



PROTECTING WATER QUALITY

A field guide to erosion, sediment and stormwater best management practices for development sites in Missouri and Kansas.

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PREFACE

Purpose

The purpose of this field guide is to provide developers, contractors, site managers and inspectors with a guide to the installation and maintenance of construction site erosion, sediment and stormwater control practices in Kansas and Missouri. Proper installation and maintenance of these structural and biological practices will protect our valuable water resources from harmful pollutants.

This guide can also be a useful reference document for engineers, planners, public officials and others involved in land disturbance activities, although it is not intended as a design manual. For detailed design guidance, please refer to the numerous references and manuals listed in [Appendix C](#) and [Appendix D](#). For further reference, see *Missouri Guide to Green Infrastructure: Integrating Water Quality into Municipal Stormwater Management 2011*. This guide also provides a summary of state-of-the-practice stormwater control measures for long-term runoff management.

Disclaimer

This guide is not intended to be a manual for designing plans and specifications, but a source of information about erosion, sediment and stormwater control best management practices. The contents should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations. Refer to state, federal and local regulations and permits for applicable design criteria. Permission has been granted for all copyrighted photos and sketches as applicable.

This is not a complete list of urban-applicable practices. For more complete information, refer to references cited throughout this guide in [Appendix C](#) and [Appendix D](#)). You may also contact your nearest Missouri Department of Natural Resources' Regional Office at www.dnr.mo.gov/regions/regions.htm or visit the Department's stormwater clearinghouse at www.dnr.mo.gov/env/wpp/stormwater.

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CHAPTER 1

PURPOSE AND SCOPE OF THIS GUIDE

Stormwater management is essential to ensuring a clean urban environment, but is just as important to building a vital community. Achieving both of these goals require a coordinated strategy. This guide provides developers, contractors, planners, local government officials and the general public information to assist them with harmonizing these community efforts.

This guide begins with a discussion on the causes and effects of stormwater impacts on community life. Persons involved with managing stormwater should understand the basics of water movement and its capacity to transmit harmful pollutants and cause physical damage. After introducing these fundamentals, the guide presents the many different options and techniques for controlling stormwater. The guide is designed to help the reader obtain the knowledge necessary to develop an effective and cost efficient strategy to manage stormwater within their unique community.

The Importance of Community Stormwater Management

High density human activities, particularly urbanization without proper design can alter water drainage patterns and add pollutants to our rivers, lakes and streams. Recent studies by the U.S. Environmental Protection Agency, or EPA, state water pollution control agencies and universities show stormwater runoff as a major source of urban water pollution. Polluted water runoff endangers humans by polluting the water sources being used for drinking, household purposes, recreation and fishing.

Soil sediment leaving the site of construction activity is a large contributor to water pollution. This sediment not only carries soil particles (the major pollutant), but can also carry attached pollutants such as petroleum products, metals, chemicals, pesticides, organic products and bacteria.

Sediment loading rates from construction sites are typically 10 to 20 times greater than pre-construction rates (North Carolina DEHNR, 1993). Over a short period of time, construction sites can contribute more sediment to receiving streams than was previously deposited over several decades.

There are three main reasons why construction activities increase pollutant loads in runoff. First, the volume and rate of runoff are typically increased, providing a larger capacity to transport pollutants to rivers and lakes. This is why it is critical that best site designs and post-construction practices are well understood and considered before the project is even designed and constructed. See [Missouri Guide to Green Infrastructure: Integrating Water Quality into Municipal Stormwater Management 2011](#). Second, the vegetation is removed leaving bare soil that is much more vulnerable to erosion, resulting in sediment moving into receiving waters. The third reason is some pollutants (e.g., petroleum products, chemicals from construction materials, metals, debris), are added to the site

during construction (*After the Storm*, EPA Fact Sheet 833-B-03-002, January 2003). These pollutants can attach to the soil particles or remain suspended in the stormwater runoff and move directly off-site to the stream.

The Evolution of Best Management Practices

The industry of erosion and sediment control is very young especially when looking at urban and construction activity controls. Urban erosion and sediment control has been regulated since the early 1970s, and in most places, since the 1990. In the beginning, the four most often used devices were the straw bale, rock construction exit, sediment basin and silt fence. Straw bales are no longer recognized by EPA, and many local ordinances do not allow their use. This guide will cover straw bale use for very small areas of sheet flow only. The rock construction exit will be covered but has been found to have little effect for reducing track out, and it requires very high maintenance.

