CHAPTER 6

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6.00A EROSION PREVENTION AND SEDIMENT CONTROL

This chapter covers the practices that are applicable to construction sites and other clearing, grading or filling that is usually of a temporary nature. Avoiding erosion in the first place by preserving vegetation and using proper site design is always the best choice for water quality. Unfortunately, this is not always possible on an active construction site. Under these circumstances, sediment-control practices that trap sediment before it is carried off site are used. Although many of these practices are effective for trapping coarse sediment, most fine, suspended sediment will not be stopped.

In addition to causing turbid conditions, fine sediment carries a significant load of nutrients and other pollutants that can harm water quality. Effective control of fine sediment is difficult, and requires the use of sediment basins that maintain a permanent pool of water. Even when these structures are used, all fine sediment will not be trapped. That is why it is important to stabilize construction sites and prevent erosion as soon as possible. Virtually all construction sites will affect water quality; however, proper erosion and sediment control can minimize these problems.

HOUSEKEEPING

Many of the best management practices (BMPs) in chapter 7, Pollution Prevention, are applicable to the construction site, including storage, stockpiles, spills and vehicle maintenance. These measures must be addressed by the pollution-control plan for the site. The erosion-and-sediment-control plan is one part of the overall pollution-control plan.

EROSION- AND SEDIMENT-CONTROL PLAN

Careful planning is an important part of erosion and sediment control. With careful planning, problem areas can be avoided, which will minimize both the erosion potential and the cost of sediment-control measures. Also, staging construction to not open up the whole site all at once should be required where possible.

An erosion and sediment control plan should be prepared to document planning decisions and to explain this information to reviewing officials and the contractor. The following steps are generally recommended when preparing an erosion- and sediment-control plan as appropriate for the nature of the project and the sensitivity of the site.

1. Data Collection

The existing site conditions should be evaluated to gather information that will be needed for the erosion-and-sediment-control plan. The information obtained should be plotted on a site map and explained in the narrative portion of the plan. The following data should be collected and may be marked on a topographic map of the site.

a. **Topography.** Prepare a topographic map of the site to show the existing contour elevations at intervals of not more than 2 feet (ft).

b. **Drainage patterns.** Locate and clearly mark all existing drainage patterns on the topographic map.

c. **Soils.** Determine major soil type(s) on the site topographic map. Soils information can be obtained from a soil survey if one has been published for your county. If a soil survey is not available, one can be requested from the Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service office. Or, one can enlist the services of a commercial soil-evaluation firm.

d. **Ground cover.** Show the existing vegetation on the site. Features, such as tree clusters and unique vegetation, should be shown on the map. In addition, existing denuded or exposed soil areas should be indicated.

e. **Adjacent areas.** Delineate areas adjacent to the site on the topographic map. Features, such as streams, roads, houses or other buildings and wooded areas, should be shown. Streams which will receive runoff from the site should be surveyed to determine their capacity and stability.

f. **Sensitive areas.** Special note should be made of all environmentally sensitive areas, such as lakes, streams, wetlands, fens, rare biological communities and rare wooded areas.

2. Data Analysis

When all of the data in Step 1 are considered together, a picture of the site's potential and limitations will begin to emerge. The site planner should be able to determine those areas that have potentially critical erosion hazards. The following are some important points to consider in site analysis:

a. **Topography.** The primary topographic considerations are gradient of slope and slope length. The erosion potential increases with slope and length of flow for potential runoff. When the slope has been determined, areas of similar gradient should be outlined. Slope gradients can be grouped into three general ranges of soil erodibility: (1) 0-6%, low-to-moderate erosion hazard; (2) 6-12%, moderate-to-high erosion hazard; and (3) 12% and over, severe erosion hazard.

Within these slope-gradient ranges, the greater the slope length, the greater the erosion hazard. Highly erosive soils, such as silt sands, will also increase erosion potential. Therefore, when determining potentially critical areas, the site planner should be aware of excessively long slopes and erosive soil conditions.

b. **Natural drainage.** Natural drainage patterns exist on the land. These patterns, which consist of overland flow through swales, depressions and natural watercourses, should be identified in order to plan around critical areas where water will concentrate. Where possible, natural drainageways should be used to convey runoff over and off the site to avoid the expense and problems of constructing an artificial drainage system. Man-made ditches and waterways will become part of the erosion problem if they are not properly stabilized. Care should also be taken to ensure that increased runoff from the site will not cause

instability or flooding downstream. Possible sites for stormwater detention should also be located at this time.

c. **Soils.** Soil properties, such as flood hazard, natural drainage depth to bedrock, depth to seasonal water table, permeability, shrink-swell potential, texture and potential erodibility, will exert a strong influence on land-development decisions.

d. **Ground cover.** Ground cover is the most important factor in terms of preventing erosion. Any existing vegetation that can be saved will help prevent erosion. Trees and other vegetation protect the soil as well as beautify the site after construction. If the existing vegetation cannot be saved, the planner must consider staging construction, temporary seeding or temporary mulching. Staging of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once and the time without ground cover is minimized. Temporary seeding and mulching involve seeding or mulching areas that would otherwise lie open. The National Pollutant Discharge Elimination System (NPDES) construction stormwater permit requires that temporary cover be installed within 7-21 days depending on the slope for all exposed slopes within 100 ft of the waters of the state of Minnesota. Temporary cover is the most economical way to limit the time of exposure and reduce the hazard of erosion.

e. **Adjacent areas.** This should be the primary focus of all plans. An analysis of adjacent properties should focus on areas downslope from the construction project. Waters that will receive direct runoff from the site should be the major concern. The potential for sediment pollution of these waters should be considered as well as the potential for downstream channel erosion due to increased volume, velocity and peak flow rate of stormwater runoff from the site. The potential for sediment deposition on adjacent properties due to sheet and rill erosion should also be analyzed so that appropriate sediment-trapping measures can be planned.

3. Development of the Site Plan

The principles explained in this manual can be used to minimize long-term effects on water quality from the site, as well as at the time of construction. However, erosion and sediment control planning must be an integral part of the site-planning process, not just an afterthought. The potential for soil erosion should be a significant consideration when deciding upon the layout of buildings, parking lots, roads and other facilities. Costly erosion- and sediment-control measures can be minimized if the site design can be adapted to existing site conditions and good conservation principles are used.

4. Preparing the Plan

When the layout of the site has been decided, a plan to prevent erosion and control sedimentation from leaving the disturbed areas must be formulated.

The site planner should be guided primarily by the NPDES General Construction Permits or local permits which establish a minimum level of control for all projects. The site planner should

determine which of these criteria are applicable to the site and select conservation practices that can be used to satisfy the permits.

The following general procedure is recommended for erosion and sediment control planning:

a. **Determine limits of clearing and grading.** Decide exactly which areas must be disturbed to accommodate the proposed construction. Pay special attention to critical areas that must not be disturbed, such as critical slopes or areas where trees should be saved. Where possible, leave a protective zone around critical areas that should not be disturbed. Buffer zones/filter strips around wetlands and adjacent to streams, rivers and lakes should be staked and posted to protect them from construction activity.

b. **Divide the site into drainage areas.** Determine how runoff will travel over the site. Consider how erosion and sedimentation can be controlled in each small drainage area before looking at the entire site. Remember, it is easier to prevent erosion than to contend with sediment after it has been carried downstream.

c. **Select erosion- and sediment-control practices.** Erosion- and sediment-control practices can be divided into three broad categories: (1) vegetative controls, (2) structural controls and (3) management measures.

   Vegetative controls are the first line of defense to prevent erosion. The best way to protect the soil surface is to preserve the existing ground cover. If land disturbance is necessary, temporary stabilization must be used on areas that will be inactive for long periods (7 to 21 days, depending on slope, are described in the NPDES permit).

   Structural controls are generally more costly and less efficient than vegetative controls. Structural controls are usually necessary, since not all disturbed areas can be protected with vegetation. They are usually the second or third lines of defense used to capture sediment before it leaves the site.

   Management measures include:

   - staging the construction on large projects so that one area can be stabilized before another is disturbed.
   - developing and carrying out a regular maintenance schedule for erosion- and sediment-control practices.
   - marking off limits of land disturbance on the site with tape, signs, orange safety fence or other methods, so workers can see areas that are to be protected.
   - making sure all workers understand the major provisions of the erosion and sediment control plan; for example, by holding regular erosion-control meetings before and during the life of the project with owners, contractors and other affected parties, and keeping these people updated if plans are changed.
   - delegating responsibility for implementing the erosion and sediment control to one individual (preferably the job superintendent or foreman).

d. **Plan for post-project stormwater management.** Where increased runoff will cause the capacity of a receiving channel to be exceeded, the site planner will need to select appropriate stormwater-management measures. Any changes to discharges from a site must be in compliance with regulations of the local watershed district or water-management organization. Ponds may be required by MPCA permits, local ordinances or other agencies.

The final step is consolidating the pertinent information and developing it into a specific erosion-and-sediment-control plan for the project. The general criteria planning flow charts at the end of this chapter can help the planner identify needs and select appropriate practices.

The plan consists of two parts: (1) a narrative, commonly known as project specifications and special provisions, and (2) a site plan. The narrative explains site problems and their solutions with all necessary documentation. The site plan is one or a series of maps or drawings that contain information explained in the narrative.

Checklists of items that should be included in a narrative and a site plan are shown in section 6.00b. These checklists can be used by a site planner as a quick reference to determine whether all the major items are included in the erosion-and-sediment-control plan.

Technical Assistance

A number of possible sources of erosion and sediment control planning assistance are available within the state:

Soil and Water Conservation Districts. One of the primary functions of these districts is to provide assistance to landowners for soil conservation planning and implementation. There are 91 soil and water conservation districts throughout the state serving its 87 counties. These districts have elected representatives (supervisors) from each locality.

USDA Natural Resources Conservation Service. The NRCS provides technical assistance and conservation planning and implementation to landowners throughout the country through local soil and water conservation districts. In addition, the NRCS, along with the University of Minnesota, prepares soil surveys within the state.

University of Minnesota Extension Service. The extension service can provide valuable information on establishment of turf and plant materials. The extension service has a number of useful publications and will have soil samples analyzed upon request to determine requirements for turf establishment on a particular site.

PERMITS

A NPDES permit may be required from the Minnesota Pollution Control Agency (MPCA) for activities that involve clearing, grading or filling. Work in waters, including wetlands, may require Minnesota Department of Natural Resources or U.S. Army Corps of Engineers permits. Local units of government may also require permits. For details, contact the appropriate agencies.

LOCAL PROGRAMS

In many areas, erosion and sediment control on construction sites is regulated by local ordinance. These ordinances can be an effective tool for achieving sediment control when there is a program in place to support them. There is a wide diversity in local approaches to these ordinances and the programs used to implement them. Because of the differences in local needs and programs, a

model ordinance or program is not presented here. For information about the local erosion-and-sediment-control program and ordinances that are in effect, contact your local unit of government or the local soil and water conservation district.

PLAN REVIEW

When a state or local program requires development of erosion-and-sediment-control plans, a review process involving the owner, contractor and local reviewer should be used. The reviewing team will need a certain level of technical expertise to properly evaluate a plan. The reviewing team needs to be able to read a topographic map and be familiar with the BMPs and general criteria presented in this manual. Experience in soil and water management is helpful in anticipating problem areas. This manual should help a review team become familiar with the practices and criteria. With experience, the review team will learn to detect trouble areas and determine the most effective erosion-control practices.

Several resources, which supplement the information in the plan, may be helpful to the review team. These resources include local stormwater-management plans, wetland inventories, lake inventories, topographic maps and soil surveys. The checklists for site plan and narrative preparation can also be used as checklists for review.

A preconstruction conference with the owner or developer, contractor, and local review team is strongly recommended. During this meeting, the plan can be jointly reviewed, any problems or misconceptions resolved, and a basis for clear communication and good working relations established.

INSPECTIONS

Regular on-site inspections are strongly recommended after construction begins, and are required as a part of compliance with the NPDES Storm Water permit, and possibly other permits. The NPDES permit requires inspections after every rainfall and/or every 7 days. Inspection insures that the approved plan is implemented, provides the land developer with technical assistance as needed, provides a means to determine whether changes to the plan are necessary and to note deviations from the plan when they first occur.

Essential elements of an inspection program include:

- inspection during or immediately following initial installation of sediment controls, in particular, silt fence sediment basins, sediment traps, diversions and other structural measures;
- inspection following every rain event which results in runoff that leaves the construction site, to check for damage to controls;
- inspection prior to seeding deadlines, particularly in the fall;
- final inspection of projects nearing completion to ensure that temporary controls have been removed, stabilization is complete, drainageways are in proper condition, and that the final contours agree with the proposed contours on the approved plan. This inspection should be made prior to the release of any performance guarantees.

In addition, interim inspections should be made, giving particular attention to the maintenance of installed controls.

All inspections must be documented by a written report or log. These reports should contain all rainfall events, the date and time of inspections, dates when land-disturbing activities begin, comments concerning compliance or noncompliance, and notes on any verbal communications concerning the project. A sample inspection log is shown in section 6.00b.

6.00B Erosion Prevention And Sediment Control: INSPECTOR'S COMPLIANCE GUIDE (under Minnesota's General Storm Water Permit for Construction Activity)

When doing inspections:

1. Document time and date of the inspection, weather conditions and on-site contact persons.
2. Report any potential violations to the general contractor and representative of the owner.
3. Document all potential problems in field notes and photographs.

RECORDS

The project's final plans and specifications, which include both temporary and permanent control plan requirements, must be available at the construction site in either a field office or an inspector's or contractor's vehicle.

Temporary Erosion and Sediment Control Plan, completed in accordance with the permit Appendix A must be available within 24 hours.

Permanent Erosion and Sediment Control Plan, completed in accordance with the permit Appendix B must be available within 24 hours.

Records of all inspections must be available within 24 hours, including:

- date of all rainfall events
- date and time of inspections,
- finding of inspections,
- corrective actions taken (including dates and times), and
- documentation of all changes to the Temporary Erosion and Sediment Control Plan made during construction.

If the records requirements are not being complied with, it may be a violation of permit provisions (see permit provisions parts I.C.1, I.C.2.a, I.C.2.b, I.C.2.c).

Permit Coverage Card

A notice of stormwater permit coverage card must be placed in a visible location at the construction site throughout the duration of the project. The card can be placed at any of the following locations:

- construction site entrance, visible from the nearest public roadway;
- where no construction site entrance exists, at a location visible from the nearest public roadway;
- at the field office (if applicable); or

- for linear utility and noncontiguous municipal projects (*i.e.*, city street improvements), at the office responsible for the project's administration.

If the records requirements are not being complied with, it is a violation of permit provisions (see permit provisions parts I.C.2.d, I.C.3).

EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION

Erosion Control. Permittee must use horizontal slope grading, construction phasing, temporary diversions, and/or other practices that minimize erosion.

Exposed slopes within 100 lineal feet from a water of the state, or from a curb, gutter, storm sewer inlet, or temporary or permanent drainage ditch that is connected to a water of the state should have temporary protection or permanent cover within the following time frames:

- steeper than 3:1, within 7 days.
- less than 3:1, but steeper than 10:1, within 14 days.
- flatter than 10:1, within 21 days.

If erosion control is not being complied with, it is a violation of permit provisions (see permit provisions parts I.D.1.a, I.D.1.b).

Ditch and Outlet Stabilization. The bottom of any temporary or permanent drainage ditch constructed to drain water from a construction site must be stabilized within 100 lineal feet from a water of the state. Stabilization must be initiated ***within 24 hours*** of connecting the drainage ditch to a water of the state, existing gutter, storm sewer inlet, drainage ditch or other stormwater-conveyance system that discharges to waters of the state. Stabilization must be completed within five calendar days. (Note: Normally this should be completed before connection)

Before to connecting any pipe to a water of the state or drainage ditch, the pipe's outlet must be provided with temporary or permanent energy dissipation to prevent erosion.

If the ditch and outlet stabilization is not being complied with, it is a violation of permit provisions (see permit provisions parts I.D.1.c, I.D.1.d).

PERIMETER CONTROLS. All down gradient perimeter sediment-control bmps must be in place before any up gradient land-disturbing activity begins.

The permittee must minimize vehicle tracking of sediment off-site wherever vehicles exit the construction site onto paved surfaces. In areas where curb and gutter exist, inlet protection must be in place, along with a plan to keep impervious surfaces free of sediment.

Where 10 or more contiguous acres of exposed soil contribute to a discernible point of discharge, temporary sedimentation basins meeting the following criteria must be provided prior to runoff leaving the site of entering waters of the state:

- Basins must provide 1,800 cubic ft of storage per exposed acre drained.

- Basin outlets must be designed to prevent short circuiting and the discharge of floating debris.

If the perimeter controls are not being complied with, it is a violation of permit provisions (see permit provisions parts I.D.2.a, I.D.2.b, I.D.2.c.1, I.D.2.c.2).

If permanent ponds are required, they can often be used in place of temporary ponds, but construction sediment should be removed before final Notice of Termination has been submitted.

BMP INSPECTION

Inspect all erosion- and perimeter-sediment-control BMPs to ensure integrity and effectiveness. All nonfunctional perimeter-sediment-control BMPs should be repaired when the trapped sediment reaches one-third of the height, or replaced or supplemented with functional BMPs ***within 24 hours of discovery***. All nonfunctional erosion-control BMPs should be repaired or ***replaced within 24 hours*** of discovery, or as soon as field conditions allow access.

Inspect all sedimentation basins to ensure their effectiveness. When the depth of the sediment collected in the basin reaches the heights of the riser, or the storage volume, the basin should be drained and the sediment removed within 72 hours of discovery, or as soon as field conditions allow access.

If inspection and maintenance is not being complied with, it is a violation of permit provisions (see permit provisions parts I.E.1.a, I.E.1.b).

SEDIMENT LEAVING THE SITE

Inspect all drainage ditches and other waters of the state for evidence of sediment leaving the site. Unless the project has received approval or certification for depositing fill into waters of the state, the permittee should remove all sediment in drainageways, catch basins or other waters of the state and restabilize the areas where sediment removal results in exposed soil. The removal and stabilization must take place ***within seven days*** of discovery unless precluded by legal, regulatory or physical access restraints. If precluded, removal and stabilization must take place within seven calendar days of obtaining access.

Inspect all construction site vehicle exit locations for evidence of sediment being tracked off-site. Sediment should be removed from paved surfaces which do not drain back into the construction site ***within 24 hours of discovery***.

If sediment leaving the site is not being inspected and corrected, it is a violation of permit provisions (see permit provisions parts I.E.1.c, I.E.1.d).

VIOLATION FOLLOW-UP

Alleged violations must be brought to the attention of the on-site general contractor and representative of the owner (if that person is present) before leaving the site.

Inspectors should follow this procedure:

1. Thoroughly and accurately document all potential violations through the use of field-inspection notes, photographs and audiovisual equipment, if possible.
2. Write up a detailed inspection report and transmit it to the responsible party as soon as possible after the inspection.
3. Request all potential violations be corrected in accordance with the time frames specified in the permit.
4. Report continued potential violations and inadequate response to inspections to the MPCA.

Violations not remediated in accordance with the time frames specified in the permit are subject to MPCA enforcement action, pursuant to Minn. Stat. §§ 115.071, 116.072, and 609.671, for violation of water-quality environmental laws.

Sample Check List:

CHECKLIST FOR RESOURCE MANAGEMENT PLAN REVIEW
BY: SCOTT SOIL AND WATER CONSERVATION DISTRICT

General information to be included with or as part of the Resource Management Plan (RMP):

- ❑ Project Description – narrative describing the nature and extend of the land disturbing activity.
- ❑ Existing Site Conditions – describe existing topography, drainage patterns and wetlands.
- ❑ Soils – show soil boundaries, include: mapping unit, soil name, slopes and hydrologic group.
- ❑ Location Map – show the site with respect to the surrounding areas.
- ❑ Drawing Data – indicate north, show scale and include benchmark for horizontal and vertical datum.
- ❑ Plan Preparer – name and phone number of individual responsible for plan preparation.
- ❑ Existing Contours – show existing 2 foot contours (at least 200 ft beyond property boundaries).
- ❑ Final Contours – show proposed 2 ft contours for proposed grading.
- ❑ Existing Vegetation – show different cover conditions for the entire site with approximate areas.
- ❑ Property Boundaries – show property boundaries, lot lines, section lines and adjacent plats.
- ❑ Adjacent Areas – narrative describing which neighboring properties will be affected by proposed plat.
- ❑ Elevation and Grade – street and ditch grades, pond, wetland, lake NWL and HWL, pipe inverts.
- ❑ Location of BMP's – location of erosion and sediment control features (BMP Criteria).
- ❑ Location of Utilities – location of existing and proposed utilities if known.

Stormwater Management information to be included on or with the Resource Management Plan

- ❑ Drainage Areas – show existing and proposed drainage areas used for stormwater analysis.

- ❑ Runoff Curve Numbers (RCN's) – detailed breakdown of existing and proposed RCN's used.
- ❑ Impervious Coverage – list assumptions for determining impervious area (house pad, driveway, etc.).
  List new impervious area for each subwatershed (if 1 acre or more drains to a discernible point, a wet detention pond is needed for treatment of runoff prior to discharge to water of the state according to W.W. Walker criteria. If development does not require a pond based on these standards and the development will be creating over an acre of impervious, a wet detention pond is still needed).
- ❑ Drainage Calculations – show calculations for 2, 10 and 100 year peak discharge rates comparing existing and proposed conditions with comparable subwatersheds (TR 55 method or similar methodologies).
- ❑ Precipitation Events – rainfall depths for the 2, 10 and 100 year 24-hour frequency storm events are 2.8, 4.2 and 6.0 inches respectively (reference US Weather Bureau Technical Paper 40). Stormwater ponding will be based on the 6.0 inch event. On site conveyance systems will be designed for the 4.2 inch event.
- ❑ Detention Pond – calculations for pond used to control peak discharge rates (BMP Criteria)
- ❑ Wet Detention Pond – NURP pond used for nutrient removal and peak discharge rate control. Show calculations for estimated inflow and outflow, permanent and temporary storage volumes, mean depth, outlet design, downstream stabilization, emergency spillway, pond profile and pond cross section. (W.W. Walker criteria.)
- ❑ Floatable Skimmers – included on outlet of wet detention ponds. Show construction details on plan.
- ❑ Volume Increase – increased RCN's will increase the volume and duration of runoff leaving the site. These increases in volume and duration may have a negative effect on downstream conveyance.
- ❑ Ground Water Sensitivity – areas identified as being highly susceptible to ground water contamination need the following standards incorporated into the design of the wet detention pond: pond will be lined with 2 ft of impermeable soil.
- ❑ Flood Plain – show protected waters on the grading plan with associated predicted 100 year flood plain. Show calculations for 100 year flood plain predictions.
- ❑ Any land locked areas need to be accounted for in the design analysis for existing conditions. If no outlet is present, what is the predicted 100 year flood elevation and how will this be maintained?
- ❑ Show existing tile lines. Design should plan as though tiles will no longer function unless an easement is supplied for future maintenance.

Erosion Control information to be included on or with the Resource Management Plan

- ❑ Implementation Schedule – list the order of operations for construction activities. Include:
  1. Phasing of construction – start and completion dates for each phase.
  2. List order of operations – all erosion control measures shall be installed and must be functional prior to upslope grading activities taking place.
  3. Contact Person – individual responsible maintaining the erosion and sediment control features.
  4. Disposal or removal of erosion and sediment control features upon final stabilization of project.
  5. Pond clean out – removal of sediment from pond upon final stabilization to design elevations.
- ❑ Critical Erosion Areas – describe areas with potential for serious erosion problems.
- ❑ Limits of Disturbed Area – if 5 acres or more drain to a discernible point, then a temporary sediment control basin is needed to treat runoff.
- ❑ Stabilization of exposed and soil stockpile areas.
- ❑ Stabilizing of waterways and outlets – on site conveyance systems capable of handling the 5 year
  24-hour frequency storm (3.6") without erosion.
- ❑ Adjacent properties protected from erosion.
- ❑ Storm Sewer Inlets – protection provided to prevent sediment laiden water from entering (if applicable).
- ❑ Permanent Erosion Control – grass seed, fertilizer and mulching specifications and rates listed. Mulch anchoring methods and time requirements for permanent seeding listed. (15 days after substantial grading completed).
- ❑ Rip Rap – rip rap placed at all culvert outfalls to minimize scour.
- ❑ Rock Construction Entrances – entrances planned where applicable to minimize tracking onto roads.
- ❑ BMP Construction Details – include on the erosion control plan all construction details for BMP's used.
- ❑ Incorporate horizontal slope grading where applicable.

Wetlands

- ❑ Has wetland delineation been submitted to the LGU and the Scott Soil and Water Conservation District for review.
- ❑ Have the wetlands been surveyed as part of the plat.
- ❑ Show normal water levels and 100 year flood elevations for all wetlands.
- ❑ Have wetland easements been identifed around all wetland areas delineated as wetland.
- ❑ Have wetland regulations been complied with prior to approval of preliminary plat.

6.00C Erosion Prevention and Sediment Control: PROVISIONS IN CONTRACTS

Once the planner has decided upon methods of pollution prevention and control, the plan must be implemented. Work that is being constructed under unit-priced contracts will require a clear and concise explanation of the requirements in contract documents.

The specifications for the job should include a detailed description of the pollution-prevention-and-control work required, stating clearly what is required, when it is required and who is responsible for carrying it out. Do not rely upon a boilerplate statement of the contract that states that the contractor must comply with all local ordinances to cover all pollution-prevention-and-control work. Any work that will be required should be clearly described and included in appropriate bid items. Unit-priced bid items are suggested because they provide more flexibility for quantity variations than do lump-sum bid items. A sample contract specification for including details on this work is shown below.

The best construction-and-management practices possible will not help if they are not installed at the proper time. The contract should specify that sediment-control structures must be installed before the contributing drainage area is disturbed. There are times when this may not be possible, but those are the exception and not the rule. Also, sediment-control structures will not be effective unless they are maintained. Specifications should indicate how and when practices should be maintained. Another provision that may be important to include on some jobs is to require approval for the contractor to open new work areas. This provision is not intended to prevent the contractor from having an efficient operation; it is intended to prevent areas from being stripped several months before they are needed. It also provides an opportunity to discuss sediment-control measures for the area that is about to be opened.

The drawings for a job should show the location for planned pollution-prevention-and-control structures. Details of structures should also be shown so they are installed and maintained properly.

During construction, change orders may be needed to address additional pollution-prevention-and-control needs that are identified in the field. Also, the contractor's operation may eliminate the need for certain measures or may alter the location where they will be most effective. All changes to the plan should be documented.

Sample Construction Specification for Pollution Control

1. **Scope**

   The work should consist of installing measures or performing work to control erosion and minimize delivery of sediment and other pollutants to water and air during construction operations in accordance with these specifications.

2. **Materials**

   All materials should meet the requirements of the Material Specifications listed in these specifications.

3. **Erosion- and Sediment-control Measures**

   The measures should include, where appropriate, but not be limited to, the following (as shown on the drawings or as specified in the appropriate section of this specification).

   - Staging of Earthwork Activities. The excavation and moving of soil materials should be scheduled so that the smallest possible area will be unprotected from erosion for the shortest time feasible.
   - Seeding. Seeding to protect disturbed areas should be used as specified on the drawings or in the appropriate sections of this specification.
   - Soil Stabilization. Soil stabilizers, mulching, sodding, erosion-control blankets or turf-reinforcement mats should be used as appropriate to temporarily protect soil surfaces from erosion.
   - Diversions. Diversions should be used to divert water away from work areas or to collect runoff from work areas for treatment and safe disposition.
   - Stream Crossings. Stream crossings should be used where fording of streams by equipment is necessary.
   - Sediment Basins. Sediment basins should be used to settle and filter out sediment from eroding areas to protect water quality and properties below the construction site.
   - Silt Fences. Silt fences should be used to trap sediment from areas of limited runoff. Silt fences are temporary and should be removed when the contributing area is permanently stabilized.
   - Inlet Protection. Inlet protection is required in the permit and should be used as appropriate.
   - Waterways. Waterways should be protected by the safe disposal of runoff from surface areas, diversions, and other structures or measures.

Sample Construction Specification for Pollution Control *(cont.)*

4. **Chemical Pollution**

   Gasoline, oil, sanitary facilities, such as toilets, and other chemicals or tanks should not be located next to streams, wells or springs. They should be located a sufficient distance to prevent water contamination, and should be installed in accordance with all state and local regulations.

   The contractor should provide tanks, barrels, secondary containment, dikes, spill-collection materials or sumps (using approved materials) to collect pollutants produced as a byproduct of the project's work (for example, drained lubricating or transmission oils, hydraulic fluid, antifreeze/ coolants, greases, soaps or asphalt). At the completion of work, the pollutants should be removed from the site and disposed of in accordance with state and local regulations.

5. **Air Pollution**

   State and local regulations concerning the burning of brush, slash or other materials must be adhered to. In no case will tires be allowed to ignite or be burned with tree or brush piles.

   All public or haul roads used during construction of the project should be maintained as necessary to suppress dust.

6. **Maintenance and Removal**

   All measures and works should be adequately maintained in a functional condition as long as needed during the construction operation. All temporary measures should be removed and the site restored as nearly to original condition as practicable as directed by the engineer.

7. **Measurement and Payment**

   For all items of work for which specific unit prices are established in the contract, each item will be measured to the nearest unit applicable. Payment for each unit will be made at the contract unit price for that item. Such payment will constitute full compensation for all labor, materials, equipment, tools, labor, and other items necessary and incidental to the completion of the work.

8. **Withholding**

   Payment will be subject to withholding of a portion of the contract amount to cover the reasonable value of any uncompleted operation that is designated as a part of the complete project. The amounts withheld for erosion control will be based upon the estimated surface area exposed to probable erosion without the required surface-finishing and turf-establishment operations being completed.

9. **Items of Work and Construction Details**

   In this section, you should list specific practices that are required, material specifications, maintenance requirements, etc. Be certain to specify when they must be installed, and how long they must remain in place.

6.00D Erosion Prevention and Sediment Control: CONSTRUCTION SEQUENCE SCHEDULING

Reduce on-site erosion and off-site sedimentation by performing land-disturbing activities and installing erosion-protection and sedimentation-control practices in accordance with a planned schedule.

CONDITIONS WHERE PRACTICE APPLIES

All land development that clears, grades or fills a significant land area.

PLANNING CONSIDERATIONS

The removal of existing surface ground cover leaves a site vulnerable to accelerated erosion. Good planning will reduce land clearing, provide necessary controls, and restore protective cover.

DEFINITION

A construction sequence schedule is a specified work schedule that coordinates the timing of land-disturbing activities and the installation of erosion-protection and sedimentation-control measures.

PURPOSE

Purpose of the construction sequence schedule is to address erosion prevention and sediment control in an efficient and effective manner. Appropriate sequencing of construction activities can be a cost-effective way to help accomplish this goal. The plan can be open to changes that should be discussed at the erosion control project meetings.

Scheduling considerations are summarized in Table 6.01a. The generalized construction activities shown in the table do not usually occur in a specified linear sequence, and schedules will vary due to weather and other unpredictable factors. However, the proposed construction sequence should be indicated clearly in the erosion-and-sedimentation-control plan.

Construction access is normally the first land-disturbing activity. Exercise care not to damage valuable trees or disturb designated buffer zones. Trees should be protected around the drip line of the branches. Avoid activities that will compact the root zone.

Principal sediment basins and traps should be installed before any major site-grading takes place. Erect additional sediment traps and silt fences as grading takes place to keep sediment contained on site at appropriate locations.

Key runoff-control measures should be located in conjunction with sediment traps to divert water from planned undisturbed areas out of the traps and sediment-laden water into the traps. Install diversions above areas to be disturbed prior to grading. Place necessary perimeter dikes with stable outlets before opening major areas for development. Install additional needed runoff-control measures as grading takes place.

Table 6.00D-1 Considerations for construction scheduling

Construction Activity	Schedule Consideration
Identify and label protection areas (*e.g.*, buffer zones, filter strips, trees).	Site delineation should be completed before construction begins.
Construction access. Construction entrance, construction routes, equipment parking areas and cutting of vegetation (necessary perimeter controls).	First land-disturbing activity -- Establish protected areas and designated resources for protection. Stabilize bare areas immediately with gravel and temporary vegetation as construction takes place.
Sediment traps and barriers. Basin traps, sediment fences, and outlet protection (necessary perimeter controls).	Install principal basins after construction site is accessed. Install additional traps and barriers as needed during grading.
Runoff control. Diversions, silt fence, perimeter dikes, water bars, and outlet protection.	Install key practices after principal sediment traps and before land grading. Install additional runoff control measures during grading.
Runoff conveyance system. Stabilize stream banks, storm drains, channels, inlet and outlet protection, and slope drains.	Where necessary, stabilize stream banks as early as possible. Install principal runoff conveyance system with runoff-control measures. Install remainder of system after grading.
Grubbing and grading. Site preparation: cutting, filling and grading, sediment traps, barriers, diversions, drains, surface roughening.	Begin major grubbing and grading after principal sediment and key runoff control measures are installed. Clear borrow and disposal areas only as needed. Install additional control measures as grading progresses.
Surface stabilization: temporary and permanent seeding, mulching, sodding and installing riprap.	Apply temporary or permanent stabilization measures immediately on all disturbed areas where work is delayed or complete.
Building construction: buildings, utilities, paving.	Install necessary erosion and sedimentation control practices as work takes place.
Landscaping and final stabilization: topsoiling, planting trees and shrubs, permanent seeding, mulching, sodding, installing riprap.	Last construction phase - Stabilize all open areas, including borrow and spoil areas. Remove and stabilize all temporary control measures.
Maintenance	Maintenance inspections should be performed weekly, and maintenance repairs should be made immediately after periods of rainfall.

The main runoff-conveyance system with inlet and outlet protection devices should be installed early, and used to convey stormwater runoff through the development site without creating

gullies and washes. Install inlet protection for storm drains as soon as the drain is functional to trap sediment on site in shallow pools and to allow flood flows to safely enter the storm-drainage system. Install outlet protection at the same time as the conveyance system to prevent damage to the receiving stream.

Normally, install stream stabilization, including necessary stream crossings, independently and ahead of other construction activities. It is usually best to schedule this work as soon as weather conditions permit. Site clearing and project construction increases storm runoff, often making stream-bank-stabilization work more difficult and costly.

Begin grubbing and grading as soon as key erosion- and sediment-control measures are in place. Once a scheduled development area is cleared, grading should follow immediately so that protective ground cover can be re-established quickly. Do not leave any area bare and exposed for extended periods (see NPDES permit requirements). Leave adjoining areas planned for development or ones that are to be used for borrow and disposal undisturbed as long as possible to serve as natural buffer zones.

Runoff control is essential during the grading operation. Temporary diversions, slope drains, and inlet and outlet protection installed in a timely manner can be very effective in controlling erosion during this critical period of development.

After the land is cleared and graded, apply surface stabilization on graded areas, channels, dikes and other disturbed areas. Stabilize any disturbed area where active construction will not take place for 21 working days (see NPDES permit requirements) by temporary seeding and/or mulching or by other suitable means. Install permanent stabilization measures after final grading, in accordance with the vegetative plan. Temporary seeding and/or mulching may be necessary during extreme weather conditions with permanent vegetation measures delayed until a more suitable installation time.

Coordinate building construction with other development activities so that all work can take place in an orderly manner and on schedule. Experience shows that careful project scheduling improves efficiency, reduces cost and lowers the potential for erosion and sedimentation problems.

Landscaping and final stabilization is the last major construction phase, but the topsoil stockpiling, tree preservation, undisturbed buffer area, and well-planned road locations established earlier in the project may determine the ease or difficulty of this activity. All disturbed areas should have permanent stabilization practices applied. Unstable sediment should be removed from sediment basins and traps and incorporated into the topsoil, not just spread on the surface. All temporary structures should be removed after the area above has been properly stabilized. Borrow and disposal areas should be permanently vegetated or otherwise stabilized.

In planning construction work, it may be helpful to outline all land-disturbing activities necessary to complete the proposed project. Then list all practices needed to control erosion and sedimentation on the site. These two lists can then be combined in logical order to provide a practical and effective construction-sequence schedule.

