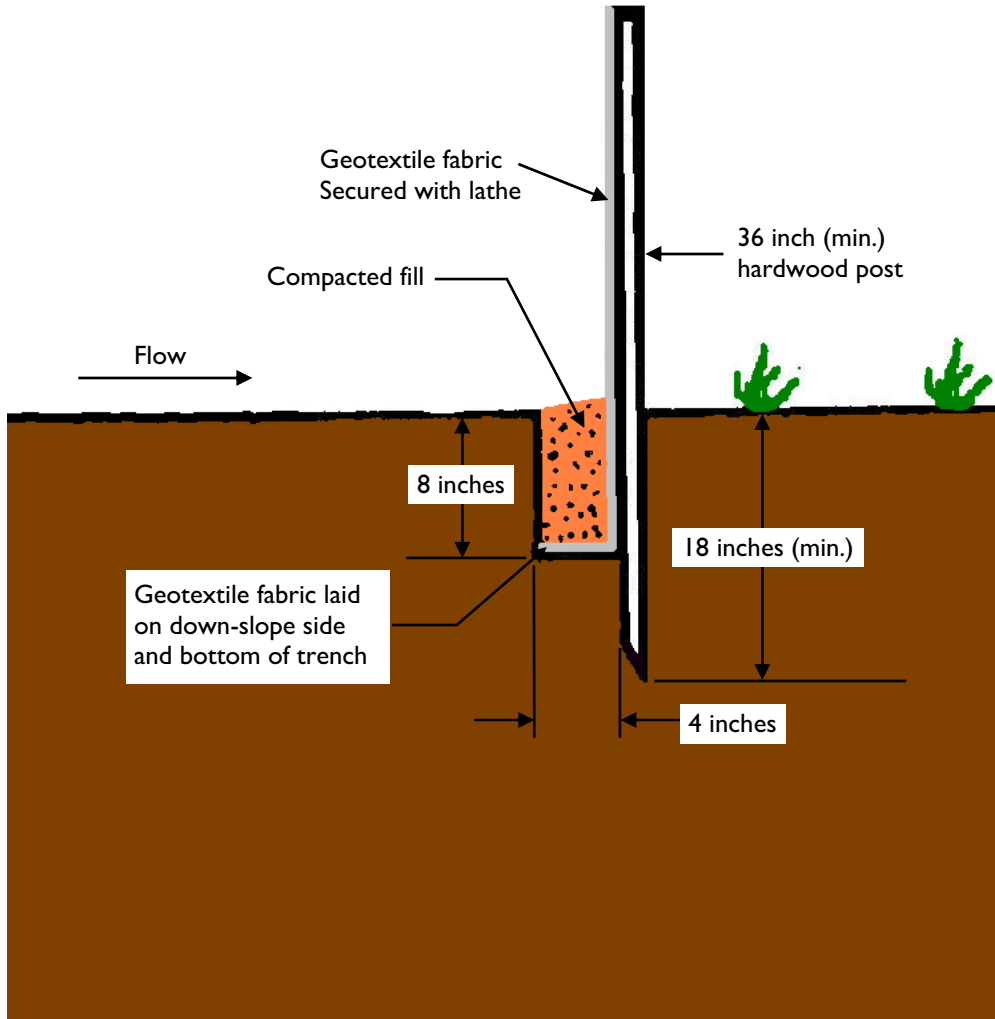
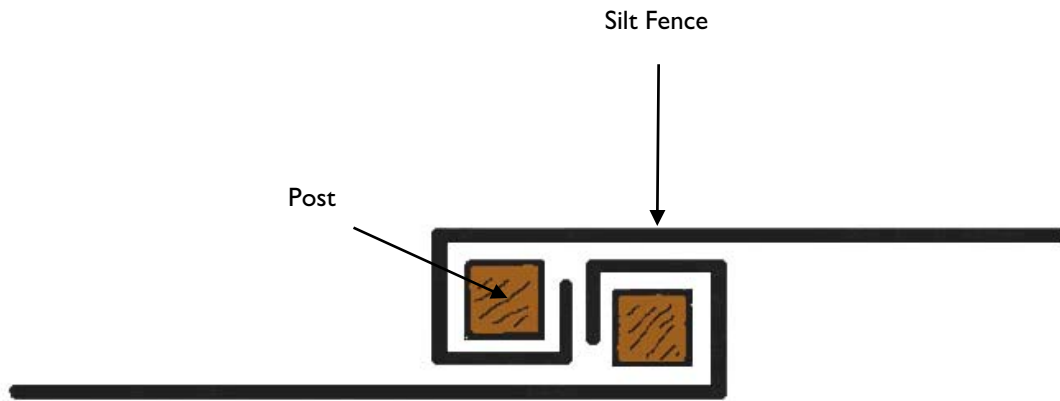


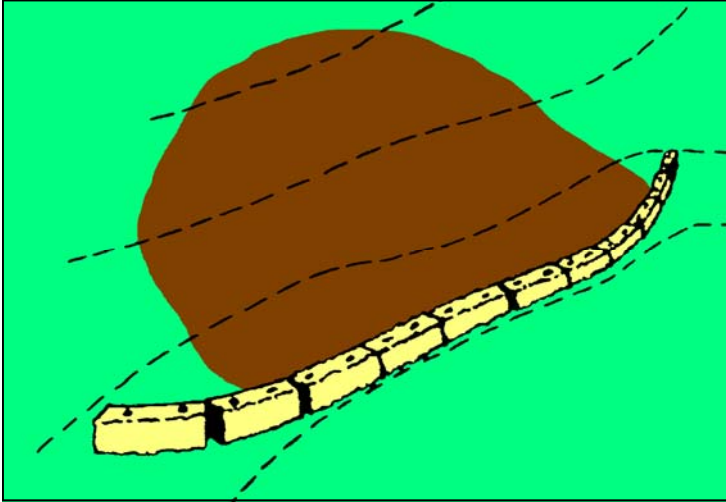
Exhibit 3



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SEDIMENT BARRIERS & FILTERS

Straw Bale Dam



*A **straw bale dam** is a temporary barrier consisting of a row of entrenched and anchored straw bales, or similar material, installed on the contour to intercept and treat sediment-laden storm water runoff from small, unvegetated drainage areas.*

Source: Adapted from Minnesota Pollution Control Agency, Minnesota Construction Site Erosion and Sediment Control Planning Handbook, 1987

Purpose

To trap sediment from small, disturbed areas by reducing the velocity of sheet flow. Straw bale dams capture sediment by ponding water to allow deposition, not by filtration.

Note: Straw bale dams should not be utilized as a first choice when selecting a sediment barrier or filter measure. This option should only be used when other materials are not available. Straw bales are not recommended for use as a diversion and should not be used across a stream, channel, ditch, swale, or anywhere that concentrated flow is anticipated; or on paved surfaces, because of the lack of an anchoring system. Straw bales are often specified when clear zone issues are associated with a highway project. This application will require intensive maintenance.

Specifications

Drainage Area

- Limited to one-quarter acre per 100 linear feet of barrier.
- Further restricted by slope steepness (see Table 1).

Effective Life

Less than three months.

STRAW BALE DAM

Location

- Installed parallel to the slope contour.
- Minimum of 10 feet beyond the toe of the slope to provide a broad, shallow sediment pool.
- Accessible for maintenance (removal of sediment and straw bale replacement).

Spacing

Table 1. Slope Steepness Restrictions

Percent Slope		Maximum Distance Above Straw Bale Barrier
< 2%	< 50:1	100 feet
2% – 5%	50:1 to 20:1	75 feet
5% – 10% ¹	20:1 to 10:1	50 feet
10% – 20% ¹	10:1 to 5:1	25 feet
> 20% ¹	> 5:1	15 feet

¹ Consider other alternatives.

Note: Multiple rows of straw bale barriers are not recommended on the same slope.

Trench

- Depth – four inches minimum.
- Width – width of straw bale.
- After installing straw bale barrier, backfill with soil material and compact.

Materials

- Straw bales – 14 inches by 18 inches by 36 inches minimum.
- Anchor stakes
 - Steel rebar or 2 x 2 inch hardwood stakes with one end sharpened/pointed.
 - Length – 36 inches minimum.

STRAW BALE DAM

Installation

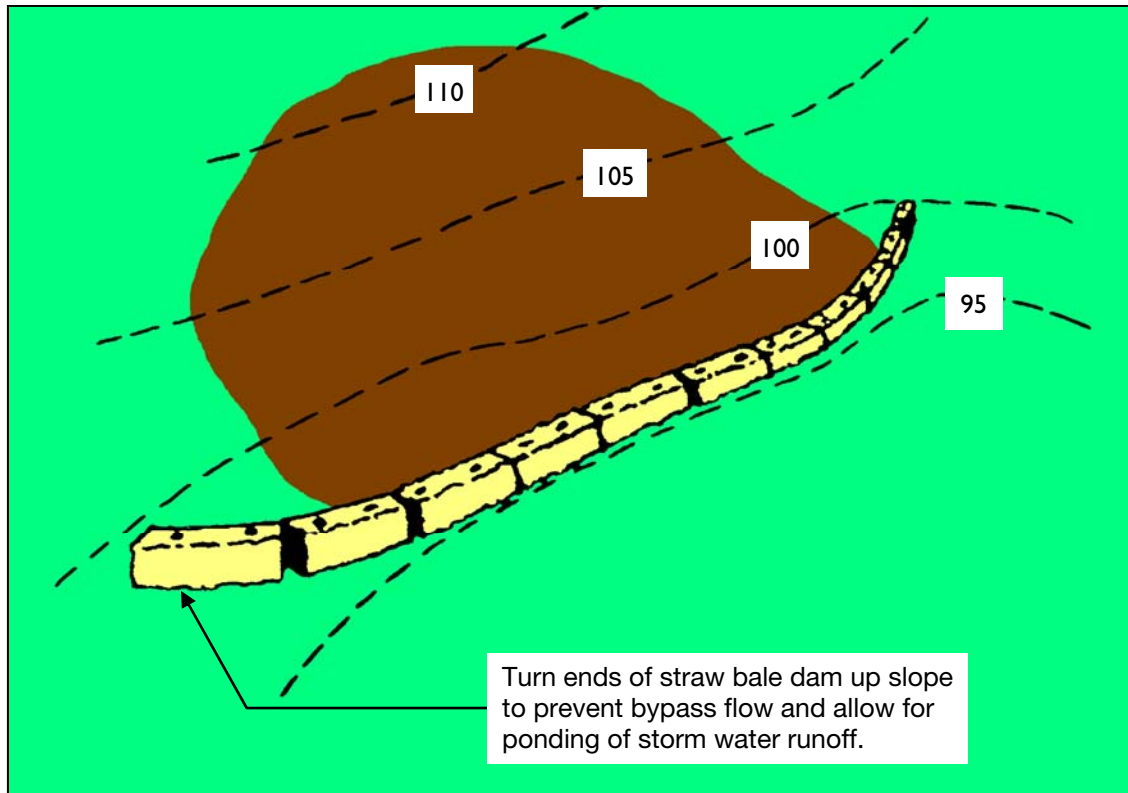
1. Lay out the location of the straw bale barrier so that it is parallel to the contour of the slope and at least 10 feet beyond the toe of the slope to provide a sediment storage area (see Exhibit 2). Turn the ends of the straw bale barrier up-slope such that the point of contact between the ground and the bottom of the straw bale barrier end terminates at a higher elevation than the top of the straw bale barrier at its lowest point (see Exhibit 1).
2. Excavate a trench at least four inches deep and one bale wide (see Exhibits 3 and 4).
3. Place each bale in the trench with the bindings oriented around the sides of the bale rather than on the top and bottom of the bale (to minimize deterioration of the bindings).
4. Abut each bale tightly against the preceding bale and anchor it in place by driving two anchor stakes through the bale. Drive the first stake toward the previously laid bale to force the bales together. Drive the stakes into the ground until the top of each stake is flush with the top of the bale.
5. Chink (tightly wedge) straw into any gaps between the bales to prevent sediment-laden water from running through.
6. Backfill the trench with excavated soil placed against the straw bales to ground level on the down-slope side and to four inches above ground level on the up-slope side of the straw bale barrier. Compact the fill material to keep it in place.