This guide will look at alternatives and controls to add to the rock exit to make it more effective. Significantly different is the added emphasis to erosion control as the first step in reducing sediment runoff. The sediment (silt) fence will still be covered but should be limited to small areas of overland sheet flow. There are many alternatives to sediment fence that are more effective, are easier to install and maintain and that limit the amount of ponding behind them.

This guide will likely not be updated as fast as new and improved devices are added to this industry. The thing to remember is to explore new and different control devices to find the ones that work best for the situation at the site. It is important to change out devices found to be less effective at controlling the discharge of sediment and other pollutants from the construction site.

This guide also will cover the Stormwater Pollution Prevention Plan, or SWPPP, which will explain the use of different devices and control measures that are a moving target during the construction project. The plan to control pollutants in stormwater runoff from the construction site is ever evolving and changing as the site conditions change. Changing and moving the control devices to fit the conditions of the site is a requirement of your land disturbance permit.

This guide will provide developers, contractors, planners, local government officials and the general public with the latest information on erosion. Sediment and stormwater control practices. Using practices that are state-of-the practice will achieve the greatest balance between providing environmental protection and achieving development goals at construction sites.

Development plans and designs that integrate well with the surrounding environment and embrace the existing community infrastructure will more often avoid the delays and cost associated with having to reevaluate and reconstruct these practices at a later date. Consequently, the installation of proper practices within the context of the environmental site design will support community growth, while “dated” practices may become a hindrance.

Current Legislation

As a result of evolving knowledge and skill for controlling stormwater, there will continue to be a changing mix of regulatory requirements in obtaining the necessary environmental permits. Success in implementing a community stormwater management program requires certain permitting processes be understood and integrated into the overall planning efforts. Erosion, sedimentation and stormwater runoff control is governed by federal, state and

local regulations. State permit coverage is required for all land-disturbing construction activities that disturb one or more acres over the life of the project or that are part of a larger common plan of development or sale that will disturb one or more acres over the life of the project. This includes projects less than one acre that are part of a larger common plan of development or sale. In addition to federal and state regulations governing land disturbance activities, more than 150 municipalities in Missouri are also required to regulate construction activities. Also, some non-regulated municipalities choose to enforce erosion and sediment control. In many cases, it may be necessary to obtain a permit from both the state and the municipality. The statutes currently in force are:

Federal

The federal Clean Water Act of 1972 and additions in 1987 established certain water pollution control regulations and permit requirements. Section 402 within the Clean Water Act titled National Pollutant Discharge Elimination System, or NPDES, provides for permit coverage to be obtained for the discharge of stormwater by industrial activities. In 1992, the NPDES program was modified to include land disturbance through construction as an industrial activity to regulate the discharge of sediments and other pollutants during construction. EPA administers the NPDES permit program but authorization can be granted to the state level (most states have permitting authority.) The Missouri Department of Natural Resources has delegated authority to regulate the NPDES permit program in Missouri and the Kansas Department of Health and Environment, or KDHE, has delegated authority to regulate the NPDES permit program in Kansas. EPA typically acts more as an auditor for the state programs, but retains the authority to directly enforce the regulations of construction sites.

The U.S. Army Corps of Engineers governs the placing of dredge or fill material in waterbodies and development or removal of wetland areas. This falls under Section 404 of the Clean Water Act. Other Clean Water Act permits are available on the Missouri Department of Natural Resources' website at www.dnr.mo.gov/env/wpp/stormwater/sw-other-site-permits.htm which includes the following information.

General Information

Missouri Department of Natural Resources

- Dam Safety Permits (www.dnr.mo.gov/env/wrc/damsft/pubs_av.htm#forms) from the Department's Water Resources Center may be required for dam construction activities, especially if the dam is 35 feet or greater in height or the water is listed on Missouri's Impaired Waters List (www.dnr.mo.gov/env/wpp/waterquality/303d/index.html). Contact the Water Resources Center prior to building a dam. See general Dam and Reservoir Safety Program information at www.dnr.mo.gov/env/wrc/damsft/damsfthp.htm.
- Sand and Gravel Mining Permits (www.dnr.mo.gov/env/lrp/homesg.htm) may be required from the Department for commercial removal of in-stream sand and gravel. Contact the Department's Land Reclamation Program for permit applications and instructions. Call 573-751-4041 or 800-361-4827 and ask for the Industrial Minerals Unit.
- 401 Certification (www.dnr.mo.gov/env/wpp/401/index.html) from the state department per Section 401 of the Clean Water Act is required when placing material, or fill, into the jurisdictional waters of the U.S. Examples are culverts under road crossings, riprap along stream banks and stormwater outfall pipes. The term jurisdictional waters here refer to large lakes, rivers, streams and wetlands, including those that don't always contain water. The permitting and certification process is shared between the Department, under Section 401, and the U.S. Army Corps of Engineers, under Section 404.