DESIGN CRITERIA

At a minimum, the construction sequence schedule should show the following:

- the erosion- and sedimentation-control practices to be installed,
- principal development activities,
- the measures that should be in place before other activities are begun, and
- compatibility with the general construction schedule of the contract.

CONSTRUCTION SPECIFICATIONS

Many timely construction techniques, such as shaping earthen fills daily to prevent overflows and constructing temporary diversions ahead of anticipated storms, can reduce the erosion potential of a site. These type of activities cannot be put on the construction sequence but should be used whenever possible.

Following a planned construction-sequence schedule to control erosion should help keep field personnel aware of the possibilities of erosion prevention through construction management.

MAINTENANCE

Follow the construction sequence throughout project development. When changes in construction activities are needed, amend the sequence schedule in advance to maintain management control.

Orderly modification assures coordination of construction and erosion-control practices to minimize erosion and sedimentation problems. When major changes are necessary, you may want to send a copy of the modified schedule to the local permitting authority.

6.00E Erosion Prevention and Sediment Control: PRESERVATION AND PROTECTION DESIGNATION

DEFINITION

Preservation and protection designation includes practices to preserve and protect desirable features of the landscape (especially endangered species habitats, rare biological communities, wetlands, fens, trees or tree stands, erodible slopes and waters) from damage during project development.

PURPOSE

The purpose is to preserve and protect areas that have present or future value for use in protection from erosion, for landscape and aesthetic value, or for other environmental benefits.

CONDITIONS WHERE PRACTICE APPLIES

Preservation and protection designation should be used on development sites that contain important resources.

PLANNING CONSIDERATIONS

Preserving and protecting trees and other natural plant groups often results in a more stable and aesthetically pleasing development. During site evaluations, note where valuable trees and other natural landscape features should be preserved, then consider these trees and plants when determining the location of roads, buildings or other structures.

Trees that are near construction zones should be either protected or removed, because damage during construction activities may cause their death later.

Features of the landscape should be considered for preservation when they:

- are rare or endangered or have historical significance.
- stabilize the soil and prevent erosion.
- reduce stormwater runoff by intercepting rainfall, promote infiltration, and lower the water table through transpiration.
- moderate temperature changes, promote shade and reduce the force of wind.
- provide buffers and screens against noise and visual disturbance, providing a degree of privacy.
- filter pollutants from the air, remove carbon dioxide from the air and produce oxygen.
- provide a habitat for animals and birds.
- increase property values and improve site aesthetics.

Consider the following characteristics when selecting areas to be protected and saved:

Tree vigor. Preserve healthy trees. Where there are many trees or a large forested area, consider the use of a professional natural resources manager. This person can provide on-site, expert advice on methods to minimize damage to the remaining trees. In areas where oak wilt disease is likely, try to time land-clearing operations so they do not coincide with the spring-summer danger season for insect-caused transmission of this disease. The period from April 15 to July 1 is the critical time when oaks should not be damaged lest they attract the insects that spread oak wilt. (Repair and paint immediately if damaged.)

Vegetation age. Old, picturesque trees may be more aesthetically valuable than smaller, younger trees, but they may require more extensive protection or may be at the end of their life cycle. Remnants of native grass prairies are also very rare and should be protected.

Species. Preserve those species that are most suitable for site conditions and landscape design. Vegetation that is short-lived or susceptible to storm damage or is susceptible to attack by insects or disease may be poor choices for preservation.

Aesthetics. Choose trees that are aesthetically pleasing, shapely, large or colorful. Avoid trees that are leaning or in danger of falling. Occasionally, an odd-shaped tree or one of unusual form may add interest to the landscape if it is strategically located. However, be sure the tree is healthy.

Wildlife benefits. Choose areas that are preferred by wildlife for food, cover, migration or nesting. A mixture of evergreens and hardwoods may be beneficial. Evergreen trees are important for cover during the winter months, whereas hardwoods are more valuable for food.

Water-quality benefits. Preserve vegetation adjacent to lakes, streams and wetlands and in areas of potentially erodible soils.

DESIGN CRITERIA

Construction activities can significantly injure or kill vegetation unless protective measures are taken. Although direct contact by equipment is an obvious means of damaging trees, most serious damage is caused by root zone stress from compacting, filling, or excavating too closely to the tree. Clearly mark boundaries to maintain sufficient undisturbed area around the trees. Consider the use of a professional arborist or forester in the development of the plan.

The following criteria should be considered when developing sites in wooded areas:

- Leave critical areas (such as flood plains, steep slopes and wetlands) with desirable trees in their natural condition or only partially clear them.
- Locate roadways, storage areas and parking pads away from valuable tree stands. Follow natural contours, where feasible, to minimize cutting and filling in the vicinity of trees.
- Select trees to be preserved before siting roads, buildings or other structures.
- Plan ahead for utility installation. Minimize trenching in areas with trees.
- Designate groups of trees and individual trees to be saved on the erosion-and-sedimentation-control plan.
- Do not excavate, traverse or fill closer than 25 ft of the dripline, or perimeter of the canopy, of trees to be saved (MnDOT 2572).
- If possible, disturb no more than 25% of the roots within the dripline of any tree. For forest-grown trees, use the critical root radius approach, which is calculated by multiplying the tree

height by 40%. This approach increases the protection zone for forest-grown trees, which have a smaller canopy spread.

CONSTRUCTION SPECIFICATIONS

1. Place barriers to prevent the approach of equipment within 25 ft of the dripline of trees to be retained (see Figure 6.00E-1).

2. Do not nail boards to trees during building operations.

3. Do not cut tree roots inside the tree dripline.

4. Do not place equipment (including vehicle parking), construction materials, topsoil or fill dirt within the limit of the dripline of trees to be saved.

5. If a tree marked for preservation is seriously damaged, remove it and replace it with a tree of the same or similar species, 2-inch caliper or larger, from balled-and-burlapped nursery stock when activity in the area is complete.

6. During final site cleanup, remove barriers around trees.

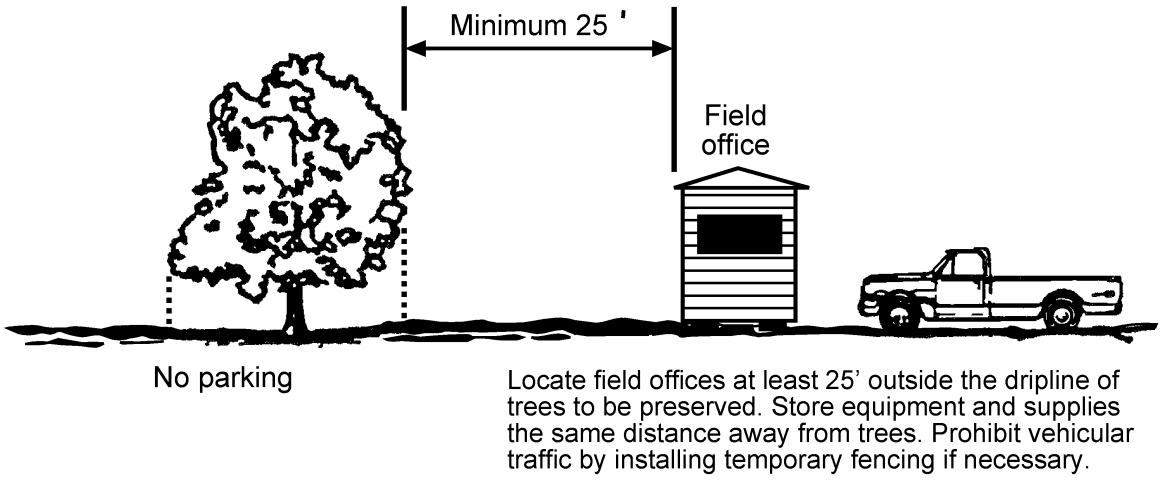


Figure 6.00E-1 Dripline setback (source: Minnesota Department of Transportation, February 1997)

MAINTENANCE

Inspect daily and repair barriers and stakes as needed.

In spite of precautions, some damage to protected trees may occur. In such cases:

- Repair any damage to the crown, trunk or root system immediately.
- Repair roots by cutting off the damaged areas and painting the wounds with tree paint. Spread peat moss or moist topsoil over exposed roots.
- Repair damage to bark by trimming around the damaged area as shown in Figure 6.00E-2, taper the cut to provide drainage, cut out only the injured area--do not paint. During April, May and June, damage to oak trees should be repaired within 15 minutes to prevent against oak wilt. Wounds on oak trees should be painted.
- Cut off all damaged limbs above the tree collar at the trunk or main branch. Use three separate cuts as shown in Figure 6.00E-3 to avoid peeling bark from health areas of the tree.

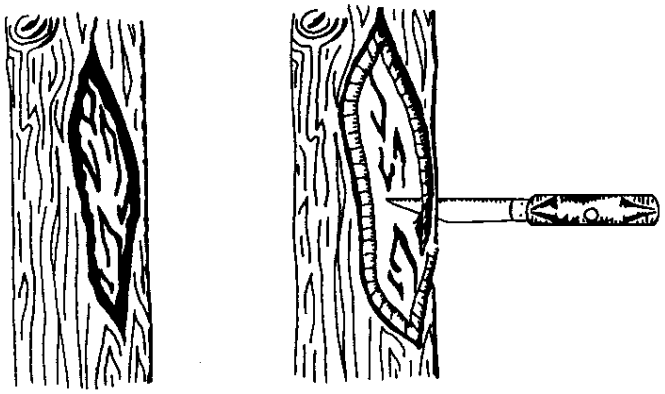
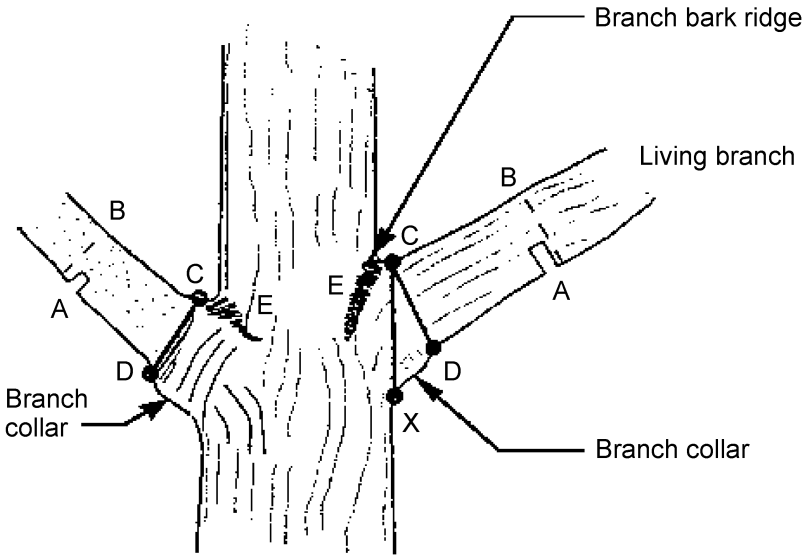


Figure 6.00E-2 Trimming a tree wound (source: North Carolina, May 1994)



First cut partway through the branch at point A.

Make a second cut completely through branch from point B to A.

Make the final cut from point C to D.

If D is hard to find drop a plumb line vertically down to point X. The angle XCD should be approximately equal to XCE.

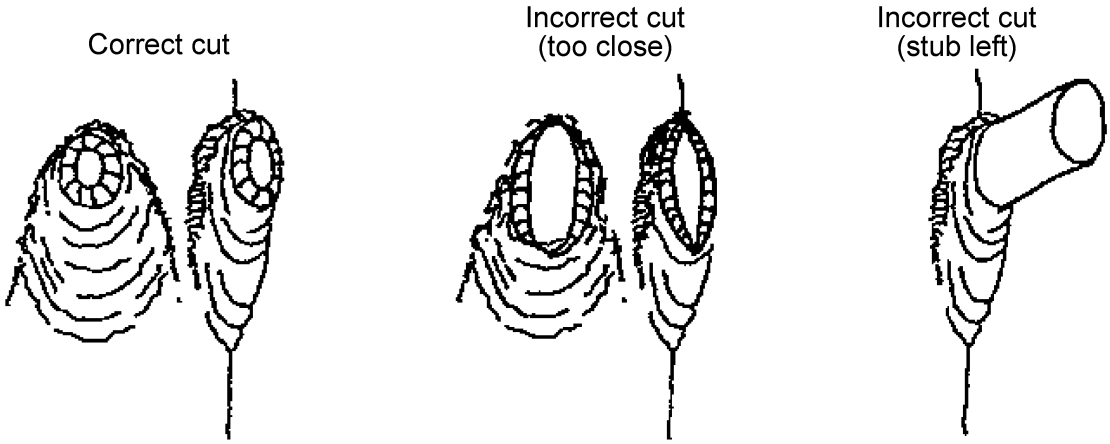


Figure 6.00E-3 The Shigo pruning method leaves a branch collar. Flush pruning does not leave a collar, making it impossible for the wound to close completely and leaving an entry point for decay organisms, insects and diseases. (Source: North Carolina, May 1994.)

6.01 Site Preparation: LAND GRADING

DEFINITION

Land grading is reshaping the ground surface to planned grades as determined by engineering survey evaluation and layout.

PURPOSE

The purpose of grading is to provide more suitable topography for buildings, facilities and other land users; to control surface runoff; and to minimize soil erosion and sedimentation both during and after construction. The plan should define areas that must not be disrupted by grading and filling, including staking, marking and fencing required to prevent damage to these areas.

These practices are applicable where grading to a planned elevation is necessary and practical for the proposed development of a site and for proper operation of sedimentation-control practices.

PLANNING CONSIDERATIONS

Fitting a proposed development to the natural configurations of an existing landscape reduces the erosion potential of the site and the cost of installing erosion- and sedimentation-control measures. It may also result in a more desirable and less costly development.

Before grading begins, decisions must be made on the gradient of cut-and-fill slopes, how they will be protected from runoff, how they will be stabilized and how they will be maintained. The grading plan establishes drainage areas, directs drainage patterns and affects runoff velocities.

The grading plan forms the basis of the erosion-and-sedimentation-control plan. Key considerations that affect erosion and sedimentation include deciding which slopes are to be graded, when the work will start and stop, the degree and length of finished slopes, where and how excess material will be disposed of, and where borrow is needed.

Leaving undisturbed temporary and permanent buffer zones (*i.e.*, vegetated buffer strips) in the grading operation may provide an effective and low-cost erosion-control measure that will help reduce runoff velocity and volume and off-site sedimentation. In developing the grading plan, always consider how to take advantage of undisturbed water-disposal outlets before storm drains or other constructed outlets are installed.

DESIGN CRITERIA

Base the grading plan and installation upon adequate surveys and soil investigations. In the plan, show disturbed areas, cuts, fills, and finished elevations of the surface to be graded. Include in the plan all practices necessary for controlling erosion on the graded site and minimizing sedimentation downstream. Such practices may include--but are not limited to--sediment basins, diversions, mulching, vegetation, vegetated and lined waterways, grade-stabilization structures, and surface and subsurface drains. The practices may be temporary or permanent, depending upon the need after construction is completed.

In the grading plan, make provisions to intercept and conduct all surface runoff to stable watercourses to minimize erosion on newly graded slopes.

Use slope breaks, such as diversions or benches, as appropriate to reduce the length of cut-and-fill slopes to limit sheet and rill erosion and prevent gullying. A spacing guide is shown in Table 6.01-1.

Table 6.01-1 Spacing guide for slope breaks

Slope	Spacing (ft)
50% (2:1)	20
33% (3:1)	35
25% (4:1)	45
15-25%	50
10-15%	80
6-10%	125
3-6%	200
< 3%	300

Stabilize all graded areas with vegetation, crushed stone, riprap or other ground cover as soon as grading is completed or work is interrupted for 21 working days or more. Use mulch, or other temporary measures, to stabilize areas temporarily where final grading must be delayed. The finished cut-and-fill slopes, which are to be vegetated with grass and legumes, should not be steeper than 2:1. Slopes that will be mowed should not be steeper than 3:1. Slopes in excess of 2:1 may warrant mechanically stabilized earth walls, reinforced soil slopes or retaining walls. Roughen the surface of all slopes during the construction operation to retain water, increase infiltration and facilitate vegetation. Finish grade slopes vertically so that machine tracks act as check dams instead of allowing rills to develop.

Do not place cuts or fill so close to property lines without adequately protecting adjoining properties from erosion, sedimentation, slippage, subsidence or other damages, especially at the toe of the slope.

Provide subsurface drainage to intercept seepage in areas with high water tables that would affect slope stability or bearing strength or create undesirable wetness.

Do not place fill next to a channel bank, where it can create bank failure or result in deposition of sediment downstream.

Show all borrow and disposal areas within the project limits in the grading plan, and ensure all disposal locations are adequately drained and stabilized. (Note: Erosion prevention and sediment control is also required for these areas when NPDES permits are required.)

Show environmentally sensitive areas on the grading plan and ensure that they are adequately identified and protected.

Provide stable channels and floodways to convey all runoff from the developed area to an adequate outlet without causing increased erosion or off-site sedimentation.

MAINTENANCE

Periodically check all graded areas and the supporting erosion control practices, especially after heavy rainfalls (or as required by the NPDES permit). Promptly remove all sediment from diversions and other water-disposal practices. If washouts or breaks occur, repair them *immediately*. Prompt maintenance of small, eroded areas before they become significant gullies is an essential part of an effective erosion-and-sedimentation-control plan.

6.02 Site Preparation: BORROW AND STOCKPILE AREAS

PURPOSE

The objective is to control the potential erosion and runoff from borrow or stockpile areas.

DEFINITION

This section deals with borrow and stockpile areas for construction-related activities. Borrow or stockpile areas are areas cleared, graded or filled to provide borrow material or where earthen material for grading or filling is stockpiled. This does not include stockpiles of other materials, such as salt or concrete, which are covered in other sections.

PLANNING CONSIDERATIONS

These areas should be considered a part of the erosion-control plan and should be stabilized on any cleared, graded or filled areas of a construction site.

6.03 Site Preparation: CONSTRUCTION ROAD STABILIZATION

DEFINITION

This practice involves the stabilization of temporary construction-access routes, on-site vehicle transportation routes, and construction parking areas.

PURPOSE

The purpose of this practice is to control erosion on temporary construction routes and parking areas.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all traffic routes and parking areas for temporary use by construction traffic.

PLANNING CONSIDERATIONS

Improperly planned and maintained construction roads can become a continual erosion problem. Excess runoff from roads causes erosion in adjacent areas, and an unstabilized road may become a dust problem. Construction vehicle traffic routes are especially susceptible to erosion because they become compacted and collect and convey runoff water along their surfaces. Rills, gullies and troublesome muddy areas form unless the road is stabilized.

During wet weather, unstabilized dirt roads may become so muddy they are virtually unusable, generating sediment and interrupting work. Proper grading and stabilization of construction routes often saves the contractor money by improving the overall efficiency of the construction operation while reducing the erosion problem.

Situate construction roads to reduce erosion potential, following the natural contour of the terrain. Avoid steep slopes, wet or rocky areas and highly erosive soils.

Controlling runoff from the road surface and adjoining areas is a key erosion-control consideration. Generally, locate construction roads in areas where seasonally high water tables are deeper than 18 inches. Otherwise, subsurface drainage may be necessary. Minimize stream crossings and install them properly (see Practices 6.70, Temporary Stream Crossing, and 6.71, Permanent Stream Crossing).

When practical, install permanent paved roads and parking areas and use them for construction traffic early during the construction operation to minimize site disruption.

DESIGN CRITERIA

Road grade. A maximum grade of 10 to 12% is recommended, although grades up to 15% are permissible for short distances.

Road width. The width of roads should be 14-foot minimum for one-way traffic, 20-foot minimum for two-way traffic.

Side slope of road embankment should be 2:1 or flatter.

Ditch capacity. Roadside ditch and culvert capacities should be designed for the 10-year peak runoff.

Stone surface. Use a 6-inch course aggregate base material or other base specified in *Minnesota Department of Transportation Standard Specifications*.

Permanent road standards. Design standards are available from the Minnesota Department of Transportation (MnDOT) district engineer. Follow these specifications for all permanent roads.

CONSTRUCTION SPECIFICATIONS

1. Clear roadbed and parking areas of all vegetation, roots and other objectionable material.

2. Ensure that road construction follows the natural contours of the terrain if possible.

3. Locate parking areas on naturally flat areas if they are available. Keep grades sufficient for drainage but generally not more than 2-3%.

4. Provide surface drainage, and divert excess runoff to stable areas by using water bars and level spreaders (see part 4.14, Runoff-control Measures).

5. Keep cuts and fills at 3:1 or flatter for safety and stability and to facilitate establishment of vegetation and maintenance.

6. Spread base material evenly over the full width of the road and smooth to avoid depressions.

7. Where seepage areas or seasonally wet areas must be crossed, install subsurface drains and/or geotextile fabric before placing the base material (see Practice 6.81, *Subsurface Drains*).

8. Stabilize and vegetate all roadside ditches, cuts, fills and other disturbed areas or otherwise appropriately stabilize them as soon as grading is complete (*see: Surface Stabilization*).

9. Provide appropriate sediment-control measures to prevent off-site sedimentation.

MAINTENANCE

Inspect construction roads and parking areas periodically for condition of surface. Topdress with new gravel and regrade as needed. Check road ditches and other seeded areas for erosion and sedimentation after runoff-producing rains. Maintain all vegetation in a healthy, vigorous condition. Sediment-producing areas should be treated immediately.

6.04 Site Preparation: TEMPORARY CONSTRUCTION ENTRANCE

DESCRIPTION AND PURPOSE

A temporary construction entrance is a stone pad located where vehicles leave a construction site. The purpose of the stone pad is to provide an area where mud can be removed from tires before a vehicle leaves the site. The stone pad consists of clean rock designed in such a way that vehicle tires will sink in slightly. This helps remove mud from the tires as the vehicle passes over the pad. If a wash rack is used, it provides an area where vehicle tires can be washed.

EFFECTIVENESS

The effectiveness of temporary rock construction entrances for trapping sediment depends upon the length, depth of rock, frequency of use and maintenance, as well as the type of structure used. A newly installed rock construction entrance meeting the recommendations included here will be relatively effective for removing mud from tires before construction vehicles leave the site. However, once the rock voids become clogged with mud, the practice will not serve its intended purpose until the rock is replaced. Washing vehicle tires with pressurized water over a wash rack is very effective for removing mud.

PLANNING CONSIDERATIONS

It is always preferable to prevent mud from being deposited upon a road rather than cleaning the road off later. Mud on a road can create a safety hazard as well as a sediment pollution problem.

In some cases, the action of tires moving over a gravel pad may not adequately clean tires. In those cases, the tires may need to be washed with water before the vehicle leaves the site. When water is used to wash tires, a wash rack will keep the driving surface mud-free. Wash water will need to be treated or recycled.

DESIGN RECOMMENDATIONS

1. The rock used for gravel pads should be a minimum 1- to 3-inch size, such as MnDOT coarse aggregate. The aggregate should be placed in a layer at least 6 inches thick. Generally, the larger the aggregate, the better.

2. The rock entrance should be at least 50 ft long; however, longer entrances may be required to adequately clean tires.

3. Geotextile fabric may be needed under the rock to prevent migration of mud from the underlying soil into the stone.

4. If tires are cleaned with water, the wash water should be directed to a suitable settling area. A wash rack installed on the rock pad may make washing more convenient and effective. The wash rack would consist of a heavy grating over a lowered area. The grating may be a prefabricated rack, such as a cattle guard, or it may be constructed on site of structural steel.

In any case, the wash rack must be strong enough to support the vehicles that will cross it. Figure 6.04-1 shows a typical wash rack installation.

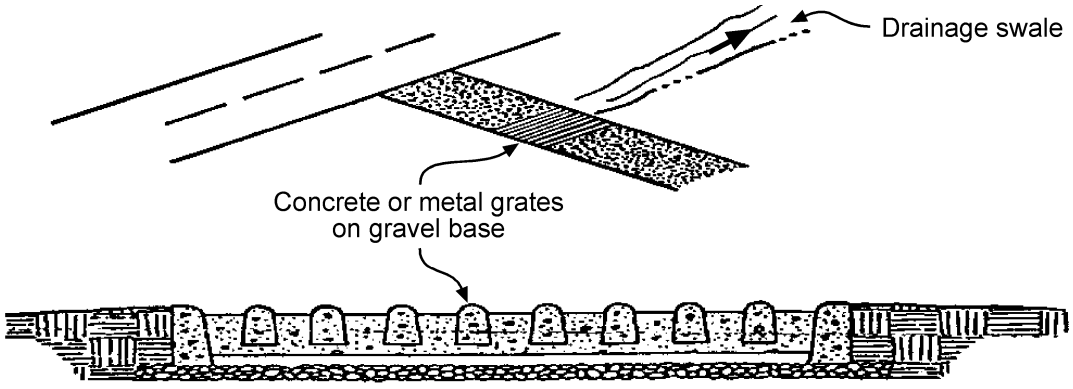


Figure 6.04-1 Typical wash rack installation

MAINTENANCE

The rock pad needs occasional maintenance to prevent the tracking of mud onto paved roads. This may require periodic topdressing with additional rock or removal and reinstallation of the pad.

6.05 Site Preparation: LOT BENCHING

DESCRIPTION AND PURPOSE

Lot benching is the grading of lots within a subdivision so that the runoff from each lot is directed to a stable outlet rather than to an adjacent lot. This practice is most applicable in subdivision developments on hilly or rolling topography.

Lot benching will reduce the slope and length of slope of disturbed areas, thereby reducing the erosion potential. This practice also establishes drainage patterns on individual lots within a subdivision at the time of rough grading. This prevents drainage problems later during home construction.

EFFECTIVENESS

Lot benching can be very effective for controlling erosion on hilly developments. By reducing slope lengths and the steepness of slopes, the potential for erosion is lowered. The amount of benefit derived from this practice depends upon the steepness of the slopes and the erodibility of soils on the site. For example, on a site with 6% slopes and typical slope lengths of 150 ft, lot benching can reduce erosion rates by 85%.

PLANNING CONSIDERATIONS

Lot benching should be done during rough grading operations on the site. In addition to the erosion-control benefits, this allows the planner to establish drainage patterns for the development. After rough grading, the lots should be protected from erosion by temporary or permanent seeding and mulching, depending upon the length of time expected until home construction.

DESIGN RECOMMENDATIONS

1. The lots should be graded so that runoff flows towards the cut slope of the lot located on the uphill side of the lot. This prevents runoff from being directed over a steep slope to a lower lot.

2. Runoff from each lot should be directed to the street, a road ditch or another stable outlet rather than onto an adjacent lot.

3. The final grade of the building site should be as flat as possible.

MAINTENANCE

If an extended period of time passes before homes are built, maintenance of the vegetation may be required. Maintenance may include mowing or spraying to control noxious weeds.

6.06 Site Preparation: TEMPORARY STREAM CROSSINGS

DEFINITION

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

PURPOSE

Temporary stream crossing provide a means for construction vehicles to cross streams or watercourses without moving sediment into streams, damaging the stream bed or channel, or causing flooding.

CONDITIONS WHERE PRACTICE APPLIES

Temporary stream crossings are used where heavy equipment must be moved from one side of the stream channel to another, or where light-duty construction vehicles must cross the stream channel frequently for a short time.

PLANNING CONSIDERATIONS

These projects may need state, federal or local permits, so check with the appropriate agencies for their requirements.

Careful planning can minimize the need for stream crossings. Try to avoid crossing streams. Whenever possible, complete the development separately on each side and leave a natural buffer zone along the stream. Temporary stream crossings are a direct source of water pollution, they may create flooding and safety hazards, they can be expensive to construct, and they cause costly construction delays if they are washed out.

Select locations for stream crossings where erosion potential is low. Evaluate stream channel conditions, overflow areas, and surface runoff control at the site before choosing the type of crossing. When practical, locate and design temporary stream crossings to serve as permanent crossings to keep stream disturbance to a minimum.

Plan stream crossings in advance of need and, when possible, construct them during dry periods to minimize stream disturbance and reduce cost. Ensure that all necessary materials and equipment are on-site before any work is begun. Complete construction in an expedient manner and stabilize the area immediately.

When construction requires dewatering of the site, construct a bypass channel before undertaking other work. If stream velocity exceeds that allowed for the in-place soil material, stabilize the bypass channel with riprap or other suitable material. After the bypass is completed and stable, the stream may be stabilized (See also section 4.50, Riprap Stabilization, and part 4.13, Diversion Structures.).

Unlike permanent stream crossings, temporary stream crossings may be allowed to overtop during peak storm periods. However, the structure and approaches should remain stable. Keep any fill needed in flood plains to a minimum to prevent upstream flooding and reduce erosion potential. Use riprap to protect locations subject to erosion from overflow.

A sediment trap is generally not recommended, and may be more damaging to the stream than if none were installed. Where they may be found to be appropriate, in-stream sediment traps may be used immediately below stream crossings to reduce downstream sedimentation. When using an in-stream sediment trap, excavate the basin a minimum of 2 ft below the stream bottom and approximately two times the cross-sectional flow area of the existing channel. Ensure that the flow velocity through the basin does not exceed the allowable flow velocity for the in-place soil material; otherwise, the basin should not be excavated. The use of manufactured sediment-removing mats may also be applicable.

Temporary stream crossings may need local, state or federal permits.

Stream crossings are of three general types: bridges, culverts and fords. Consider which method best suits the site conditions.

Bridges. Where available materials and designs are adequate to bear the expected loading, bridges are preferred for temporary stream crossing (Figure 6.06-1). Bridges usually cause the least disturbance to the streambed, banks and surrounding area. They provide the least obstruction to flow and fish migration. They generally require little maintenance, can be designed to fit most site conditions, and can be easily removed and their materials salvaged. However, bridges are generally the most expensive temporary stream crossings to design and construct. Further, they may offer the greatest safety hazard if they are not adequately designed, installed and maintained, and if washed out, they cause a longer construction delay and are more costly to repair.

In steep watersheds, tie a cable or chain to one corner of the bridge frame and secure the other end to a substantial object. This will prevent flood flows from carrying the bridge downstream, where it may damage other property.

Culvert crossings. Culverts are the most common stream crossings. In many cases, they are the least costly to install, can safely support heavy loads, and are adaptable to site conditions. Construction materials for culverts are readily available and can be salvaged. However, the installation and removal of culverts causes considerable disturbance to the stream and surrounding area. Culverts also offer the greatest obstruction to flood flow and are subject, therefore, to blockage and washout (Figure 6.06-2).

Fords. Fords made of stabilizing material, such as rock, are often used in steep areas subject to flash flooding, where normal flow is shallow (less than 3 inches deep) or intermittent. Fords should only be used where crossings are infrequent. Fords are especially adapted for crossing wide, shallow watercourses (Figure 6.06-3).

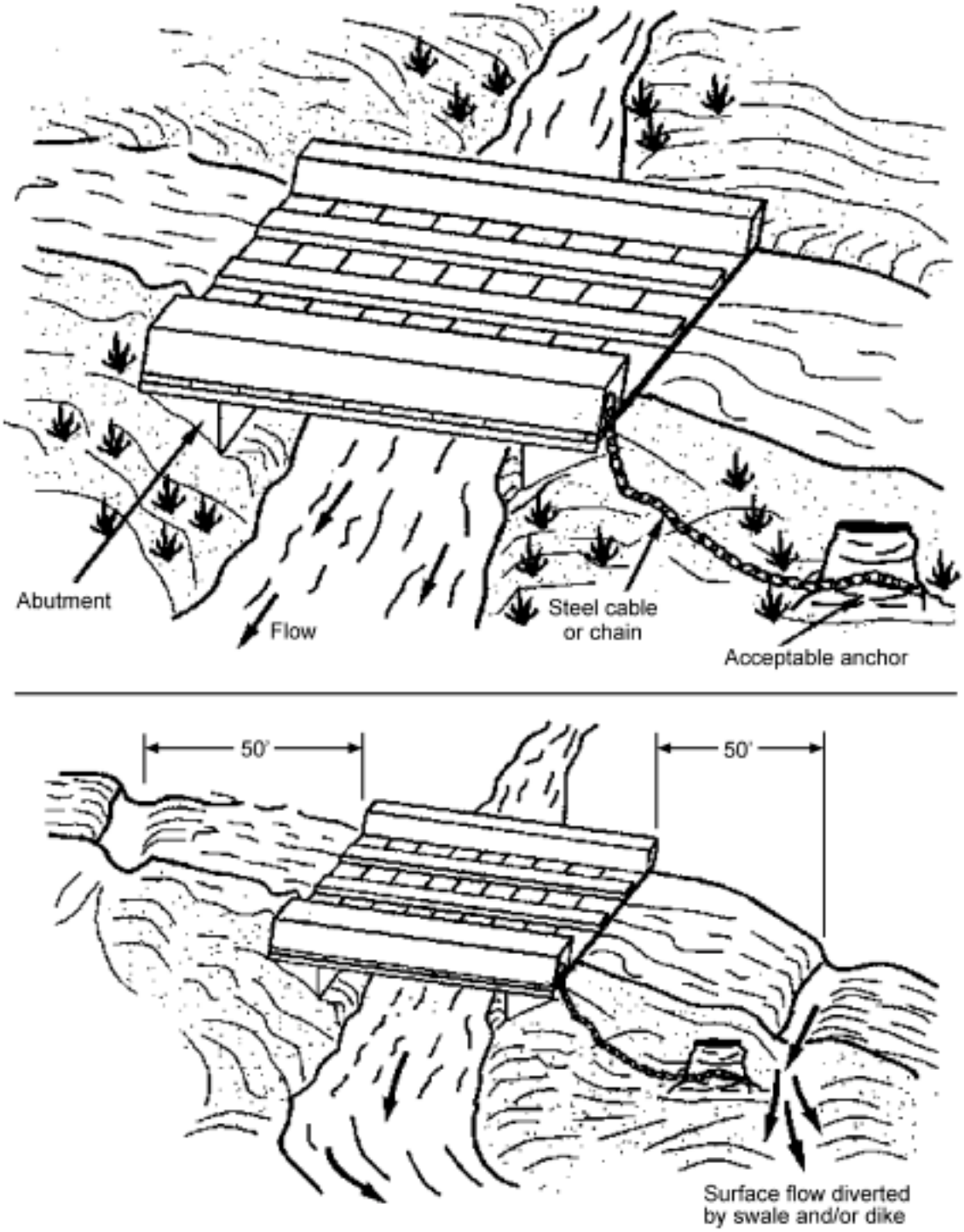


Figure 6.06-1 Temporary bridge crossing (source: *1983 Maryland Standards and Specifications for Soil Erosion and Sediment Control)*

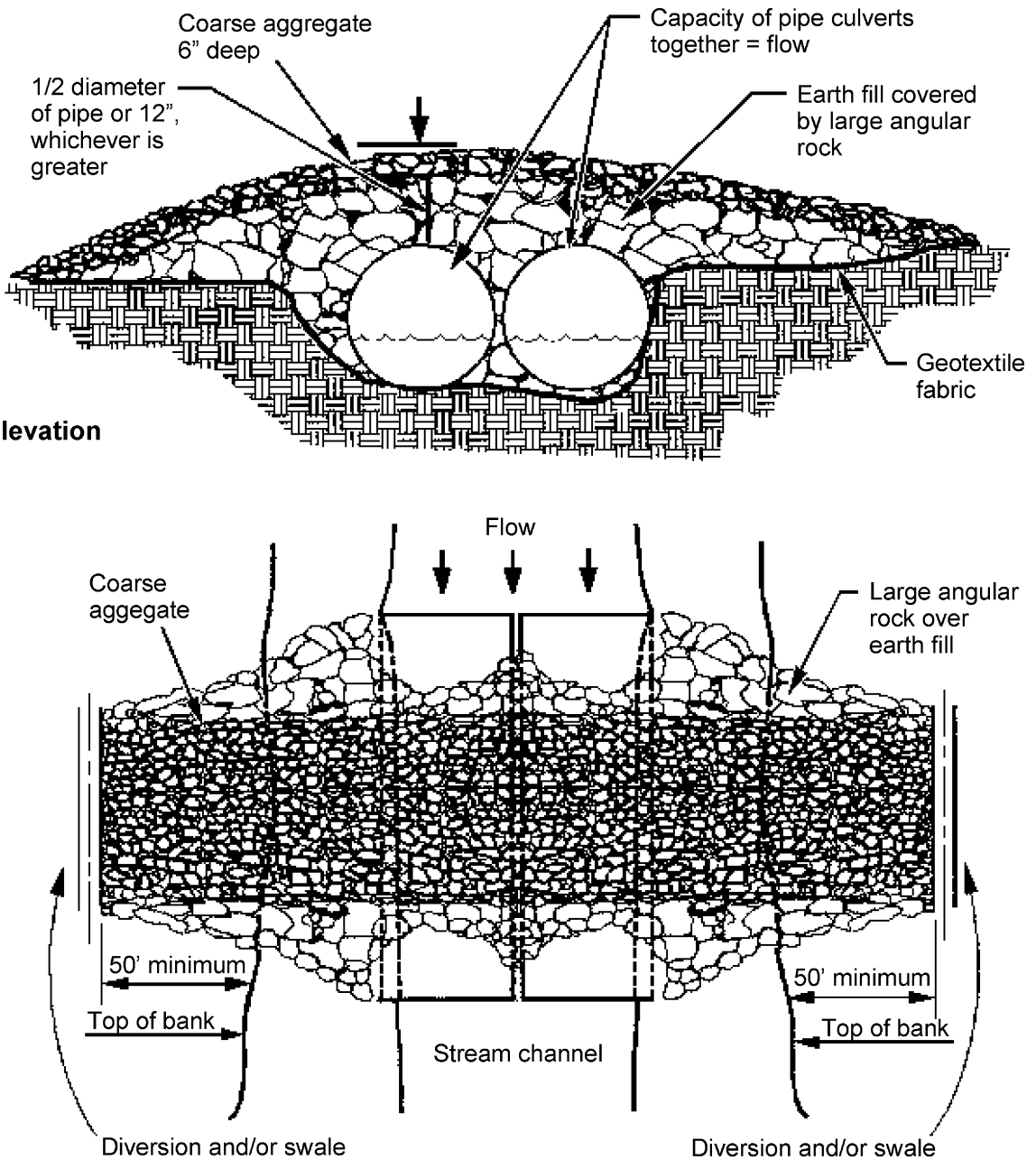


Figure 6.06-2 Temporary culvert crossing (source: Virginia Department of Conservation and Recreation, 1992)

When properly installed, fords offer little or no obstruction to flow, can safely handle heavy loading, are relatively easy to install and maintain, and, in most cases, may be left in place at the end of the construction.