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Remove sediment deposits promptly (to ensure adequate storage volume for the next rain), taking care not to undermine the entrenched bales.
- Inspect for deterioration or damage from construction activities; replace damaged bales immediately.
- When the contributing drainage area has been stabilized, remove all of the straw bales and sediment deposits, grade the site to blend with the surrounding area, and stabilize.

STRAW BALE DAM

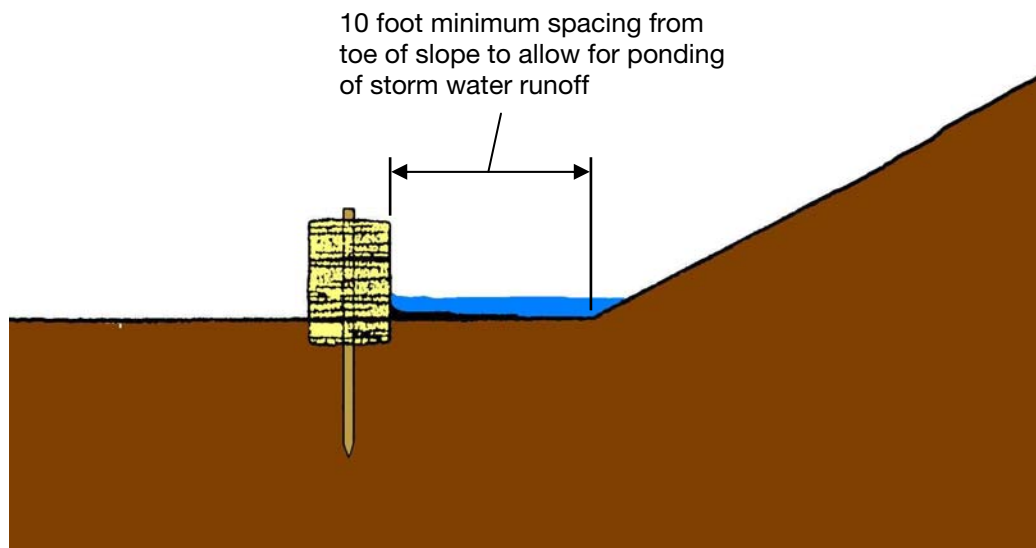
Exhibit 1



Source: Adapted from Minnesota Pollution Control Agency, Minnesota Construction Site Erosion and Sediment Control Planning Handbook, 1987

STRAW BALE DAM

Exhibit 2



Source: California Regional Water Quality Control Board, San Francisco Bay Region Erosion and Sediment Control Field Manual, Second Edition

Exhibit 3

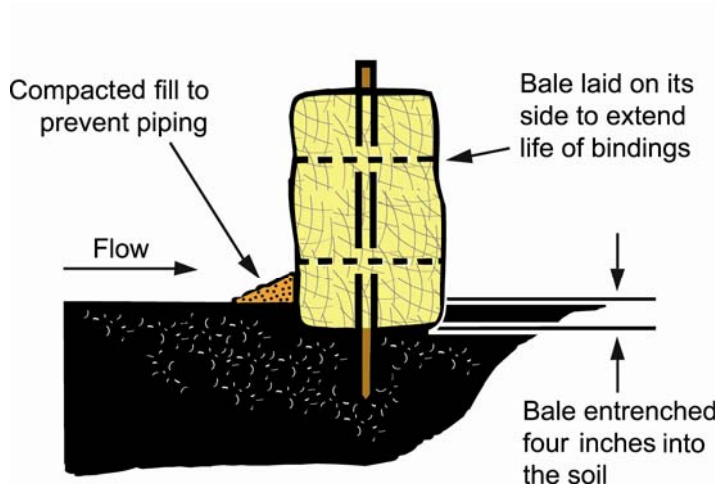
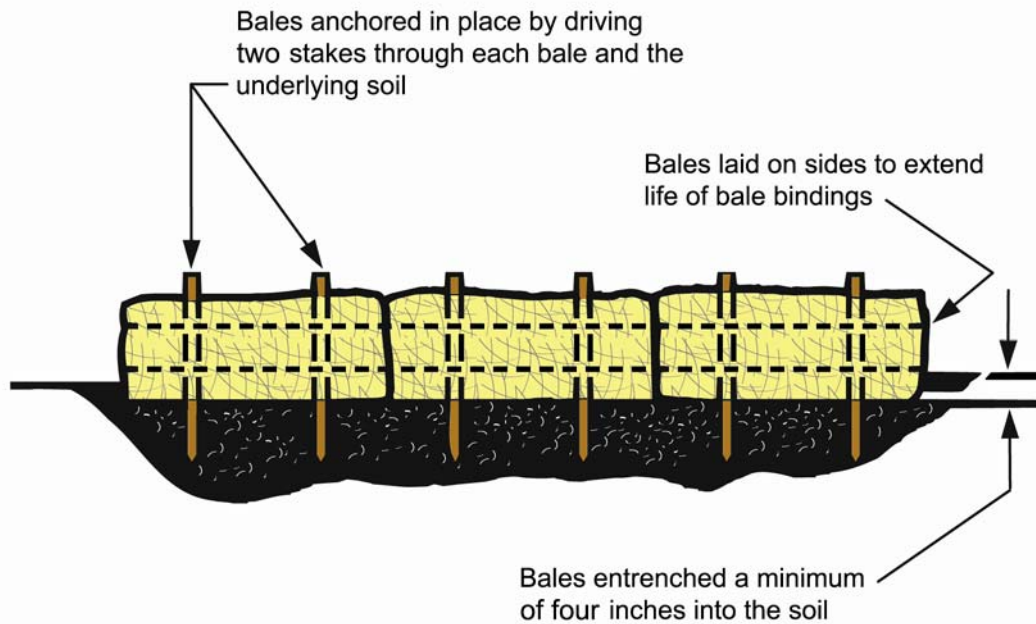


Exhibit 4



SEDIMENT BARRIERS & FILTERS

Filter Berm



Source: Rexius, Inc.

*A **filter berm** is a temporary barrier consisting of a compost ridge installed on the contour to intercept and treat sediment-laden storm water runoff from small, unvegetated drainage areas.*

Purpose

To trap sediment from small, disturbed areas by reducing velocity of sheet flow. Filter ridges capture sediment by filtering storm water runoff and by ponding water to allow settling and deposition.

Note: A filter ridge is not recommended for use as a diversion and shall not be used across a stream, channel, ditch, swale, or anywhere that concentrated flow is anticipated.

Specifications

Drainage Area

- Limited to one-quarter acre per 100 linear feet of ridge.
- Further restricted by slope steepness.

Table 1. Filter Ridge Size Requirements

Slope		Maximum Distance Above Filter Ridge (linear feet)	Filter Ridge Minimum Size Requirements (Width to Height Ratio of 2:1)
0% – 2%	< 50:1	100	2 ft x 1 ft
2% – 10%	50:1 to 10:1	75	2 ft x 1 ft
10% – 20%	10:1 to 5:1	50	2 ft x 1 ft
20% – 33%	5:1 to 3:1	25	2.6 ft x 1.3 ft
> 33%	> 3:1	15	3 ft x 1.5 ft

Location

- Installed on the contour.
- Five to 10 feet from toe of slope.
- Ends of filter ridge turned upslope so that base of ridge ends terminate at a higher elevation than the top of the berm at its lowest point.

Compost/Mulch Specifications

- Feedstocks may include but are not limited to well-composted vegetable matter, leaves, yard trimmings, food scraps, composted manures, paper fiber, wood bark, Class A biosolids (as defined in federal regulations 40 CFR Part 503), or any combination thereof.
- Compost shall be produced using an aerobic composting process meeting CFR 503 regulations, including time and temperature data indicating effective weed seed, pathogen and insect larvae kill.
- Compost shall be well decomposed, stable, and weed free.
- Variable particle size with maximum dimensions of three inches in length, one-half inch in width, and one-half inch in depth.
- Refuse free (less than one percent by weight).
- Free of any contaminants and materials toxic to plant growth.
- Inert materials not to exceed one percent by dry weight.
- pH of 5.5 to 8.0.
- Carbon-nitrogen ratio not to exceed 100.
- Moisture content not to exceed 45 percent by dry weight.

Bonding Agents

Tackifiers, flocculants, or microbial additives may be used to remove sediment and/or additional pollutants from storm water runoff. (All additives combined with compost materials should be tested for physical results at a certified erosion and sediment control laboratory and biologically tested for elevated beneficial microorganisms at a United States Compost Council, Seal of Testing Assurance, approved testing laboratory.)

Anchoring Method

Bonding agents per manufacturer's specifications.

Application

1. Remove existing vegetation, large soil clods, rocks, stumps, large roots, and debris in areas where filter ridge is to be constructed.
2. Construct the filter ridge. Use a pneumatic blower and three-wheeled ridge building machine or construct per manufacturer's directions. (Seed or sod may be applied at the time of installation for permanent applications.)

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Remove accumulated sediment when it reaches one-quarter the height of the filter ridge.
- Inspect to ensure that the ridge is holding its shape and producing adequate flow.
- Repair eroded and damaged areas.
- If ponding becomes excessive, ridges should be removed and reconstructed.
- Reseed, if applicable.
- If the filter ridge is not designed as a permanent filter or part of the natural landscape and the contributing drainage area has been stabilized, use a bulldozer, loader, rake, or other device to remove the ridge, incorporate it into the soil, or spread it over the top of the soil surface for final seeding.

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SEDIMENT BARRIERS & FILTERS

Filter Tube/Filter Sock



A filter tube/filter sock is a temporary barrier consisting of permeable material (i.e., aggregate, compost, excelsior, or straw, etc.) contained in a permeable geotextile fabric or non-biodegradable net matrix installed to intercept and treat sediment-laden runoff from small, unvegetated drainage areas.

Purpose

To trap sediment by intercepting runoff and reducing the velocity of sheet flow or concentrated flow (limited application). Filter socks capture sediment by ponding water to allow settling and deposition.

Note: A filter sock, unlike a filter ridge, may be used as a diversion and across shallow swales where concentrated flow is anticipated.

Specifications

Drainage Area

- Limited to one-quarter acre per 100 linear feet of barrier.
- Further restricted by slope steepness.

Table 1. Filter Sock Size Requirements, Sheet Flow Application

Slope		Maximum Distance Above Filter Sock (linear feet) for Minimum Filter Sock Sizes (diameter of sock)			
		8 inch	12 inch	18 inch	24 inch
0% – 2%	< 50:1	125	250	300	350
2% – 10%	50:1 to 10:1	100	125	200	250
10% – 20%	10:1 to 5:1	75	100	150	200
20% – 33%	5:1 to 3:1	25	50	75	100
> 33%	> 3:1	10	25	50	75

Location

- Slope Application
 - Installed on the contour.
 - Five to 10 feet from toe of slope (10 feet preferred).
- Channel/Swale Application
 - Perpendicular to channel flow.
 - Less than one acre of drainage area.
 - Utilize larger product, typically 18 or more inches.
- Drop Inlet Protection
 - Refer to standards and principles contained in the **Temporary Drop Inlet Protection** section on page 143.
- Accessible for maintenance (removal of sediment and replacement if needed).

Materials

- Geotextile fabric sock or a non-biodegradable netting matrix.
- Specifications for permeable material:

Compost/Mulch Specifications

- Feedstocks may include, but are not limited to, well-composted vegetable matter, leaves, yard trimmings, food scraps, composted manures, paper fiber, wood bark, Class A biosolids (as defined in federal regulations 40 CFR Part 503), or any combination thereof.
- Compost shall be produced using an aerobic composting process meeting CFR 503 regulations, including time and temperature data indicating effective weed seed, pathogen and insect larvae kill.
- Compost shall be well decomposed, stable, and weed free.
- Variable particle size with maximum dimensions of two inches in length, one-half inch in width, and one-half inch in depth.

Table 2. Compost Particle Size

Percent Passing Sieve Size			
2-Inch Sieve	1-Inch Sieve	¾-Inch Sieve	¼-Inch Sieve
100%	99%	70%	25%

- Refuse free (less than one percent by weight).
- Free of any contaminants and materials toxic to plant growth.
- Inert materials not to exceed one percent by dry weight.
- pH of 5.5 to 8.0.
- Carbon-nitrogen ratio not to exceed 100.