U.S. Army Corps of Engineers

- A 404 permit (<http://apps.ecy.wa.gov/permithandbook/permitdetail.asp?id=37>) from the Corps is required per Section 404 of the Clean Water Act for the discharge of dredged or fill material in all waters of the United States, including rivers, streams, lakes and wetlands. This includes work such as site development fills, causeways or road fills, dams and dikes, artificial islands, bank stabilization (riprap, seawalls and breakwaters) levees, landfills, fish attractors, mechanized clearing of wetlands and certain types of excavation activities, etc.
- Map of Missouri's five Corps districts and their program service areas (www.dnr.mo.gov/env/wpp/401/corps-map3.gif).
- Kansas City District map of counties and general program information (www.nwk.usace.army.mil/regulatory/boundary.htm).
- Rock Island District Mississippi Valley Division (Northeast corner of Missouri) (www.mvr.usace.army.mil/).
- Memphis District Mississippi Valley Division (Southeast bootheel corner of Missouri) (www.mvm.usace.army.mil/).
- St. Louis District list of counties (www.mvs.usace.army.mil/permits/permtcou.htm) and general program information (www.mvs.usace.army.mil/permits/TOCStL.htm).
- Little Rock District boundary map (Southern Missouri) (www.swl.usace.army.mil/regulatory/images/districtlettersize.pdf) and general program information (www.swl.usace.army.mil/regulatory/index.html).
- The Corps may also require a permit for any work or structures in, under or over any navigable Waters of the United States per Section 10 of the Rivers and Harbors Appropriations Act of 1899 (www.epa.gov/owow/wetlands/regs/sect10.html). This includes such items as boat docks, boat ramps, powerlines, excavation, filling, etc. This is more likely to be applicable in projects adjacent to the Lake of the Ozarks, the Osage River below Bagnell Dam and the Missouri, Mississippi and Gasconade rivers.

State

The Missouri Department of Natural Resources, the Kansas Department of Health and Environment and most other states regulate the quality of stormwater runoff by requiring permit coverage under the NPDES program - whenever there is land disturbance due to construction subject to regulations. In Missouri, the NPDES program is regulated through the Missouri Clean Water Law (10 CSR 20-6.200). The general land disturbance permit addresses the reduction or elimination of pollution in stormwater and certain non-stormwater discharges from:

- Construction sites that will disturb one acre or greater.
- Construction activities that are part of a larger common plan of development or sale that will disturb one acre or more over the life of the project.

Local Government

You may also need to obtain a permit or similar approval from the municipality where your construction project is located. Visit the Missouri Department of Natural Resources' Stormwater Clearinghouse website at www.dnr.mo.gov/env/wpp/stormwater/sw-phaseII-communities.pdf for a list of municipal separate storm sewer systems, or MS4s, required to implement a construction program. Note also that several unregulated MS4s choose to regulate erosion and sediment control.

Local Municipal Separate Storm Sewer System Programs

The NPDS permit program also requires certain entities that manage municipal separate storm sewer systems, or MS4s, to have a land disturbance ordinance and permit program. If your construction project falls within any of these local programs, you will also need to understand and abide by the local ordinance and permit program. You may also need to obtain permit coverage or similar approval for the municipality where your construction project is located. Visit the Missouri Department of Natural Resources' Stormwater Clearinghouse website at www.dnr.mo.gov/env/wpp/stormwater/sw-phaseII-communities.pdf for a list of municipal separate storm sewer systems required to implement a construction program.