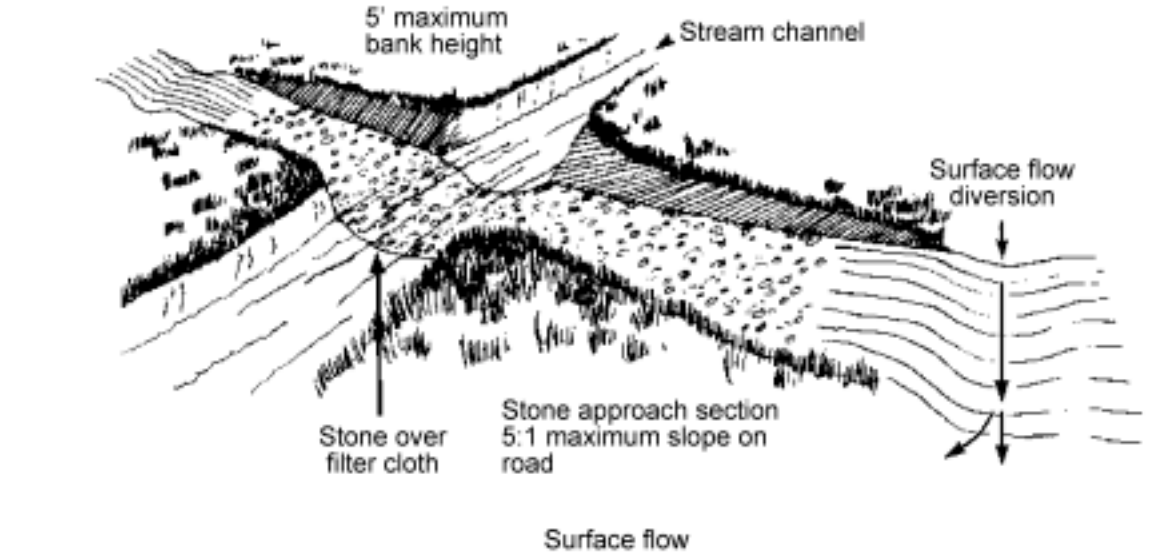


Figure 6.06-3 A well-constructed ford offers little obstruction to flow, while safely handling heavy loadings. (Source: Virginia Department of Conservation and Recreation, 1992.)

Problems associated with fords include the following:

- Approach sections are subject to erosion. Generally, do not use fords where bank height exceeds 5 ft.
- Excavation for the installation of the riprap-gravel bottom and filter material causes major stream disturbance. In some cases, fords may be adequately constructed by shallow filling without excavation.
- The stabilizing material is subject to washing out during storm flows and may require retrieval and replacement.
- Mud and other contaminants are brought directly into the stream on vehicles unless the use of crossings is limited to no-flow conditions.

DESIGN CRITERIA

Temporary stream crossings may be subject to local, state or federal requirements and restrictions. In addition to erosion and sedimentation control, structural stability, utility and

safety must be taken into consideration when designing temporary stream crossings. Bridge designs, in particular, should be undertaken by a qualified engineer.

- The anticipated life of a temporary stream crossing structure is usually considered to be one year or less. Remove the structure immediately after it is no longer needed.

- As a minimum, design the structure to pass bankfull flow or peak flow, whichever is less, from a two-year peak storm, without overtopping.

- Ensure that design flow velocity at the outlet of the crossing structure is nonerosive for the receiving stream channel (see part 4.53, Riprap, or part 4.45, Outlet Stabilization Structures).

- Consider overflow for storms larger than the design storm and provide a protected overflow area.

- Design erosion-control practices associated with the stream crossing to control erosion from surface runoff at the crossing and during a 10-year peak storm runoff.

CONSTRUCTION SPECIFICATIONS

1. Keep clearing and excavation of the stream banks and bed and approach sections to a minimum.

2. Divert all surface water from the construction site onto undisturbed areas adjoining the stream. Line unstable stream banks with riprap or otherwise appropriately stabilize them.

3. Keep stream crossings at right angles to the stream flow. This is particularly important when culverts are used.

4. Align road approaches with the center line of the crossing for a minimum distance of 30 ft. Raise bridge abutments and culvert fills a minimum of 1 ft above the adjoining approach sections to prevent erosion from surface runoff and to allow flood flows to pass around the structure.

5. Stabilize all disturbed areas subject to flowing water, including planned overflow areas, with riprap or other suitable means if design velocity exceeds the allowable for the in-place soil.

6. Ensure that bypass channels necessary to dewater the crossing site are stable before diverting the stream. Upon completion of the crossing, fill, compact and stabilize the bypass channel appropriately.

7. Remove temporary stream crossings immediately when they are no longer needed. Restore the stream channel to its original cross section, and smooth and appropriately stabilize all disturbed areas.

8. Leave in-stream sediment traps in place to continue capturing sediment.

MAINTENANCE

Inspect temporary stream crossings after runoff-producing rains to check for blockage in channel, erosion of abutments, channel scour, riprap displacement or piping. Make all repairs immediately to prevent further damage to the installation.

6.07 Site Preparation: PERMANENT STREAM CROSSINGS

DEFINITION

A permanent stream crossing is a structure installed across a stream or watercourse for the purpose of crossing.

PURPOSE

Permanent stream crossings provide a suitable means for construction and post-construction traffic to cross a watercourse.

PLANNING CONSIDERATIONS

These projects may need state, federal or local permits, so check with the appropriate agencies for their requirements.

Planning considerations for permanent stream crossings are essentially the same as for temporary ones except that permanent stream crossings should not be subject to frequent overflow.

Permanent stream crossing locations are selected primarily on flooding potential, traffic safety and traffic patterns of the area served, but erosion and sediment control must also be considered. To minimize flooding and erosion problems, locate permanent stream crossings in the higher, better-drained sections of the stream reach whenever practical.

Where road water enters the stream, install permanent protection measures, such as paved flumes, concrete head walls, riprap outlet structures or stabilized pipe drops, to prevent erosion. During installation of the crossing, locate sedimentation-control measures to protect the stream. Protect the stream section at the crossing from erosion from flood-flow velocities by using paving or properly designed riprap.

DESIGN CRITERIA

Design permanent stream crossings in accordance with standards and specifications, considering maximum loading anticipated, safety, flow capacities and other requirements for MnDOT installation approval. Crossings are also subject to Minnesota Department of Natural Resources or federal permit requirements.

Minimum design criteria for erosion control are:

- Ensure that the 10-year peak flow velocity at the stream crossing outlet is nonerosive to the receiving stream.
- Ensure that all permanent erosion-control practices provide adequate protection for the 10-year peak storm runoff.

CONSTRUCTION SPECIFICATIONS

1. Keep clearing and excavation of the stream banks and bed and approach sections to a minimum.

2. Divert all surface water from the construction site onto undisturbed areas adjoining the stream. Line unstable stream banks with riprap or otherwise appropriately stabilize them.

3. Keep stream crossing at proper angles to the stream flow. This is particularly important when culverts are used.

4. Align road approaches with the center line of the crossing for a minimum distance of 30 ft. Raise bridge abutments and culvert fills a minimum of 1 ft above the adjoining approach sections to prevent erosion from surface runoff and to allow flood flows to pass around the structure.

5. Ensure that bypass channels necessary to dewater the crossing site are stable before diverting the stream. Upon completion of the crossing, fill, compact and stabilize the bypass channel appropriately.

6. Install protective ground covers to provide permanent erosion protection and improve the appearance. However, choose protective ground cover that does not interfere with driver site distance from roadway.

7. Ensure that permanent measures needed to control erosion from road-water runoff (such as riprap and paved channels, paved flumes, or riprap outlet protection) meet all construction requirements for those practices.

MAINTENANCE

Inspect permanent stream crossings periodically and after major storms to check for channel blockage, erosion of abutments, channel degradation, riprap displacement, slope failure and piping. Make all needed repairs immediately to prevent further damage to the installation.

6.10 Flow Control

This part describes practices that prevent pollution by controlling flow. The basic concept is to keep flows off areas that can cause problems.

6.11 Flow Control: TEMPORARY DIVERSIONS

DESCRIPTION AND PURPOSE

A temporary diversion is a temporary ridge of compacted soil, a channel, a flexible conduit such as a poly tube, or any combination of these located across a slope above a disturbed area.

Temporary diversions prevent erosion by diverting runoff away from unprotected slopes to a stable outlet. They can also be used to direct sediment-laden runoff to a sediment-trapping structure.

EFFECTIVENESS

Although temporary diversions will not control the detachment of soil particles from raindrop impact, they will reduce the amount of runoff flowing over a disturbed area. This will limit the potential transport of these particles by runoff. Temporary diversions can also be effective for controlling rill and gully erosion by preventing concentrated runoff from flowing over erosion-prone areas.

PLANNING CONSIDERATIONS

These projects may need state, federal or local permits, so check with the appropriate agencies for their requirements.

Temporary diversions normally have a life of two years or less.

If the temporary diversion will remain in place for longer than 30 days, it should be protected with vegetation. The grade of the diversion channel should be flat enough so that an erosion problem is not created.

If the diversion will be left in place permanently, it should meet the criteria for Storm Water Conveyance Channels (see part 4.12).

DESIGN RECOMMENDATIONS

1. Capacity is based upon maximum drainage area rather than storm frequency.

2. The maximum drainage area should be five acres.

3. Channel grades of less than 2% should be stabilized with vegetation. Grades greater than 2% should be stabilized with erosion-control blankets or turf-reinforcement mats. If flow velocities could exceed 9 ft per second (fps), rock riprap or turf reinforcement mats should be considered.

4. The temporary diversion should be at least 1.5 ft in height when measured from the channel. The side slopes should be at least 1:1. See Figure 6.11-1 for a typical cross section.

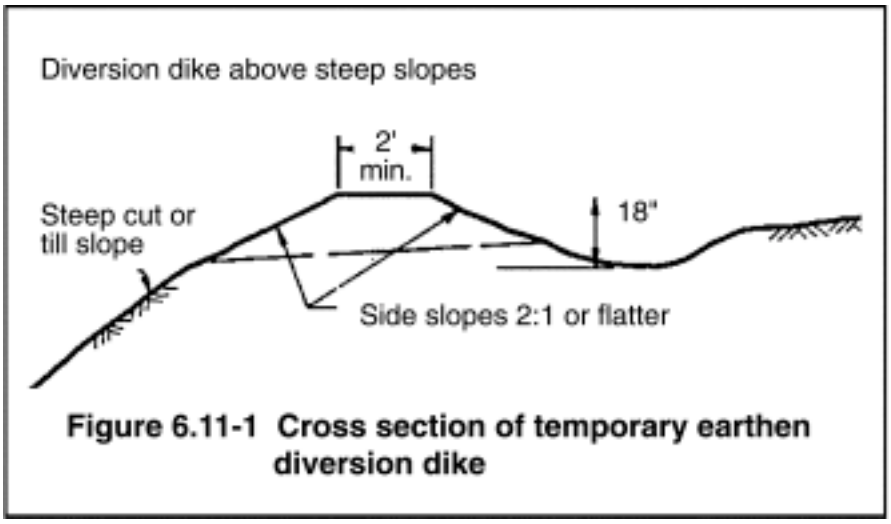


Figure 6.11-1 Cross section of temporary earthen diversion dike

5. If the diverted runoff is sediment-free, it should be released through a stable outlet or channel. If the runoff is sediment-laden, it should be diverted to a sediment-trapping structure.

MAINTENANCE

The diversion should be inspected after all significant runoff events. Any damage should be repaired promptly.

6.12 Flow Control: DIVERSION DIKES (Perimeter Protection)

DEFINITION

A diversion dike is a dike or dike and channel constructed along the perimeter of a disturbed construction area.

PURPOSE

Diversion dikes are used to prevent storm runoff from entering the work area or to prevent sediment-laden runoff from leaving the construction site.

CONDITIONS WHERE PRACTICE APPLIES

Diversion dikes may be located at the upslope side of a construction site to prevent surface runoff from entering the disturbed area or at the downslope side of the work area to divert sediment-laden runoff to on-site sediment traps or basins. Diversion dikes do not usually encircle the entire area.

The upslope dike can improve working conditions at the construction site and prevent erosion. The downslope dike assures that sediment-laden runoff will not leave the site without treatment.

PLANNING CONSIDERATIONS

A diversion dike is a special application of a temporary or permanent diversion. It differs from other diversions in that the location and grade are usually fixed, and the cross section and stabilization requirements are based on the existing grade of the work boundary. Hence, the design cross section may vary significantly throughout the length. Give special care to avoid erosive velocities in steep areas. Identify areas where sedimentation will occur since they are often subject to overtopping.

Immediately stabilize diversion dikes after construction, but make sure the channel-flow area is stabilized during construction. Exercise caution in diverting flow to be certain that the diverted water is released through a stable outlet and that the flow will not cause flood damage. Diversion dikes may be either temporary or permanent depending on site conditions (Figure 6.12-1).

DESIGN CRITERIA

Drainage area. Use diversion dikes to protect areas of five acres or less.

Capacity. The capacity of a diversion dike should be consistent with the hazard involved and design life and with a 10-year peak runoff minimum.

Velocity. See part 4.12. Stormwater Conveyance Channels, for channel-lining measures to use for expected flow velocity and shear stresses.

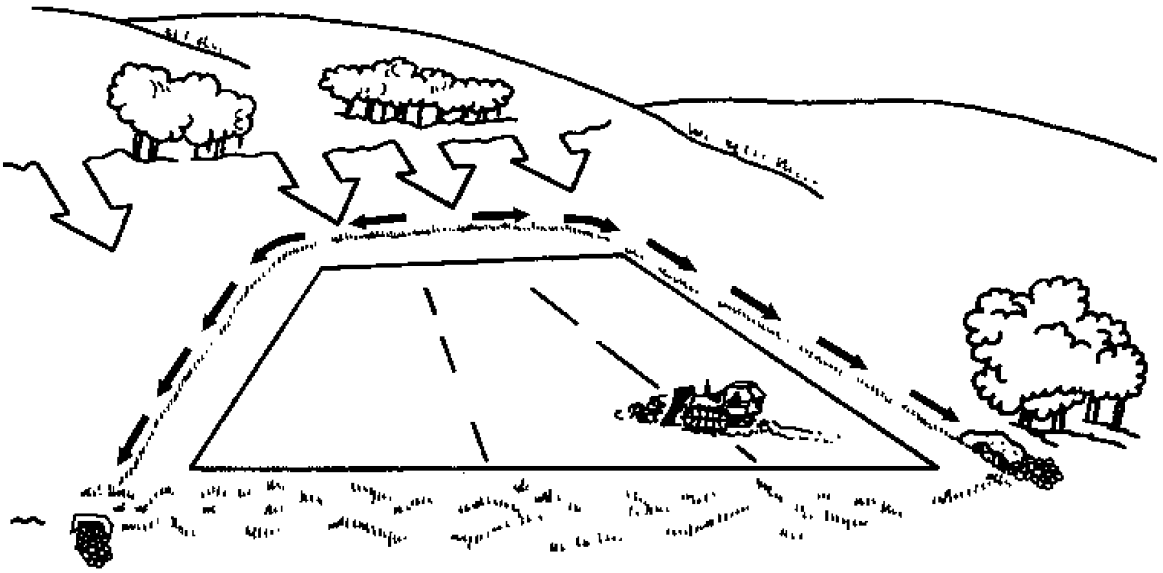


Figure 6.12-1 Perimeter dikes prevent surface runoff from entering construction sites. (Source: North Carolina, May 1994.)

Dike Design. Side slope: 2:1 or flatter; 3:1 or flatter where vehicles must cross; Width: 2.0 ft minimum top width. Height: 1.5 ft minimum. Freeboard: 0.5 ft minimum. Settlement: 10% of fill height minimum.

Channel Design. Shape: parabolic, trapezoidal, or V-shaped. Side slope: 2:1 or flatter; 3:1 or flatter where vehicles must cross. Stabilization: based on velocity by reaches.

Grade. Dependent on site topography. Channel should have positive grade.

Outlet. Divert sediment-laden water into a temporary sediment trap or sediment basin. Runoff from undisturbed areas should empty into an outlet-protection device, such as a level spreader or riprap outlet structure, unless well-stabilized natural outlets exist.

CONSTRUCTION SPECIFICATIONS

1. Remove and properly dispose of all trees, brush, stumps and other objectionable material. Fill and compact, to natural ground level or above, all ditches and gullies that will be crossed by machinery.

2. Disk the base of the dike before placing fill.

3. Ensure that the constructed cross section meets all design requirements.

4. Compact the dike by tracking with compaction equipment.

5. Ensure that the top of the dike is not lower at any point than the design elevation plus the specified settlement after it has been compacted.

6. Leave sufficient area along the dike to permit machine regrading and cleanout.

7. Immediately stabilize and vegetate the dike after its construction and stabilize the flow portion in accordance with design requirements.

MAINTENANCE

Inspect diversion dikes once a week and after every rainfall. Immediately remove sediment from the flow area and repair the dike.

Check outlets and make timely repairs as needed to avoid gully formation. When the area above the temporary diversion dike is permanently stabilized, remove the dike and fill and stabilize the channel to blend with the natural surface.

6.13 Flow Control: TEMPORARY RIGHT-OF-WAY DIVERSIONS

DESCRIPTION AND PURPOSE

A temporary right-of-way (roadway) diversion is a ridge of compacted soil, loose rock or gravel placed across roads, disturbed right-of-ways or similar long sloping areas that are disturbed (see Figure 6.13-1). This ridge is used to divert water onto stabilized areas and to shorten the distance that runoff will flow down a long slope. This reduces the erosion potential of the runoff.

This practice is normally used where there will be little or no construction traffic using the right-of-way until it is stabilized. Gravel diversions are more applicable where traffic must use the right-of-way before it is stabilized.

EFFECTIVENESS

The effectiveness of temporary right-of-way diversions for controlling erosion depends upon the land slope and erodibility of the soil. In most cases, use of this practice will provide good control of rill and gully erosion in the disturbed right-of-way area.

PLANNING CONSIDERATIONS

Construction of overhead utilities, underground utilities and roads often requires the clearing of long strips of right-of-way over sloping terrain. Runoff may concentrate on these disturbed areas and can have a high potential for erosion. If the runoff is diverted off these disturbed areas onto stabilized areas at regular intervals, the potential for erosion can be greatly reduced. This will also aid in the establishment of permanent cover by reducing the potential for rills and gullies. Once the right-of-way is stabilized, temporary diversions can be removed.

DESIGN RECOMMENDATIONS

1. Temporary right-of-way diversions should be spaced according to the land slopes as shown in Table 6.13-1.

Table 6.13-1

Land Slope (percent)	Diversion Spacing (feet)
1	300
2	200
3-5	150
5 or greater	100 (or less)

2. The maximum drainage area above the diversions should be three acres. With increase in slope, the watershed should be smaller.

3. The width of a diversion base should be at least 6 ft. When vehicles will cross the diversion, the base should be 16 ft with a top width of 4 ft. This is to prevent vehicles from becoming hung up on the ridge.

4. The diversion should be at least 18 inches high. The slope of the diversion channel should be less than 2%.

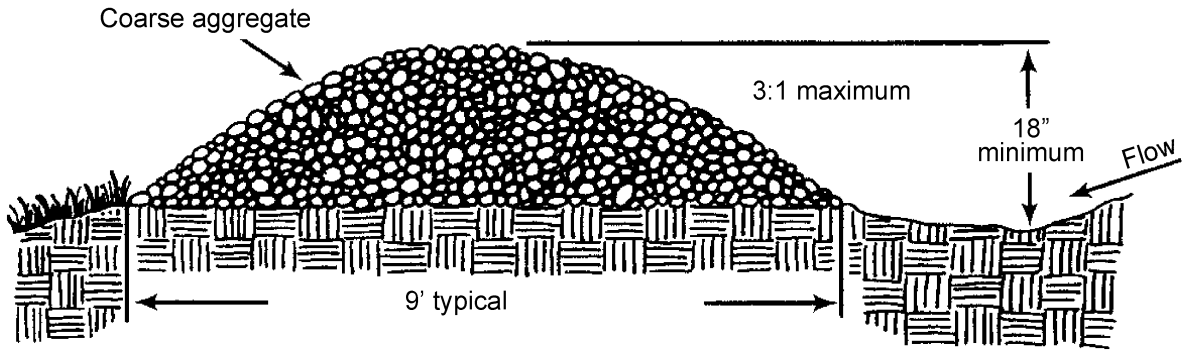


Figure 6.13-1 Temporary gravel diversion dike for vehicle crossing (modified from Virginia Department of Conservation and Recreation, 1992)

5. Before the diversion is constructed, the base should be scarified to provide a bond between the existing soil and the fill material.

MAINTENANCE

Diversions should be inspected regularly and repaired as needed for scour, bank failure, breaching, obstructions and other damage.

6.14 Flow Control: RIGHT-OF-WAY DIVERSIONS (WATER BARS)

DEFINITION

A right-of-way diversion, or water bar, is a ridge or ridge and channel constructed diagonally across a sloping road or utility right-of-way that is subject to erosion.

PURPOSE

Water bars are used to limit the accumulation of erosive volumes of water by diverting surface runoff at predesigned intervals.

CONDITIONS WHERE PRACTICE APPLIES

Use a water bar where protection is needed to prevent erosion from runoff on sloping access rights-of-way or other long, narrow, sloping areas generally less than 100 ft in width.

PLANNING CONSIDERATIONS

Construction of access roads, power lines, pipelines and similar installations often requires clearing long, narrow rights-of-way over sloping terrain (Figure 6.14-1). Disturbance and compaction promotes gully formation in these cleared strips by increasing the volume and velocity of runoff. Gully formation may be especially severe in tire tracks and ruts. To prevent gullying, runoff can often be diverted across the width of the right-of-way to undisturbed areas by using small, predesigned diversions. Give special consideration to each outlet area as well as to the cumulative effect of added diversions. Use gravel to stabilize the diversion where significant vehicular traffic is anticipated.

DESIGN CRITERIA

Height. A water bar should have a 18-inch minimum, measured from the channel bottom to the ridge top.

Side slope. The side slope should be 2:1 or flatter; 3:1 or flatter where vehicles cross.

Base width of ridge. The base width of a water bar should have a 6 ft minimum (Figure 6.14-2).

Spacing of water bars is shown in Table 6.14-1.

Table 6.14-1 Spacing of water bars on right-of-way less than 100 ft wide

Slope (%)	Spacing (ft)
< 5	125
5 to 10	100
10 to 20	75
20 to 35	50
> 35	25

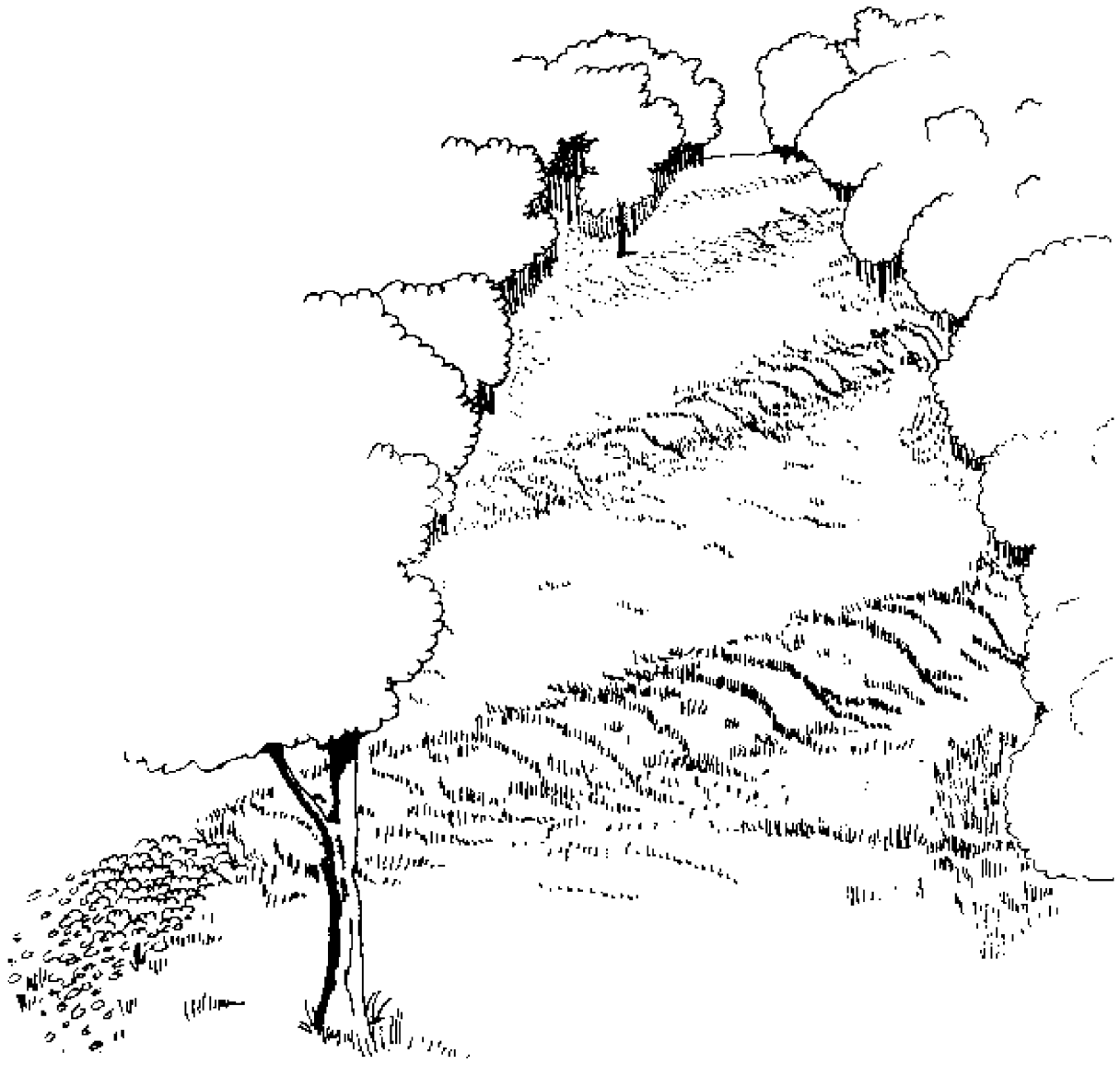


Figure 6.14-1 Water bars to protect utility right-of-way (source: North Carolina, May 1994)

Grade and angle. A crossing angle should be selected to provide a positive grade not to exceed 2%.

Outlet. Diversions should have stable outlets, either natural or constructed. Site spacing may need to be adjusted for field conditions to use the most suitable areas for water disposal.

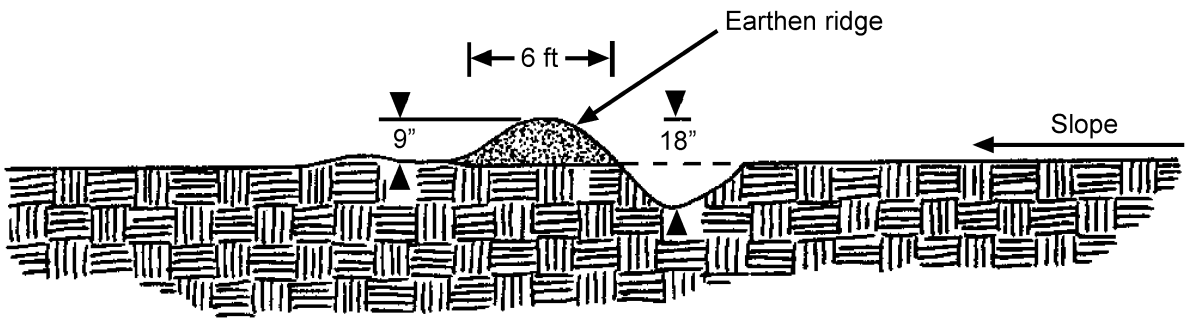


Figure 6.14-2 Section view of a water bar (source: North Carolina, May 1994)

CONSTRUCTION SPECIFICATIONS

1. Install the diversion as soon as the right-of-way has been cleared and graded.

2. Disk the base for the constructed ridge before placing fill.

3. Track and compact the ridge to the design cross section.

4. Locate the outlet on an undisturbed area. Adjust field spacing of the diversion to use the most stable outlet areas. When natural areas are not deemed satisfactory, provide outlet protection (see Level Spreaders, and Outlet-stabilization Structures).

5. Immediately stabilize and vegetate the portions of the diversions not subject to construction traffic. Stabilize with gravel areas to be crossed by vehicles.

MAINTENANCE

Periodically inspect right-of-way diversions for wear and after every heavy rainfall for erosion damage. Immediately remove sediment from the flow area and repair the dike. Check outlet areas and make timely repairs as needed. When permanent road drainage is established and the area above the temporary right-of-way diversion is permanently stabilized, remove the dike and fill the channel to blend with the natural topography, and appropriately stabilize the disturbed area.

6.15 Flow Control: CHANNELIZATION

DESCRIPTION AND PURPOSE

Channelization is the process by which the total flow or the primary flow of a channel or waterway is changed. Channelization may be for various purposes, including flood control, erosion control, and to create new contiguous land. The changes may be temporary or permanent, depending on the project needs and objectives.

DESIGN RECOMMENDATIONS

1. All dredging and/or work on the bed and banks of waters of the state should be conducted in such a manner as to minimize the extent of the bottom disturbance and minimize any increase in suspended solids in the waters. Diversion structures (see part 4.13) or temporary cofferdams (see part 6.19) may be options in certain cases.

2. The stream bank should be stable. Stream-stabilization measures, such as riprap or vegetation, should be used if needed to prevent erosion and should be constructed of site-appropriate materials.

3. These projects may require state, federal or local permits, so check with the appropriate agencies for their requirements.

CONSTRUCTION SPECIFICATIONS

Before the start of the project, develop construction specifications, which include water-pollution-abatement plans, that adhere to the following applicable steps:

1. Material, labor and equipment for temporary control measures and acceptable maintenance should be provided during the life of the project. To effectively prevent water pollution, the use of berms, dikes, dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, slope drains and other erosion-control devices or methods is encouraged in the disturbed areas. Surface cover materials should be anchored to prevent their entering waters of the state by erosion or rising water levels.

2. Temporary pollution-control measures should be included for all construction activity associated with the project where such work is necessary (for example, spoil-disposal areas, haul roads, equipment storage, and plant or waste-disposal sites).

3. The temporary pollution-control provisions should be coordinated with any permanent erosion-control features to the extent practical to assure economical, effective and continuous erosion control throughout the construction and postconstruction period.

4. The surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill operations should be minimized and immediate permanent or temporary

control measures should be taken to prevent contamination of adjacent streams and other water courses, lakes, ponds and areas of water impoundment. Cut slopes should be stabilized by seeding with mulching or with erosion-control blankets as the excavation proceeds. Slopes should be graded properly to minimize erosion. The project should be phased so that stabilization can be accomplished before the channel becomes a water of the state.

5. All permanent erosion-control features should be incorporated into the project at the earliest practicable time. Provisions should be made for continual checking and maintenance of all control measures, particularly during periods of rainfall, to insure maximum effectiveness. Temporary pollution-control measures will be used to correct conditions that develop during construction. Temporary measures may also be needed before installation of permanent erosion-control features; or to control erosion that develops during normal construction practices, but are not associated with the project's permanent control features.

6. Control the area of excavation, borrow and embankment operations commensurate with the progress of finish grading, mulching, seeding, and other such permanent erosion-control measures. Should seasonal limitations make such coordination unrealistic, temporary erosion-control measures should be taken.

7. Placement of fill in wetlands and waterways should be minimized as much as practicable, while maintaining adequate slope safety and protection to prevent erosion. Placement of fill is only allowed with the proper permits. Slopes that provide safe and stable banks, while minimizing the extent of filling in wetlands and waters, should be utilized on a case-by-case basis.

8. Upon completion, the project area should be rehabilitated by landscaping, planting and maintaining vegetation or other work, so that the area will be restored to as natural a condition as possible.

9. Other BMPs to reduce overall impacts, such as green belts, timing of fertilization, and the preservation of wetlands, should be considered and, when feasible and practical, adopted.

6.16 Flow Control: TEMPORARY STREAM DIVERSION

DESCRIPTION AND PURPOSE

A temporary stream diversion is a channel or flexible conduit, such as a poly tube, that is used to temporarily change the course of a stream.

Temporary stream diversions allow work to be conducted in the permanent stream channel without its being subjected to water flows. Stream diversions are typically used for relatively large structures or projects in the stream channel when cofferdams cannot be used.

EFFECTIVENESS

Properly designed stream diversions will limit erosion and sediment transport (see Figure 6.16-1).

PLANNING CONSIDERATIONS

These projects may need state, federal or local permits, so check with the appropriate agencies for their requirements.

Temporary stream diversions will generally have a life of two years or less, depending on the time needed for construction of the structure or completion of the project.

The two main considerations when designing a stream diversion are adequate channel capacity and sufficient erosion resistance (see Figure 6.16-2).

When calculating capacity of a channel, the maximum expected retardance should be used. If the channel will be vegetated, maximum retardance would usually be when vegetation reaches its maximum growth. When calculating velocity, the minimum retardance should be used. For vegetated channels, this would usually be the early-season, dormant condition. Rock-lined or paved channels will not have this seasonal variation in retardance, so one retardance can be used for both designs.

A number of other factors must be considered when designing a channel. The type of cross section selected is very important to these considerations. The section on Stormwater-conveyance Channels covers these considerations.