FILTER TUBE/FILTER SOCK

- Moisture content not to exceed 45 percent by dry weight.

Aggregate Specification

- INDOT CA No. 5 or No. 8 aggregate.

Straw, Excelsior, etc. Specification

- Premanufactured.

Anchoring Method

- Posts - 2 x 2 inch hardwood or steel posts.

Bonding Agents (optional)

Tackifiers, flocculants, or microbial additives may be used to remove sediment and/or additional pollutants from storm water runoff. (All additives combined with compost materials should be tested for physical results at a certified erosion and sediment control laboratory and biologically tested for elevated beneficial microorganisms at a United States Compost Council, Seal of Testing Assurance approved testing laboratory.)

Installation

1. Lay out the location of the filter sock barrier so that it is parallel to the contour of the slope and at least 10 feet beyond the toe of the slope to provide a sediment storage area. Turn the ends of the filter sock barrier up slope such that the point of contact between the ground and the bottom of the filter sock barrier end terminates at a higher elevation than the top of the filter sock barrier at its lowest point.
2. Excavate a trench with a depth and width equal to at least one-fourth the diameter of the filter sock or follow the manufacturer's recommendations. Where applicable, the trench may also be excavated upslope of a curb or sidewalk. Placing the product against the curb or sidewalk will provide additional stability and resistance to surface flow.
3. Construct the filter sock or utilize a pre-manufactured product. For compost use a pneumatic blower or similar device to provide adequate and consistent fill in the sock. (Seed or sod may be applied at the time of installation for permanent applications.)
4. If more than one sock is placed in a row, the socks should be overlapped; not abutted.
5. Anchor the filter sock barrier in place by driving posts through the barrier and into the underlying soil material. Posts should be spaced no more than five feet apart and driven through the middle of the sock. The posts should

FILTER TUBE/FILTER SOCK

be driven a minimum of 18 inches deep into the soil. The stake should be flush with the top of the sock.

6. Backfill the trench with excavated soil placed against the filter sock barrier to ground level on the down-slope side and to two inches above ground level on the up-slope side of the filter sock barrier. Compact the fill material to keep it in place.

Options for Installation

- These products may be placed in a series on the contour at intervals on a slope.
 - Follow the manufacturer's recommendations for this application, including spacing and diameter of product.
 - This application will require careful layout and installation. Alternatives, including immediate stabilization, should be considered as the first alternative. This application also requires extensive maintenance and daily inspections.
 - Typical applications include:
 - ◆ Slopes less than 20 percent (5:1). Place socks at a maximum interval of 20 feet (a closer spacing is more effective).
 - ◆ Slopes between 20 percent (5:1) and less than 50 percent (2:1). Place socks at a maximum interval of 15 feet (a closer spacing is more effective).
 - ◆ Slopes greater than 50 percent (2:1). Place socks at a maximum interval of 10 feet (a closer spacing is more effective).

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days. When installed in a series at intervals on a slope, inspection should be done daily.
- Remove accumulated sediment when it reaches one-quarter the height of the filter sock.
- Inspect to ensure that the sock is maintaining its integrity and producing adequate flow.
- Repair eroded and damaged areas.
- If ponding becomes excessive, socks should be removed and either reconstructed or new product installed.
- Reseed, if applicable.
- If the filter sock is not designed as a permanent filter or part of the natural landscape and the contributing drainage area has been stabilized, use a blade or knife to cut open sock and use a bulldozer, loader, rake, or other device to incorporate the organic material into the soil, or spread it over the top of the soil surface for final seeding. Remove and dispose of sock if necessary.

SITE MANAGEMENT MEASURES

Site management measures listed in this section of the manual have been designed to minimize pollutants associated with building materials and the operation and maintenance of mechanical equipment associated with construction activities. With a few exceptions, every measure listed in this section of the manual will be applicable to an active construction site.

The measures listed here address everything from controlling and managing sediment (both waterborne and airborne) associated with the operation of construction equipment to the proper storage and handling of materials associated with building and infrastructure construction.

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SITE MANAGEMENT MEASURES

Dust Control



Dust control is a construction site management measure used to control the blowing and movement of dust on construction sites and associated land-disturbing activities. Dust control measures may consist of either chemical, structural, or mechanical measures.

Purpose

To reduce wind-borne soil particles (dust) that may be transported and deposited in waterbodies, create a health hazard, and/or a visibility hazard.

Specifications

Site Management

- Dust control measures may be applied at any construction site, but should always be utilized for sites with dry, unvegetated soils that are exposed to wind or vehicle traffic that can potentially result in the generation of dust.
- Where practical, locate haul roads and stockpiles away from existing residential housing, businesses, and public areas.
- Limit construction equipment on haul roads to the extent practical. Construction equipment should maintain low speeds of 15 miles per hour or less.
- Trucks leaving a project site should be covered, especially where conditions may result in blowing of haul material.
- Minimize areas of disturbed, unvegetated soil exposed to traffic and wind.
- Water quality impacts should always be considered when selecting a dust control treatment.

Materials

- Temporary Methods –
Select an appropriate method to reduce dust generation from haul roads, heavy traffic areas, paved roads, or large open areas of unvegetated land. A combination of appropriate methods will yield the best results.
 - Watering/Irrigation
 - ◆ Typically used for haul roads and heavy traffic areas.
 - ◆ Used as an emergency treatment measure.
 - Dust suppressants that are commercially available. Some products may be toxic to the environment. The level of toxicity and proximity to waterbodies and other unique resource areas should be considered when selecting a product. Products should be strictly applied according to the standards and specifications of the manufacturer and in accordance with applicable local, state, and federal regulations.

Chlorides

- ◆ Typically used for unpaved construction haul roads.
- ◆ Calcium Chloride (CaCl) and Magnesium Chloride (MgCl).
- ◆ Hygroscopic product that absorbs water.
- ◆ Applied as a liquid solution or dry granules/flakes.
- ◆ Apply and maintain in an environmentally safe manner.
- ◆ Application can inhibit plant growth.
- ◆ Runoff from treated areas can pollute waterbodies.

Resins

- ◆ Typically applied to haul roads, soil stockpiles, unvegetated soils, or used as a tackifier.
- ◆ Manufactured from petroleum, wood residue, or other chemicals.
- ◆ Bonds soil particles together.
- ◆ Water sheds off soils treated with these products.
- ◆ Low environmental impact after application.
- ◆ Avoid introducing resins into waterbodies during application.

Polymer Products (acrylic polymers and polymer emulsions)

- ◆ Typically used on soil stockpiles, unvegetated soils.
- ◆ May also be applicable to haul roads.
- ◆ Bonds soil particles together.
- ◆ Used to stabilize and/or seal soils.
- ◆ Apply with truck or hydroseeding machine.

DUST CONTROL

- ◆ Use restricted to anionic polymer mixtures and shall have less than or equal to .05 percent free acrylamide monomer by weight as established by the U.S. Food and Drug Administration and the U.S. Environmental Protection Agency.

Ligninsulfonates

- ◆ Typically used for haul roads.
- ◆ Derived from wood pulp.
- ◆ Bonds soil particles, however retains some plasticity.
- ◆ Water soluble and could lose bonding capability in heavy rain.
- ◆ Environmentally friendly.

Tillage

- ◆ Large open disturbed areas.
- ◆ Used as an emergency treatment measure.
- ◆ Relatively flat areas of less than two percent.
- ◆ Chisel plows with shanks spaced 12 to 18 inches apart, straight-toothed harrows, or similar tillage equipment.
- ◆ Best if implemented before soil begins to blow.

Mulch (see **Mulching** on page 55)

- ◆ Disturbed areas.
- ◆ Effective, temporary measure.
- ◆ Fast and effective measure.

Temporary Vegetative Cover (see **Temporary Seeding** on page 31)

- ◆ Disturbed areas.
- ◆ Effective, temporary measure.

Physical Barriers

- ◆ Emergency treatment measure.
- ◆ Solid board fences, snow fences, burlap fences, crate walls, bales of hay, etc.
- ◆ Used to control air currents and soil migration.

Street Sweeping

- ◆ Paved areas.
- ◆ Maintenance measure.
- ◆ Street sweeper, vacuum truck, or a bucket end loader.

Nonerosive, Nonvegetative Soil Cover Measures

- ◆ For example, aggregate (see **Temporary Construction Ingress/Egress** on page 17), tarps, etc.
- Permanent Methods
 - Permanent vegetative cover (see **Permanent Seeding** on page 35 and **Tree Preservation and Protection** on page 13).
 - Preserve existing vegetation that is suitable to reducing blowing soil and diminishing wind velocity.

Application

Prepare site for the application method or product that was selected for dust control. For example, all haul roads should be bladed smooth with a crown or slope to avoid ponding and compacted as needed.

Watering

1. Sprinkle soil surface until soil is moist.
2. Apply at a rate to keep the soil moist/wet, but not saturated or muddy. Over watering may result in muddy conditions and a high potential for tracking of sediment off-site by vehicle tires/tracks.
3. Reapply as required. Constant repetition is required for effective control. Frequency will be dependent on soil type and construction traffic.

Commercially Available Dust Suppressants

Includes chlorides (calcium and magnesium), resins, polymer products, and ligninsulfonates.

1. Apply according to the standards and specifications of the manufacturer and in accordance with all applicable local, state, and federal regulations.
2. Prepare site for application.
3. Apply and maintain according to the recommendation of the manufacturer.

Mulch

1. Apply mulch and anchor in place by crimping or applying a tackifier (see **Mulching** on page 55).

Temporary Vegetative Cover

1. Prepare seedbed, seed, and apply mulch. Mulch should be anchored in place (see **Temporary Seeding** on page 31 and **Mulching** on page 55).

Physical Barriers

1. Select an appropriate barrier for site conditions.
2. Place the barrier or barriers at right angles to the prevailing winds at intervals of approximately 10 times the height of the barrier.

Street Sweeping

1. Choose a method that does not generate large amounts of dust. Rotary brushes fixed to the front of equipment may just resuspend dust particles.
2. Clear sediment from the paved area.
3. Dispose of all cleared material properly so that is not redeposited in the street.

Tillage

1. Best if implemented before soil begins to blow.
2. Tillage should begin on the windward side of the site and leave six-inch furrows, preferably perpendicular to the prevailing wind direction to gain the greatest reduction.
3. Roughen the soil surface to bring clods to the surface.

Maintenance

- Inspect daily.
- Repeat treatments as needed when using temporary dust control methods.
- Commercial products should be used in accordance with the recommendations of the manufacturer.

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SITE MANAGEMENT MEASURES

Vehicle Wash Pads

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SITE MANAGEMENT MEASURES

Concrete Washout



Concrete washout areas are designated locations within a construction site that are either a prefabricated unit or a designed measure that is constructed to contain concrete washout. Concrete washout systems are typically used to contain washout water when chutes and hoppers are rinsed following delivery.

Purpose

Concrete washout systems are implemented to reduce the discharge of pollutants that are associated with concrete washout waste through consolidation of solids and retention of liquids. Uncured concrete and associated liquids are highly alkaline which may leach into the soil and contaminate ground water or discharge to a waterbody or wetland which can elevate the pH and be harmful to aquatic life. Performing concrete washout in designated areas and into specifically designed systems reduces the impact concrete washout will have on the environment.

Specifications

Site Management

- Complete construction/installation of the system and have washout locations operational prior to concrete delivery.
- Do not wash out concrete trucks or equipment into storm drains, wetlands, streams, rivers, creeks, ditches, or streets.
- Never wash out into a storm sewer drainage system. These systems are typically connected to a natural conveyance system.
- Where necessary, provide stable ingress and egress (see **Temporary Construction Ingress/Egress Pad** on page 17).
- It is recommended that washout systems be restricted to washing concrete from mixer and pump trucks and not used to dispose of excess concrete or

CONCRETE WASHOUT

residual loads due to potential to exceed the design capacity of the washout system. Small amounts of excess or residual concrete (not washout water) may be disposed of in areas that will not result in flow to an area that is to be protected.

- Install systems at strategic locations that are convenient and in close proximity to work areas and in sufficient number to accommodate the demand for disposal.
- Install signage identifying the location of concrete washout systems.