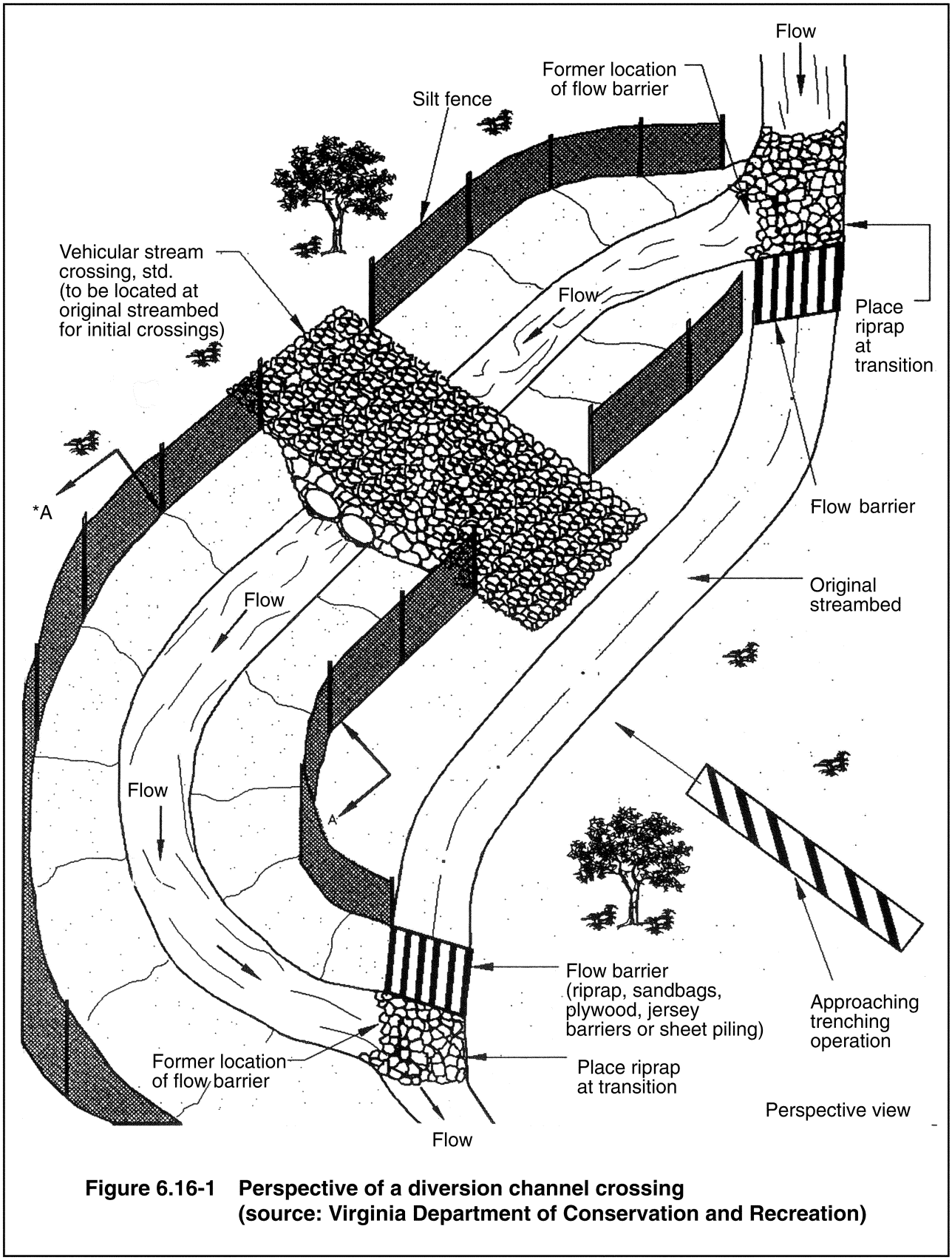
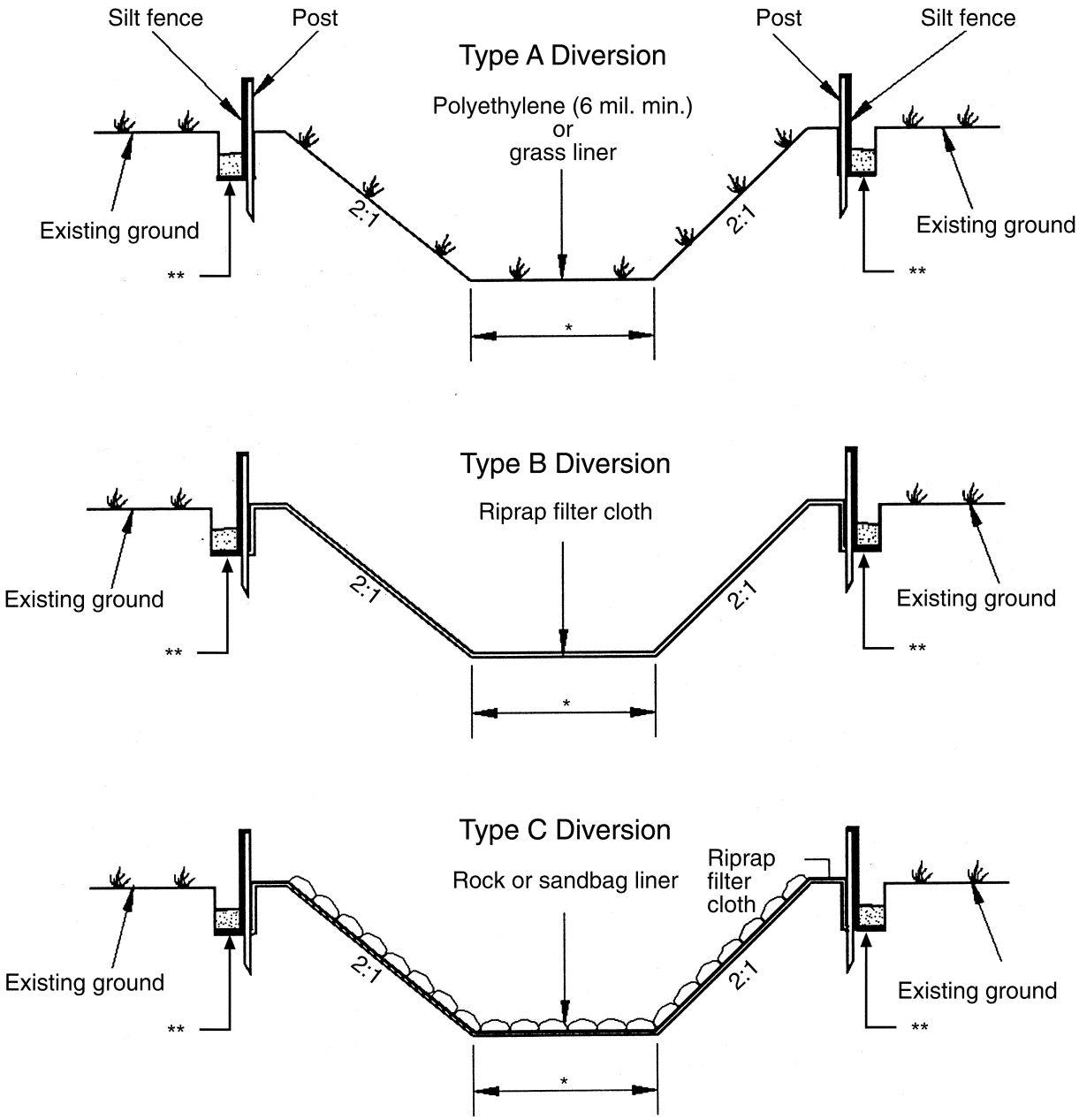


Figure 6.16-1 Perspective of a diversion channel crossing (source: Virginia Department of Conservation and Recreation)



* 6' minimum or width of existing stream whichever is less
** Entrench silt fence and filter cloth in same trench

Figure 6.16-2 Cross section of diversion channel crossing, showing acceptable linings (source: Virginia Department of Conservation and Recreation)

DESIGN RECOMMENDATIONS

In addition to the design recommendations for capacity, velocity, and channel cross section in the section on Stormwater-conveyance Channels, the following steps should be taken.

1. Construct the new diversion channel during dry conditions, usually in late summer or winter. Avoid disturbance during known breeding times of affected fish and animals in and around the stream.

2. Stabilize the diversion channel before connecting to the permanent waterway by lining the channel with geotextile erosion-control blankets, turf-reinforcement mats, or by using rock riprap. If flow velocities could exceed 9 fps, rock riprap or turf reinforcement mats should be considered.

3. Excavate from landward to the water with breakthrough occurring at the last practical moment.

4. Connect the diversion channel by breaking through the natural barrier at the downstream end first, then the upstream end.

5. Divert flow to the new temporary diversion channel.

6. Dewater the old channel, discharging to a treatment system -- not into a diversion channel or downstream.

7. Construct the structure or conduct the project in the permanent channel.

8. Stabilize the permanent channel.

9. Re-establish permanent channel flow. Close the temporary diversion channel by blocking the upstream end first, then the downstream end. Then, dewater the diversion channel and backfill.

10. Again, it should be emphasized that permits will probably be required.

MAINTENANCE

Temporary stream diversions should be inspected regularly and repaired as needed for scour, bank failure, breaching, obstructions and other damage. Upon completion of the project, the area should be completely restored so that it will recover to its original condition or better.

6.17 Flow Control: TEMPORARY SLOPE DRAINS

DESCRIPTION AND PURPOSE

A temporary slope drain is a flexible conduit which extends from the top to the bottom of a disturbed slope that serves as a temporary outlet for a diversion. Temporary slope drains convey runoff from the top to the bottom of the disturbed slope without causing erosion on or at the bottom of the slope. These are temporary structures which typically are used for up to two years (Figure 6.17-1).

EFFECTIVENESS

Temporary slope drains can eliminate gully erosion problems on a disturbed slope that would have resulted from concentrated flows discharged at a diversion outlet.

PLANNING CONSIDERATIONS

There is often a significant lag time between the grading of a slope and the installation of permanent drainage structures that dispose of runoff from a drainage area above the slope. During this time, the slope is vulnerable to severe gully erosion from concentrated runoff. A temporary slope drain used in conjunction with a diversion can prevent this erosion until permanent structures are installed.

DESIGN RECOMMENDATIONS

1. The area drained by a temporary slope drain should not exceed five acres.

2. The conduit should consist of heavy-duty material, such as corrugated metal or plastic such as PVC or ABS, manufactured for this purpose. The conduit should have grommets for anchoring at a spacing of 10 ft or less.

3. When a detailed design is not available, the chart below may be referred to for minimum recommendations of slope-drain diameter.

4. The entrance section should consist of a standard flared end section. The pipe that passes through the diversion should be in good condition and capable of making watertight joints at the ends. It is very important that all joints remain watertight and that backfill around the pipe is hand-compacted to prevent a failure of the diversion.

5. The diversion used to divert water to the temporary slope drain should meet the requirements for Diversions or Temporary Diversions. The height of the diversion at the pipe should be the diameter of the pipe plus 0.5 ft. Where this is higher than the normal diversion height, the fill elevation should be carried level until it intersects with the normal diversion height.

6. The outlet should be located at an erosion-resistant location or protected according to Outlet Protection.

7. Tie pipes and solidly anchor them as needed to prevent failure.

MAINTENANCE

The slope drain should be inspected after each rainfall that produces runoff. Any needed repairs should be made promptly. The slope drain should not be crossed by construction equipment.

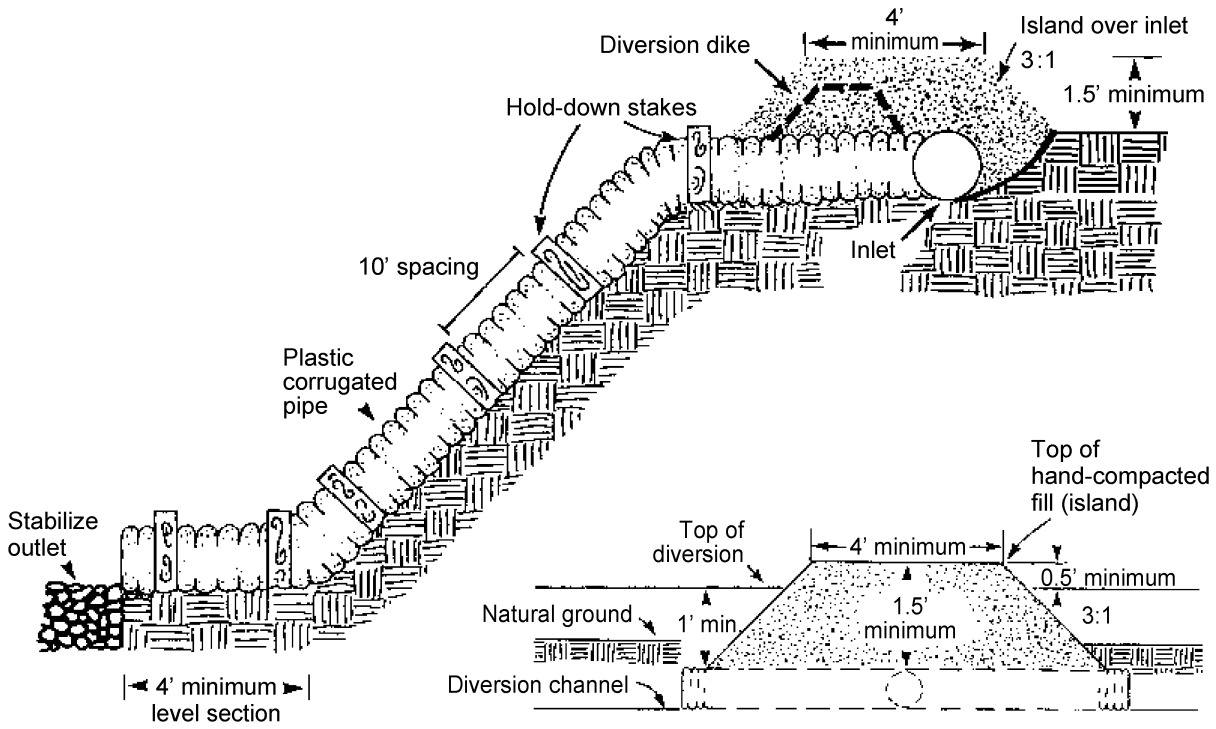


Figure 6.17-1 Cross section of a temporary a slope drain (source: North Carolina, May 1994)

6.18 Flow Control: TEMPORARY OUTLET CONTROLS

DESCRIPTION AND PURPOSE

Temporary outlet controls are protective measures used to prevent erosion at the outlet of temporary pipes or channels. These structures are intended to protect soil from turbulence and high velocities, which can otherwise cause scour erosion.

EFFECTIVENESS

Temporary outlet controls can prevent scour erosion in channels, which will reduce the effects of turbidity and sedimentation downstream.

PLANNING CONSIDERATIONS

These projects may need state, federal or local permits, so check with the appropriate agencies for their requirements.

High-velocity flows from pipes or channels cause considerable erosion. To prevent erosion, velocities must be reduced to allowable levels before the flow enters an unprotected area.

Outlets should not be discharged onto unstable slopes or steep slopes.

Outlet protection usually consists of a structural apron lining. Apron linings can be made of riprap, concrete, grouted riprap or other structural materials. In some cases, flow velocities may be too high for economical use of an apron. In those cases, a stilling basin or impact basin may be more appropriate. A stilling basin is an excavated pool of water that is lined with riprap and used to dissipate energy from high-velocity flow. An impact basin is a reinforced concrete structure that slows water velocities to an acceptable level before discharging water to an outlet channel. Refer to the following reference for more information on energy dissipaters: *Hydraulic Design of Stilling Basins and Energy Dissipaters*, Engineering Monograph No. 25, U.S. Department of the Interior, Bureau of Reclamation.

DESIGN RECOMMENDATIONS

Outlet protection may or may not require a detailed design, depending upon the scope and complexity of the job. For outlets with very high velocities or very low tailwater conditions, outlet protection should be designed only by a qualified engineer. The following criteria are recommended for the design of structurally lined aprons below pipe outlets:

1. The tailwater depth must be determined immediately downstream of the outlet pipe. The maximum capacity of the pipe should be used when computing tailwater. If the tailwater elevation is less than the elevation halfway up on the pipe outlet, the outlet is classified as a minimum-tailwater-condition outlet. If the tailwater exceeds this level, the outlet is classified as a maximum-tailwater-condition outlet. Pipes that discharge onto broad, flat areas without a defined channel can usually be classified as a minimum-tailwater-condition outlets.

Use Figure 6.18-1 for minimum tailwater conditions and Figure 6.18-2 for maximum tailwater conditions.

2. The most desirable configuration for the outlet is a straight section. This is the only alignment that should be used for the ground design charts here. If a curve is necessary before the end of the apron, a special design should be used.

   The dimensions of the apron should be determined from the appropriate table. Apron-length requirements are computed from Figure 6.18-1 or 6.18-2 as applicable. The apron should be constructed level and at the elevation of the outlet pipe invert.

3. The apron can be constructed of riprap, cable-tied concrete or other suitable material. If riprap is used, the median rock size (d50) can be determined from Figures 6.18-1 or 6.18-2. A geotextile or granular bedding material should be used under the apron if riprap is used. Refer to section 4.50, Riprap, for gradation and thickness recommendations.

MAINTENANCE

Outlet protection should be inspected periodically to check for scour. Any needed repairs should be made promptly to prevent further damage.

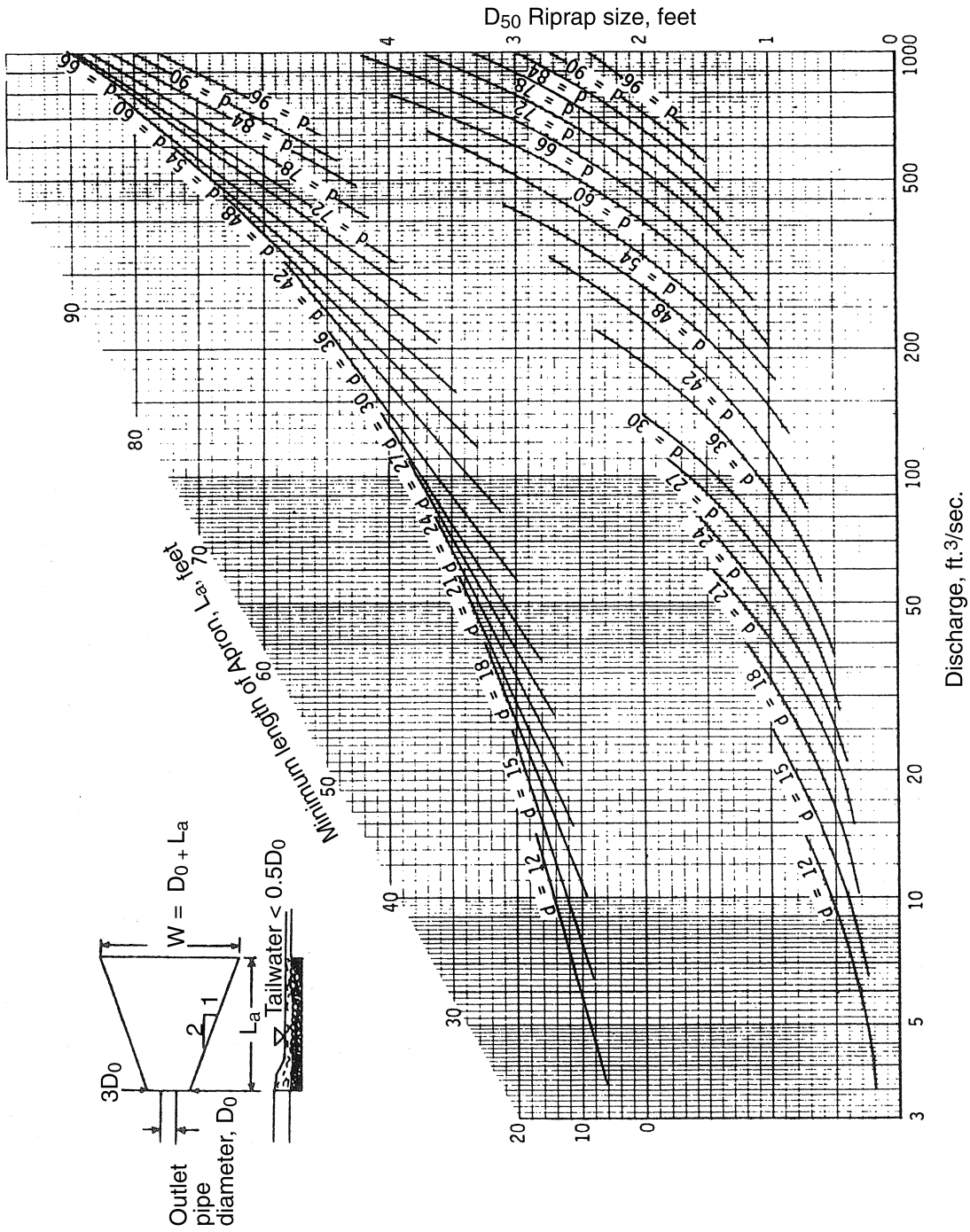


Figure 6.18-1 Design of outlet protection from a round pipe flowing full, minimum tailwater condition (T_W<0.5 diameter)

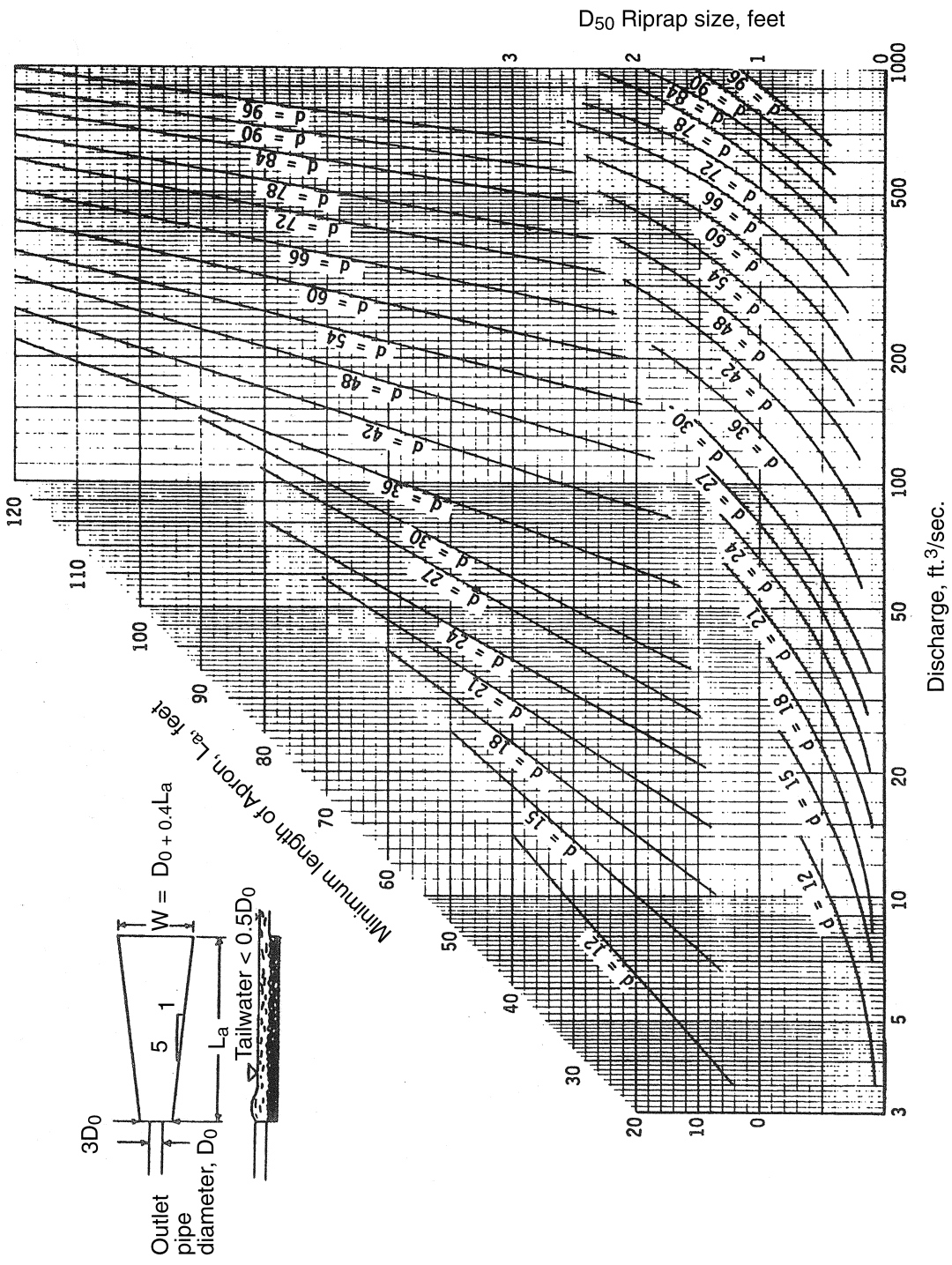


Figure 6.18-2 Design of outlet protection from a round pipe flowing full, maximum tailwater condition ($T_w \geq 0.5$ diameter)

6.19 Flow Control: COFFERDAMS

DESCRIPTION AND PURPOSE

Cofferdams are temporary dams that are used to exclude water from foundations of any type of structure. Cofferdams are used to exclude the water during construction work in water. They include excavation, construction and backfilling for a large number and type of projects. Sheet-pile cofferdams are usually used for larger projects, such as bridge piers. Smaller, easily constructed earth-fill cofferdams are usually used to protect smaller projects. In sensitive areas, portable fabric dams can be used to exclude water while preventing possible downstream siltation from eroding earthfill dams (see Figure 6.19-1).

Cofferdams can function as barriers in a river channel immediately upstream from foundations or earth-fill or rock-fill dams. They keep the water from the foundation, while a diversion tunnel or other structure transmits the water flow back to the channel downstream from the site. The site can be excavated, fill placed, and other activities conducted without being subjected to water flows.

PLANNING CONSIDERATIONS

These projects may need state, federal or local permits, so check with the appropriate agencies for their requirements.

DESIGN RECOMMENDATIONS

1. Cofferdams should be placed, constructed and operated so as to cause minimum disruption to the aquatic environment especially during fish spawning. The slopes of earth-fill cofferdams may need to be stabilized to prevent erosion in flowing water. Sheet pile or collapsible fabric dams should be considered in sensitive areas, such as spawning areas.

2. Dewatering and treatment of dewatering discharge should be carefully considered in the design of the cofferdam structure (see Dewatering). If no treatment of dewatering discharge is feasible, measures to prevent activities from affecting the discharge should be considered. Measures, such as the placement of a concrete work base by “tremie” tube inside the cofferdam, filtered sump pits, or well-point dewatering, should be considered.

3. Stockpile locations for excavated material should be provided. If backfilling to original contours is required or prudent, care should be taken to avoid turbidity and downstream or off-site siltation. No backfilling with hydraulic dredge or slurry should be used, unless it is designed for in the plans. Note that permits may be required.

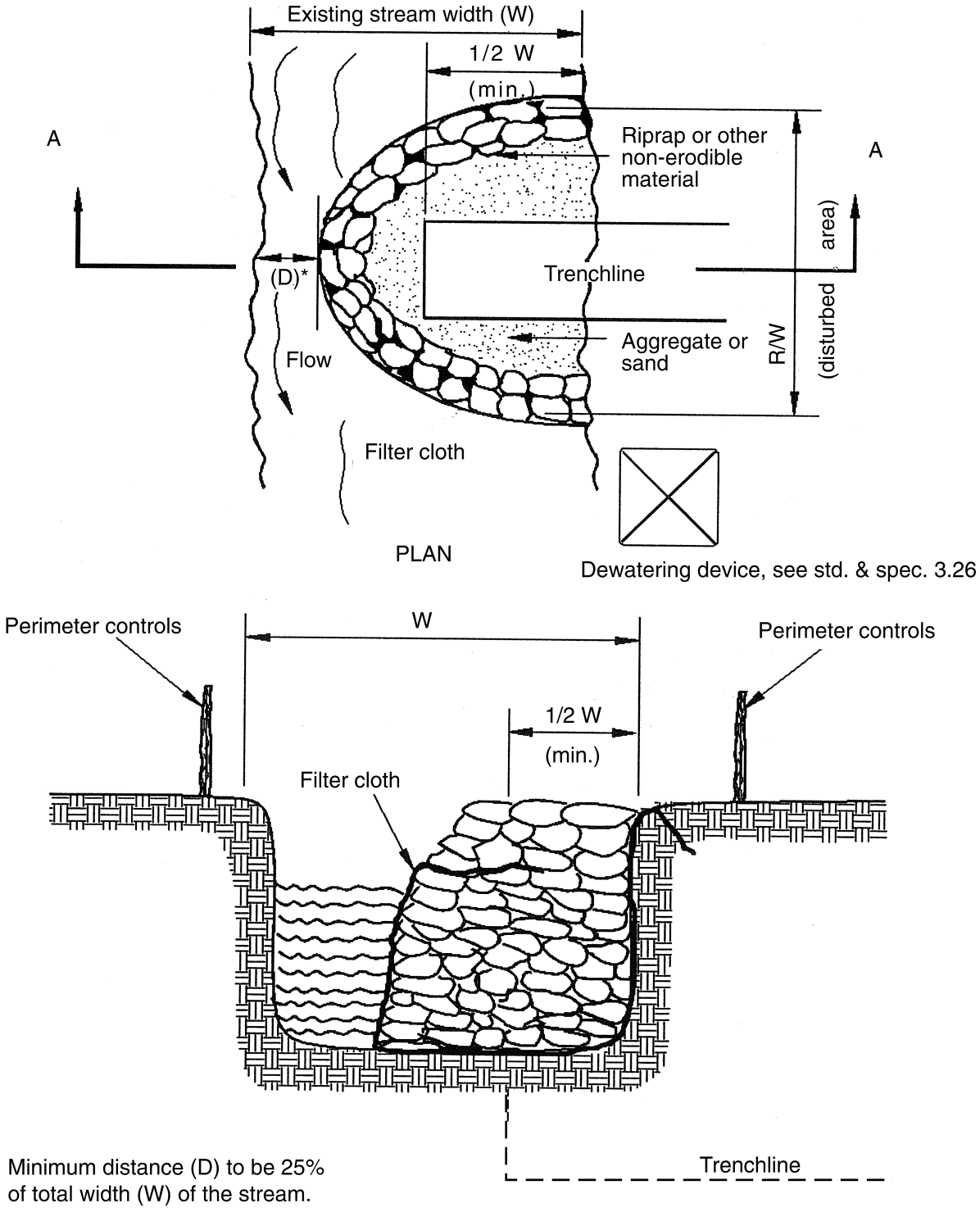


Figure 6.19-1 Cofferdam crossing (source: Virginia Department of Conservation and Recreation)

6.20 Vegetative Stabilization: SOIL EROSION AND SLOPE FAILURE

DEFINITION

Erosion is the removal of soil particles from a surface primarily due to water action. Erosion may also be caused by wind, ice action, boat-induced wave action, uncontrolled runoff or human and animal activities.

Failure is the collapse or slippage of large masses of soil by action of gravity through additional shear stress or decreased shear strength. Slope failure often occurs on the bank of a stream or lake which has been undercut by erosion at the base of the slope. It can also be a problem on steep slopes in upland areas, especially where vegetation has been removed or destroyed. Construction activities can cause slope failure by removing surface cover or the toe of the slope. When a slope fails, it sloughs off either a thin layer or a large mass of soil.

Soil erosion and slope failure are two of the more important impacts of urbanization. While they are natural processes, they are accelerated by urban development.

THE PROCESS

The movement of wind and water tends to erode the natural soils and deposit the resulting sediments elsewhere. This is a natural process that tends to balance over time. Erosion at one location is roughly balanced by deposition at another. However, erosion is often accelerated by human activity, and it becomes a problem when it affects human activities.

In many instances, accelerated failure or erosion is an indication that significant changes have occurred relating to management of land and water resources in the watershed. Any change in land use that removes vegetative cover, increases runoff or changes sediment loads in a stream can cause a soil that was previously stable to become a problem. Examples of such changes include increasing urbanization, intensive farming, or channelization of waterways.

Solving slope failure and erosion problems is difficult because local solutions that do not address the underlying causes in the watershed will likely affect the equilibrium of the system and may negatively impact downslope or downstream areas. Understanding the nature and causes of soil erosion and failure is the first step toward finding appropriate solutions.

Vegetative canopy and root systems help reduce the risk of failure and erosion. In addition, protecting the plant systems can help address the fundamental changes in hydraulics brought about by development or other changes in the management of the watershed system.

6.21 Vegetative Stabilization: FERTILIZER MANAGEMENT

DESCRIPTION

Fertilizer management involves controlling the rate, timing and method of fertilizer application so that plant nutrient needs are met while minimizing the chance of polluting surface or ground water.

TARGET POLLUTANTS

This practice is directed at controlling phosphorus and nitrogen in construction and landscaped areas. Phosphorus is the major surface water concern because it leads to excessive algal growth. Nitrogen is a special concern because of potential ground water contamination by nitrates.

PLANNING CONSIDERATIONS

If the seedbed consists of at least 6 inches of fertile topsoil, fertilizer may not be required. If the topsoil consists of subsoil or blends of several soil horizons and fills, the soil most likely will be deficient in one or more nutrients necessary for plant establishment and growth. In all cases, it is highly recommended that a soil test for available plant macronutrients — nitrogen, phosphorus and potassium (N-P-K) — pH, and cation exchange capacity (CEC) or soluble salts be performed within the season of planting. In addition, suspected problem soils may require micronutrient analysis, especially if the area is, or has been, dominated by annual weeds, such as foxtails and spotted knapweed. The soil must be sampled in accordance with standard sampling procedures. Follow the recommendation of the soil-test laboratory. In general, areas of suspected soil differences (wet areas verses upland) should be sampled separately, but soil may be bulked, mixed and a representative sample sent to a state or federal certified soil-test laboratory (soil kits should generally not be used). The University of Minnesota Extension Service is one of several facilities available for testing soils.

Fertilizer described in this section should be a commercial grade of slow-release fertilizer. Usually the slow-release component is nitrogen, but all components of the fertilizer blend should have a regulated release rate. The rate of release may be regulated by water, temperature or microorganisms. In all cases, loss of phosphorus to the waters of the state should be avoided and should be addressed as part of the erosion-prevention plan. The fertilizer type may vary from liquid to granular forms, and should be appropriate for the method of application (broadcast, banded, hydroseeded, etc.), following the manufacturer's recommendations for application suitability. Care must be exercised not to ruin the coating or process that regulates the release of nutrients. Method and depth of incorporation of the fertilizer must be considered also. For example, banding of slow-release fertilizer at the time of seeding, in general, allows lower levels of nutrients, and will feed the desired plants, not the weeds.

A fertilizer with an N-P-K ratio of approximately 22-5-10, with 0.5% to 8% added iron, magnesium and sulfur, represents a good, all-around blend, but the needed ratio should be based on the soil test for the plant communities that are to be fertilized. It is acceptable to have up to

20% soluble nitrogen, with the remaining 80% in any form of water-insoluble nitrogen, as long as the product has a documented rate and method of dissolution into soil.

In general, the fertilizer should be placed at a rate up to 2 pounds (lb) of actual nitrogen per 1,000 square feet (ft^2) for turf-variety seed communities (MnDOT seed mixes 50B and above) and 1 lb of actual nitrogen per 1,000 ft^2 for native seed communities (MDOT seed mixes 5B to 38A). Matching the fertilizer composition with special soil need conditions on a case-by-case basis will allow soluble forms of nitrogen fertilizer to deal adequately with cellulose-type compost and other soil amendments. Fertilizer application should be restricted to carefully controlled applications within 100 lineal ft of a water of the state.

6.22 Vegetative Stabilization: TEMPORARY SEEDING AND STABILIZATION

DESCRIPTION AND PURPOSE

Temporary seeding is the establishment of temporary vegetative cover on disturbed areas by seeding with suitable fast-growing annual vegetation. This is intended to provide a temporary vegetative cover relatively quickly that will protect the soil from erosion until permanent stabilization.

This practice is normally used to stabilize construction areas that will be inactive for more that 21 days but less than one year. Applicable areas include topsoil stockpiles, rough graded areas, sediment basin dikes, temporary earthen structures and graded areas undergoing settlement.

EFFECTIVENESS

Temporary seeding is only effective for erosion control once vegetation has become established. A good stand of vegetation will protect soil from erosion by raindrop impact and will also slow runoff to prevent rill erosion. The vegetation can also act as a filter, trapping coarse sediment particles carried by runoff. After establishment, temporary seeding can reduce sheet erosion by approximately 90% (USDA, SCS, 1976).

PLANNING CONSIDERATIONS

Preventing erosion is always preferred over sediment control. Often because of the nature of the work, good erosion control is not feasible on construction sites. When a disturbed area will be inactive for a prolonged period, erosion-control measures should be used. Areas that will not be disturbed over the winter should be temporarily seeded and stabilized.

Temporary seeding is an effective erosion-control practice. Annual plants that sprout quickly are used for this practice. Proper seedbed preparation and the use of quality seed is important for good germination and growth. A poor stand (less than 50% cover) will not provide adequate erosion control.

SEEDING RECOMMENDATIONS

1. Select the desired type of vegetation from temporary see mix tables 1, 2 or 3, as appropriate.

2. Proper seedbed preparation is essential for the seed to germinate and grow. The seedbed should be tilled to a depth of about 3 inches. In compacted or hard soils, it may be necessary to use a disc, ripper or other relatively heavy tillage equipment to prepare the seedbed. The seedbed should not be prepared under excessively wet conditions.

3. It is essential that fertilizer be incorporated into the top 2 to 4 inches of soil during seedbed preparation. If the fertilizer is not incorporated, it is more available for loss in runoff and can cause pollution problems. It is best to use a slow-release fertilizer to provide nutrients during the whole establishment cycle and to minimize nutrient flushing.

Fertilizer should only be used after a soil test confirms what should be added.

4. The soil surface must be firm — less than 200 lb per square inch (psi), but not compacted at the time of seeding. When the area is compacted or hardened, it must be loosened by disking, light ripping, chisel plowing, harrowing or other means.

5. Seed should be evenly applied with a cyclone seeder, drill or cultipacker seeder. Small grains and grasses should be planted no more than 0.5 inch deep.

6. If seeding is done during the spring or summer on flat slopes, and these areas have favorable soil and moisture conditions, mulching is optional. At other times of the year, and on steeper slopes or during hot, dry conditions, the temporary seeding should be mulched according to part 6.26, Mulching.

MAINTENANCE

If the seeding fails to grow, it may need to be re-established to provide adequate erosion control. Also, noxious weeds may need to be controlled by mowing or spraying.

Temporary seed mixes (cover crops)

Seeding rates are all expressed in pounds of pure live seed (PLS).

Table 6.22-1 One-year temporary seed mixes for fall or spring applications

Mixture	Plant Species	% of Total	Rate (lb/acre)	Applications
100A	Winter wheat	100	100	Fall (until Oct. 1)
110A	Oats	100	100	Spring
none	Annual rye	100	200	All year

Table 6.22-2 All-season mixes, and/or two- to three-year stabilizing requirements

Mixture	Plant Species	% of Total	Rate (lb/acre)	Applications
120A	ReGreen™	100	25	All year
125A	ReGreen™	88	22	All year
	Alfalfa, Vernal	12	3	All year
	Total:	100	25	

Table 6.22-3 Stabilization mix developed to stabilize erodible areas for three to seven years. Also may be used as a mix that will be tilled back into the soil.

MIXTURE 90A MODIFIED/90B		
Common Name	**Botanical Name**	**% of Mix**
ReGreen™	NA	20.0
Partridge pea	*Chamaecrista fasciculata*	9.0
Wheatgrass, slender	*Elymus trachycaulus*	9.0
Ryegrass, perennial	*Lolium perene*	20.0
Alfalfa, creeping	*Medicago sativa*	7.0
Timothy	*Phleum pratense*	10.0
Dropseed, sand	*Sporobolis cryptandrus*	7.0
Clover, alsike	*Trifolium hybridum*	7.0
Clover, red	*Trifolium pratense*	11.0
	Total	**100.0**
Seeding rate: 50 lb/acre		

6.23 Vegetative Stabilization: PERMANENT SEEDING

DESCRIPTION AND PURPOSE

Permanent seeding is the establishment of perennial vegetation on a disturbed area. It is intended to stabilize disturbed areas in a manner compatible with the intended use and adjacent stakeholders. This practice is used when vegetation is desired to permanently stabilize a site.

EFFECTIVENESS

Once it is established, permanent seeding is very effective for controlling soil erosion. Until the area is stabilized, mulch should be used to provide protection. Permanent seeding protects soil from erosion by raindrop impact and overland flow. Vegetation also maintains the infiltration capacity of soil, thereby reducing the volume of runoff that will occur. Once established, permanent seedings can reduce soil erosion rates by 99% (USDA, SCS, 1976).

PLANNING CONSIDERATIONS

On projects that will take several years before development, longer-lasting cover crops, such as ReGreen^{TM}, may be acceptable. It is important to select the proper seed mixture for the intended use of the area, the soil conditions on the site and the climate. Some types of vegetation are well suited to high-intensity use, but they may not be appropriate for a roadside, where low maintenance is desired. With the wide variation in soil types and climate in Minnesota, it is important to select vegetation well suited to the site. The tables provide recommendations for seed mixtures in urban areas based upon intended use, climate by region of the state and soil conditions.

SEEDING RECOMMENDATIONS

1. Fertilizer is helpful to the growth of vegetation, but it can also be a serious pollutant if it is not applied correctly. Fertilizer must be incorporated during seedbed-preparation operations. If fertilizer is incorporated and the seeded area is protected from erosion, fertilizer loss will be minimized. Fertilizer should only be applied in accordance with the results of a soil test. It is best to use a slow-release fertilizer to provide nutrients during the whole establishment cycle and to minimize nutrient flushing.

2. The seedbed should be prepared to a depth of about 3 inches. In compacted or hard soils, it may be necessary to use a disc, ripper or other heavy tillage implement to prepare a seedbed. Seedbeds should not be prepared under excessively wet soil conditions. After seeding, the seedbed should be firmed with a non-smooth drum roller or cultipacker to ensure good seed-to-soil contact.

3. The seed should be drilled or broadcast with equipment that will uniformly distribute. Small grass seeds and legumes should be planted ¼ to ½ inch deep. Large grass seed should not be planted deeper than ¾-inch.

4. The recommended seeding dates given in Table 6.23-3 are the optimum seeding dates for the seed mixtures in Table 6.23-1. These charts should be used as a guide, and consideration should be made for seasonal weather patterns. In general, do not plant during dry periods, when the seed will germinate, but the seedlings will not develop sufficiently to survive until spring. Instead, postpone the seeding and do it later as a dormant seeding. Dormant seedings are used in the fall after soil temperatures are cold enough to prevent germination until spring.

5. Mulching is important for erosion control and moisture conservation on new seedings. (See section 6.50, Mats and Mulches.)

MAINTENANCE

Mowing or spraying may be needed to control weeds during establishment. Spraying should be avoided if it will kill legumes or other dicots in a mixture. If the vegetation is mowed, a blade height of 5 to 6 inches should be used initially to prevent damage to the new seedlings.

The lists below are representative only. Plant species adjustments may be required, depending on intended use. Check with the Minnesota Department of Transportation Environmental Services Section, the Minnesota Department of Natural Resources and the local Soil and Water Conservation District, for additional suggestions based on soil fertility and erosion-prevention requirements.

I. NATIVE MIXES

Native mixes are used in two general groups of seeds: (1) upland mixes and (2) wetland mixes. The subtables provide variations for various parts of the state and woodland edges.

A. Upland Type

Description: Reaches a height of 36-48 inches. Excellent for use on all soil types. Statewide use, but best for oak savanna and prairie regions.

Table A Seed Mix Tabulation

Mixture 15B

Common Name	Botanical Name	Percent of Mix
Bluestem, big	*Andropogon gerardi*	5
Grama, sideoats	*Bouteloua curtipendula*	10
Wild rye, Canadian	*Elymus canadensis*	5
Wheatgrass, slender	*Elymus trachycaulus*	5
Ryegrass, annual	*Lolium italicum*	10
ReGreen™	NA	34
Forbs* (see tables below)	NA	5
Switchgrass	*Panicum virgatum*	2
Bluestem, little	*Schizachyrium scoparium*	12
Indiangrass	*Sorghastrum nutans*	12
	Total	**100**

Drill rate: 30 lb/acre.
Broadcast rate: 30 lb/acre & add 10 lb/acre ReGreen™.

***Forb Mixes**

These are broken down into regions of the state or environment conditions and should be added to the seed mix tabulation shown above.

Planting rate is specified in the seed mix tabulation, above. All species should be provided in equal weights.

Table A-1 NW Forb Mix

Description: Native forbs to be added to native grass mixtures in northwestern Minnesota.

Common Name	Botanical Name	Common Name	Botanical Name
Onion, prairie	*Allium stellatum*	Blazingstar, rough	*Liatris aspera*
Aster, heath	*Aster ericoides*	Blazingstar, tall	*Liatris pycnostachya*
Aster, smooth-blue	*Aster laevis*	Bergamot, wild	*Monarda fistulosa*
Milkvetch, Canada	*Astragalus canadensis*	Penstemon, showy	*Penstemon grandiflorum*
Prairie clover, white	*Dalea candidum*	Coneflower, columnar	*Ratibida columnifera*
Prairie clover, purple	*Dalea purpureum*	Black-eyed Susan	*Rudbeckia hirta*
Tick-trefoil, showy	*Desmodium canadense*	Goldenrod, stiff	*Solidago rigida*
Coneflower, narrow-leaved	*Echinacea angustifolia*	Vervain, blue	*Verbena hastata*
Ox-eye, common	*Heliopsis helianthoides*	Vervain, hoary	*Verbena stricta*
Bushclover, round-headed	*Lespedeza capitata*	Alexanders, golden	*Zizia aurea*

Table A-2 SE Forb Mix

Description: Native forbs to be added to native grass mixtures in southeastern Minnesota.

Common Name	Botanical Name	Common Name	Botanical Name
Milkweed, butterfly	*Asclepias tuberosa*	Blazingstar, tall	*Liatris pycnostachya*
Aster, heath	*Aster ericoides*	Bergamot, wild	*Monarda fistulosa*
Aster, smooth-blue	*Aster laevis*	Penstemon, showy	*Penstemon grandiflorum*
Milkvetch, Canada	*Astragalus canadensis*	Coneflower, grey-headed	*Ratibida pinnata*
Partridge pea	*Chamaecrista fasiculata*	Black-eyed susan	*Rudbeckia hirta*
Prairie clover, white	*Dalea candidum*	Goldenrod, stiff	*Solidago rigida*
Prairie clover, purple	*Dalea purpureum*	Spiderwort, Ohio	*Tradescantia ohiensis*
Tick-trefoil. showy	*Desmodium canadense*	Vervain, blue	*Verbena hastata*
Ox-eye, common	*Heliopsis helianthoides*	Vervain, hoary	*Verbena stricta*
Blazingstar, rough	*Liatris aspera*	Alexanders, golden	*Zizia aurea*

Table A-3 SW Forb Mix

Description: Native forbs to be added to native grass mixtures in southwestern Minnesota.

Common Name	Botanical Name	Common Name	Botanical Name
Milkweed, butterfly	*Asclepias tuberosa*	Blazingstar, tall	*Liatris pycnostachya*
Aster, smooth-blue	*Aster laevis*	Bergamot, wild	*Monarda fistulosa*
Milkvetch, Canada	*Astragalus canadensis*	Penstemon, showy	*Penstemon grandiflorum*
Partridge pea	*Chamaecrista fasiculata*	Coneflower, columnar	*Ratibida columnifera*
Prairie clover, white	*Dalea candidum*	Coneflower, grey-headed	*Ratibida pinnata*
Prairie clover, purple	*Dalea purpureum*	Black-eyed susan	*Rudbeckia hirta*
Tick-trefoil. showy	*Desmodium canadense*	Goldenrod, stiff	*Solidago rigida*
Coneflower, narrow-leaved	*Echinacea angustifolia*	Vervain, blue	*Verbena hastata*
Ox-eye, common	*Heliopsis helianthoides*	Vervain, hoary	*Verbena stricta*
Blazingstar, rough	*Liatris aspera*	Alexanders, golden	*Zizia aurea*

Table A-4 Woodland-edge forbs

Description: Native forbs to be added to native grass mixtures in northeastern Minnesota.

Common Name	Botanical Name	Common Name	Botanical Name
Hyssop, fragrant-giant	*Agastache foeniculum*	Lobelia, great-blue	*Lobelia siphilitica*
Anemone Canada	*Anemone canadensis*	Monkey flower	*Mimulus ringens*
Milkweed, marsh	*Asclepias incarnata*	Bergamot, wild	*Monarda fistulosa*
Milkweed, butterfly	*Asclepias tuberosa*	Black-eyed susan	*Rudbeckia hirta*
Aster, heath	*Aster ericoides*	Golden-glow, wild	*Rudbeckia laciniata*
Aster, smooth-blue	*Aster laevis*	Brown-eyed susan	*Rudbeckia triloba*
Aster, large-leaved	*Aster macrophyllus*	Aster, upland-white	*Solidago ptarmicoides*
Milkvetch, Canada	*Astragalus canadensis*	Goldenrod, stiff	*Solidago rigida*
Tic-trefoil, showy	*Desmodium canadense*	Vervain, blue	*Verbena hastata*
Sunflower, early	*Heliopsis helianthoides*	Alexander's, golden	*Zizia aurea*

B. Wetland Types

Description: Native sedge/prairie meadow mix. Reaches a height of 36-48 inches. Developed for use on hydric soils and for wetland restorations. See separate tables for meadow forbs, grasses and sedges.

Installation Note: Sedges, meadow grasses and forbs are best installed by broadcast method, separate from main grass mix, in autumn, if possible.

TABLE B SEED MIX TABULATION

MIXTURE 25A MODIFIED/25B

Common Name	Botanical Name	Percent of Mix
Bluestem, big	*Andropogon gerardi*	10
Wild rye, Canadian	*Elymus canadensis*	8
Wheatgrass, slender	*Elymus trachycaulus*	6
Ryegrass, annual	*Lolium italicum*	6
Switchgrass	*Panicum virgatum*	2
Indiangrass	*Sorghastrum nutans*	18
Meadow Forbs (see table)	NA	4
Meadow Grass Mix (see table)	NA	8
ReGreen™	NA	32
Sedge Mix (see table)	NA	6
Total	**100**	

Drill Rate: 30 lb/acre.
Broadcast Rate: 30 lb/acre & add 10 lb/acre ReGreen™

Meadow Grasses, Sedges and Meadow Forbs: for inclusion in mixture 25A Modified/25B.

Table B-1 Meadow Grass Mix (5 of 6 species minimum)

Common Name	Botanical Name	Common Name	Botanical Name
Fringed brome	*Bromus ciliata*	Reed Manna grass	*Glyceria grandis*
Blue-joint grass	*Calamagrostis canadensis*	Fowl Manna grass	*Glyceria striata*
Virginia wild rye	*Elymus virginicus*	Prairie cordgrass	*Spartina pectinata*

Table B-2 Sedge Mix (6 of 7 species minimum)

Common Name	Botanical Name	Common Name	Botanical Name
Bottlebrush sedge	*Carex comosa*	Wool grass	*Scirpus cyperinus*
Lake sedge	*Carex lacustris*	Soft-stem bulrush	*Scirpus vallidus*
Tussock sedge	*Carex stricta*	Green bulrush	*Scripus atrovirens*
Common rush	*Juncus effusus*		

Table B-3 Meadow forbs

Common Name	Botanical Name	Common Name	Botanical Name
Anemone, Canada	*Anemone canadensis*	Blazingstar, tall	*Liatris pycnostachya*
Milkweed, marsh	*Asclepias incarnata*	Lobelia, great-blue	*Lobelia siphilitica*
Aster, New England	*Aster novae-angliae*	Monkey flower	*Mimulus ringens*
Aster, swamp	*Aster puniceus*	Bergamot, wild	*Monarda fistulosa*
Tick-trefoil, showy	*Desmodium canadense*	Black-eyed Susan's	*Rudbeckia hirta*
Joe-pye weed	*Eupatorium maculatum*	Goldenrod, grass-leaved	*Solidago graminifolia*
Boneset	*Eupatorium perfoliatum*	Vervain, blue	*Verbena hastata*
Ox-eye, common	*Heliopsis helianthoides*	Ironweed	*Veronia fasciculata*
Iris, blue-flag	*Iris virginica-shrevii*	Culver's root	*Veronicastrum virginianum*
Blazingstar, meadow	*Liatris ligulistylis*	Alexander's, golden	*Zizea aurea*

Rate: As specified in the seed mix tabulation, above. All species should be provided in equal weights.

II. General Purpose Mixes/Non-native Mixes

The general-purpose mixes are of two types: (1) forage and hay mixes and (2) low-maintenance turf mixes. The subtables provide alternative seeds to be mixed with the basic seed mixture.

A. Coarse grass type, may be mowed for forage or hay. Can be left unmowed.

Description: Forage and native grass mix. Reaches a height of approximately 24 inches. General purpose seed mix for roadsides.

Table A Non-native mix

MIXTURE 50A MODIFIED/50B

Common Name	Botanical Name	Percent of Mix
Wheatgrass, slender 'Revenue'	*Agropyron trachycaulum*	8
Bluestem, big 'Bison'	*Andropogon gerardi*	7
Bromegrass, smooth	*Bromus inermis*	15
Ryegrass, perennial	*Lolium perene*	20
Alfalfa, creeping	*Medicago sativa*	4
Legume, native (see table)	NA	1
Switchgrass 'Dakota'	*Panicum virgatum*	8
Timothy	*Phleum praetense*	7
Bluegrass, Kentucky 'Park'	*Poa pratensis*	30
	TOTAL	**100**

Table A-1 Acceptable native legumes

Common Name	Botanical Name
Milkvetch, Canada	*Astragalus canadensis*
Prairie clover, purple	*Dalea purpureum*
Tic-trefoil, showy	*Desmodium canadense*
Bush-clover, round-headed	*Lespedeza capitata*
Vetch, American	*Vicia americana*
Rate: 50 lb/acre	

B. Low-maintenance turf mix. Designed for sod replacements, salted edges, heavy foot traffic and boulevards.

Table B Non-native mix

MIXTURE 60A MODIFIED/60B

DESCRIPTION: Reaches a height of approximately 12 inches

Common Name	Botanical Name	Percent of Mix
Fescue, creeping-red 'Cindy'	*Festuca rubra*	10
Ryegrass, perennial 'Elf'	*Lolium perene*	14
Bluegrass, Canada 'Reubens'	*Poa compressa*	12
Bluegrass, fowl	*Poa palustris*	10
Bluegrass, common '98/85'	*Poa pratensis*	12
Bluegrass, Kentucky 'Park'	*Poa pratensis*	12
Bluegrass, Kentucky 'Caliber'	*Poa pratensis*	10
Alkali grass, 'Salty'	*Puccinella distans*	19
White clover	*Trifolium repens*	1
	Total	**100**
Rate: 100 lb/acre		

6.25 Vegetative Stabilization: SODDING

DESCRIPTION AND PURPOSE

Sodding is the stabilization of a disturbed area with permanent vegetation by laying sod. Sodding provides immediate erosion protection to soil, which is desirable in cases where the erosion potential would be high during vegetative establishment by seeding.

EFFECTIVENESS

Sodding can provide effective protection from erosion immediately after it is laid. The sod protects soil from erosion by raindrop impact and overland flow. It also slows runoff and can trap coarse sediment particles carried by runoff. Sodding can reduce erosion rates by as much as 99% (USDA, NRCS, 1976).

PLANNING CONSIDERATIONS

Before using sod, the planner should be sure that the varieties of grass are compatible with the intended use, soils and desired level of maintenance. The selection of varieties will be much more limited than they are when establishing vegetation from seed. Many of the sods are grown for home lawn use and may prove unsatisfactory if they are used in a location where low maintenance is important.

Sodding is a very good means of establishing vegetation instantly in erosion-prone areas, such as swales, steep slopes and areas adjacent to paved surfaces.

SODDING RECOMMENDATIONS

1. The soil must be prepared as it would be for a seeding. The upper 3 inches must be loosened and be relatively free of clods rocks and debris. The soil surface should be smoothed and firmed prior to sodding to eliminate surface irregularities which would impair good root-to-soil contact.

2. The sod should meet the requirements of MnDOT specification 3878, or equivalent (MnDOT, 1988).

3. Sod should not be cut or laid in excessively wet or dry conditions. During periods of high temperature, the soil should be lightly moistened just before the sod is laid. The joints in the sod should be staggered, and the sod should be laid so that the edges are tightly butted together (see Figure 6.25-1).

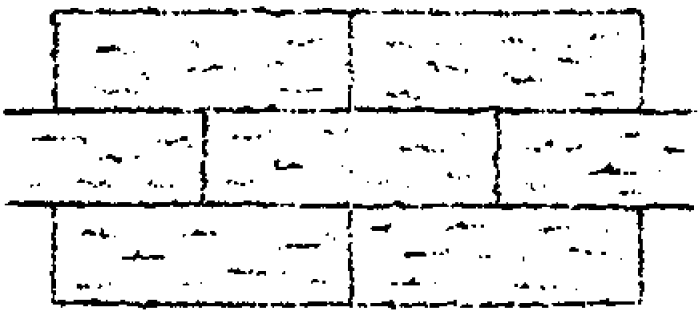
4. On slopes of 3:1 or greater, or in areas of concentrated flow, the sod should be pegged down. On steep slopes with sheet flows, the sod should be laid with the length perpendicular to the water flow (see Figure 6.25-2).

5. After the sod is laid, it should be rolled to provide good contact between the sod and the soil.

6. After it is rolled, the sod should be watered so that the soil is moistened to a depth of 4 inches below the sod. Watering should continue as needed until the sod is established. (One inch of water per week is a good rule of thumb.)

7. The first mowing should not be attempted until the sod is firmly rooted, usually two to three weeks after it is laid. Mower blade height should be set at about 3 inches for the first mowing.

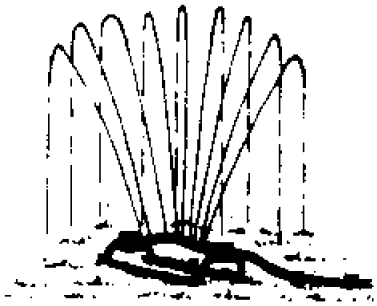
8. Sodding should be restricted when you have 30 or fewer growing days to establish roots.



Lay sod in a staggered pattern with strips butted tightly against each other. A sharpened mason's trowel can be used to tuck down the ends and trim pieces.

Butting—angled ends caused by the automatic sod cutting must be matched correctly.

Roll sod immediately to achieve firm contact with the soil.

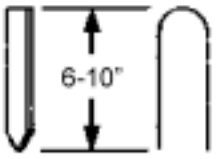


Water to a depth of 4" as soon as the sod is laid, and continue watering as needed.

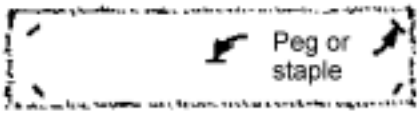
Mow when the sod is established (2-3 weeks). Set the mower high (2-3").

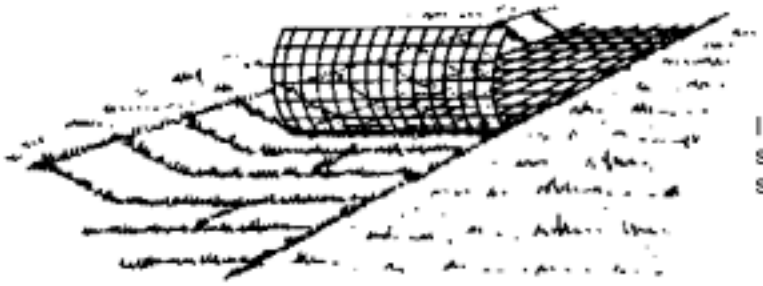
Figure 6.25-1 Proper installation of sod (modified from North Carolina, May 1994)

Lay sod across the direction of flow.



Use pegs or staples to fasten sod firmly at the ends of strips and in the center, or every 3-4' if the strips are long. When ready to mow, drive pegs or staples flush with the ground





In critical areas, secure sod with netting and staples.

Figure 6.25-2 Installation of sod in waterways (modified from North Carolina, May 1994)

6.30 TREATMENT MEASURES

This part includes measures used to remove sediment from water except for ponds, which are covered in chapter 5 of this manual.

6.31 Treatment Measures: SILT FENCES

DESCRIPTION AND PURPOSE

A silt fence is a temporary sediment barrier consisting of a geotextile, which is attached to supporting posts trenched into the ground. Sediment-laden runoff ponds uphill from the silt fence and runoff is filtered as it passes through the geotextile (see Figure 6.31-1 for a typical installation of a silt fence).

Silt fences are intended to intercept and detain small amounts of sediment from disturbed areas in order to keep the sediment from leaving the site. Silt fences can also prevent sheet erosion by decreasing the velocity of runoff. In some instances, straw or hay bales could be used; however, their failure rate is high (see Figure 6.31-2 for a detail of silt fences on a slope).

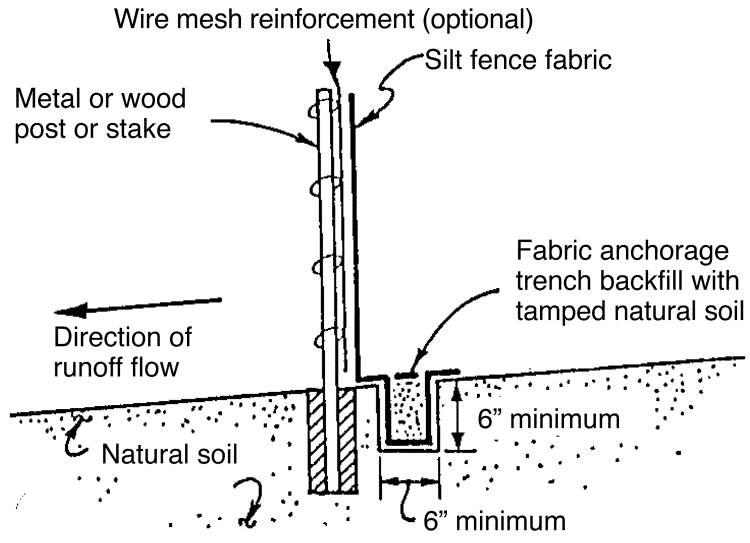
The use of silt fences as a sediment barrier is not recommended in areas of concentrated flow, such as ditches; in those cases, soil berms, silt dikes, straw waddles and excelsior logs, or rock check dams should be used.

PLANNING CONSIDERATIONS

A silt fence is a permeable barrier that should be planned as a system to retain sediment on the construction site. The fence retains sediment primarily by retarding flow and promoting deposition behind the fence. In operation, the fence generally becomes clogged with fine particles, which in turn reduces the flow rate. This causes a pond to develop more quickly behind the fence. The designer should anticipate ponding and provide sufficient storage areas and overflow outlets to prevent flows from overtopping the fence. Since silt fences are not designed to withstand high standing water, locate them so that only shallow pools can form. Tie the ends of a silt fence into the landscape to prevent flow around the end of the fence before the pool reaches design level. Often a crescent shape will perform better than the traditional straight line. Provide stabilized outlets to protect the fence system and release storm flows that exceed the design storm.

Deposition occurs as the storage pool forms behind the fence. The designer can direct flows to specified deposition areas through appropriate positioning of the fence or by providing an excavated area behind the fence. Plan deposition areas at accessible points to facilitate routine cleanout and maintenance. Show deposition areas in the erosion-and-sedimentation-control plan. A silt fence acts as a diversion if placed slightly off the contour. This may be used by the designer to control shallow, uniform flows from small, disturbed areas and to deliver sediment-laden water to deposition areas.

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



(Note: Depending upon configuration, attach fabric to wire mesh with hog rings, steel posts with tie wires, or wood posts with staples.

Figure 6.31-1 Typical installation for silt fence

DESIGN RECOMMENDATIONS

1. Silt fences should be installed on the contour (as opposed to up and down a hill) and constructed so that flow cannot bypass the ends.

2. Ensure that the drainage area is no greater than 1/4 acre per 100 ft of fence.

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

4. Where all runoff is to be stored behind the silt fence, ensure that the maximum slope length behind the fence does not exceed the specifications shown in Table 6.31-1.

5. By design, ensure that the depth of impounded water does not exceed 2 ft at any point along the fence.

Table 6.31-1 Maximum slope length and slope for which silt fence is applicable

		By Calculation	By Calculation	By Accepted Design Practices
Slope H:V	**Percent**	**Silt fence storage equals 2 ft for a 100-year event**	**Silt fence storage equals 2 ft for a 2-year event or 3 ft for a 100-year event**	
100:1	1%	400 ft	900 ft	100 ft
50:1	2%	200 ft	450 ft	75 ft
25:1	4%	100 ft	225 ft	75 ft
20:1	5%	80 ft	180 ft	75-50 ft
17:1	6%	67 ft	150 ft	50 ft
12.5:1	8%	50 ft	112 ft	50 ft
10:1	10%	40 ft	90 ft	50-25 ft
5:1	20%	20 ft	45 ft	25-15 ft
4:1	25%	16 ft	36 ft	15 ft
2:1	50%	8 ft	18 ft	15 ft

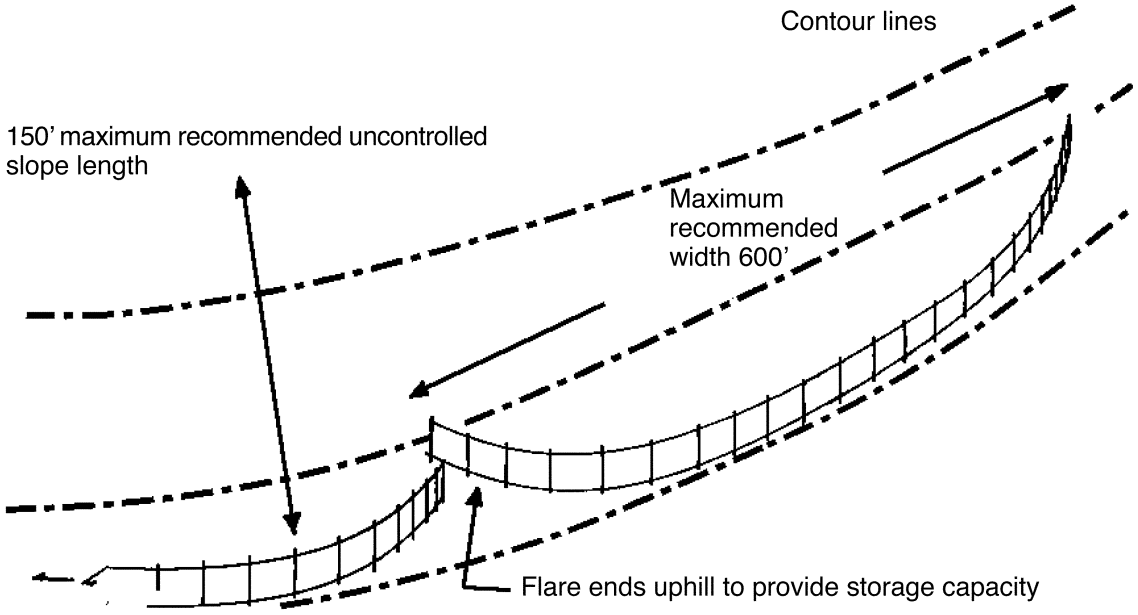


Figure 6.31-2 Typical silt fence layout

CONSTRUCTION SPECIFICATIONS

SILT FENCE

This description covers silt fence for use in retaining sediment and preventing off-site sedimentation. The following types are provided for specific uses:

Heavy Duty	General use during site grading, to protect critical areas and bodies of water. This type has metal posts and woven wire fence material as backing for the geotextile material.
Standard	Light-duty applications, to protect temporary construction or to supplement the other types of silt fence. This type is installed with plow type equipment with stakes spread at 8 ft intervals.
Preassembled	Light-duty applications, to protect temporary construction or to supplement the other types of silt fence. This type often has posts pre-attached to the silt fence geotextile.
Machine-sliced Installation	For most applications

The following describes the components of the silt fence which consists of a geotextile, which may have wire backing, and posts. (See Table 6.31-2 for further specifications)

GEOTEXTILE

Geotextile should be uniform in texture and appearance and have no defects, flaws or tears that would affect its physical properties. It should contain sufficient ultraviolet (UV) ray inhibitor and stabilizers to provide a minimum two-year service life outdoors.

Backing

Wire mesh backing is required with heavy duty silt fence. Use three vertically placed wire fasteners ("hog rings") to fasten the geotextile woven wire fence material at a minimum spacing of 2 ft.

Posts

Steel posts are used for heavy duty silt fence and machine sliced method of installation. Standard applications may use wooden posts, which should have a sharpened end and should be set in the ground at least 1.5 ft deep. Each post should be securely fastened to the geotextile and net backing by ties or staples suitable for such purpose.

FIELD ASSEMBLY

The geotextile should be attached to the upstream side of the post and any backing. The bottom edge of the geotextile should be buried at least 6 inches deep in a vertical slot or trench, with the soil pressed firmly against the embedded geotextile.

MACHINE SLICE INSTALLATION

A geotextile fabric should be inserted in a slit in the soil (6-12 inches deep) so that no flow can pass under the silt fence. The slit should be created such that a horizontal chisel point, at the base of a soil-slicing blade, slightly disrupts soil upward as the blade slices through the soil. This upward disruption minimizes horizontal compaction and creates an optimal soil condition for mechanical compaction against the geotextile. The geotextile should be mechanically inserted directly behind the soil-slicing blade in a simultaneous operation, achieving consistent placement and depth. No turning over (plowing) of soil is allowed for the slicing method.

The contractor should compact the soil immediately next to the silt fence fabric with the wheels of a tractor, skid steer or roller. Drive over each side of the silt fence two to four times.

Each post should be tied in three places with 50 lb plastic zip ties. Position the post with the projections, or nipples, facing away from the silt fence fabric. Place all three ties within the top 8 inches of fabric, puncturing holes vertically a minimum of 1 inch apart. Position each tie diagonally through the fabric so that it rests on top of a post nipple and tighten.

MATERIALS

General

Use a synthetic geotextile fabric which is certified by the manufacturer or supplier as conforming to the requirements shown in Table 6.31-2.

Table 6.31-2 Specifications for 3 types of silt fence

Description	Heavy Duty	Standard	Machine Slice
Geotextile			
Type	Woven	Woven	Monofilament
Width	48 inches	36 inches	36 inches
Grab Tensile Strength ASTM D 4632	100 lb Min.	100 lb Min.	130 lb
Apparent Opening Size AOS ASTM D 4751	20-70 Sieve	20-70 Sieve	30-40 Sieve
UV Stability ASTM D 4355 500 hr.	70% Min.	70% Min.	70% Min.
Top-fastening Component	Overlap Around Woven-wire Backing	Sewn-in Cord	
Net Backing			
Material	Woven Wire		
Min. Weight	14-1/2 gauge		
Min. Mesh Opening	2 inches		
Max. Mesh Opening	6 inches		
Min. Width	30 inches		
Tensile Strength ASTM D 4595	100 lb/ft		
UV Stability ASTM D 4355 500 h	70% Min.		
Posts	(E)		
Material	Metal	Wood	Metal
Min. Size	1.25 lb/ft	1.5 inch by 1.5 inch	1.25 lb/ft
Min. Length	5 ft	4 ft	5 ft
Min. Embedment	2 ft	1.5 ft	2 ft
Max. Spacing	8 ft	8 ft	6 ft
Type of Post Fasteners	U-shaped clips No. 16 gauge wire	Gun staples 0.5 inch long	Plastic zip ties (50-lb tensile strength)
Min. Fasteners Per Post	3	5	3

Geotextile fabric should contain UV ray inhibitors and stabilizers to provide a minimum of two years of expected usable construction life at a temperature range of 0 to 120° F.

Ensure that posts for silt fences are either 1.5-inch hardwood with a minimum length of 4 ft or 1.25 lb/linear ft steel, with a minimum length of 5 ft. Make sure that steel posts have projections to facilitate fastening the fabric. Post spacing will be site specific, but under all condition 6-8 ft. on center is a standard maximum.