Location

- Locate concrete washout systems at least 50 feet from any creeks, wetlands, ditches, karst features, or storm drains/manmade conveyance systems.
- To the extent practical, locate concrete washout systems in relatively flat areas that have established vegetative cover and do not receive runoff from adjacent land areas.
- Locate in areas that provide easy access for concrete trucks and other construction equipment.
- Locate away from other construction traffic to reduce the potential for damage to the system.

General Design Considerations

- The structure or system shall be designed to contain the anticipated washout water associated with construction activities.
- The system shall be designed, to the extent practical, to eliminate runoff from entering the washout system.
- Runoff from a rainstorm or snowmelt should not carry wastes away from the washout location.
- Washout will not impact future land uses (i.e., open spaces, landscaped areas, home sites, parks).
- Washout systems/containment measures may also be utilized on smaller individual building sites. The design and size of the system can be adjusted to accommodate the expected capacity.

Prefabricated Washout Systems/Containers

- Self-contained sturdy containment systems that are delivered to a site and located at strategic locations for concrete disposal.

- These systems are manufactured to resist damage from construction equipment and protect against leaks or spills.
- Manufacturer or supplier provides the containers. The project site manager maintains the system or the supplier provides complete service that includes maintenance and disposal.
- Units are often available with or without ramps. Units with ramps lend themselves to accommodate pump trucks.
- Maintain according to the manufacturer's recommendations.

Designed and Installed Units

These units are designed and installed on site. They tend to be less reliable than prefabricated systems and are often prone to failure. Concrete washout systems can be constructed above or below grade. It is not uncommon to have a system that is partly below grade with an additional containment structure above grade.

- Washout systems shall utilize a pit or bermed area designed and maintained at a capacity to contain all liquid and concrete waste generated by washout operations.
- The volume of the system must also be designed to contain runoff that drains to the system and rainfall that enters the system for a two-year frequency, 24-hour storm event.

■ Below Grade System

- ◆ A washout system installed below grade should be a minimum of ten feet wide by ten feet long, but sized to contain all liquid and waste that is expected to be generated between scheduled cleanout periods. The size of the pit may be limited by the size of polyethylene available. The polyethylene lining should be of adequate size to extend over the entire excavation.
- ◆ Include a minimum 12-inch freeboard to reasonably ensure that the structure will not overtop during a rain event.
- ◆ Line the pit with ten millimeter polyethylene lining to control seepage.
- ◆ The bottom of excavated pit should be above the seasonal high water table.

■ Above Grade System

- ◆ A system designed and built above grade should be a minimum of ten feet wide by ten feet long, but sized to contain all liquid and waste that is expected to be generated between scheduled cleanout periods. The size of the containment system may be limited by the size of

polyethylene available. The polyethylene lining should be of adequate size to extend over the berm or containment system.

- ◆ The system design may utilize an earthen berm, straw bales, sandbags, or other acceptable barriers that will maintain its shape and integrity and support the polyethylene lining.
- ◆ Include a minimum four-inch freeboard as part of the design.

Washout Procedures

- Do not leave excess mud in the chutes or hopper after the pour. Every effort should be made to empty the chutes and hopper at the pour. The less material left in the chutes and hopper, the quicker and easier the cleanout. Small amounts of excess concrete (not washout water) may be disposed of in areas that will not result in flow to an area that is to be protected.
- At the washout location, scrape as much material from the chutes as possible before washing them. Use non-water cleaning methods to minimize the chance for waste to flow off site.
- Remove as much mud as possible when washing out.
- Stop washing out in an area if you observe water running off the designated area or if the containment system is leaking or overflowing and ineffective.
- Do not back flush equipment at the project site. Back flushing should be restricted to the plant as it generates large volumes of waste that more than likely will exceed the capacity of most washout systems. If an emergency arises, back flush should only be performed with the permission of an on-site manager for the project.
- Do not use additives with wash water. Do not use solvents or acids that may be used at the target plant.

Materials

- Minimum of ten millimeter polyethylene sheeting that is free of holes, tears, and other defects. The sheeting selected should be of an appropriate size to fit the washout system without seams or overlap of the lining (**designed and installed systems**).
- Signage.
- Orange safety fencing or equivalent.
- Straw bales, sandbags (bags should be ultraviolet-stabilized geotextile fabric), soil material, or other appropriate materials that can be used to construct a containment system (**above grade systems**).

CONCRETE WASHOUT

- Metal pins or staples at a minimum of six inches in length, sandbags, or alternative fastener to secure polyethylene lining to the containment system.
- Non-collapsing and non-water holding cover for use during rain events (optional).

Installation

Prefabricated Washout Systems/Containers

- Install and locate according to the manufacturer's recommendations.

Designed and Installed Systems

- Utilize and follow the design in the storm water pollution prevention plan to install the system.
- Dependent upon the type of system, either excavate the pit or install the containment system.
- A base shall be constructed and prepared that is free of rocks and other debris that may cause tears or punctures in the polyethylene lining.
- Install the polyethylene lining. For excavated systems, the lining should extend over the entire excavation. The lining for bermed systems should be installed over the pooling area with enough material to extend the lining over the berm or containment system. The lining should be secured with pins, staples, or other fasteners.
- Place flags, safety fencing, or equivalent to provide a barrier to construction equipment and other traffic.
- Place a non-collapsing, non-water holding cover over the washout facility prior to a predicted rainfall event to prevent accumulation of water and possible overflow of the system (optional).
- Install signage that identifies concrete washout areas.
- Post signs directing contractors and suppliers to designated locations.
- Where necessary, provide stable ingress and egress (see **Temporary Construction Ingress/Egress Pad** on page 17) or alternative approach pad for concrete washout systems.

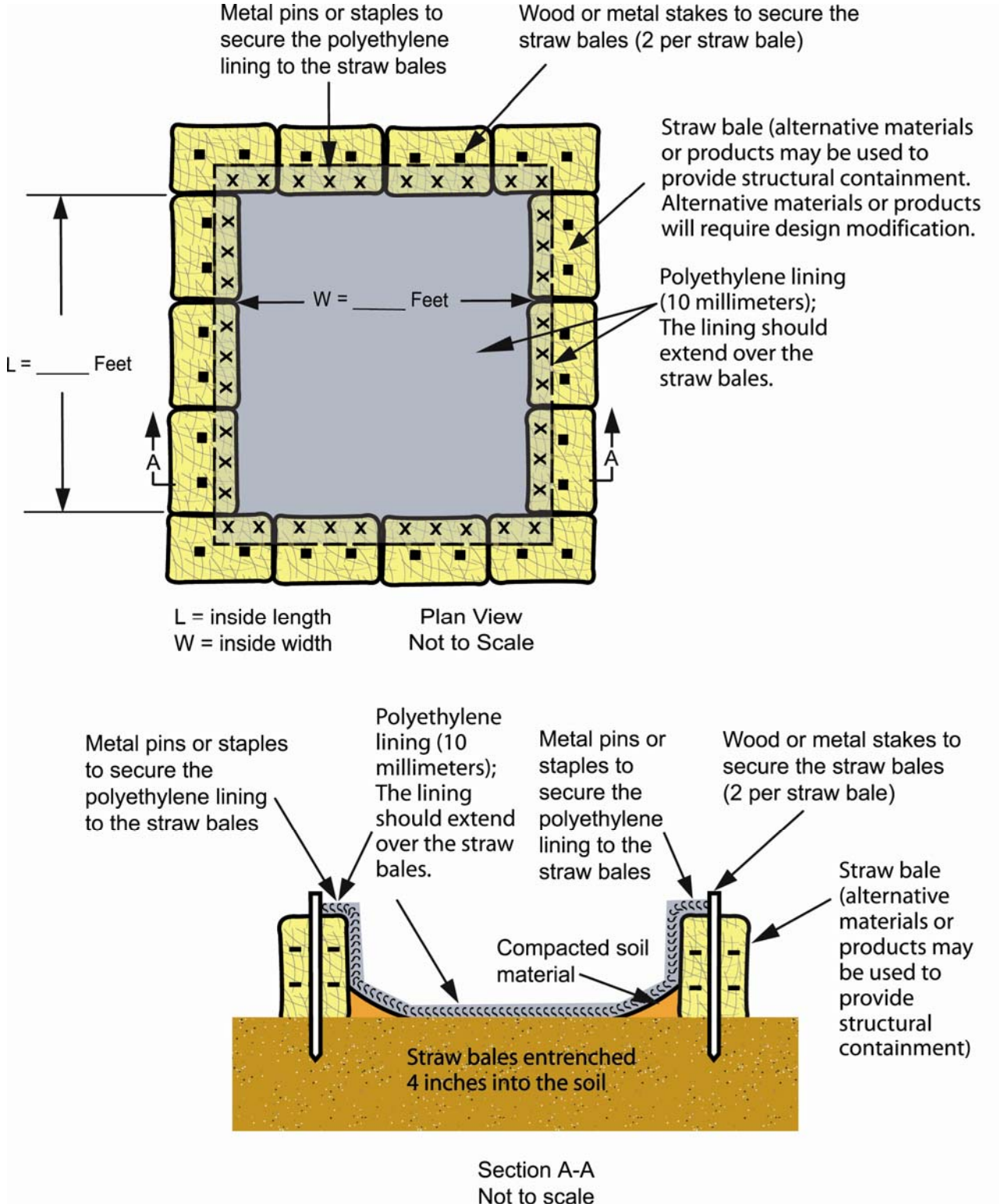
Maintenance

- Inspect daily and after each storm event.
- Inspect the integrity of the overall structure including, where applicable, the containment system.
- Inspect the system for leaks, spills, and tracking of soil by equipment.
- Inspect the polyethylene lining for failure, including tears and punctures.
- Once concrete wastes harden, remove and dispose of the material.
- Excess concrete should be removed when the washout system reaches 50 percent of the design capacity. Use of the system should be discontinued until appropriate measures can be initiated to clean the structure. Prefabricated systems should also utilize this criterion, unless the manufacturer has alternate specifications.
- Upon removal of the solids, inspect the structure. Repair the structure as needed or construct a new system.
- Dispose of all concrete in a legal manner. Reuse the material on site, recycle, or haul the material to an approved construction/demolition landfill site. Recycling of material is encouraged. The waste material can be used for multiple applications including but not limited to roadbeds and building. The availability for recycling should be checked locally.
- The plastic liner should be replaced after every cleaning; the removal of material will usually damage the lining.
- The concrete washout system should be repaired or enlarged as necessary to maintain capacity for concrete waste.
- Concrete washout systems are designed to promote evaporation. However, if the liquids do not evaporate and the system is near capacity it may be necessary to vacuum or remove the liquids and dispose of them in an acceptable method. Disposal may be allowed at the local sanitary sewer authority provided their National Pollutant Discharge Elimination System permits allow for acceptance of this material. Another option would be to utilize a secondary containment system or basin for further dewatering.
- Prefabricated units are often pumped and the company supplying the unit provides this service.
- Inspect construction activities on a regular basis to ensure suppliers, contractors, and others are utilizing designated washout areas. If concrete waste is being disposed of improperly, identify the violators and take appropriate action.