INSTALLATION

1. Silt fence that is inadequately embeded in the ground will blow out, releasing water and sediment under the fence. Failure to properly install, inspect and maintain are the primary causes of this failure.

2. Silt fences can also be overtopped by sediment build up over several storm events. The silt fence must be maintained when sediment reaches 1/3 the height of the silt fence. For a 3 ft silt fence, cleaning should be conducted whenever there is on 1 ft of silt build up.

3. Another primary area of failure is for silt fences to be overtopped in a concentrated flow area. The silt fence is not meant to be placed in concentrated flow areas, and slope length calculations of Table 6.31-1 do not apply to concentrated flows.

4. Silt fences are not terraces; they cannot be put in sequence to extend the slope length allowable. Other methods must be used if the allowable distance is exceeded.

5. Another area of failure is for the silt fence to be eroded around the ends. The fence must be tied into the slope so that the base of the fence is above the design storage depth.

6. Construct the silt fence from a continuous roll of geotextile if possible. Cut to the length of the barrier to avoid joints. When joints are necessary, securely fasten the geotextile fabric. It is preferred that the material be overlapped to the next post or geotextile may be wrapped together around posts.

7. For heavy duty use support standard strength silt fence by woven wire mesh fastened securely to the upslope side of the posts using hog rings and tie wires. Extend the wire mesh support to the bottom of the trench. Woven wire is not required with the standard silt fence or slicing method of installation.

8. When a wire-mesh support fence is used, space posts no more than 8 ft apart. Support posts should be driven securely into the ground to a minimum of 2 ft.

9. Unless machine-slice methods are used, excavate a trench approximately 6 inches wide and 6 inches deep along the proposed line of posts and upslope from the barrier.

10. Backfill the trench with compacted soil or gravel placed over the geotextile.

11. Never attach silt fence to trees.

MAINTENANCE

1. Inspect silt fences at least once a week and after each rainfall, or as required by permits. Make any required repairs immediately. Repair scoured areas on the back side of fence at this time to prevent future problems.

2. Should the fabric of a silt fence collapse, tear, decompose or otherwise become ineffective, replace it within 24 hours of discovery.

3. Remove silt deposits once they reach one-third the height of the fence to provide adequate storage volume for the next rain and to reduce pressure on the fence. Take care to avoid undermining the fence during cleanout.

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

Note: Other specifications are acceptable, make sure your project specifications are appropriate for your project

6.32 Treatment Measures: FLOTATION SILT CURTAINS

DESCRIPTION AND PURPOSE

A flotation silt curtain is a silt barrier for use within a lake or pond, stream or other water. The flotation silt curtain consists of a geotextile curtain weighted at the bottom and attached to a flotation device, or carrier, at the top (See figure 6.32-1). This structure is used to isolate an active construction area within a waterbody to prevent silt-laden water from migrating out of the construction zone. A moving water silt curtain can be used in rivers and streams, while a still-water-type curtain is used in lakes and ponds.

EFFECTIVENESS

Flotation silt curtains are effective for limiting the migration of suspended sediment within a lake or pond. They will not reduce the amount of disturbance from work performed in water, but they will minimize the area that is impacted.

PLANNING CONSIDERATIONS

Flotation silt curtains are to be used as a last resort and should be used in conjunction with other protection measures. In some cases, it may not be practical or possible to avoid construction within a lake or stream. A flotation silt curtain can be used to isolate the water-quality effects from this type of work. The silt curtain should be located so that the amount of water included in the construction zone is minimized.

DESIGN RECOMMENDATIONS

1. The curtain should be constructed of a nylon fabric with a minimum tensile strength of 300 lb per inch of fabric.

2. The top of the curtain should have a flotation carrier consisting of high quality polyethylene foam. The flotation carrier should also have a high quality cable in it to carry loads imposed upon the curtain.

3. The bottom edge should be weighted by cable or chain with an adequate weight for the situation. Anchors must also be used to keep the curtain in place. The weight and spacing of anchors will be site-specific.

4. Where the curtain is made up of sections, the sections should be joined so that silt cannot permeate through the connection (grommets and laces for still water and mechanically for moving water).

MAINTENANCE

The silt curtain should be maintained until the construction area is stabilized and turbidity is reduced to acceptable background levels.

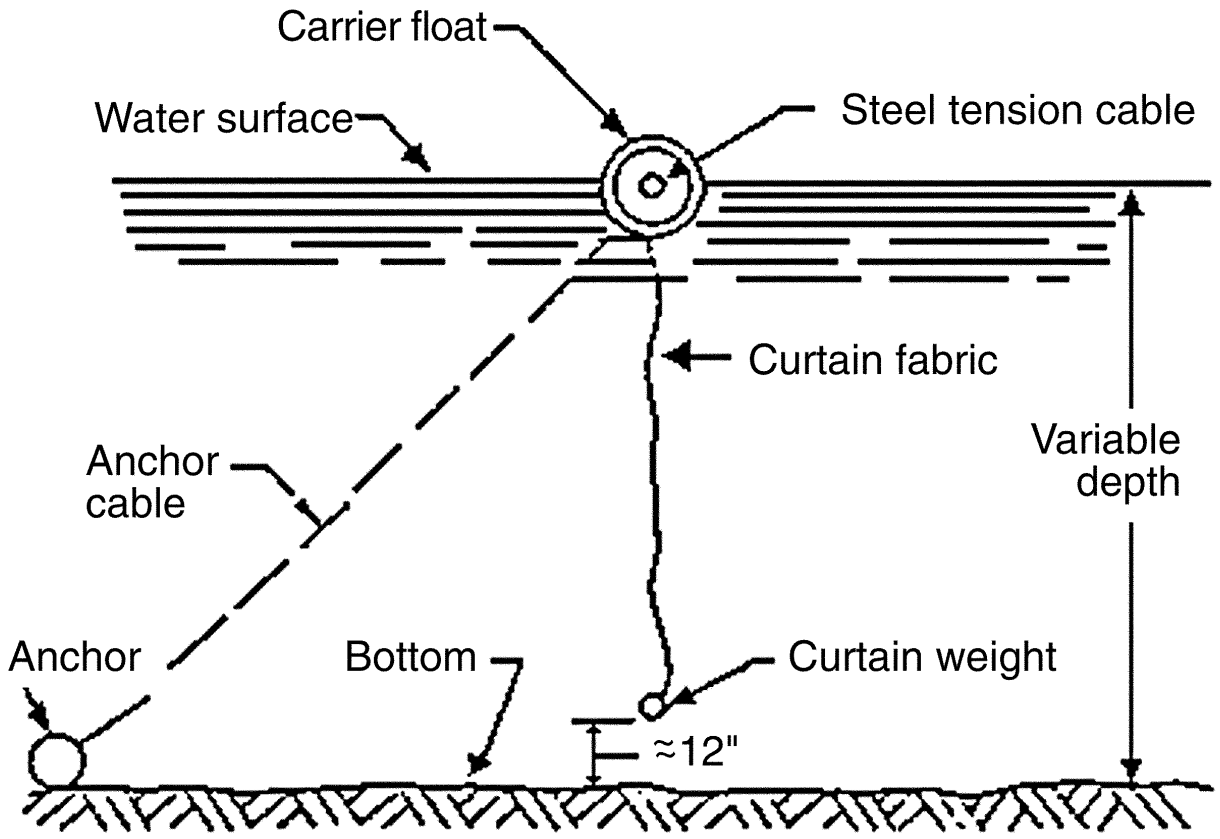


Figure 6.32-1 Flotation silt curtain

6.33 Treatment Measures: CHECK DAMS

DESCRIPTION AND PURPOSE

Check dams are generally used in concentrated-flow areas, such as ditches and swales. The use of rock check dams has been well established, while the use of silt dikes, waddles and fiber logs is a relatively new but growing technology. Check dams can either be permanent or temporary barriers to slow flow velocities and/or to filter concentrated flows. Ditch check dams tend to pond water. Under low-flow situations, water ponds behind the structure and then seeps slowly through, infiltrates or evaporates. Under high-flow situations, water flows over and/or through the structure. Check dams do not include staked hay bales or silt fence placed in a concentrated-flow area.

EFFECTIVENESS

Check dams provide relatively good removal of coarse and medium-size sediment from runoff. However, most fine silt and clay particles will pass though the voids on these structures. Check dams provide several advantages over staked hay bales: they require less maintenance, are effective in medium- to heavy-flow situations, and can be a permanent erosion-control measure. In the case of waddles and fiber logs, many times these will become a permanent part of vegetation establishment.

PLANNING CONSIDERATIONS

Slopes should not exceed 10%; a drop structure should be considered if the slope is greater than 10%. The maximum drainage area should be less than five acres, and flow velocities should not exceed 12 fps for a 10-year, 24-hour storm frequency.

DESIGN RECOMMENDATIONS

Rock check dams should consist of well-graded stone consisting of a mixture of rock sizes. For example: Class IV riprap with the percent less than the specified rock diameter.

100% < 24 inches
75% < 15 inches
50% < 9 inches
10% < 4 inches

Other options include 1.5-inch clean gravel and river rock. When riprap is provided on a project, the riprap can be temporarily used for rock checks, removed, and then reused for the permanent riprap installation. In a series of check dams, the top center of the downstream check dam should be at the bottom of the upstream check dam (see Figure 6.33-1).

A triangular silt dike is a triangular-shaped foam block covered with geotextile fabric. When laid in the channel, it will form a check dam. Triangular silt dikes are light-weight and easy to install and maintain.

Straw waddles and excelsior logs are straw and wood-fiber cores wrapped with synthetic netting. They can be partially buried in a channel to create mini dams. They are available in many diameters to meet site requirements. They can be helpful in establishing permanent vegetation in a channel.

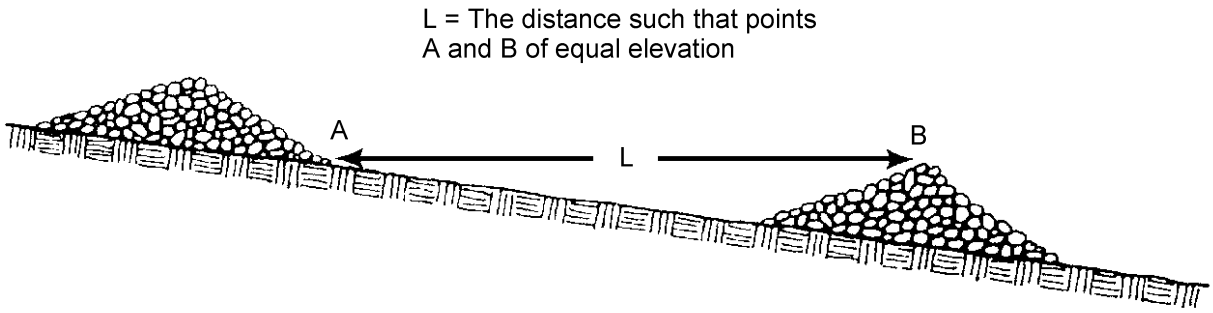


Figure 6.33-1 Space check dams in a channel so that the crest of the downstream dam is at the elevation of the toe of the upstream dam. (Source: Virginia Department of Conservation and Recreation, 1992.)

The spacing between ditch checks should be such that the bottom of the upstream check should be at the same elevation as the top of the downstream check. The spacing can be calculated by multiplying the height of the check dam by the slope H:V or by dividing by the slope in %. For a 2 ft size check dam the V indicates the spacing:

Table 6.33-1

Ditch grade (%)	Spacing (feet)
1	200
2	100
4	50
6	33
Above 6% ditch grade, you may need to flatten the slope	
8	25
10	20

To increase the effectiveness of rock check dams, a shallow pool upstream of the check is recommended. The pool allows additional sediment storage.

CONSTRUCTION SPECIFICATIONS

Install all structural check dams as recommended by the manufacturer. When stone dams are used, generally follow the following procedures:

1. Place stone to the lines and dimensions shown in the plan over a nonwoven geotextile fabric foundation.

2. Keep the center stone section at least 9 inches below natural ground level where the dam abuts the channel banks.

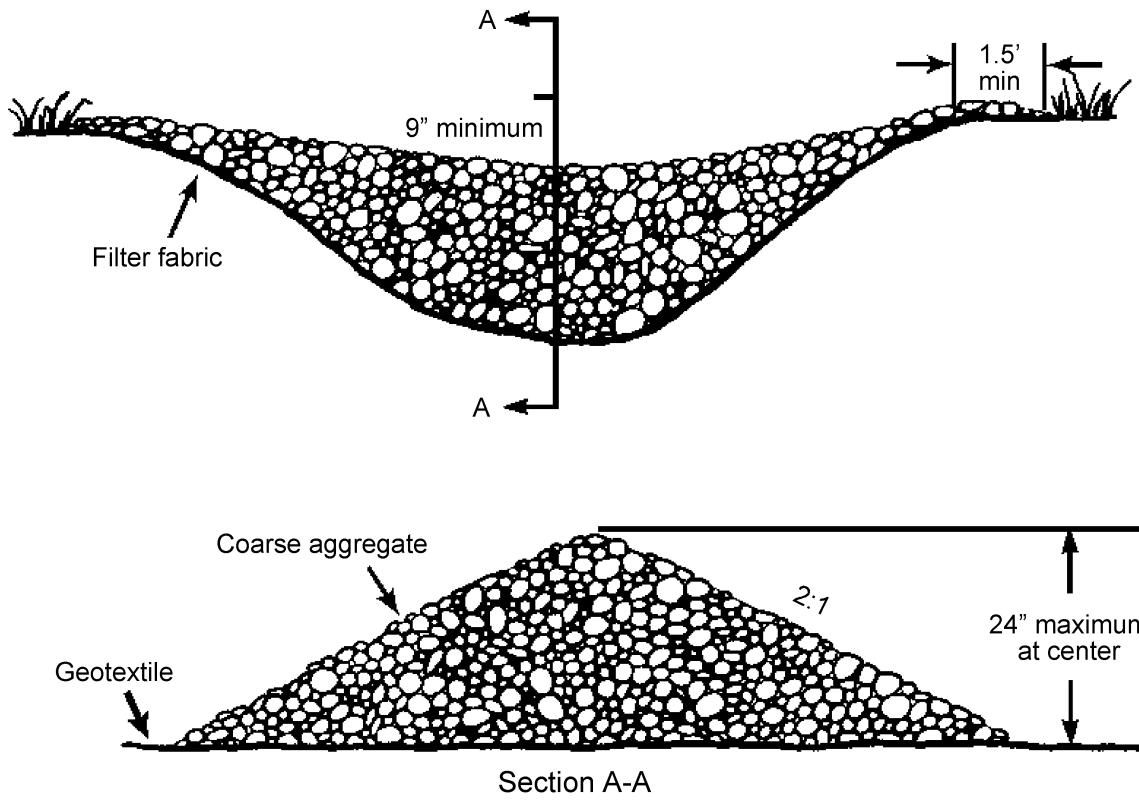


Figure 6.33-2 Stone check dam: stone should be placed over the channel banks to keep water from cutting around the dam. (Source: Virginia Department of Conservation and Recreation, 1992.)

3. Extend stone at least 1.5 ft beyond the ditch banks (Figure 6.33-2) to keep overflow water from undercutting the dam as it re-enters the channel.

4. Set spacing between dams to assure that the elevation at the top of the lower dam is the same as the toe elevation of the upper dam.

5. Protect the channel downstream from the lowest check dam, since water will flow over and around the dam.

6. Make sure that the channel reach above the most-upstream dam is stable.

7. Ensure that channel appurtenances, such as culvert entrances below check dams, are not subject to damage or blockage from displaced stones.

MAINTENANCE

Inspect check dams and channels for damage after each runoff event.

Anticipate submergence and deposition above the check dam and erosion from high flows around the edges of the dam. Correct all damage immediately. If significant erosion occurs between dams, install a protective riprap liner in that portion of the channel (See section 4.50, Riprap.).

Remove sediment accumulated behind the dams as needed to prevent damage to channel vegetation, allow the channel to drain through the stone check dam, and prevent large flows from carrying sediment over the dam. Add stones to dams as needed to maintain design height and cross section.

6.34 Treatment Measures: STRAW (OR HAY) BALE SEDIMENT BARRIERS

Note: Straw (or hay) bale sediment barriers are effective sediment-control practices only when they are used in appropriate locations and properly installed and maintained. Generally, alternatives, such as stone check dams, or silt fences should be used, especially in areas of concentrated flow. In many cases, installation or maintenance conditions are not met and the practice fails.

This practice is only recommended when proper planning is used and adequate construction supervision is available to ensure that the structure is installed and maintained correctly. Check dams (see part 6.3.) are more reliable and should be used if possible

DESCRIPTION AND PURPOSE

A straw (or hay) bale sediment trap is a row of entrenched and anchored bales, which are installed so that they detain and filter sediment-laden runoff.

This type of sediment trap is intended to remove coarse sediment from small amounts of runoff before it leaves the site.

The use of straw bales for a sediment trap is not recommended in areas of concentrated flow, such as ditches; instead, rock check dams should be used.

EFFECTIVENESS

Straw bales are moderately effective for trapping medium and coarse-grained sediment particles. They are generally not effective for trapping fine silt or clay particles in runoff. And, if straw bales are improperly installed, they can actually increase the amount of erosion by concentrating runoff and causing gully erosion.

PLANNING CONSIDERATIONS

Straw bale sediment traps are generally used in locations where silt fences could be used. Silt fences are almost always preferable to straw bales because they have a lower failure rate, are more effective and have a longer life. Because straw bale sediment traps have been widely used in the past, their proper use and installation is presented here for the planner's consideration.

DESIGN RECOMMENDATIONS

1. The slope length above the bales should be 100 ft or less.

2. The bales should be installed on the contour with their ends flared upslope, as shown in Figure 6.34-1.

3. The bales should be composed of clean straw or hay.

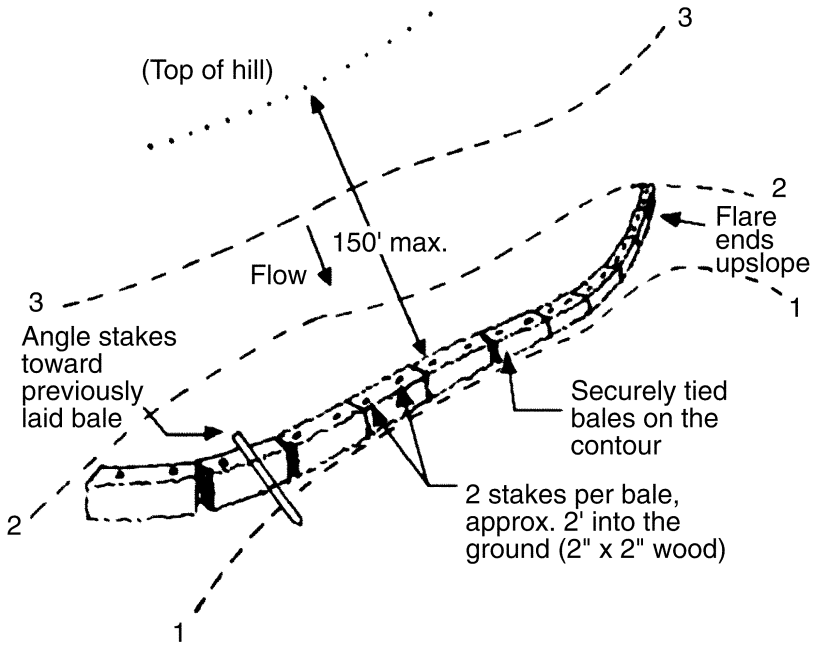


Figure 6.34-1 Placement and anchoring detail for straw bale sediment trap

4. The bales should be trenched 4 inches into the ground and should be staked with steel fence posts or 2" x 2" wood stakes. The stakes should be angled toward the previously laid bale.

5. Soil should be compacted on the upslope side of bales as shown in Figures 6.34-2 and 6.34-3. Loose straw should be wedged between the bales.

MAINTENANCE

Straw bale sediment traps should be inspected after every significant runoff event. Sediment deposits should be removed from behind the barrier as needed. Sediment should not be allowed to accumulate to a depth of more than one-half the height of the bales. Damaged, destroyed or rotted bales should be replaced immediately.

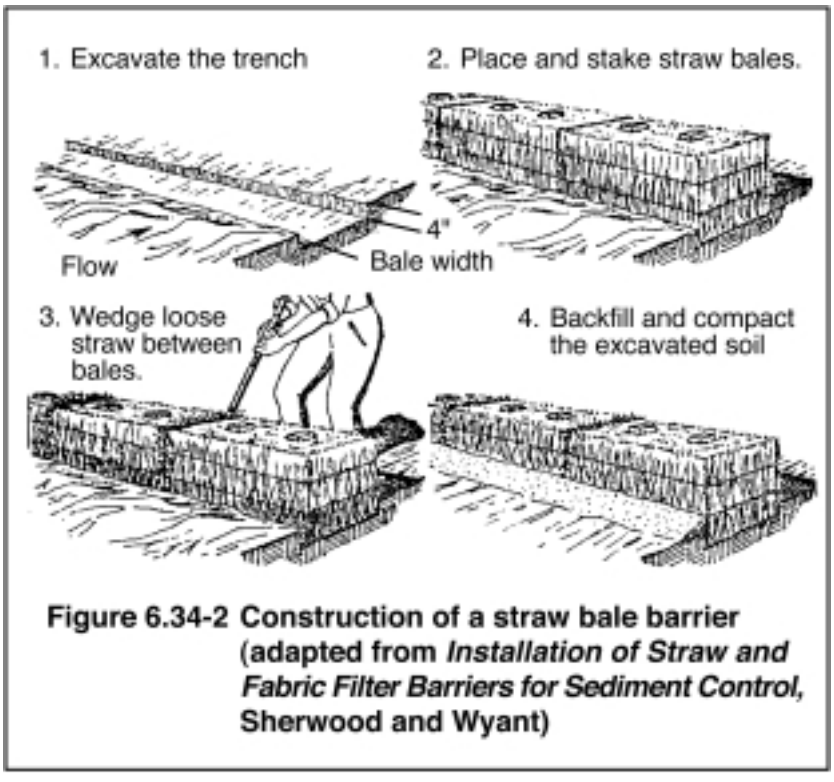


Figure 6.34-2 Construction of a straw bale barrier (adapted from *Installation of Straw and Fabric Filter Barriers for Sediment Control,* Sherwood and Wyant)

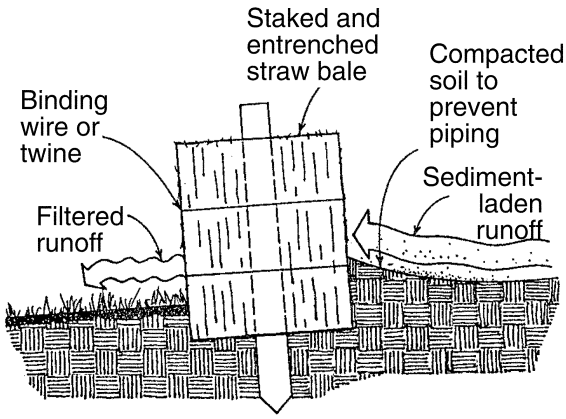


Figure 6.34-3 Cross section of a properly installed straw bale (source: *Michigan Soil Erosion and Sedimentation Control Guidebook*, 1975)

6.35 Treatment Measures: STORM DRAIN INLET PROTECTION

DESCRIPTION AND PURPOSE

Storm drain inlet protection is a sediment barrier placed around a storm drain drop inlet. This structure is used to trap sediment before it enters a storm sewer. This will keep sediment from being transported to lakes or streams and can also prevent clogging of the storm sewer caused by heavy sediment loads.

EFFECTIVENESS

Storm drain inlet protection provides relatively good removal of coarse and medium-size sediment from runoff. However, most fine silt and clay particles will pass though gravel filters on these structures. The Type A sediment barrier will do a better job of removing fine silt and clay from runoff.

PLANNING CONSIDERATIONS

It is critical that the storm sewer inlet not be completely blocked by inlet protection when public safety is a concern. Blocking an inlet has caused streets to flood and sediment to build up, creating a safety hazard. Erosion-control practices should be used in addition to this practice to limit sediment movement from disturbed areas. The inlet protection should be left in place until the drainage area is stabilized.

DESIGN RECOMMENDATIONS

Inlet protection should only be used in locations where sediment can be removed and temporary ponding will not create a safety hazard or cause property damage. Various designs have been adapted for different conditions. These individual types are described beginning on page 6.35-2.

NEW TECHNOLOGIES

Filter baskets and socks (bags) inserted under and around the catch basin grill are applicable where the inlet drains a relatively flat area and concentrated flows are not expected. Inlet drains with filtering devices have also been developed and may be useful in some applications. These devises must be installed, operated and maintained in accordance with manufacturer specifications.

MAINTENANCE

After any significant rainfall, storm sewer inlet protection must be inspected. Sediment should be removed as needed. Excavated sediment should be placed where it will not create an erosion problem, and inlet protection should be removed as soon as the contributing drainage area is stabilized.

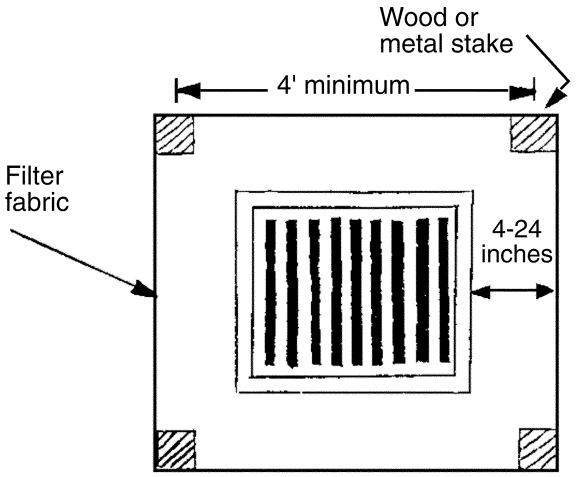


Figure 6.35-1 Type A silt-fence inlet sediment barrier

TYPE A-SILT-FENCE INLET SEDIMENT BARRIER

1. This method is applicable where the inlet drains a relatively flat area (slopes of less than 3%) where sheet flow is typical. This method is not recommended for inlets receiving concentrated flows, such as in road ditches.

2. The silt fence should be constructed in accordance with Practice 6.31, Silt Fence, except that the posts should be no more than 4 ft apart.

3. Each side of the inlet protection should be at least 4 ft long.

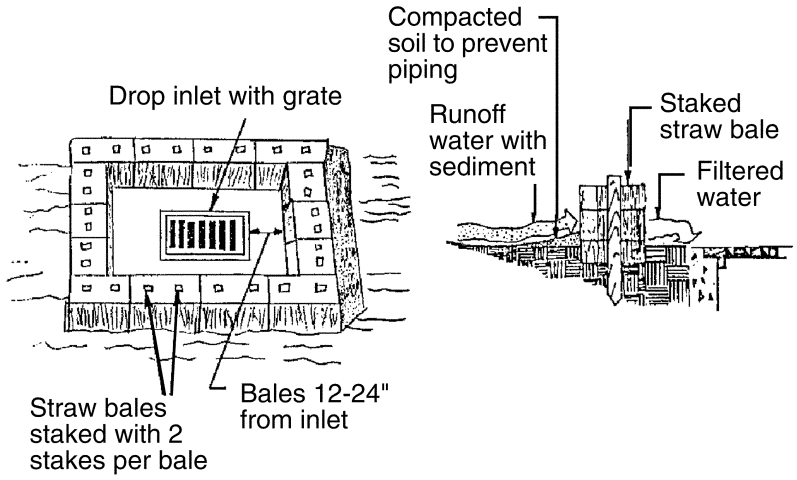


Figure 6.35-2 Type B straw-bale inlet sediment barrier (source: *Michigan Soil Erosion and Sedimentation Control Guidebook*)

TYPE B - STRAW BALE INLET SEDIMENT BARRIER

1. This method is applicable for the same conditions as Type A. Type A is preferred. Type B should only be used when Type A cannot be readily used, flow velocities are low, and the practice would be of temporary or limited duration.

2. The bales should be installed in accordance part 6.41, Sediment Traps. As mentioned in that practice, proper installation is imperative.

3. Straw bales should be set back 12 to 24 inches from the inlet.

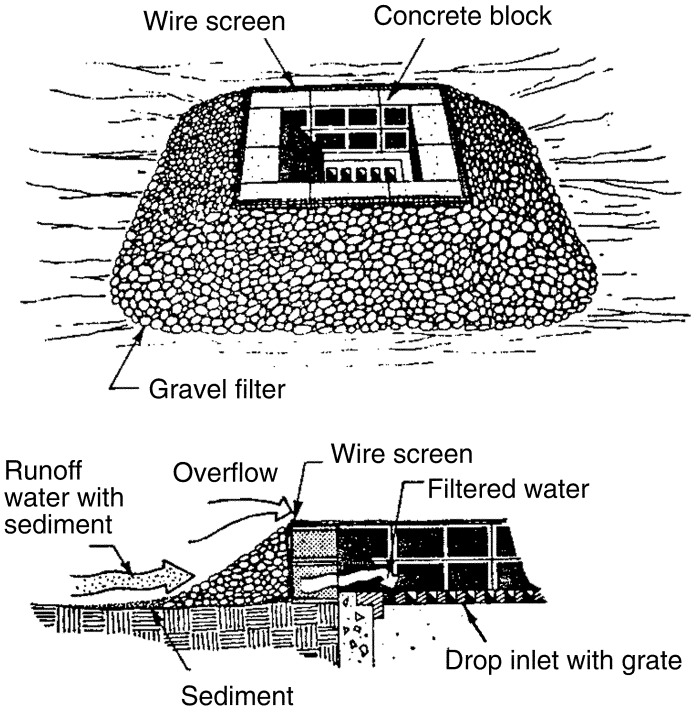


Figure 6.35-3 Type C block-and-gravel inlet sediment filter (source: Virginia Department of Conservation and Recreation)

TYPE C – BLOCK-AND-GRAVEL DRAIN INLET SEDIMENT FILTER

1. This method of inlet protection is applicable if heavy flows are expected and when an overflow capacity is needed to prevent excessive ponding around the structure.

2. Place concrete blocks lengthwise on their sides around the inlet as shown in Figure 6.35-3. The height of the barrier can be varied, depending upon needs, by stacking various sizes of block. The blocks should be between 12 and 24 inches high.

3. Wire mesh should be placed over the edges of the block before the rock is placed to prevent rocks from being washed through the block. Hardware cloth with ½-inch mesh should be used.

4. Stone should be placed against the wire mesh to the top of the block. The stone should be 1- to 3-inch washed gravel.

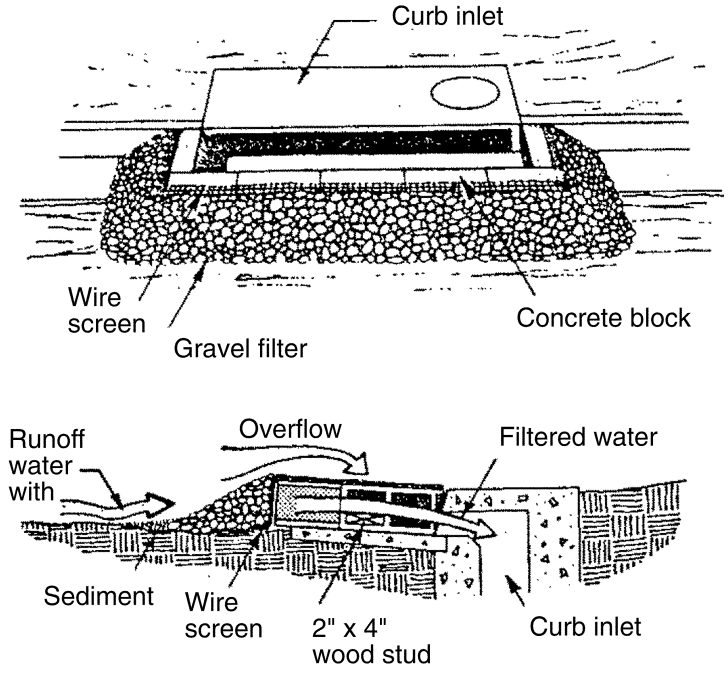


Figure 6.35-4 Type D block-and-gravel curb inlet sediment filter (source: Virginia Department of Conservation and Recreation)

TYPE D – BLOCK-AND-GRAVEL CURB INLET SEDIMENT FILTER

1. This method of inlet protection is applicable at curb inlets where an overflow capability is necessary to prevent excessive ponding in front of the structure. Public safety should be considered when using this practice.

2. Concrete blocks should be placed on the side around the inlet as shown in Figure 6.35-4. A 2x4 should be placed through the outer hole of the two spacer blocks to support the front row of blocks.

3. Wire mesh with 2-inch openings should be placed over the openings in the blocks to prevent gravel from being washed through the blocks.

4. Stone should be placed against the wire mesh to the top of the block. The stone should be 1- to 3-inch washed gravel.

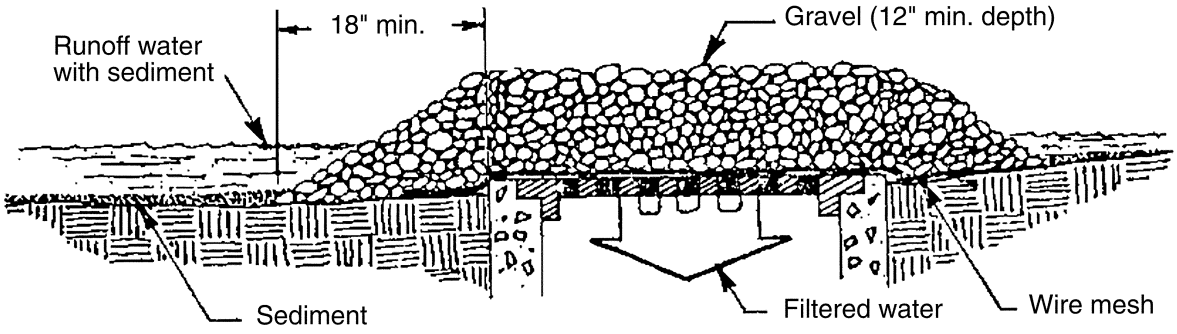


Figure 6.35-5 Type E gravel-and-wire-mesh drop inlet sediment filter

TYPE E – GRAVEL-AND-WIRE-MESH DROP INLET SEDIMENT FILTER

1. This method is applicable where heavy concentrated flows are expected and where ponding around the structure will not be inconvenient or cause damage to adjacent structures.

2. Wire mesh should be placed over the grating as shown in Figure 6.35-5 to prevent gravel from being washed into the storm drain. The wire mesh should have 1/2-inch openings and extend one foot beyond the grating.

3. The stone should be 1-3-inch washed gravel. The stone should be at least 12 inches deep and extend at least 18 inches beyond the grating.

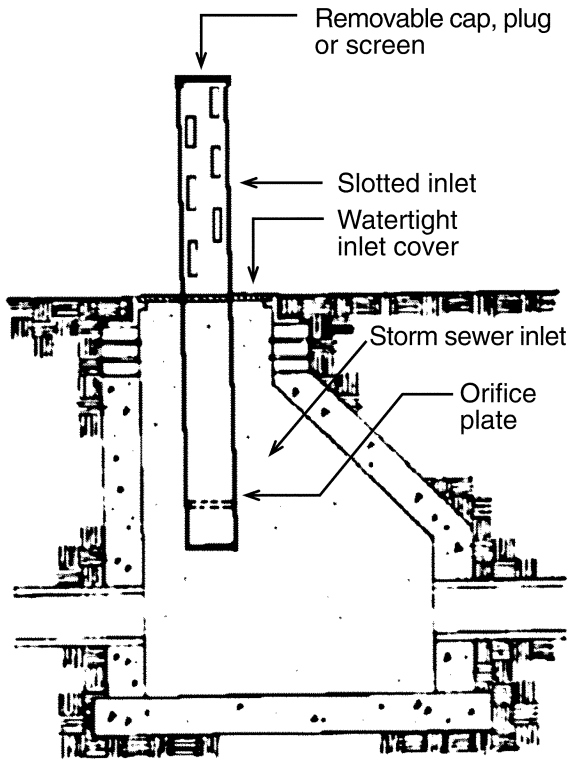


Figure 6.35-6 Type F slotted-riser storm sewer inlet (source: *Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois*, 1981)

TYPE F – SLOTTED-RISER STORM SEWER INLET

1. This method is applicable where heavy concentrated flows are expected and where ponding around the structure will not cause excessive inconvenience or damage to adjacent structures.

2. The riser may be made of corrugated metal, smooth metal or polyvinyl chloride (PVC) pipe. An orifice plate should be used to restrict flow. A flow velocity through the slots of 2 fps or less is suggested. Inlets constructed according to the standard dimensions table in Figure 6.35-6 will meet this criterion.

3. A prefilter consisting of geotextile or rock should be placed around the slotted riser.

6.40 Miscellaneous Measures: DEWATERING

DESCRIPTION

Dewatering encompasses various methods used to remove and discharge excess water from a construction site. The most common method is to pump water out of areas where it does not otherwise drain off, such as excavated areas, sediment basins and sediment traps. Dewatering may also include methods, such as sand point wells, used to lower the ground water table to provide a stabilized area for construction. Cofferdams and diversion structures may be used to keep water from a dewatered area or a site.

PURPOSE

Dewatering may be used during construction to remove accumulated water and sediments from sediment traps and basins to ensure their effectiveness throughout the project. At the end of the project, dewatering of sediment traps and basins is appropriate prior to removing the last sediment-control measures. Water remaining in excavated areas may be eliminated by dewatering so that construction can proceed on schedule.

PLANNING CONSIDERATIONS

These projects may need state, federal or local permits, so check with the appropriate agencies for their requirements.

Water pumped out of cofferdams, excavations, footings and other areas where water can accumulate may contain high concentrations of suspended solids. The solids are sometimes already suspended in the water, or the pumping process can mix the solids into the water. Water that is pumped from a sand point for dewatering operations can also contain high levels of sediment, especially at first. In either case, adequate sediment control must be provided before the pumped water is discharged. If the pumped water is running clear or begins to run clear, the sediment-control devices may be bypassed as long as sediment is not re-introduced into the system.

Discharging pumped water that contains suspended sediment can cause substantial amounts of pollutants to enter Minnesota's surface waters. Sediment smothers aquatic organisms, covers habitat and provides nutrients that cause excessive weed and algal growth. It can be related to processes that raise the water temperature, reduce the amount of dissolved oxygen, and hinder successful fish spawning.

Sediment-laden water affected by construction or other activity must be treated by temporary sedimentation traps, basins, geotextile filters or other appropriate BMPs. These guidelines include several suggested types of dewatering structures, which have different applications, depending on site conditions and types of operation.

DESIGN RECOMMENDATIONS

Water not affected by construction activity can be diverted around a construction site or removed by well points and discharged to a stable outlet without treatment. However, treatment of waters affected by construction activity must be provided. We recommend the following measures be considered diversion structures, well points, filtered sump pits, sediment traps, treatment ponds, and other dewatering systems that are appropriate for the discharge and effectiveness of the system. The appropriation and discharge of water may require additional local, state or federal permits.

OPERATIONS

A dewatering structure must be sized (and operated) to allow pumped water to flow through the device at the appropriate rate, without exceeding the design criteria for the treatment system.

Design criteria specific to each particular dewatering device should be developed.

MAINTENANCE

1. The dewatering system must be inspected frequently and repaired or replaced if sediment buildup recurs or if the structure does not function as designed.

2. The accumulated sediment that is removed from a dewatering device must be spread onsite and stabilized, used as fill or disposed of at an approved disposal site.

Examples of construction-site dewatering practices that are <u>not</u> acceptable include:

1. straight pipe pumping sediment-laden water directly to a lake, pond, river, stream, brook, wetland or marsh;

2. straight pipe pumping sediment-laden water directly to a storm drain inlet or catch basin; and

3. discharging water in a manner that causes erosion of the site or receiving channels.

6.41 Miscellaneous Measures: SEDIMENT TRAPS

DESCRIPTION AND PURPOSE

A temporary sediment trap is a small, temporary ponding area formed by constructing an earthen embankment with an outlet across a swale. Temporary sediment traps are intended to detain sediment-laden runoff from small, disturbed areas long enough to allow the majority (at least 75%) of the sediment to settle out.

EFFECTIVENESS

Temporary sediment traps provide good control of coarse sediment and are moderately effective for trapping medium-size sediment particles. However, they have a relatively low trapping efficiency for fine silt and clay particles suspended in runoff. If a higher trapping efficiency is desired, a temporary sediment basin with a larger storage volume and longer detention time should be used.

PLANNING CONSIDERATIONS

For maximum effectiveness, sediment traps should be located as close as possible to the disturbed area. Temporary diversions can be used to direct sediment-laden runoff to the sediment trap. Every effort should be made to exclude runoff from undisturbed areas. Sediment traps and other sediment-control measures should be installed before work is begun in the contributing drainage area.

DESIGN RECOMMENDATIONS

1. A temporary sediment trap should only be used in a location with a drainage area of five acres or less and where it will be used for two years or less.

2. Sediment traps must have an outlet to carry runoff through the structure. The outlet can be a pipe outlet, gravel outlet or other suitable device. The outlet must be capable of handling the runoff from a 10-year-frequency, 24-hour-duration storm without failure or significant erosion.

3. For pipe outlets, see Practice 6.37, Temporary Sediment Basins, for design requirements.

4. If a gravel outlet is used, it should be located in the low point of the embankment. The minimum length in feet of a gravel outlet should be four times the number of acres in the drainage area. The crest of the gravel outlet should be level and ft below the top of the embankment. See Figure 6.41-1.

The gravel used for the outlet should be 1- to 2-inch size, such as MnDOT CA-1 or CA-2 coarse aggregate. Geotextile can be installed inside the gravel filter to improve the sediment-trapping efficiency of the structure. However, this increases the probability that the outlet will become clogged.

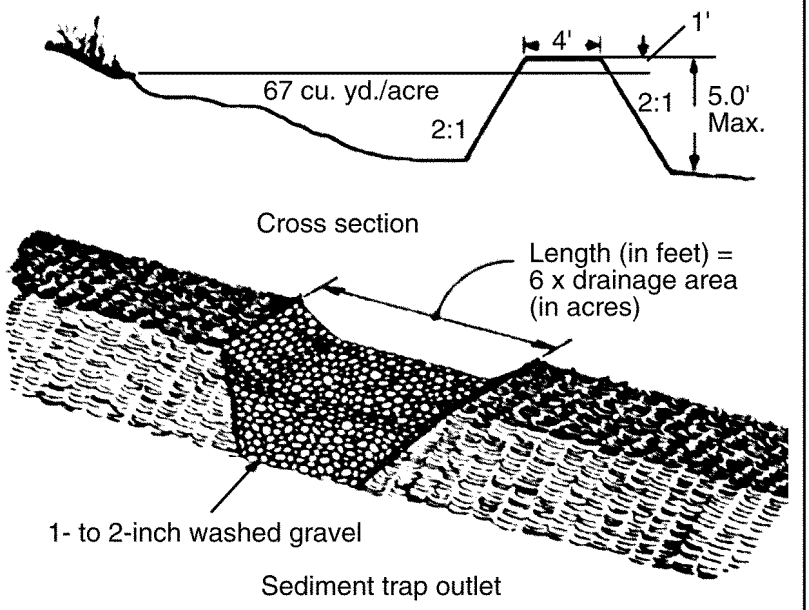


Figure 6.41-1 Temporary sediment trap with gravel outlet (source: Virginia Department of Conservation and Recreation)

MAINTENANCE

As previously mentioned, the sediment should be removed when it fills half of the capacity of the sediment trap. If the outlet becomes clogged with sediment, it should be cleaned to restore its flow capacity.

The structure should be inspected after significant runoff events to check for damage or operational problems. Once the contributing drainage area has been stabilized, the structure should be removed.

6.42 Miscellaneous Measures: SUMP PITS

DESCRIPTION AND PURPOSE

A sump pit is a temporary hole or pit placed so that it can collect water so that the water can be discharged relatively unaffected by construction or other activity. Other uses may be to dewater sediment traps and basins or excavations. A perforated standpipe wrapped in an appropriate geotextile designed to minimize plugging is placed in the center of the pit. Then the area is backfilled with filter stone. Water that collects in the pit flows through the gravel into the standpipe and is pumped out to a filtering device or, in some cases, directly to a receiving water. The sump-pit discharge may be pumped directly to a receiving water only if the perforated portion of the standpipe has been properly wrapped in geotextile and the discharge water is clear.

PLANNING CONSIDERATIONS

A sump pit may be used to dewater a cofferdam, sediment trap or basin, or it may be used during construction when water collects in an excavation. A sump pit may be used for dewatering where space is limited, such as in urban areas. It should generally be used only for small flows and volumes.

DESIGN RECOMMENDATIONS

1. The number of sump pits and their locations will depend on the site and any state or local requirements. A detailed design is not required, but construction should conform to the general criteria outlined in Figure 6.42-1.

2. The standpipe should have perforations to allow water to flow in and it should be extended at least 1 ft over the top of the pit.

3. If the sump pit is to discharge directly into a receiving water or storm-drainage system, the standpipe must be wrapped in geotextile before the pit is backfilled with stone.

4. Pit dimensions must be sight specific.

5. The standpipe should be constructed by perforating a 12- to 24-inch-diameter corrugated metal or PVC pipe.

6. A base of 2-inch aggregate should be placed in the pit to a depth of 12 inches. After the standpipe is installed, the pit surrounding it should be backfilled with 2-inch aggregate.

7. The standpipe should extend 12-18 inches above the lip of the pit.

8. If the discharge will be pumped directly to a storm-drainage system, the standpipe must be wrapped with geotextile filter cloth meeting the property values in Table 6.42-1, before it is installed.

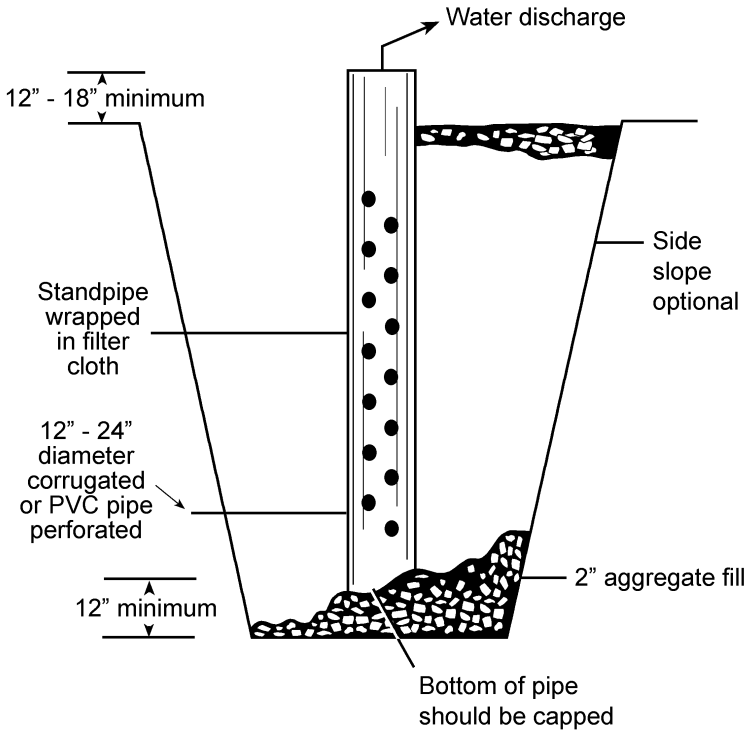


Figure 6.42-1 Sump pit dewatering (source: USEPA, April 1992)

9. If desired, hardware cloth, a three-dimensional synthetic material or chicken wire may be placed around the standpipe before attaching the filter cloth. This will increase the rate of water seepage into the pipe and prevent plugging.

Table 6.42-1 Geotextile filter fabric requirements for temporary sedimentation basin outlet design for dewatering

Property	Test Method	Unit	Minimum Avg. Roll Value	
			Machine Direction	Cross Direction
Grab tensile strength	ASTM D 4632	kN (lb)	1.62 (365)	0.89 (200)
Grab tensile elongation	ASTM D 4632	%	24	10
Mullen burst strength	ASTM D 3786	kPa (psi)	3445 (500)	
Puncture strength	ASTM D 4833	kN (lb)	0.51 (115)	
Trapezoid tear strength	ASTM D 4533	kN (lb)	0.51 (115)	0.33 (75)
Apparent opening size	ASTM D 4751	U.S. Std. Sieve	40 (0.420mm)	
Percent open area	COE-02215-896	%	10	
Permitivity	ASTM D 4491	ft/sec^{-1}	1.36	
Permeability	ASTM D 4491	cm/sec	0.092	
Flow rate	ASTM D 4491	$l/min/m^2$ (gpm/ft^2)	4074 (100)	
UV resistance after 500 hours	ASTM D 4355	% strength retained	90	

6.43 Miscellaneous Measures: SMALL FLOW-TREATMENT DEVICES

DESCRIPTION AND PURPOSE

This design is for the treatment of small dewatering flows that are affected by contractor activity using a filter box. A filter box is a structure that can be made of steel, sturdy wood or other materials suitable to handle the pressure requirements imposed by the volume of water. Fifty-five-gallon drums welded top to bottom are normally readily available and, in most cases, will suffice. These devices are not normally recommended but may be used on a site specific basis.

PLANNING CONSIDERATIONS

A filter box allows only minimal settling time for sediment particles. Therefore, filter boxes should only be used when site conditions restrict the use of other methods.

DESIGN RECOMMENDATIONS

1. The bottom of the box should be made porous by drilling holes (or some other method).

2. One- to 3-inch coarse aggregate meeting the gradations requirements in Figure 6.40-1 should be placed over the holes to a minimum depth of 12 inches (metal hardware cloth may need to be placed between the aggregate and the holes if holes larger than the majority of the stone have been made in the bottom of the box).

3. Geotextile should be placed on top of the coarse aggregate.

4. Six inches of washed sand should be placed on top of the geotextile.

5. Because of the fast flow of sediment-laden water through the aggregate, the effluent must be directed over a well-vegetated strip of at least 75 ft after leaving the base of the filter box.

6. Once the water level nears the top of the box, the pump must be shut off while the box drains and additional capacity is made available.

7. The box should be designed and constructed to allow for emergency flow over the top of the box.

8. Clean-out of the box is required once one-third of the original capacity is depleted due to sediment accumulation. The clean-out point should be clearly marked on the tank.

9. If the stone filter becomes clogged with sediment so that it no longer adequately functions, the stones must be pulled away from the inlet, cleaned, and replaced.

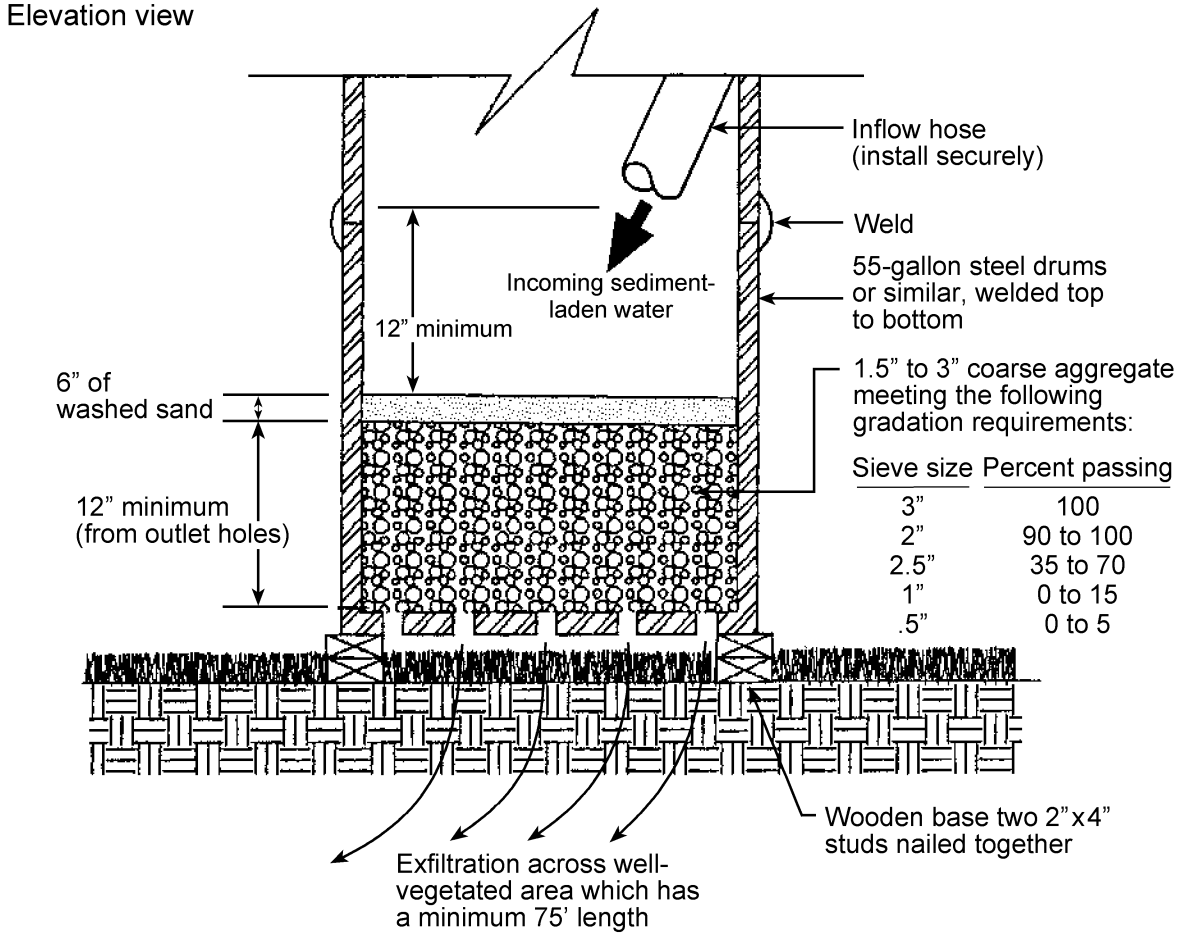


Figure 6.43-1 Cross section of a filter box (source: USEPA, April 1992)

6.44 Miscellaneous Measures: STRAW BALE/SILT FENCE TRAPS

DESCRIPTION AND PURPOSE

A straw bale/silt fence sediment trap is a temporary settling/filtering device for water that is discharged from dewatering activities. This structure should consist of straw bales or a silt fence, a stone outlet (a combination of riprap and aggregate) and an excavated wet-storage pit oriented as shown in Figure 6.44-1.

PLANNING CONSIDERATIONS

A straw bale/silt fence sediment trap can be used whenever sediment-laden water must be removed from a construction site by pumping.

DESIGN RECOMMENDATIONS

1. The structure must have a surface area which is dictated by the following formula:

   $$[\text{Pump discharge (gpm)}] \times \frac{(2.23 \times 10^{-3}\ \text{cfs})}{(1\ \text{gpm})} / (0.02\ \text{ft/sec}^{*}) = \text{required surface area (ft}^2\text{)}$$

2. The excavated area should be at least 3 ft below the base of the perimeter measures (the straw bales or silt fence).

3. The perimeter measures must be installed in accordance with the guidelines found in part 6.31, Silt Fence.

4. Once the water level nears the crest of the stone weir (emergency overflow), the pump must be shut off while the structure drains down to the elevation of the wet storage.

5. The excavated wet-storage pit may be dewatered only after a minimum of six hours of sediment-settling time. This effluent should be pumped across a well-vegetated area or through a silt fence before it is allowed to enter a surface water.

6. Once the wet-storage area becomes filled with sediment to one-half the excavated depth, accumulated sediment should be removed.

7. Once the device has been removed, ground contours must be returned to their original condition.

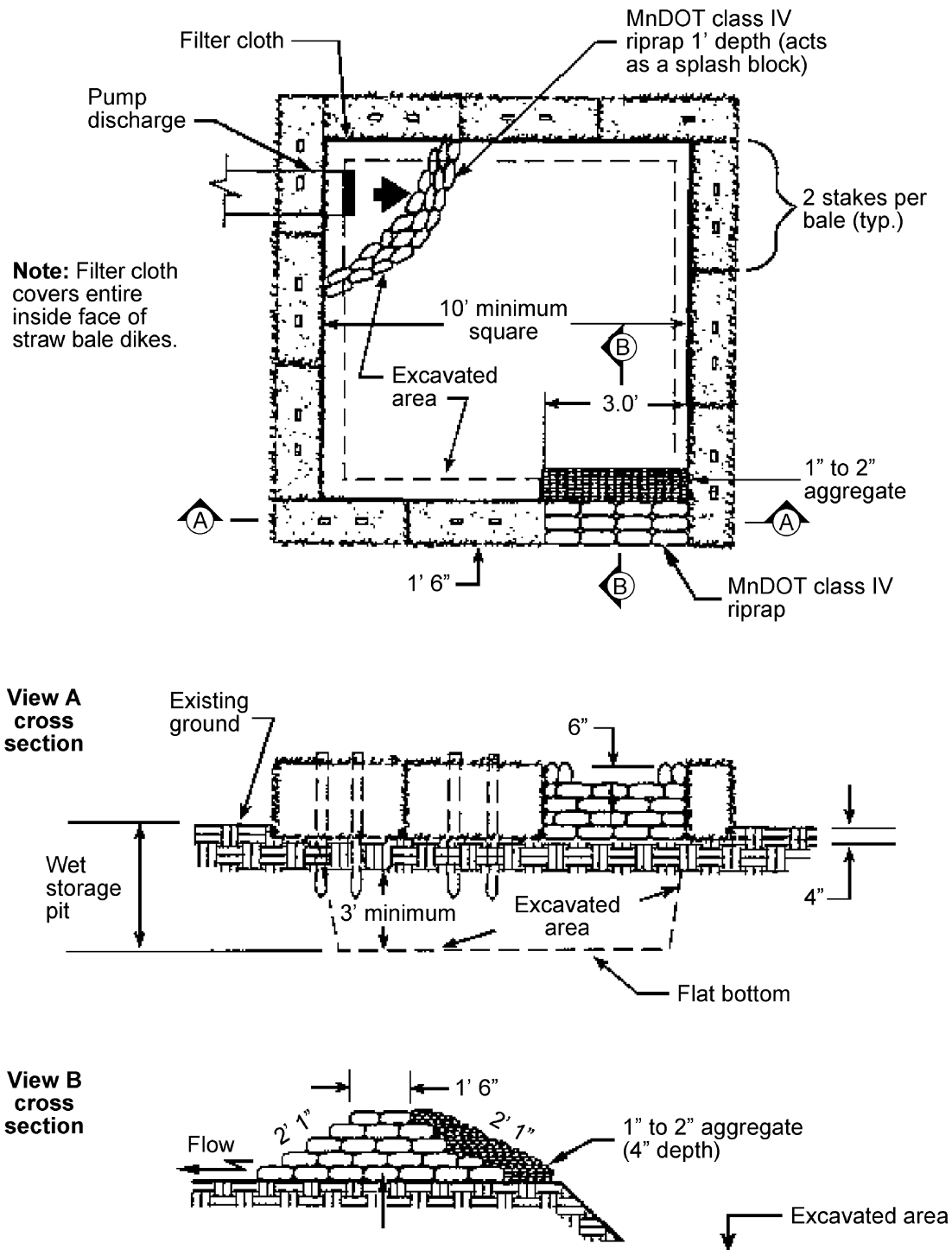


Figure 6.44-1 Combination straw bale/silt fence trap (source: USEPA, April 1992)

6.50 MATS AND MULCHES

This part describes methods of enhancing vegetation and protect soils before vegetation becomes established by reinforcing soils on a temporary or permanent basis.

6.51 Mats and Mulches: MULCHES

DEFINITION

This practice involves the application of straw or other organic materials to form a temporary, protective soil cover. The mulch material may be disc-anchored into the soil, hydraulically bonded, or covered with netting and stapled. Erosion control by hydraulically applied mulches, erosion control blankets, and turf-reinforcement mats are discussed in the following sections. Note: Decorative mulches such as wood and rock mulches, frequently used as permanent cover to accent landscape plantings, are not included in this part.

PURPOSE

A mulch protects the soil surface from the forces of raindrop impact and overland flow. Organic mulches foster the growth of vegetation, reduce evaporation, insulate the soil, and suppress weed growth.

CONDITIONS WHERE PRACTICE APPLIES

Mulch temporary or permanent seed installations immediately. Areas where vegetation cannot be established because of the season should be mulched to temporarily protect the soil surface. Use an organic mulch, and seed the area as soon as conditions are favorable for germination and seedling growth.

PLANNING CONSIDERATIONS

A surface mulch is the most effective, practical means of controlling runoff and erosion on disturbed land prior to vegetation establishment. Mulch reduces soil moisture loss by evaporation, prevents crusting and sealing of the soil surface, moderates soil temperatures, provides a suitable microclimate for seed germination, and may increase the infiltration rate of the soil.

Organic mulches, such as straw, have been found to be the most effective. Do not use materials that may contain competing weed and grass seeds. Decomposition of some wood products can tie up significant amounts of soil nitrogen, making it necessary to modify fertilization rates or to add fertilizer with the mulch.

Additional methods, such as erosion-control blankets and turf-reinforcement mats, may be needed in critical areas, such as waterways and channels and slopes steeper than 3:1.

Tackifiers, or chemical soil stabilizers or soil binders, are useful for tacking organic mulches. Various types of netting materials are also available to anchor organic mulches.

The choice of materials and anchoring of mulches should be based on slope steepness and length, soil conditions, season, type of vegetation, and size of the area. A properly applied and stabilized mulch is always beneficial for site stabilization. Mulching is especially important when conditions for germination are not optimum, such as midsummer and early winter, and on difficult areas, such as cut slopes and slopes with southern exposures.

CONSTRUCTION SPECIFICATIONS

Straw is the mulch most commonly used in conjunction with seeding. The straw should generally come from wheat or oats ("small grains"), but other sources may be specified.

Mulch may be spread by hand or with a mulch blower. Straw may be lost to wind and must be chemically or mechanically anchored to the soil immediately after it is spread. The following methods of anchoring mulch may be used:

A mulch-anchoring tool: is a tractor-drawn implement designed to punch mulch into the soil. A mulch-anchoring tool provides maximum erosion control with straw. A regular farm disc, weighted and set nearly straight, may be used instead, but it will not do a job comparable to the mulch-anchoring tool. The disk should not be sharp enough to cut through the straw. These methods are limited to slopes no steeper than 3:1, where equipment can operate safely. Operate machinery on the contour.

A tackifier is a chemical binder that secures mulch to soil. Application of tackifier should be heaviest at the edges of areas and at crests of ridges and banks, to resist wind. The tackifier should be applied uniformly to the rest of the area. A tackifier may be applied after the mulch has been spread or it may be sprayed into the mulch as the mulch is being blown onto the soil. Applying straw and a tackifier together is the most effective method. Liquid binders include latex, guar gum, proteins and an array of commercially available synthetic binders. Environmentally incompatible products, such as toxic materials, should not be used. Asphalt-based products are not allowed in some states.

A netting is often used to keep straw mulch in place until vegetation becomes established. Synthetic net is most commonly used, but jute nets are useful in channel and critical-area stabilization. Nets should be biodegradable, and degrade within six months. Nets are not designed to provide moisture-conservation benefits or erosion protection. Therefore, they are used in conjunction with organic mulches, such as straw.

In critical areas, netting should always be installed over the mulch. Hydraulic mulches, such as wood fiber, may be sprayed on top of an installed net. Install netting and matting in accordance with the manufacturer's instructions.

MAINTENANCE

Inspect all mulches periodically, and after rainstorms to check for rill erosion, dislocation or failure. Where erosion is observed, apply additional mulch. If washout occurs, repair the slope grade, reseed and reinstall mulch. Continue inspections until vegetation is firmly established.

6.52 Mats and Mulches: HYDRAULIC MULCH AND TACKIFIERS

DESCRIPTION

A hydraulic mulch is a processed material that, when mixed with water, can be applied in a continuous stream. Hydraulic mulches vary in type, composition and additives, and range from light- to heavy-duty. They are intended to form a thick, heavy-bodied crust or mat-like barrier that controls water- and wind-induced erosion. Although an infinite number of application rates could be used, one or two rates are generally specified. One rate is the blanket equivalent rate required for erosion control, usually between 3,000 and 4,000 pounds per acre, depending on manufacture recommendation for percent slope and length. The other rate, generally half the erosion blanket control rate, is especially useful for enhancing seed germination and soil stabilization on 6:1 or flatter slopes. The ratios of wood fiber and recycled newsprint that make up light-duty hydraulic mulch may vary.

MULCH MATERIALS

Bonded Fiber Matrix: A bonded fiber matrix refers to a continuous layer of elongated wood fiber strands that are held together by a water-resistant bonding agent to form a water-absorbing crust. When properly dried, this acts as an erosion-control blanket. This mulch is applied with a mechanically agitated pumping machine (hydroseeder). Bonded fibers work in a wide range of applications, but are particularly suited for more difficult sites. Properly applied, bonded fiber matrices can provide excellent erosion protection and revegetative support.

Wood Fiber Mulch: When sprayed on the soil, the virgin wood fibers and tackifier that comprise this biodegradable mulch form a blotter-like cover that readily absorbs water and allows infiltration to the underlying soil. Wood fiber mulch should be made entirely from whole wood chips, and not contain recycled materials, such as sawdust or pulverized newspaper, or any substances that inhibit germination or growth. The fibers should be colored with a dye to aid in visual metering when the mulch is applied hydraulically.

Blended Mulch: This mulch consists of specially prepared, biodegradable, shredded paper particles, wood fibers and tackifier. The blend should contain a wetting agent, deforming agent, and nontoxic dyestuff that will impart a bright green or blue color to aid in visual metering during application. Blended mulches are available in several wood-fiber-to-paper ratios; most common is 70:30 or 50:50.

Currently, manufacturers are working on a vast array of additions to these basic mulches. The use of compost, peat, and shredded soybean or other legume biomass as additives is gaining. These should be considered as soil types and site conditions warrant.

TACKIFIERS

GENERAL SPECIFICATIONS

1. *Latex-Base:* The components for the latex-base adhesive should meet the following requirements. The composition, by weight, of the latex emulsion polymer should be 48% styrene, 50% butadiene, and 2% additive; 42-46% solids; and a pH, as shipped, of 8.5 to 10.0. The emulsion should not be allowed to freeze or be exposed to sunlight for a prolonged period.

2. *Guar Gum*: Guar gum tackifiers should consist of a minimum of 95% guar gum by weight; the remainder should consist of dispersing and cross-linking additives.

3. *Other Tackifiers*: Other tackifiers include, but are not limited to: water-soluble natural vegetable gums blended with gelling and hardening agents, or a water-soluble blend of hydrophilic polymers, viscosifiers, sticking aids and other gums.

MULCH ANCHORING

Anchoring of straw mulch can be accomplished by spraying a hydromulch with tackifier immediately after the straw mulch has been placed.

CONSTRUCTION CONSIDERATIONS

Spraying of hydraulic mulch should not be performed during windy conditions, which would prevent the proper placement. The contractor should protect all traffic, signs, structures and other objects from being marked or disfigured by the mulch/tackifier material. The tackifiers specified should be applied at the manufacturer's recommended rate.

MULCH APPLICATION

Wood fiber mulch should be applied with hydraulic spray equipment in a water slurry at a minimum of 2,000 lb per acre for flatter slopes, and up to 3,500-4,000 lb per acre in critical areas where the potential for erosion exists. The tackifier can be premixed by the manufacturer, or can be added in the field. The tackifier should comprise 2-5% by weight.

Blended mulches are normally not intended for use on critical areas with high erosion potential. They are an excellent germination medium, and should be considered on flatter slopes and hard-to-reach areas. Tackifier can be premixed by the manufacturer at 2-5% by weight or can be added in the field.

The use of wood fiber mulch in combination with straw has been found to be very effective. Typically the straw mulch is blown onto the surface at a rate of 1.5 tons per acre and immediately oversprayed with wood fiber mulch at 500 lb per acre. The wood fiber mulch should have tackifier added at 2.5-5% by weight. Seeding and fertilizing should be done prior to mulching. Disk-anchoring is not required with this practice, which makes this an ideal alternative for hard-to-reach areas where disk-anchoring is not possible.

6.53 Mats and Mulches: LANDSCAPE MULCHES

DESCRIPTION AND PURPOSE

Landscape mulch is a product that prevents erosion but often is placed to prevent vegetation from growing at a site. Bark chips and shredded bark byproducts of timber processing often are used as landscape mulches. They may be applied by hand or with a mulch blower. Small stones (aggregate) are another type of landscape mulch.

SPECIFICATIONS

Wood landscape mulch should consist of raw hard or soft timber that has been run through a mechanical chipper, hammermill or tub grinder. The wood should be substantially free of mold, dirt, sawdust and foreign material and not be in an advanced state of decomposition. Wood landscape mulch should not contain chipped manufactured boards or chemically treated wood, such as waferboard, particleboard and chromated copper arsenate (CCA) or penta-treated wood. This mulch, when air dried, should all pass a 4-inch screen and not more than 20% by weight of the material should pass a No. 8 sieve (3/32 inch). Free bark or green leaf composition, either singly or combined, should not exceed 20% by weight. Individual pieces should generally not exceed 6 inches in length. The engineer usually determines the suitability of the material by visual inspection.

Aggregate mulch consists of small stones, often about 3/8-inch to 2-inch, with 5% allowable passing a 3/8-inch sieve. Crushing is allowable, but not required. Color and hardness may also be a consideration in the specifications. Aggregate mulch often results in higher soil temperatures that are detrimental to the growth of planted vegetation.

6.54 Mats and Mulches: SOIL STABILIZERS

DESCRIPTION AND PURPOSE

Soil stabilizers normally consist of calcium solution and polyacrylamide (PAM). However, wide range of synthetic compounds is available to stabilize and protect the soil surface. These include emulsions or dispersions of vinyl and other compounds, mixed with water. They may be used alone or in conjunction with wood fiber hydromulches and tackifiers. Due to their being proprietary products, little is known of the content of these products. However, they must be toxic free and have available a "*material safety data sheet*."

CONDITION WHERE PRACTICE APPLIES

Soil stabilizers are designed to reduce the erodibility of bare soils during construction activities or to enhance the performance of mulching on permanent slopes. Soil stabilizers should have proven ability to reduce the movement of soil through chemical bonding. They increase the particle size, thus making silt fence more effective, and increase the water-absorption capability of the soil.

PLANNING CONSIDERATIONS

Only the anionic form of PAM may be used. Cationic PAM is toxic. PAM and PAM mixtures and additives should be environmentally compatible and harmless to fish, wildlife and plants. They should also be noncombustible. Detailed information on performance of additives should be provided by the manufacturer.

Anionic PAM, in pure form, should have no more than 0.05% acrylic monomer (cationic) by weight, as established by the Food and Drug Administration and the U.S. Environmental Protection Agency. To maintain the ≤0.05% acrylic monomer content, the application rate for PAM, in its pure form, on slopes and channels, should not exceed 200 lb per acre (224 kg/ha). In all cases, follow manufacturer recommendations.

When used alone, chemical stabilizers do not insulate the soil or retain moisture. Therefore, they do little to aid seedling establishment. They are easily damaged by traffic and lose their effectiveness more rapidly than organic mulches. They decompose with varying times, some within 60 to 90 days.

Check labels on chemical mulches and binders for environmental concerns. Take precautions to avoid damage to fish, wildlife and water resources.

CONSTRUCTION METHODS

1. Application of soil stabilizer is intended to be conducted with conventional hydraulic seeding equipment. Soil stabilizer may also be placed by dry spreading. When dry spreading is used, the contractor must ensure that the material is applied uniformly and remains in place during subsequent wind events. The manufacturer should provide detailed instructions on the

storage, mixing and application procedures to insure proper safety and effectiveness of the product.

2. Seeding must be done in a manner that ensures direct contact with the soil. When using soil stabilizer, seed must be sown separately the soil stabilizer is applied.