CONCRETE WASHOUT

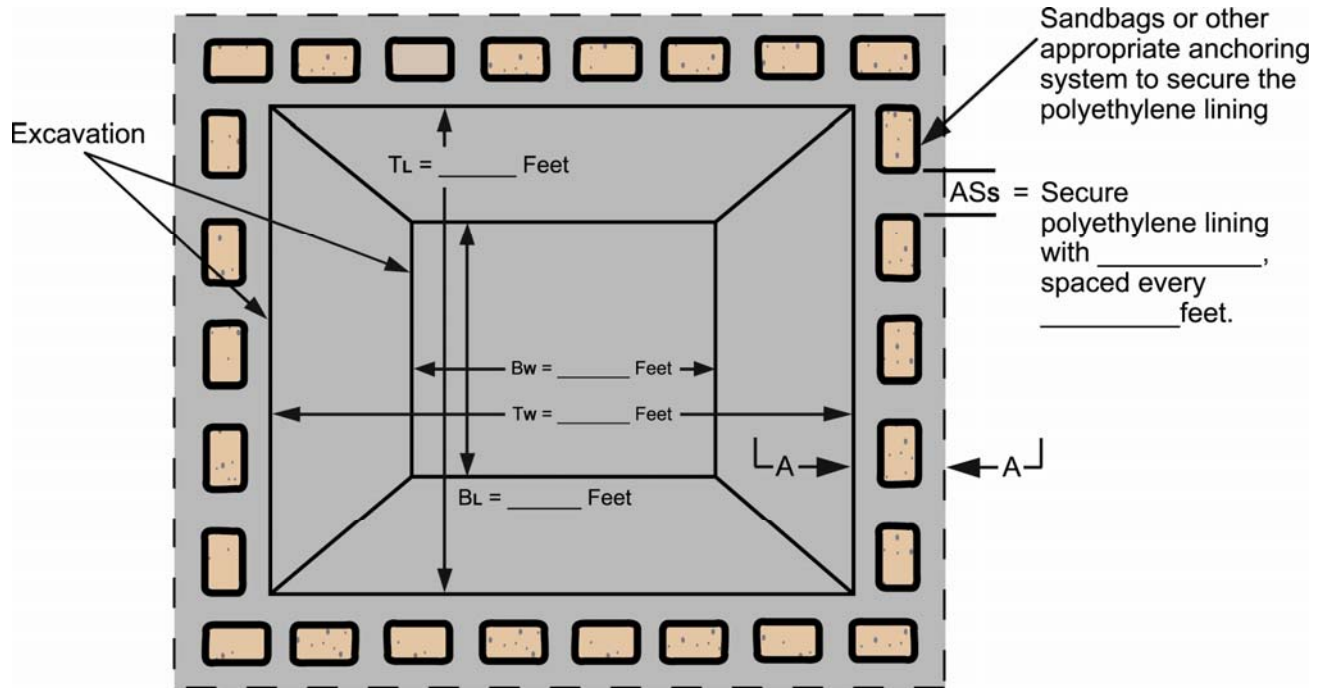
- When concrete washout systems are no longer required, the concrete washout systems shall be closed. Dispose of all hardened concrete and other materials used to construct the system.
- Holes, depressions and other land disturbances associated with the system should be backfilled, graded, and stabilized.

Concrete Washout (Above Grade System) Worksheet

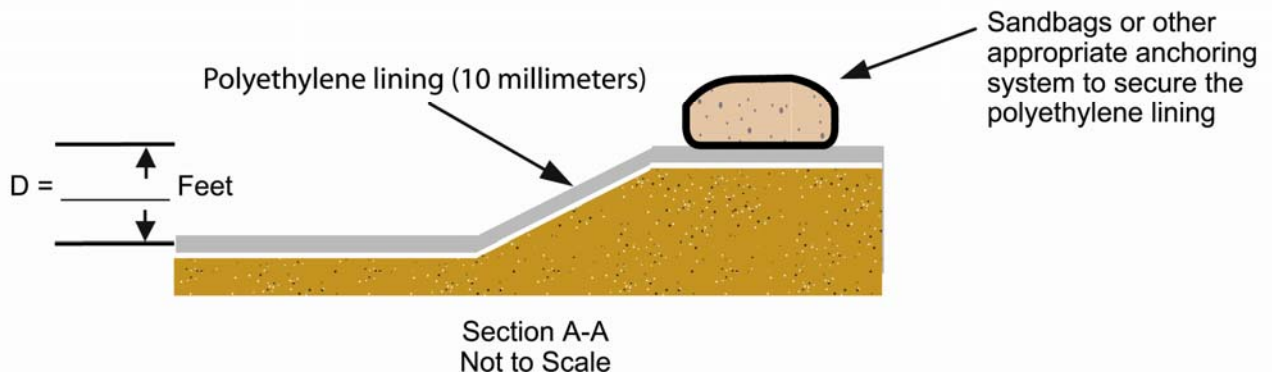


CONCRETE WASHOUT

Concrete Washout (Below Grade System) Worksheet



- TL = Top Length of Excavation
 BL = Bottom Length of Excavation
 Tw = Top Width of Excavation
 Bw = Bottom Width of Excavation
 ASs = Anchoring System type and spacing
- Plan View
 Not to Scale



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SITE MANAGEMENT MEASURES

Equipment Maintenance & Fueling

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SITE MANAGEMENT MEASURES

Storage & Handling of Materials



Source: John South, Hamilton County Soil and Water Conservation District

To be released at a later time

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STREAMBANK & SHORELINE STABILIZATION

Streambanks and shorelines often become unstable when adjacent areas undergo urban development. This is generally the result of property owners removing vegetative growth to improve aesthetic views and increased wave action from watercraft using the channel or waterbody.

Stabilization of banks and shorelines may require an operator to work in the channel or lake. There are specific measures listed in the **Channel & Lake Operations & Measures** section on pages 265–290 that may be applicable to these work activities.

Whenever construction activities are being performed adjacent to or in a channel or lake, permits may be required. It is the responsibility of all parties to obtain the appropriate permits before commencing any work.

Designs for streambank and shoreline stabilization can be complex and require detailed site investigations and the application of sound engineering principles. A professional knowledgeable of these applications and experienced in design should be consulted when using these measures.

Specific measures related to streambank and shoreline stabilization can be found in the Indiana Drainage Handbook available from the Indiana Department of Natural Resources, Division of Water.

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Sea Walls

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CHANNEL & LAKE OPERATIONS & MEASURES

Channel bank and shoreline erosion potential and off-site sedimentation is extremely high when land-disturbing activities are conducted in and around drainage channels and waterbodies. When feasible, every effort should be made to keep construction equipment out of the channel or waterbody.

Measures such as the temporary stream crossings listed in this section of the manual are designed to minimize contact between vehicular tires and tracks and channel banks/waterbody shorelines. Unfortunately, this is not always practical.

When construction activity must occur in a channel or waterbody, it is extremely important to isolate the work area using measures such as cofferdams and/or pump around/work isolation measures. Other measures such as floating turbidity barriers have been designed to slow water current flow and allow suspended soil particles to settle out.

Whenever work activities are being performed adjacent to/or within a channel or lake, permits may be required. It is the responsibility of all parties to obtain the appropriate permits before commencing any work.

Designs for channel or lake operations can be complex and require detailed site investigations and the application of sound engineering principles. A professional knowledgeable in these applications and experienced in design should be consulted when using these measures.

Additional measures related to work associated with channel and lake operations can be found in the Indiana Drainage Handbook available from the Indiana Department of Natural Resources, Division of Water.

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Temporary Stream Crossing — Bridges



A temporary bridge structure is a crossing installed across a stream or water-course for short-term use by construction vehicles or heavy equipment.

Purpose

To provide a means of moving construction vehicles across a stream with minimal impact to the stream.

Notes:

1. **Bridges are preferable to other types of stream crossings because they cause the least disturbance to the stream.**
2. **Stream and riparian areas should be left in an undisturbed state to the greatest extent practical. Stream crossings should be installed for the shortest practical period of time and removed as soon as their function is completed because they generally constrict channel flow. During periods of high flow this can result in flooding of upstream areas and a high potential for washout of the structure which may result in downstream property damage.**

Specifications

Design Considerations

- Use where channels are narrow and/or deep.
- Do not construct during periods of fish spawning.
- In some instances it may be necessary to divert or isolate channel flow (see **Pump Around/Work Isolation** on page 289) during construction and removal of the stream crossing.

Anticipated Life

Generally less than one year.

Flow Capacity

Bank-full flow or peak discharge from a two-year frequency, 24-hour duration storm event without bank overflow (whichever is less).

Overflow Areas

Protected from erosion from a 10-year frequency, 24-hour duration storm event.

Discharge Velocity at Crossing Outlet

Nonerosive for the stream channel.

Permits

One or more permits may be needed from federal, state, or local permitting agencies. **Note: Allow sufficient time for obtaining the appropriate permits.**

Crossing Location

- Locate crossing where it will cause the least amount of disturbance to the channel and surrounding vegetation. (Good locations generally include straight, shallow sections of the channel rather than channel bends and deep pool areas.)
- Install crossing perpendicular to stream flow if feasible.

Road Approaches

- Where feasible, align the first 30 to 50 feet of approach road perpendicular to channel flow. (This provides for minimal disturbance to the riparian buffer and eliminates tight turns for construction equipment, thereby reducing the potential for erosion and sediment damage to the stream.)
- Minimize erosion potential by covering with INDOT No. 2 aggregate.
- Place geotextile underlayment under aggregate if soils are soft or if area will be subject to heavy use and heavy loads. (This provides a nonerosive surface, minimizes sediment-laden storm water runoff to the stream, and reduces the potential of vehicular tracking of sediment into the stream.)

Structure

- Does not create a flooding or safety hazard.
- Strong enough to accommodate expected load (size/weight).

TEMPORARY STREAM CROSSING — BRIDGES

Materials

- INDOT CA No. 2 aggregate.
- Geotextile fabric underlayment (optional).

Installation/Removal

Stream crossings should be as narrow as practical and streambank vegetation should be preserved to the maximum extent practical.

Installation

1. Where applicable, divert storm water runoff away from roadway approaches and into well-vegetated areas, temporary sediment traps (see **Temporary Sediment Trap** on page 183), or an appropriate sediment control measure. Storm water runoff from the roadway should not discharge directly into the stream (see Exhibit 1).
2. Where applicable, divert or isolate channel flow (see **Pump Around/Work Isolation** on page 289) before starting construction of the stream crossing.
3. Cut vegetation at locations used for approach road ramps, bridge crossing, and installation of nonvegetative sediment trapping devices. **Do not** grub the stumps or root systems. (The root systems help stabilize the streambanks and can help accelerate revegetation of the area.) Remove all logs, limbs, and loose debris from the work area and dispose of materials in pre-approved areas located outside the limits of the floodplain.
4. Elevate bridge abutments at least 12 inches above the adjoining streambank to allow storm water overflow to bypass the structure without damage.
5. Construct or install the bridge as specified in the construction plans.
6. Immediately stabilize all disturbed streambanks, roadway approaches, and other disturbed areas. Stabilize with appropriate permanent vegetative stabilization measures or an appropriate nonerosive armor (see **Surface Stabilization** on page 29).

Removal

1. Remove temporary bridges, including associated materials and debris.
2. Restore the channel to its original cross section or as specified by the requirements of any applicable permits.

TEMPORARY STREAM CROSSING — BRIDGES

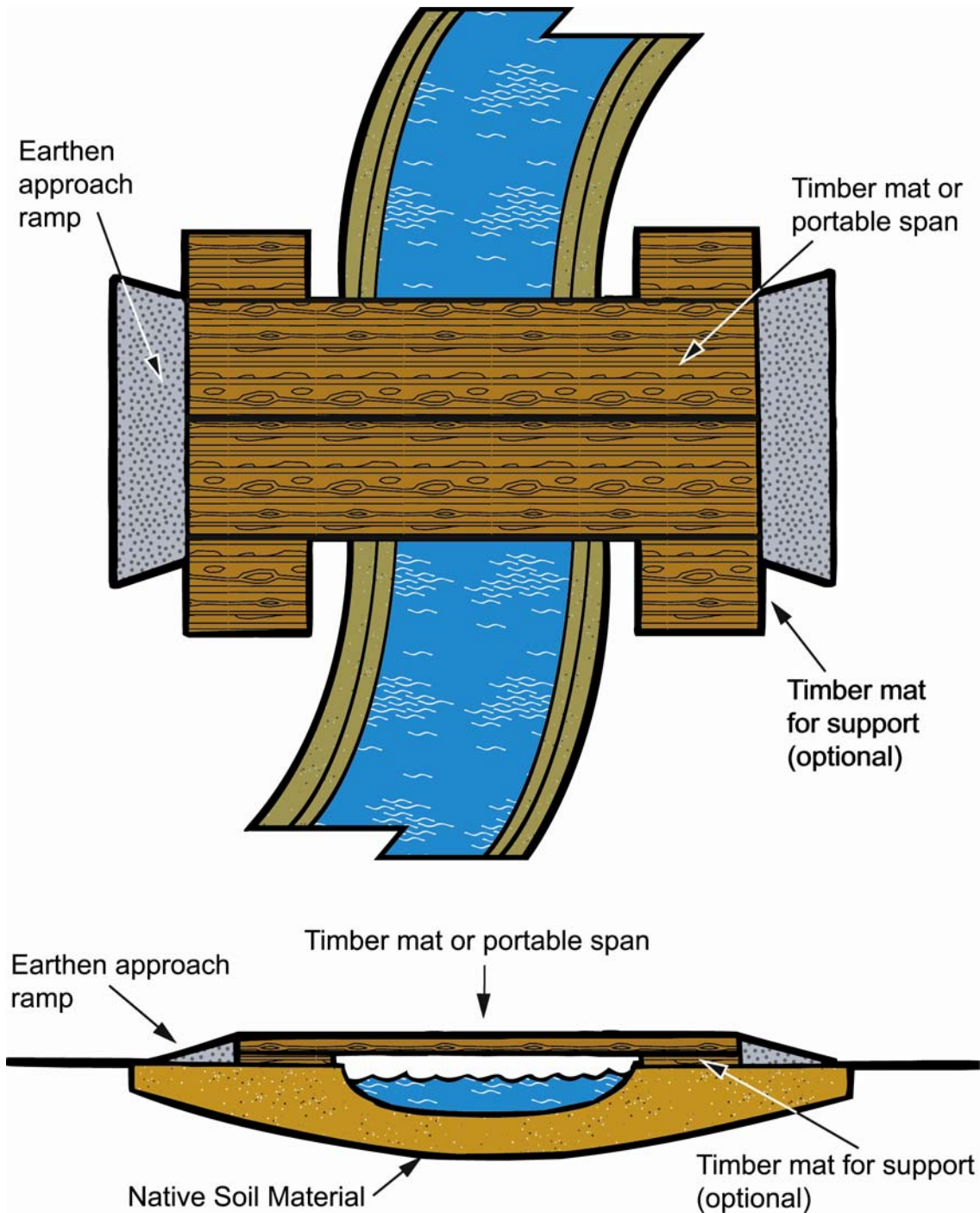
3. Immediately stabilize or armor streambanks with an appropriate stabilization measure (see **Erosion Control Blanket** on page 63; **Turf Reinforcement Mat** on page 65; and **Riprap** on page 69) or appropriate bioengineering techniques and where applicable in accordance with permit requirements.
4. Fill road approaches. Over fill by 10 percent to allow for settling.
5. Permanently stabilize all disturbed streambanks, roadway approaches, temporary roadways and other disturbed areas. Stabilize with appropriate permanent vegetative stabilization measures or an appropriate nonerosive armor (see **Surface Stabilization** on page 29).

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Check for accumulation of debris and obstructions such as limbs, logs, trash, rock, etc. around bridge abutments and bridge span areas; remove immediately.
- Inspect for erosion of streambanks and banks of approach road; repair immediately.
- Check for erosion or damage to abutments and repair immediately.

TEMPORARY STREAM CROSSING — BRIDGES

Exhibit 1



Note: This measure requires the designer to provide design specifications and dimensions.

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Temporary Stream Crossing — Culverts



A temporary culvert structure is a crossing installed in a stream or watercourse for short-term use by construction vehicles or heavy equipment.

Purpose

To provide a means of moving construction vehicles across a stream with minimal impact to the stream.

Notes:

1. **Culvert stream crossings are preferred over ford stream crossings because they only disturb the stream during structure installation and removal.**
2. **Stream and riparian areas should be left in an undisturbed state to the greatest extent practical. Stream crossings should be installed for the shortest practical period of time and removed as soon as their function is completed because they generally constrict channel flow. During periods of high flow this can result in flooding of upstream areas and a high potential for washout of the structure which may result in downstream property damage.**

Specifications

Design Considerations

- Use where wide-channel streams need to be crossed.
- Use where loads may be too heavy for bridge crossings.
- Do not construct during periods of fish spawning.
- In some instances it may be necessary to divert or isolate channel flow (see **Pump Around/Work Isolation** on page 289) during construction and removal of the stream crossing.

Anticipated Life

Generally less than one year.

Flow Capacity

Bank-full flow or peak discharge from a two-year frequency, 24-hour duration storm event without overflow (whichever is less).

Overflow Areas

Protected from erosion from a 10-year frequency, 24-hour duration storm event.

Discharge Velocity at Crossing Outlet

Nonerosive for the stream channel.

Permits

One or more permits may be needed from federal, state, or local permitting agencies. **Note: Allow sufficient time for obtaining the appropriate permits.**

Crossing Location

- Locate crossing where it will cause the least amount of disturbance to the channel and surrounding vegetation. (Good locations generally include straight, shallow sections of the channel rather than channel bends and deep pool areas.)
- Install crossing perpendicular to stream flow if feasible.

Road Approaches

- Where feasible, align first 30 to 50 feet of approach road perpendicular to channel flow. (This provides for minimal disturbance to the riparian buffer and eliminates tight turns for construction equipment, thereby reducing the potential for erosion and sediment damage to the stream.)
- Minimize erosion potential by covering with INDOT No. 2 aggregate.
- Place geotextile underlayment under aggregate if soils are soft or if area will be subject to heavy use and heavy loads. (This provides a nonerosive surface, minimizes sediment-laden storm water runoff to the stream, and reduces the potential of vehicular tracking of sediment into the stream.)

Structure

- Stable and non-erosive [clean, non-sediment producing material (i.e., no earth fill in the stream channel)].
- Must not create a flooding or safety hazard.
- Strong enough to accommodate expected load (size/weight).

TEMPORARY STREAM CROSSING — CULVERTS

Materials

- INDOT revetment riprap or larger (used as construction fill within the waterway channel).
- INDOT CA No. 2 aggregate or larger (for vehicular driving surface).
- Geotextile fabric.
- Culvert
 - Material – reinforced concrete, corrugated metal, structural plate.
 - Shape – circular, arched, or oval.
 - Size – largest pipe diameter that will fit into the existing channel without major approach fills.
 - Length – maximum length of 40 feet.
 - Strength – strong enough to support the cross section of the pipe for the maximum loads expected.
- Anchor cable.

Installation/Removal

Stream crossings should be as narrow as practical and streambank vegetation should be preserved to the maximum extent practical.

Installation

1. Where applicable, divert storm water runoff away from roadway approaches and into well-vegetated areas, temporary sediment traps (see **Temporary Sediment Trap** on page 183), or an appropriate sediment control measure. Storm water runoff from the roadway should not discharge directly into the stream (see Exhibit 1).
2. Where applicable, divert or isolate channel flow (see **Pump Around/Work Isolation** on page 289) before starting construction of stream crossing.
3. Cut vegetation at locations used for approach roads, culvert installation, and installation of non-vegetative sediment trapping devices. **Do not** grub the stumps or root systems (the root systems help stabilize the streambanks and can help accelerate revegetation of the area). Remove all logs, limbs, and loose debris from the work area and dispose of materials in pre-approved areas located outside the limits of the floodplain.
4. Remove boulders and debris in the area of the planned culvert installation. Also remove debris that can easily be carried downstream and block culverts.

TEMPORARY STREAM CROSSING — CULVERTS

5. Place geotextile fabric on the streambed and streambanks.
6. Install culvert pipes with the invert elevation at the same elevation as the streambed to prevent obstruction of stream flow and fish passage.
7. Anchor the culvert pipe in place with anchor cables and anchor stakes (to prevent floating of the pipe during high channel flow).
8. Cover the culvert pipe with riprap (use as construction fill within the waterway channel).
9. Place a minimum of 12 inches of INDOT CA No. 2, or larger, aggregate over the riprap (for vehicular driving surface). If multiple culvert pipes are used, they need to be separated by 12 inches of compacted aggregate fill. Only clean aggregate should be placed in the stream channel. **DO NOT** use fill materials other than clean stone. Culvert pipe ends must extend a minimum of 12 inches beyond the ends of the aggregate fill slope.
10. Divert storm water runoff away from roadway approaches and into well vegetated areas or temporary sediment traps (see **Temporary Sediment Trap** on page 183). Storm water runoff from the roadway should not discharge directly into the stream.
11. Immediately stabilize all disturbed streambanks, roadway approaches, and other disturbed areas. Stabilize with appropriate permanent vegetative stabilization measures or an appropriate nonerosive armor (see **Surface Stabilization** on page 29).

Removal

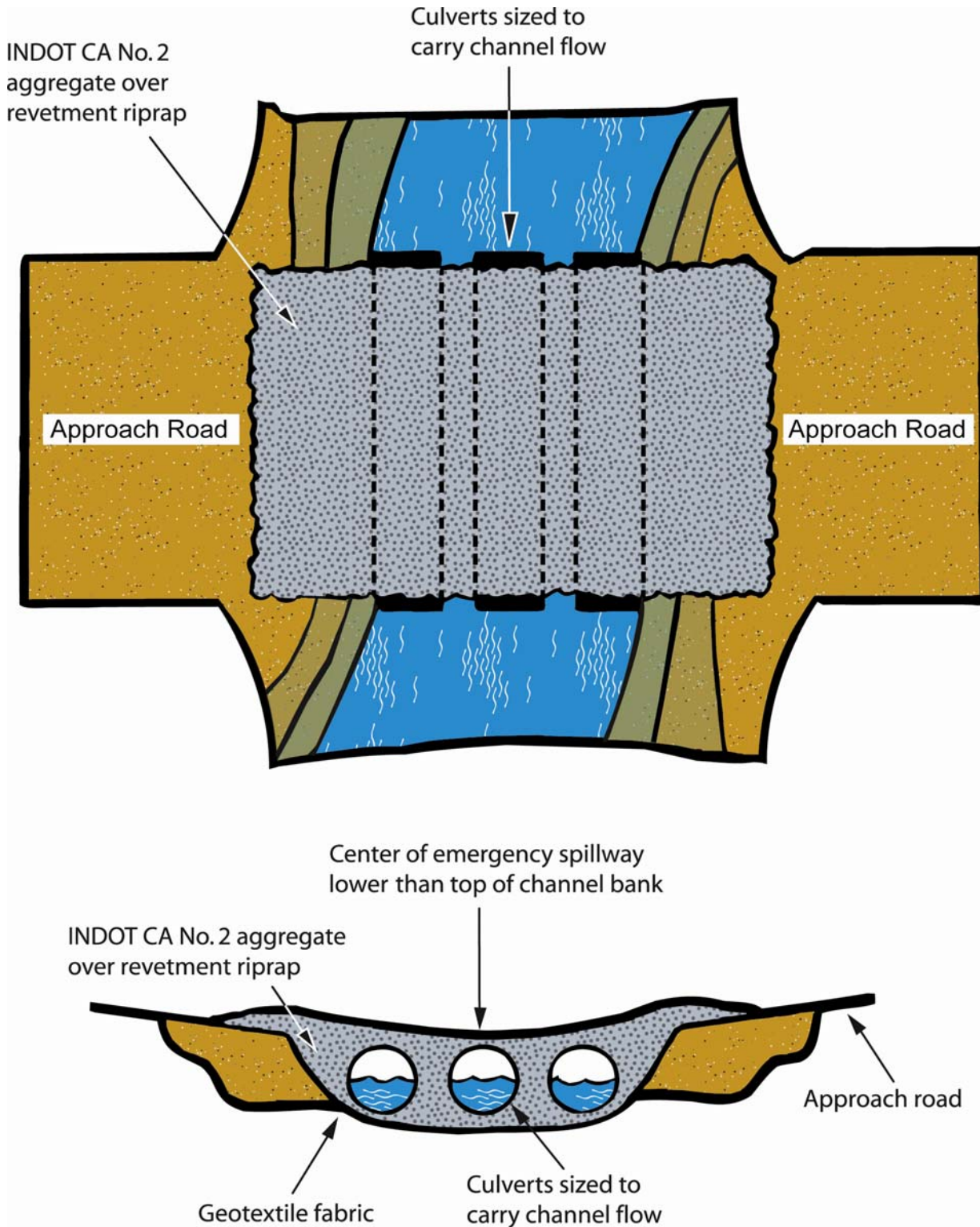
1. Remove culverts, including associated materials and debris. Clean aggregate can be left in the channel as long as it does not impede stream flow, increase flooding risk, or obstruct fish migration. (Removal of aggregate from the channel generally results in significant disturbance of the streambed and streambank, in temporary clouding of the stream, and damage to aquatic habitat.)
2. Restore the channel to its original cross section or as specified by the requirements of any applicable permits.
3. Where applicable, fill road approaches. Overfill by 10 percent to allow for settling.
4. Permanently stabilize all disturbed streambanks, roadway approaches, temporary roadways and other disturbed areas. Stabilize with appropriate permanent vegetative stabilization measures or an appropriate nonerosive armor (see **Surface Stabilization** on page 29).