3. Application rates should be as recommended by the manufacturer.

4. When soil stabilizer is used on permanent slopes, an approved mulch should be applied as well to protect and facilitate germination of new seed.

6.55 Mats and Mulches: EROSION-CONTROL BLANKETS

DESCRIPTION

Erosion-control blankets are biodegradable, open-weave blankets used for establishing and reinforcing vegetation on slopes, ditch bottoms and shorelines. Several categories are provided with different service application and specific uses as follows:

Table 6.55-1

Category	Service Application	Use	Acceptable Types
1	Very Temporary	Flat areas, shoulder drain outlets, roadway shoulders, lawns, mowed areas.	Straw, wood fiber, rapidly degradable netting on one side
2	One Season	Slopes 1:3 and steeper less than 50 ft long, ditches with gradients 2% or less, flow velocities less than 5.0 fps.	Straw, wood fiber, netting on one side
3	One Season	Slopes 1 vertical:3 horizontal and steeper, more than 50 ft long, ditches with gradients 3% or less, flow velocities less than 6.5 fps.	Straw, wood fiber, netting on two sides
4	Semipermanent	Ditches with gradients 4% or less, flow velocities less than 8.0 fps, flow depth 6 inches or less.	Straw/coconut, wood fiber, netting on two sides
5	Semipermanent	Ditches with gradients 8% or less, flow velocities less than 15.0 fps and flow depth less than 8 inches, watercourse banks within the normal flow elevation.	Coconut fiber, netting on two sides

Physical Requirements

Fiber Material: Erosion-control blankets should consist of a uniform web of interlocking fibers with net backing. The blanket should be of uniform thickness, with the material fibers being evenly distributed over the area of the blanket. The blankets should be porous enough to promote plant growth yet shield the underlying soil surface from erosion. All material should have been properly cured to achieve curled and barbed fibers. All blankets should be smolder resistant.

Net Backing: The net backing on each blanket should consist of polypropylene mesh. For Category 1 blankets, the net backing should start to decompose after one month with 80% breakdown occurring within three months. For Category 2 and 3 blankets, the netting should contain sufficient UV stabilization for breakdown to occur within a normal growing season. For Category 4 and 5 blankets, the netting should be UV stabilized to provide a service life of two to three years.

For blankets designated as "netting on two sides," the fiber material should be sandwiched between a top and a bottom layer of net backing.

Stitching: The fiber material in each blanket should be securely attached to the net backing to prevent movement of the fiber. For blankets consisting of 3-inch material fibers, the blanket should be fastened together at a spacing not to exceed 2 inches. For blankets consisting of 6-inch material fibers, the blanket should be fastened together at a spacing not to exceed 4 inches.

Staples

The staples used to anchor Category 1 and 2 blankets should be U shaped, 11 gauge or heavier steel wire having a span width of 1 inch and a length of 6 inches or more from top to bottom after bending. Staples used to anchor Category 3 and 4 and 5 blankets should have a minimum length of 8 inches.

Table 6.55-2 Blanket and staple specifications

	Straw RD 1S	Straw 2S	Straw Coconut 2S	Coconut 2S	Wood Fiber RD 1S	Wood Fiber 1S	Wood Fiber 2S	Wood Fiber HV 2S
Min. weight per Square Yard	0.50 lb	0.50 lb	0.50 lb	0.50 lb	0.64 lb	0.64 lb	0.64 lb	1.20 lb
Fiber Length: 80% Must Be Greater Than	3"	3"	3"	6"	6"	6"	6"	6"
Material	100% Straw Cuttings	100% Straw Cuttings	70% Straw plus 30% Coconut Fibers	100% Coconut Fibers	100% Excelsior Fibers	100% Excelsior Fibers	100% Excelsior Fibers	100% Excelsior Fibers
Net Backing Service Life	1-3 Months	6-9 Months	6-9 Months	24-36 Months	1-3 Months	6-9 Months	6-9 Months	24-36 Months
Net Backing Type	Rapid Photodegradable Polypropylene	Polypropylene	Polypropylene	Black UV-stabilized Polypropylene	Rapid Photodegradable Polypropylene	Polypropylene	Polypropylene	Black UV-stabilized Polypropylene
Netting Opening, Min.	0.5" x 0.5"	0.5" x 0.5"	0.5" x 0.5"	0.6" x 0.6”	0.75" x 0.75"	0.75" x 0.75"	0.75" x 0.75"	0.75" x 0.75"
Netting Weight per 1,000 Yd^2 Min. Top	14.75 lb	14.75 lb	27.65 lb	27.65 lb	14.75 lb	14.75 lb	14.75 lb	27.65 lb
Netting Weight per 1,000 Yd^2 Min. Bottom	--	14.75 lb	14.75 lb	27.65 lb	--	--	14.75 lb	27.65 lb
Staple Length	6"	6"	8"	8"	6"	6"	8"	8"
Number of Staples per Square Yard	1.5	1.5	2		1.5	1.5	2	2
Staple Diameter	0.122"	0.122"	0.15"	0.15"	0.122"	0.122"	0.15"	0.15"
RD means rapidly degradable, 1S means netting on 1 side, 2S means netting on 2 sides, HV = High Velocity								

6.56 Mats and Mulches: TURF-REINFORCEMENT MATS

DEFINITION AND PURPOSE

Turf-reinforcement mats (TRMs) are synthetic, nondegradable mats that are usually buried to add stability to soils. They come in a wide range of designs and have been proven to be valuable on slopes and in channel-lining applications. TRMs are designed to be permanent and often are filled with soil and vegetated when installed.

Turf-reinforcement matting consisting of nondegrading, three-dimensional matrix materials should be used with expected velocities of 15 fps and shear stress of 8 lb/ft^2. Beyond these velocities and shears, vegetated structures such as articulated block, cable concrete and cribwalls, should be considered. A TRM may have a biodegradable component intermixed with the synthetic portion to aid plant establishment

Mats should be appropriate for the expected velocity and shear stress. Check the manufacturer' specifications. Required minimum thickness and area holding capacity of the TRM should be defined by the manufacturer.

SPECIFICATION

Once finish grade is established, the area should be seeded, the TRM installed and, if appropriate, immediately filled with topsoil. The finish surface is normally seeded and covered with an erosion-control blanket or hydraulically applied mulch to keep the soil from eroding and aid in germination of a permanent stand of vegetation. However, TRMs are installed in a variety of ways. Follow the manufacturer's recommendations for specific applications.

6.57 Mats and Mulches: ANCHORING DEVICES

Wire Staples

Wire staples should be U-shaped, No. 11 gauge or heavier wire. They should have a span of 1 inch and a length of 6 inches or more from top to bottom after they are bent. An 8-inch staple may be required with certain blanket and soil types (see part 6.55, Erosion-control Blankets).

Biodegradable Anchoring Devices

These devices are normally used in areas that will be mowed soon after vegetation is established. All materials should be environmentally safe, and should have no potential for soil and/or water contamination. Petroleum-based plastics or composites containing petroleum-based plastics should generally not be used. The anchoring devices should maintain their mechanical anchoring ability for at least two months and degrade within four months under warm soil conditions. The below-ground portion of the anchoring devices should be shaped, using barbs, twists, bends or other methods, to provide additional mechanical pull resistance when the devices are installed in the soil.

Installation

The installation pattern and spacing of anchoring devices should vary according to the specified product, slope, and soil type. As a minimum, anchor devices should be installed according to manufacturer's recommendation and increased based on site conditions.

6.60 MISCELLANEOUS MEASURES

6.61 Miscellaneous Measures: SAND, WIND FENCES

DEFINITION

A sand or wind fence is an artificial barrier of evenly spaced wooden slats or approved fabric erected perpendicular to the prevailing wind and supported by posts. Much research has been done recently on the use of vegetation to reduce snow drifting, and it would seem that some of this research would be applicable to sand blowing.

PURPOSE

Sand or wind fence are used to reduce wind velocity at the ground surface and trap blowing materials.

CONDITIONS WHERE PRACTICE APPLIES

Sand or wind fences are used across open, bare areas subject to frequent winds, where the trapping of blowing sand (or snow) is desired. Wind fences are used primarily to prevent sand from blowing off disturbed areas onto roads or adjacent property.

PLANNING CONSIDERATIONS

Soil movement by wind depends on the physical character and condition of the soil. Normally only dry soils are moved by wind. The structure of soil in an air-dry state is the index to its erodibility. Loose, fine-textured soils are the most readily blown.

Three types of soil movement operate simultaneously in the process of wind erosion:

- suspension — fine dust particles are carried and suspended in air,
- saltation — movement of particles in short bounces on the ground, and
- surface creep — movement of large particles on the ground by both direct wind and bombardment by smaller particles.

A sand fence catches and holds blowing sand in much the same way as a snow fence prevents snow drift. The fence consists of evenly spaced wooden slats. The spaces between the slats allow wind and sand to pass through the fence, but the wind velocity is reduced, causing sand deposition along the fence and between rows of fence (Figure 6.61-1).

Sand fences can trap large amounts of sand. Their effectiveness depends on the source of sand and the frequency and velocity of wind. Use sand fences at construction sites to prevent off-site damage to roads, streams and adjacent property. Generally, locate them perpendicular to the prevailing wind and as near to parallel as possible on the leeward side of the area to be protected. Sand or wind fences have been found to be effective up to 22.5 degrees from perpendicular to the wind.

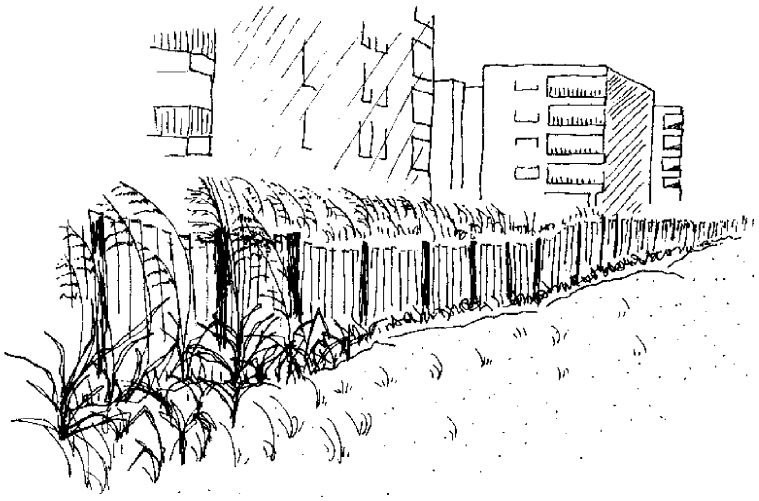


Figure 6.61-1 Sand fences trap blowing sand and debris. (Source: North Carolina, May 1994.)

DESIGN CRITERIA

No formal design criteria have been developed for sand or wind fences. Construction specifications below describe typical wind fence installation.

CONSTRUCTION SPECIFICATIONS

1. Normally, locate sand fences perpendicular to the direction of the prevailing wind. However, they may be as much as 22.5 degrees from perpendicular and still be very effective.

2. Commercial sand fences usually consist of wooden slats wired together with spaces between the slats. The distance between slats is approximately equal to the slat width (about 1.5 inches). Other materials can be used to capture sand, but they must be securely fastened in place and not spaced too far apart.

3. Erect sand fences in parallel rows 20 to 40 ft apart and 2 to 4 ft high. The number of rows installed depends on the degree of protection needed. When fences are approximately two-thirds full, erect another series of fences.

MAINTENANCE

Maintain sand fences and erect additional fences as needed until the eroding area has been permanently stabilized or, in the case of dune building, until the dune has reached the desired height and is properly vegetated.

6.62 Miscellaneous Measures: TOPSOIL APPLICATION

DEFINITION

Preserving and using topsoil to enhance final site stabilization with vegetation.

PURPOSE

Topsoil is applied to provide a suitable medium for vegetative growth.

CONDITIONS WHERE PRACTICE APPLIES

Topsoil may be applied to a site:

- where a sufficient supply of quality topsoil is available.
- where the subsoil or areas of existing surface soil present the following problems:
- the structure, pH, or nutrient balance of the available soil cannot be amended by reasonable means to provide an adequate growth medium for the desired vegetation.
- the soil is too shallow to provide adequate rooting depth or will not supply necessary moisture and nutrients for growth of desired vegetation.
- the soil contains substances toxic to the desired vegetation.
- where high-quality turf or ornamental plants are desired.
- where slopes are 2:1 or flatter.

PLANNING CONSIDERATIONS

Topsoil is the surface layer of the soil profile, generally characterized as darker than the 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 its texture as well as its color. Clay content usually increases in the subsoil. Where subsoils are often high in clay, the topsoil layer may be significantly coarser in texture. The depth of topsoil may be quite variable. On severely eroded sites, the topsoil may be gone entirely.

Advantages of topsoil include its high organic-matter content and friable consistency (soil aggregates can be crushed with only moderate pressure), and its available water-holding capacity and nutrient content. Most often topsoil is superior to subsoil in these characteristics. The texture and friability of topsoil are usually much more conducive to seedling emergence and root growth.

In addition to being a better growth medium, topsoil is often less erodible than subsoils, and the coarser texture of topsoil increases infiltration capacity and reduces runoff.

Although topsoil may provide an improved growth medium, there may be disadvantages, too. Stripping, stockpiling, hauling and spreading topsoil, or importing topsoil, may not be

cost-effective. Handling may be difficult if large amounts of branches or rocks are present, or if the terrain is too rough. Most topsoil contains the seeds of weeds, which compete with desirable species.

In site planning, compare the options of topsoiling with preparing a seedbed in the available subsoil. The clay portion of many subsoils retains moisture. When properly limed and fertilized, subsoils may provide a satisfactory growth medium, which is generally free of weed seeds.

If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly, and it will be difficult to establish vegetation.

Do not apply topsoil to slopes steeper than 2:1 to avoid slippage, nor to a subsoil of highly contrasting texture. Sandy topsoil over clay subsoil is a particularly poor combination especially on steep slopes. Water may creep along the junction between the soil layers and cause the topsoil to slough.

Do not apply topsoil to areas of existing trees. The additional soil depth reduces air infiltration into the root zone of trees. This causes stress to the tree and a decline in tree health. Since most spreading is done with machines, there is the additional factor of soil compaction. While its overall weight is less, the common skid steer loader has some of the highest ground pressures of all construction equipment.

Stripping

Strip topsoil only from those areas that will be disturbed by excavation, filling, road building or compaction by equipment. A 4- to 6-inch stripping depth is common, but depth varies depending on the site. Determine stripping depth by taking soil cores at several locations within each area that will be stripped. Topsoil depth generally varies along a gradient from hilltop to toe of the slope. Put sediment basins, diversions and other controls into place before stripping.

Stockpiling

Select stockpile location to avoid slopes and natural drainageways, avoiding traffic routes. On large sites, respreading is easier and more economical when topsoil is stockpiled in small piles located near areas where they will be used.

Sediment barriers: Use sediment fences or other barriers where necessary to retain sediment.

Temporary seeding: Protect topsoil stockpiles by temporarily seeding as soon as possible, no more than 30 working days or 120 calendar days after the formation of the stockpile (see practice 6.22, Temporary Seeding).

Permanent vegetation: If stockpiles will not be used within 12 months, they must be stabilized with permanent vegetation to control erosion and weed growth (see part 6.23, Permanent Seeding).

Site Preparation

Before spreading topsoil, establish erosion- and sedimentation-control practices, such as diversions, berms, dikes, waterways and sediment basins.
Maintain grades on the areas to be topsoiled according to the approved plan and do not alter them by adding topsoil.

Immediately before spreading the topsoil, loosen the subgrade by disking or scarifying to a depth of at least 4 inches, to ensure bonding of the topsoil and subsoil. If no amendments have been incorporated, loosen the soil to a depth of at least 6 inches before spreading the topsoil.

Spreading Topsoil

Uniformly distribute topsoil to a minimum compacted depth of 2 inches on 3:1 slopes and 4 inches on flatter slopes. To determine the volume of topsoil required for application to various depths, use Table 6.62-1. Do not spread topsoil while it is frozen or muddy or when the subgrade is wet or frozen. Correct any irregularities in the surface that result from topsoiling or other operations to prevent the formation of depressions or water pockets.

Compact the topsoil enough to ensure good contact with the underlying soil, but avoid excessive compaction, as it increases runoff and inhibits seed germination. Light packing with a roller is recommended where high-maintenance turf is to be established.

Table 6.62-1 Cubic yards of topsoil required for application to various depths

Depth (inches)	Per 1,000 Square Feet	Per Acre
1	3.1	134
2	6.2	268
3	9.3	403
4	12.4	536
5	15.5	670
6	18.6	804

On slopes and areas that will not be mowed, the surface may be left rough after topsoil is spread. A disk may be used to promote bonding at the interface between the topsoil and subsoil.

After topsoil application, follow procedures for seedbed preparation, taking care to avoid excessive mixing of topsoil into the subsoil.

6.63 Miscellaneous Measures: SURFACE ROUGHENING

DEFINITION

This practice involves the roughening of a bare soil surface with horizontal grooves running across the slope, by tracking, stair-stepping, or tracking with construction equipment.

PURPOSE

The soil surface is roughened on sites to aid the establishment of vegetative cover from seed, to reduce runoff velocity, to increase infiltration, to reduce erosion and to provide for sediment trapping.

CONDITIONS WHERE PRACTICE APPLIES

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include tracking (Figure 6.63-1), stair-step grading (Figure 6.63-2), or ripping and grooving (Figure 6.63-3a, b and c). Factors to be considered in choosing a method are slope steepness, mowing requirement and whether the slope is formed by cutting or filling.

PLANNING CONSIDERATIONS

All construction slopes require surface roughening but some may require subsurface mixing to prevent soil stratification and to facilitate stabilization with vegetation. Note that roughening equipment will be limited by the slopes on which it can work.

Rough slope surfaces are preferred because they aid the establishment of vegetation, improve water infiltration and decrease runoff velocity. Graded areas with smooth, hard surfaces may be attractive, but such surfaces increase the potential for erosion. A rough, loose soil surface gives a mulching effect that protects lime, fertilizer and seed. Nicks in the surface are cooler and provide more favorable moisture conditions than hard, smooth surfaces; this aids seed germination and establishment.

Limit roughening with tracked machinery to sandy soils to avoid undue compaction of the soil surface. Tracking is generally not as effective as the other roughening methods described in this manual.

Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back-blade during the final grading operation.

CONSTRUCTION SPECIFICATIONS

Cut Slope Roughening for Areas Not To Be Mowed

Stair-step grade or groove cut slopes with a gradient steeper than 3:1.

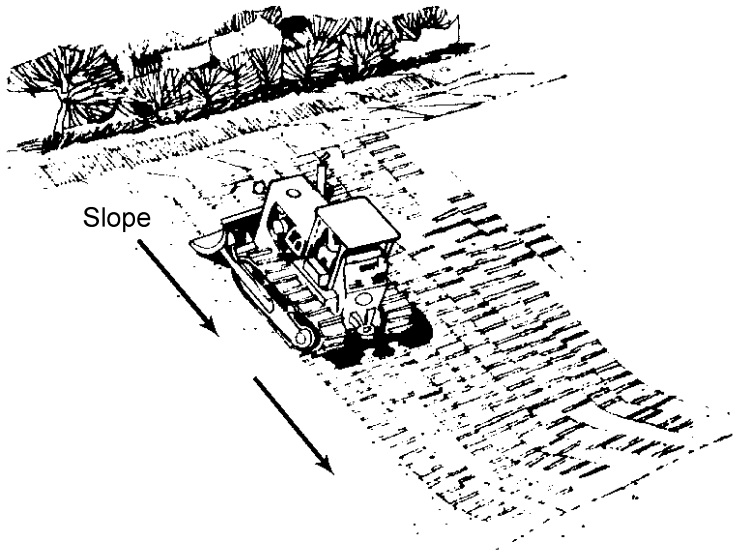


Figure 6.63-1 Bulldozer treads create grooves perpendicular to the slope. The slope should not be back-bladed during the final grading. (Source: Virginia Department of Conservation and Recreation, 1992.)

Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.

Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in toward the vertical wall.

Do not make vertical cuts more than 2 ft deep in soft materials or more than 3 ft deep in rocky materials.

Grooving uses machinery to create a series of ridges and depressions that run across the slope (on the contour).

Groove using any appropriate implement that can be safely operated on the slope, such as bulldozer ripper teeth, root rippers, chisel plows, disks, tillers, spring harrows, or the teeth on a front-end loader bucket. Do not make such grooves less than twice the thickness of the topsoil or more than 15 inches apart.

Place fill slopes with a gradient steeper than 3:1 in lifts not to exceed 9 inches, and make sure that each lift is properly compacted. Ensure that the face of the slope consists of loose, uncompacted topsoil 4 to 6 inches deep. Use grooving, as described above, to scarify the subsurface soil and to roughen the face of the slopes, if necessary.

Do not blade or scrape the final slope face.

Cuts, Fills and Graded Areas That Will Be Mowed

Make mowed slopes no steeper than 3:1.

Roughen these areas to create shallow grooves perpendicular to the slope by normal tilling, chisel-plowing or disking. Make the final pass on the contour.

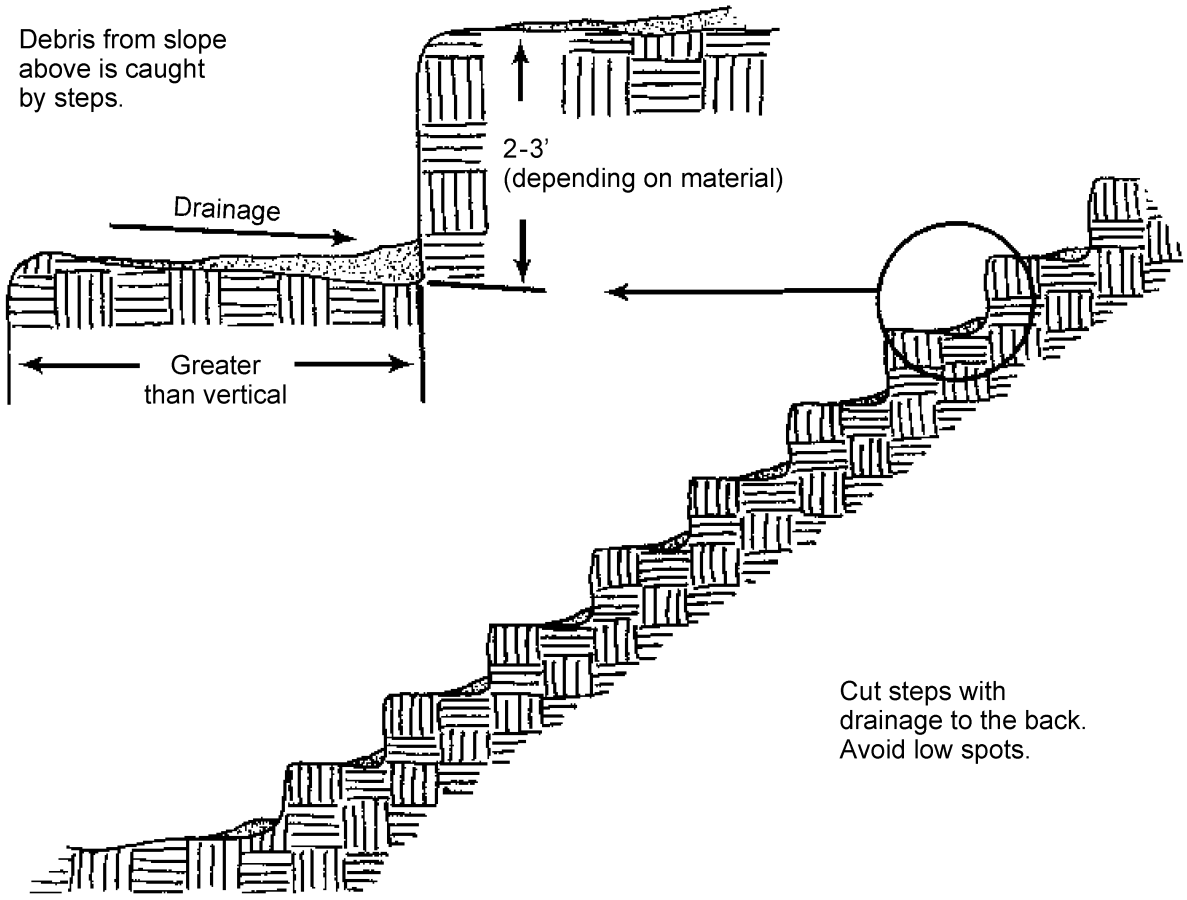


Figure 6.63-2 Stair-stepping-cut slopes (modified from Virginia Department of Conservation and Recreation, 1992)

Make grooves formed by implements close together (less than 10 inches) and not less than 1 inch deep.

Excessive roughness (clods larger than 6 inches, 3 inches for tractor mowing, 1 inch for roughening with tracked machinery) is undesirable where mowing is planned.

MAINTENANCE

Immediately seed and mulch roughened areas to obtain optimum seed germination and seedling growth. Establish good seed-to-soil contact.

Periodically check the seeded slopes for rills and washes. Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

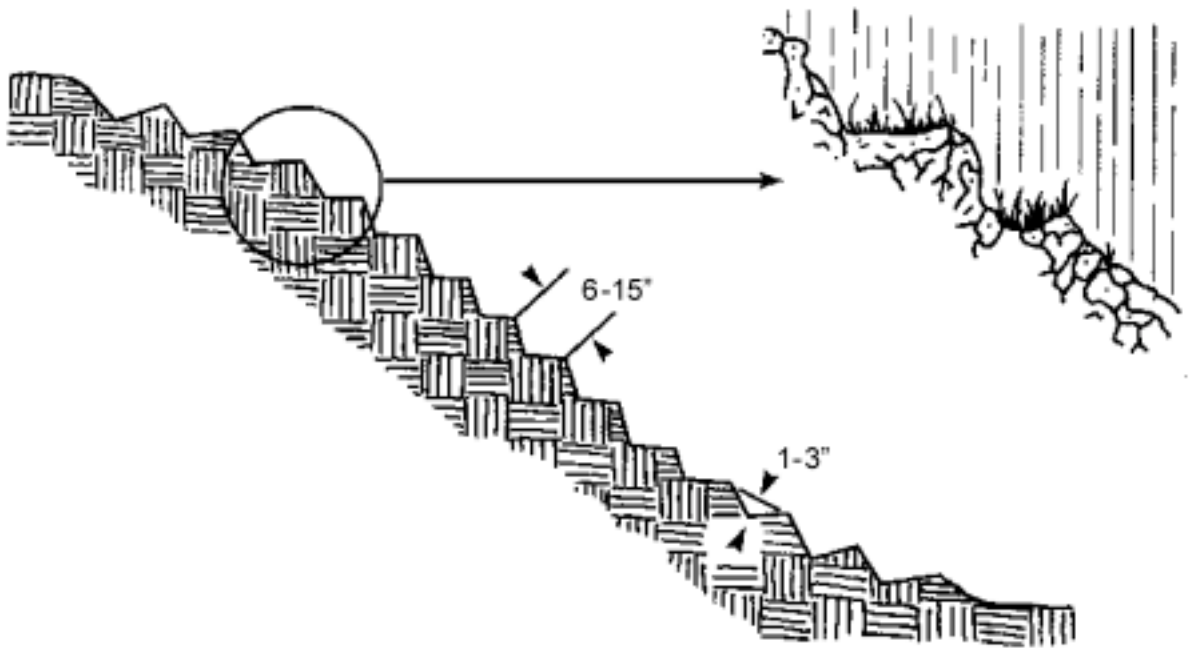


Figure 6.63-3a Groove by cutting furrows along the contour. Irregularities in the soil surface catch rainwater and retain lime, fertilizer and seed (modified from Virginia Department of Conservation and Recreation, 1992).

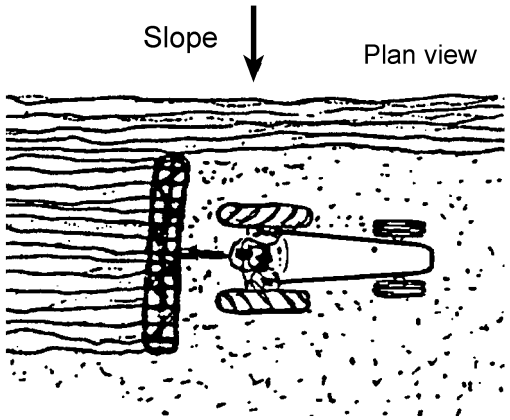


Figure 6.63-3b Roughen soil surfaces on slopes, leaving about 3-inch-high ridges for erosion resistance. Protect slopes of 3:1 or greater with mulch or erosion-control blankets.

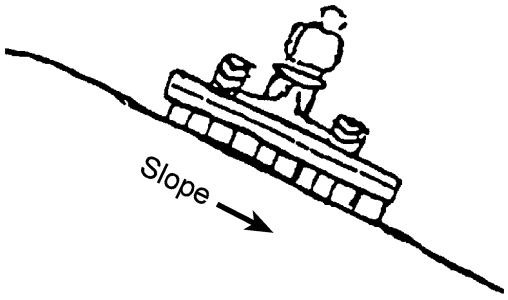


Figure 6.63-3c Operate equipment across the slope, or perpendicular to the direction of water flow, to prevent rill erosion. Immediately repair ruts.

6.64 Miscellaneous Measures: DUST CONTROL

DEFINITION AND PURPOSE

This practice involves controlling dust that results from land-disturbing activities.

Its purpose is to prevent surface and air movement of dust from disturbed soil surfaces that may cause off-site damage, health hazards and traffic problems.

CONDITIONS WHERE PRACTICE APPLIES

Use this practice on construction sites and other disturbed areas subject to surface dust movement and dust blowing where off-site damage may occur if dust is not controlled.

PLANNING CONSIDERATIONS

Construction activities that disturb soil can be a significant source of air pollution. Large quantities of dust can be generated, especially in "heavy" construction activities, such as grading for road construction and commercial, industrial or subdivision development.

In planning for dust control, it is important to schedule construction operations so that the smallest area is disturbed at one time.

Leave undisturbed buffer areas between graded areas wherever possible.

The greatest dust problems occur when the probability of rainfall erosion is least. Therefore, avoid exposing large areas of soil anytime, but for dust control especially during drought conditions.

Install temporary or permanent surface-stabilization measures immediately after completing land grading.

DESIGN CRITERIA

No formal design procedure is given for dust control. See Construction Specifications below for the most common dust-control methods.

CONSTRUCTION SPECIFICATIONS

Vegetative Cover: For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control (See section 6.20, Vegetative Stabilization.).

Mulch (Including Gravel Mulch): When properly applied, mulch offers a fast, effective means of controlling dust (See section 6.50.).

Spray-on Adhesive: Examples of spray-on adhesives for use on mineral soils (See part 6.52, Hydraulic Mulch and Tackifiers) (use manufacturer's specifications when applicable);

Table 6.64-1

Type of Adhesive	Water Dilution	Type of Nozzle	Application Rate (gallons/acre)
Anionic asphalt emulsion	7:1	Coarse spray	1,200
Latex emulsion	12.5:1	Fine spray	235
Resin in water	4:1	Fine spray	300

Calcium chloride may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high to cause water pollution or plant damage.

Sprinkling: The site may be sprinkled until the surface is wet. Sprinkling is especially effective for dust control on haul roads and other traffic routes. This method can be costly and must be performed during dry periods.

Stone used to stabilize construction roads can also be effective for dust control (see part 6.53, Landscape Mulches).

Barriers: A board fence, wind fence, sediment fence or similar barrier can control air currents and blowing soil. Place barriers perpendicular to prevailing air currents at intervals about 15 times the barrier height. Where dust is a known problem, preserve windbreak vegetation (see part 6.64, Dust Control).

Tillage: Deep plow large open disturbed areas and bring clods to the surface. This is a temporary emergency measure that can be used as soon as soil blowing starts. Begin plowing on the windward edge of the site (see also part 6.63, Surface Roughening).

MAINTENANCE

Maintain dust control measures through dry-weather periods until all disturbed areas have been stabilized.

For additional dust-control measures and discussion, part 7.25, Dust Control.

6.65 Miscellaneous Measures: HAZARDOUS WASTE DISPOSAL FOR CONTRACTORS

PURPOSE

This section is adapted from MPCA Hazardous Waste Fact Sheet #3.11, July 1997.

This fact sheet provides guidance for contractors to improve hazardous-waste management at job sites.

BACKGROUND

Contractors typically work at various remote client-owned sites. The purpose of this guidance is to improve the way construction remodeling and maintenance contractors manage hazardous waste generated at these sites.

We want to assist contractors to properly manage hazardous waste generated at job sites. This guidance does not affect whether a contractor needs a U.S. Environmental Protection Agency (USEPA) ID number or a license. Contractors may transport waste they generate at contract job sites back to their business location on their Minnesota hazardous waste license. The business will remain responsible for proper management and disposal of any consolidated hazardous waste. This guidance does not prevent the contractor from hiring a registered hazardous waste transporter to manage their hazardous waste.

See Table 6.65-1 for a list of types of contractor businesses to which this guidance applies.

Management Options

When contractors generate hazardous waste at job sites, it can be managed in one of the following ways:

- Contractors may leave hazardous wastes at job sites for proper management and disposal by the site owner.
- Contractors may transport hazardous wastes via a registered hazardous waste transporter directly to a disposal facility.
- Contractors may transport waste to a very-small-quantity generator (VSQG) collection site.
- Contractors may transport wastes to their main business location for proper storage or disposal.

Guidance Conditions

If an eligible contractor wants to transport the waste to a VSQG collection site or to their place of business, the contractor must meet the following conditions:

1. The contractor must have a valid Hazardous Waste Generator License for his or her business location. The contractor must obtain a license from the county if the business is located in Anoka, Carver, Dakota, Hennepin, Ramsey, Scott or Washington counties, or from the

MPCA if his or her business is located elsewhere in Minnesota (local zoning may control the ability to license residential business sites).

2. The contractor is the generator of the waste.

3. The waste is generated in Minnesota at a site that is not owned by the contractor.

4. The waste is generated as a result of construction, remodeling or maintenance.

5. The contractor must generate less than 2,640 lb annually at the remote job site (defined in VSQG standards Minn. R. 7045.0206, subp. 4.)

6. The waste must be stored and managed properly, as provided in Minnesota rules, both at the job site and at the contractor's business location.

7. The amount of hazardous waste transported in any load may not exceed 1,000 lb.

8. The contractor must remove any hazardous waste from the job site and deliver it to the main business location or a licensed collection site within five days of completing work, or within 24 hours of loading the waste onto the contractor's vehicle.

9. The waste must be transported in a vehicle owned and operated by the contracting business and in accordance with Minnesota Department of Transportation (MnDOT) hazardous material shipping requirements.

10. Manifesting is not required for the contractor to transport waste from the remote job site to the main business location.

11. The contractor must transport hazardous waste generated at a remote job site directly to his or her main location or to a licensed VSQG collection site.

12. Once the waste reaches the contractor's licensed business location, the business must manage the waste in accordance with applicable hazardous waste rules.

Table 6.65-1: Standard industrial codes (SICs) for contractor waste

SIC	Description of Industry Type
1521	General - Contractors-Single-Family Homes
1522	General - Contractors-Residential Buildings
1531	Operative Builders
1541	General Contractors-Industrial Buildings
1542	General Contractors-Nonresidential, other than 1541
1611	Highway & Street Construction
1622	Bridge, Tunnel, Elevated Highway Construction
1623	Water, Sewer, Pipeline, Communications, Power Construction
1629	Heavy Construction
1711	Plumbing, Heating & Air-Conditioning
1721	Painting & Paper Hanging
1731	Electrical Work
1741	Masonry, Stone Setting, Stone Work
1742	Plastering, Drywall, Acoustical Insulation Work
1743	Terrazzo, Tile, Marble, & Mosaic Work
1751	Carpentry Work
1752	Floor Laying & Floor Work
1761	Roofing, Siding & Sheet Metal Work
1771	Concrete Work
1781	Water Well Drilling
1791	Structural Steel Erection
1793	Glass & Glazing Work
1794	Excavation Work
1795	Wrecking & Demolition Work
1796	Installation or Erection of Building Equipment
1799	Special Trade Contractors
2951	Asphalt Paving Mixtures and Blocks