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Check for accumulation of debris and obstructions such as limbs, logs, trash, rock, etc. around culvert pipe inlets; remove immediately.
- Check for erosion of streambank and banks of approach roads/ramps; repair immediately.
- Check for piping along culverts; repair immediately.
- Check for sediment accumulation in aggregate materials; remove and replace with clean aggregate. **Note:** Do not apply clean aggregate over existing sediment-laden aggregate.
- Repair any damage or displacement of aggregate.

TEMPORARY STREAM CROSSING — CULVERTS

Exhibit 1



Note: This measure requires the designer to provide design specifications and dimensions.

Temporary Stream Crossing — Fords



Source: U.S. Department of Agriculture, Natural Resources Conservation Service

A **ford** is a temporary stone structure installed across a stream or watercourse for short-term use by construction vehicles or heavy equipment.

Purpose

To provide a means of moving construction vehicles across a stream with minimal impact to the stream.

Notes:

1. **Fords are the least desirable type of stream crossing because vehicles must drive through the channel, causing clouding of the stream with each crossing.**
2. **Tires and tracks of vehicles crossing a ford should be free of mud prior to entering the channel.**
3. **Stream and riparian areas should be left in an undisturbed state to the greatest extent practical.**

Specifications

Design Considerations

- Use where very little construction traffic is anticipated.
- Use in channels with a streambank height of five feet or less.
- Do not construct during periods of fish spawning.
- In some instances it may be necessary to divert or isolate channel flow (see **Pump Around/Work Isolation** on page 289) during construction and removal of the stream crossing.

Anticipated Life

Generally less than one year.

Flow Capacity

Bank-full flow or peak discharge from a two-year frequency, 24-hour duration storm event without overflow (whichever is less).

Overflow Areas

Protected from erosion from a 10-year frequency, 24-hour duration storm event.

Discharge Velocity at Crossing Outlet

Nonerosive for the stream channel.

Permits

One or more permits may be needed from federal, state, or local permitting agencies. (NOTE: Allow sufficient time for obtaining the appropriate permits.)

Crossing Location

- Locate crossing where it will cause the least amount of disturbance to the channel and surrounding vegetation. (Good locations generally include straight, shallow sections of the channel rather than channel bends and deep pool areas.)
- Install crossing perpendicular to stream flow if feasible.

Road Approaches

- Where feasible, align first 30 to 50 feet of approach road perpendicular to channel flow. (This provides for minimal disturbance to the riparian buffer and eliminates tight turns for construction equipment, thereby reducing the potential for erosion and sediment damage to the stream.)
- Minimize erosion potential by covering with INDOT No. 2 aggregate.
- Place geotextile underlayment under aggregate if soils are soft or if area will be subject to heavy use and heavy loads. (This provides a nonerosive surface, minimizes sediment-laden storm water runoff to the stream, and reduces the potential of vehicular tracking of sediment into the stream.)
- Install water bars (see **Water Bar** on page 89) to divert storm water runoff away from approach ramps where necessary.

TEMPORARY STREAM CROSSING — FORDS

Structure

- Stable and nonerosive [clean, non-sediment producing material (i.e., no earth fill in the stream channel)].
- Must not create a flooding or safety hazard.

Materials

- INDOT revetment riprap or larger.
- INDOT CA No. 2 aggregate or larger.
- Geotextile fabric.

Installation/Removal

Stream crossings should be as narrow as practical and streambank vegetation should be preserved to the maximum extent practical.

Installation

1. Where applicable, divert storm water runoff away from roadway approaches and into well vegetated areas, temporary sediment traps (see **Temporary Sediment Trap** on page 183), or an appropriate sediment control measure. Storm water runoff from the roadway should not discharge directly into the stream (see Exhibit 1).
2. Where applicable, divert or isolate channel flow (see **Pump Around/Work Isolation** on page 289) before starting construction of stream crossing.
3. Cut vegetation at locations used for approach road ramps and non-vegetative sediment trapping devices. Where feasible, **do not** grub the stumps or root systems (the root systems help stabilize the streambanks and can help accelerate revegetation of the area). Remove all logs, limbs, and loose debris from the work area and dispose of materials in pre-approved areas located outside the limits of the floodplain.
4. If necessary, install temporary diversions (see **Temporary Diversion** on page 75) and/or water bars (see **Water Bar** on page 89) in road approach sections to divert storm water runoff away from the approach ramps.
5. Excavate and grade the approach ramps, removing all spoil material from floodplain areas.
6. Lay geotextile fabric over the approach ramp foundations (for separation and stabilization), place riprap over the geotextile fabric to the lines and grades shown in the construction plans, and stabilize approach side slopes.

TEMPORARY STREAM CROSSING — FORDS

7. Excavate a foundation subgrade across the stream channel for placement of the geotextile fabric, riprap, and aggregate. Allow for placement of the geotextile fabric, riprap, and aggregate without obstructing or restricting the natural flow of the stream.
8. Lay geotextile fabric in the channel bottom (for stabilization).
9. Place riprap over the geotextile fabric to a minimum depth of the specified d_{50} (see Appendix A – Glossary of Terms). Cover the riprap with INDOT CA No. 2, or larger, aggregate (for vehicular driving surface).

Note: The top of the stone crossing should conform to existing streambed grade with no overfall or obstruction to stream flow.

Removal

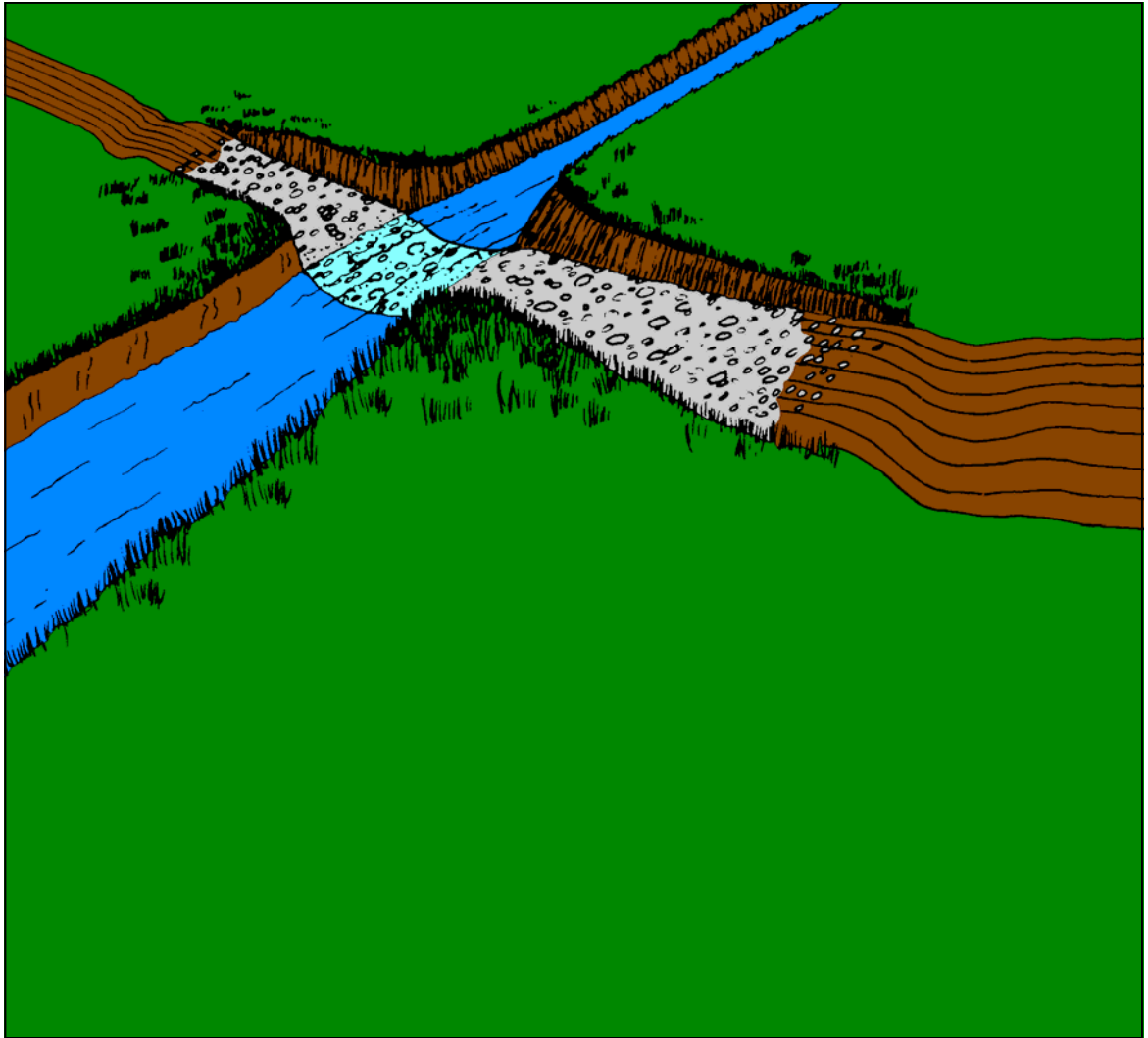
Note: Riprap and aggregate used in ford crossings should only be removed if it impedes stream flow, increases the risk of flooding, or is an obstruction to fish migration.

1. Fill road approach ramps, restoring the channel to its original cross section or as specified by the requirements of any applicable permits. Over-fill by ten percent to allow for settling.
2. Permanently stabilize all disturbed streambanks, roadway approaches, temporary roadways and other disturbed areas. Stabilize with appropriate permanent vegetative stabilization measures or an appropriate nonerosive armor (see **Surface Stabilization** on page 29).

Maintenance

- Inspect within 24 hours of a rain event and at least once every seven calendar days.
- Check for accumulated debris and obstructions; remove immediately.
- Check for erosion of streambanks and banks of approach ramps; repair immediately.
- Check for sediment deposition. Direct sediment-laden storm water runoff away from stream crossing areas and divert it to appropriate vegetated filter areas or sediment traps.
- Check for damage or displacement of aggregate; repair with clean aggregate.

Exhibit 1

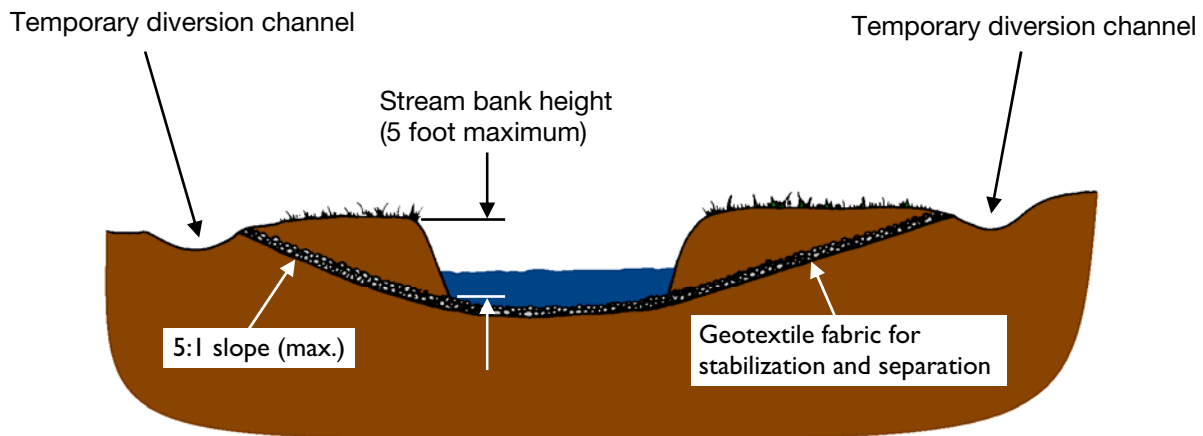


Source: Adapted from Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, 1992

TEMPORARY STREAM CROSSING — FORDS

Exhibit 2

Note: This measure requires the designer to provide design specifications and dimensions.



Source: Adapted from Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, 1992

Cofferdams



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Floating Turbidity Barriers

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Pump Around/Work Isolation

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Construction projects occasionally require some form of dewatering operation to allow for construction of building foundations, installation of utility lines, or isolation of work areas in and around waterbodies or stream channels. This usually involves the use of a pumping system which siphons water from a pit or trench. When the dewatering operation draws water from the bottom of the pit or trench, it often agitates the soil material on the bottom and results in a slurry which is pumped outside of the pit or trench. This generally results in the discharge of sediment-laden water.

Operators performing dewatering activities should take into consideration the quality of the water that will be discharged. Typically, sediment will be the primary pollutant associated with the discharge water and can be addressed through a variety of sediment control measures. However, it is not uncommon for groundwater or even surface water to contain other pollutants that can potentially be discharged through dewatering. The presence of other pollutants will typically be associated with the former land use of the project site. Several former land uses of concern might be those sites that are considered storm water hotspots. If pollutants of concern other than sediment are associated with the discharge water it may be necessary to provide additional treatment and in some situations obtain additional permits to authorize the discharge.

Measures listed in this section of the manual have been designed specifically to filter or remove soil particles from construction operations requiring the removal of groundwater and/or surface water from excavations. It is extremely important to note that these measures require intensive maintenance and require frequent monitoring, cleanout, repair and/or replacement.

The measures illustrated in this section of the manual are a representation of site management principles and storm water quality measures that can be effective for dewatering operations. The overall objective of this section is to provide options for removal of sediments that may be associated with the dewatering operation. While the measures and principles in this section are representative, the utilization of storm water measures in the Sediment Traps & Basins section on page 181 and the Sediment Barriers & Filters section on page 209 may be utilized and/or modified to specific field conditions to trap or retain sediment. Field modification by contractors of these measures is not uncommon and have proven to be innovative and effective. In addition, there are alternative measures available commercially that may be appropriate for use as part of a dewatering operation.

Designs for dewatering operations can be complex and may require site investigation and, depending on the measure selected, the application of sound engineering principles. Flow rates associated with the pumping operation are critical to the overall design and should be considered when selecting a sediment control measure. Measures should also be selected based on their performance during high flow events associated with rainfall. A professional knowledgeable in these applications and experienced in design should be consulted when selecting measures associated with dewatering.

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Filter Bags

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OTHER RELATED MEASURES

Masures contained in this section are beneficial in managing construction sites and/or controlling erosion and sedimentation. They have been included here because they do not fall cleanly into the other subsections listed in this chapter.

Measures in this section vary in their application. While some measures will not require design, others are more complex and may require detailed site investigations and the application of sound engineering principles. Measures that are more complex will require consultation of a professional knowledgeable in the application of the specific measure and experienced in design.

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OTHER RELATED MEASURES

Surface Roughening



Surface roughening is a measure used to create an intricate pattern of ridges and valleys to protect the soil surface from erosive forces, trap eroding soil particles, and enhance vegetative establishment.

Purpose

- To reduce runoff velocity and increase infiltration.
- To reduce erosion and provide for short-term trapping of sediment.
- To aid in establishment of vegetative cover from seed.

Note: Although appearing finished, graded areas with smooth hard surfaces are difficult places on which to establish vegetation.

Specifications

Location

- On slopes that are to be stabilized with vegetation.
- On graded areas that will not be immediately stabilized with vegetation (to reduce storm water runoff velocity until seeding takes place).

Roughening Slopes (Not to be Mowed)

1. Stair-step grade or groove any cut slopes having a gradient steeper than 3:1. (Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer, particularly on slopes consisting of soft rock with some subsoil.)
2. Stair-Step Construction:
 - a. Make the vertical cut distance less than the horizontal distance.
 - b. Make each vertical cut no more than two feet in soft material or three feet in rocky material.

SURFACE ROUGHENING

- c. Slope the horizontal surface of each “step” slightly inward toward the vertical wall (see Surface Roughening – Stair-Step Worksheet).
3. Groove Construction:
 - a. Use implements that can be safely operated on the slope (e.g., disk, tiller, spring harrow, front-end bucket loader teeth) to create a series of ridges and depressions that run parallel to the slope contour.
 - b. Make grooves at least three inches deep and no more than 15 inches apart (see Surface Roughening—Grooving Worksheet).

Roughening Slopes (To Be Mowed)

1. Make slopes to be mowed no steeper than 3:1.
2. Use a tiller, disk, harrow, or culti-packer to roughen the slopes, creating shallow grooves no more than ten inches apart, one inch deep, and that run parallel to the slope contour.

Roughening Areas with Tracked Machinery

1. Limit roughening with tracked machinery to sandy or relatively dry, finer-textured soils to avoid undue surface compaction. (This roughening method is generally not as effective as other roughening methods).
2. Operate the tracked machinery up and down the slope so as to leave horizontal depressions in the soil.

Note: Do not back-blade during the final grading operation.

Seeding, Fertilizing, and Mulching Roughened Areas

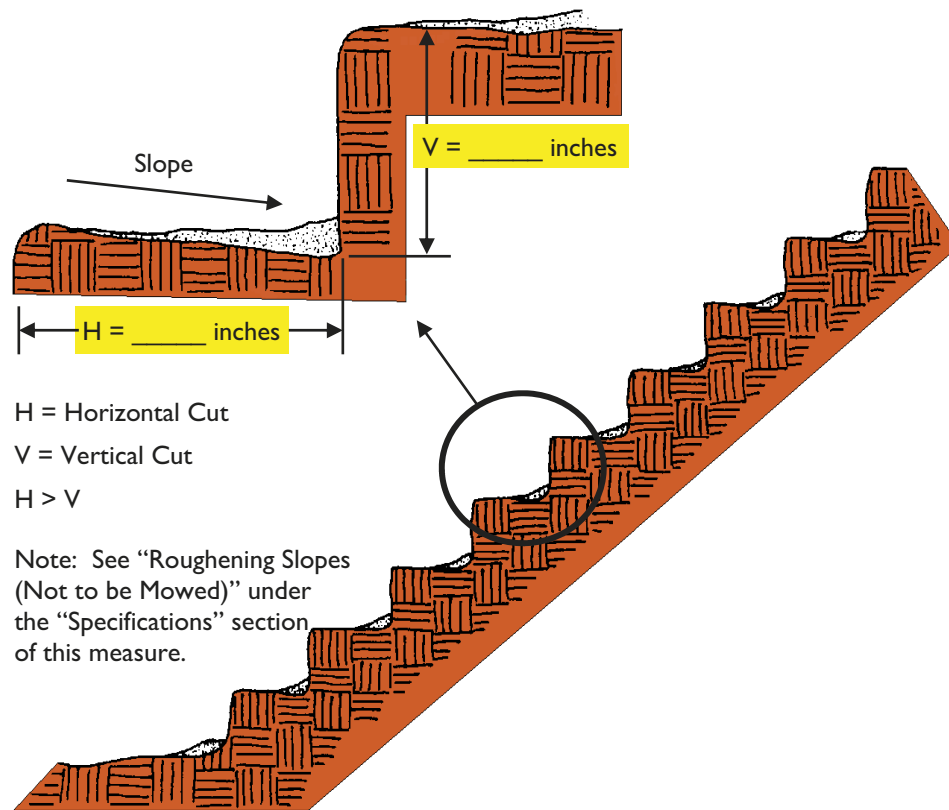
1. Immediately seed, fertilize, and mulch surface-roughened areas while soil is loose and moist to aid seed germination and vegetative growth (see **Temporary Seeding** on page 31; **Permanent Seeding** on page 35; **Mulching** on page 55 and **Compost Mulching** on page 59).
2. If roughening with tracked machinery, consider seeding, fertilizing, and mulching first, letting the cleats of the tracks incorporate the seed and fertilizer into the soil and anchor the mulch. This is especially well suited for temporary seeding when timeliness is critical and equipment is unavailable for planting operations.

Maintenance

- Inspect daily.
- Periodically check seeded slopes for rills and gullies.
- Fill eroded areas to slightly above the original grade, then reseed, apply mulch and anchor it in place.

SURFACE ROUGHENING

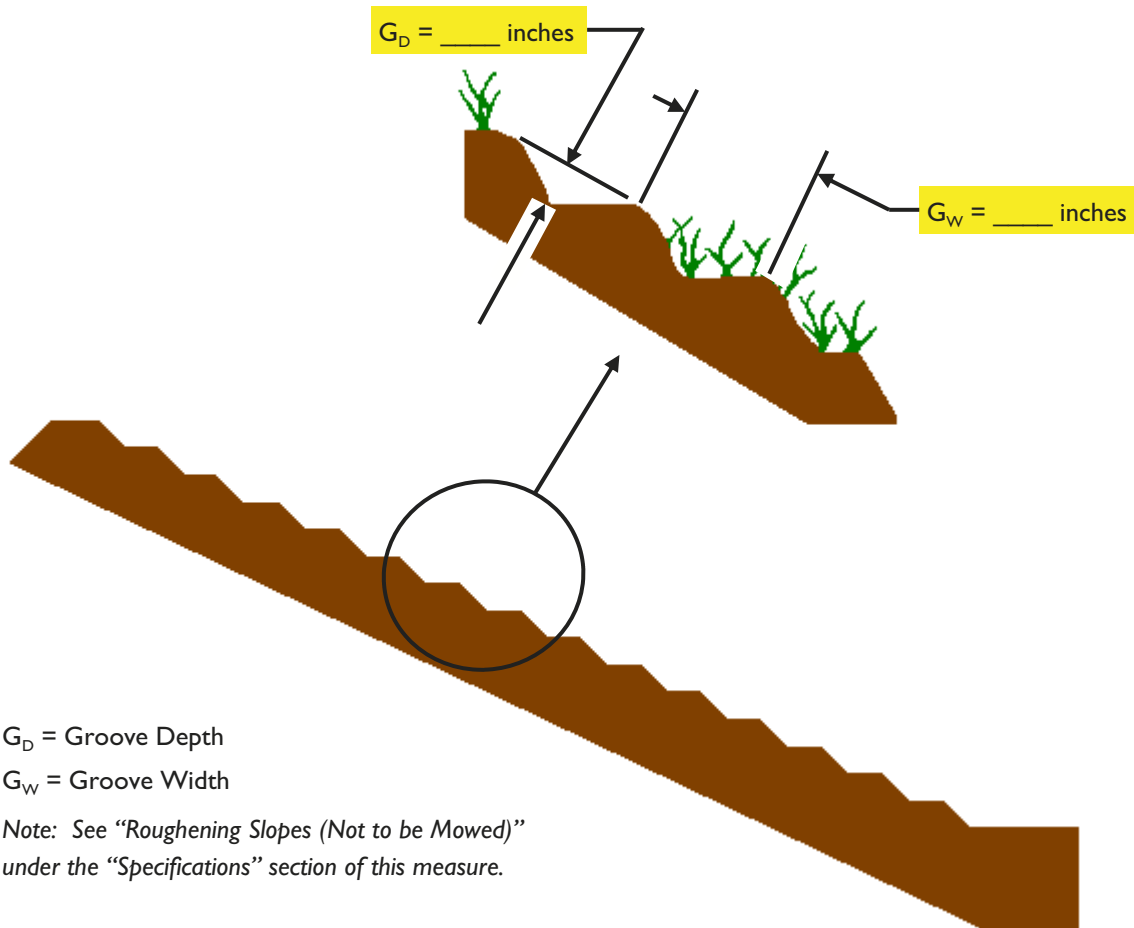
Surface Roughening – Stair-Step Worksheet



Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

SURFACE ROUGHENING

Surface Roughening – Grooving Worksheet



G_D = Groove Depth

G_W = Groove Width

Note: See "Roughening Slopes (Not to be Mowed)"
under the "Specifications" section of this measure.

Source: Adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, 1993

OTHER RELATED MEASURES

Subsurface Drainage



*Information on **subsurface drainage** is available in Appendix G – U.S. Department of Agriculture, Natural Resources Conservation Service Standards & Specifications for selected storm water quality management measures.*

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OTHER RELATED MEASURES

Retaining Walls



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