Missouri's Phase I & Phase II Stormwater Communities *Revised March 29, 2010*

Arnold	Dardenne Prairie	Ladue	Riverview, Village of
Ballwin	Dellwood	Lake Lotawana	Rock Hill
Battlefield	Des Peres	Lake St. Louis	Rolla
Bellefontaine Neighbors	Duquesne	Lakeshire	Sedalia
Bel-Nor, Village Of	Ellisville	Lebanon	Shrewsbury
Bel-Ridge, Village Of	Excelsior Springs	Lee's Summit	Sikeston
Belton	Farmington	Liberty	Springfield*
Berkeley	Fenton	Manchester	St Charles
Black Jack	Ferguson	Marlborough, Village of	St. Ann
Blue Springs	Festus	Marshall	St. Charles County
Boone County	Florissant	Maryland Heights	St. George
Breckenridge Hills	Fort Leonard Wood	Maryville	St. John
Brentwood	Frontenac	Mexico	St. Joseph
Bridgeton	Fulton	MoDOT	St. Louis (MSD)
Buchanan County	Gladstone	Moberly	St. Louis County
Byrnes Mill	Glendale	Moline Acres	St. Martins
Callaway County	Grain Valley	Neosho	St. Peters
Calverton Park, Village of	Grandview	Newton County	Sugar Creek
Cape Girardeau	Green Park	Nixa	Sunset Hills
Carl Junction	Greene County	Normandy	Town And Country
Carterville	Greenwood	North Kansas City	U.S. Medical Center for Federal Prisoners
Carthage	Hanley Hills, Village of	Northwoods	
Cass County	Hannibal	Norwood Court, Town of	University of Missouri-Col
Charlack	Hazelwood	Oakland	Valley Park
Chesterfield	Herculaneum	O'Fallon	Vinita Park
Christian County	Holts Summit	Olivette	Warrensburg
Clarkson Valley	Independence*	Overland	Warson Woods
Clay County	Jackson, City of	Ozark	Washington
Claycomo, Village of	Jackson County (Salem E)	Pagedale	Weatherby Lake
Clayton	Jasper County	Parkville	Webb City
Cole County	Jefferson City	Pevely	Webster Groves
Columbia	Jefferson County	Platte County	Weldon Spring
Cool Valley	Jennings	Pleasant Valley	Wentzville
Cottleville	Joplin	Poplar Bluff	West Plains
Country Club, Village of	Kansas City*	Raymore	Wildwood
Crestwood	Kennett	Raytown	Winchester
Creve Coeur	Kirksville	Richmond Heights	Woodson Terrace
Crystal City	Kirkwood	Riverside	

*Three of these communities came in under Phase I. Communities may be added to or removed from this list after further review. This list is also subject to change upon completion of the 2010 U.S. Census.

Missouri Permit Requirements

Land Disturbance General Permit Requirements

Site owners or operators disturbing land due to construction activity within Missouri generally need to apply for permit coverage, to be issued under one of the following three general Missouri State Operating Permits. In some circumstances, the Missouri Department of Natural Resources may require you to submit an application for a site-specific permit.

All general permits listed below are available on the department's website at

www.dnr.mo.gov/env/wpp/stormwater/sw-land-disturb-permits.htm.

1. MO-R10A-Z - General construction or land disturbance activities.
2. MO-R100 - Construction or land disturbance activity performed by or under contract to a city, county or other governmental jurisdiction.
3. MO-R109 – Construction or land disturbance near valuable resource waters.

Valuable resource waters are stormwater discharges within 1,000 stream feet of:

- Streams identified as a losing stream.
- Reservoirs or lake used primarily as a public drinking water supply.
- Streams or lakes listed as an outstanding national or state resource waters, such as cold water trout streams.
- Streams, lakes or reservoirs identified as critical habitat for endangered species.
- Streams, lakes, or reservoirs listed as impaired for sediment or an unknown pollutant by standard Missouri Department of Natural Resources methodology.

Also included as valuable resource waters are stormwater discharges:

- Within 100 stream feet of a permanent stream (Class P) or major reservoir (Class L2).
- Within two stream miles upstream of biocriteria reference locations.
- Where any of the disturbed area is defined as a wetland (Class W), by 10 CSR 20-7.031(1)(F)7.
- The stormwater discharges to a sinkhole or other direct conduit to groundwater.

Other permits or authorizations may be necessary for your construction project.

For more information visit www.dnr.mo.gov/env/wpp/stormwater/sw-other-site-permits.htm.

Permit Coverage Application Forms and Fees:

To obtain permit coverage from the State of Missouri for land disturbing activities visit www.dnr.mo.gov/env/wpp/stormwater/sw-land-disturb-permits.htm.

To obtain land disturbance permit coverage for construction projects complete, sign and submit *Form E - Application for General Permit*, Form--MO 780-0795 and *Form G - Application for Stormwater Permit Under the General Permit: Land Disturbance*, Form--MO 780-1408. If the land disturbing activity is between one and five acres, use *Form O - Application for Land Disturbance Less than 5 Acres*, Form--MO 780-1829 instead of Form G. These forms must be signed by persons according to the requirements in the regulations.

The permit coverage fee is \$300 and must be included with the forms and submitted to your local Missouri Department of Natural Resources office.

Missouri Department of Natural Resources Central and Regional Offices

Central Office
 PO Box 176
 Jefferson City, MO 65102-0176
 573-751-3443

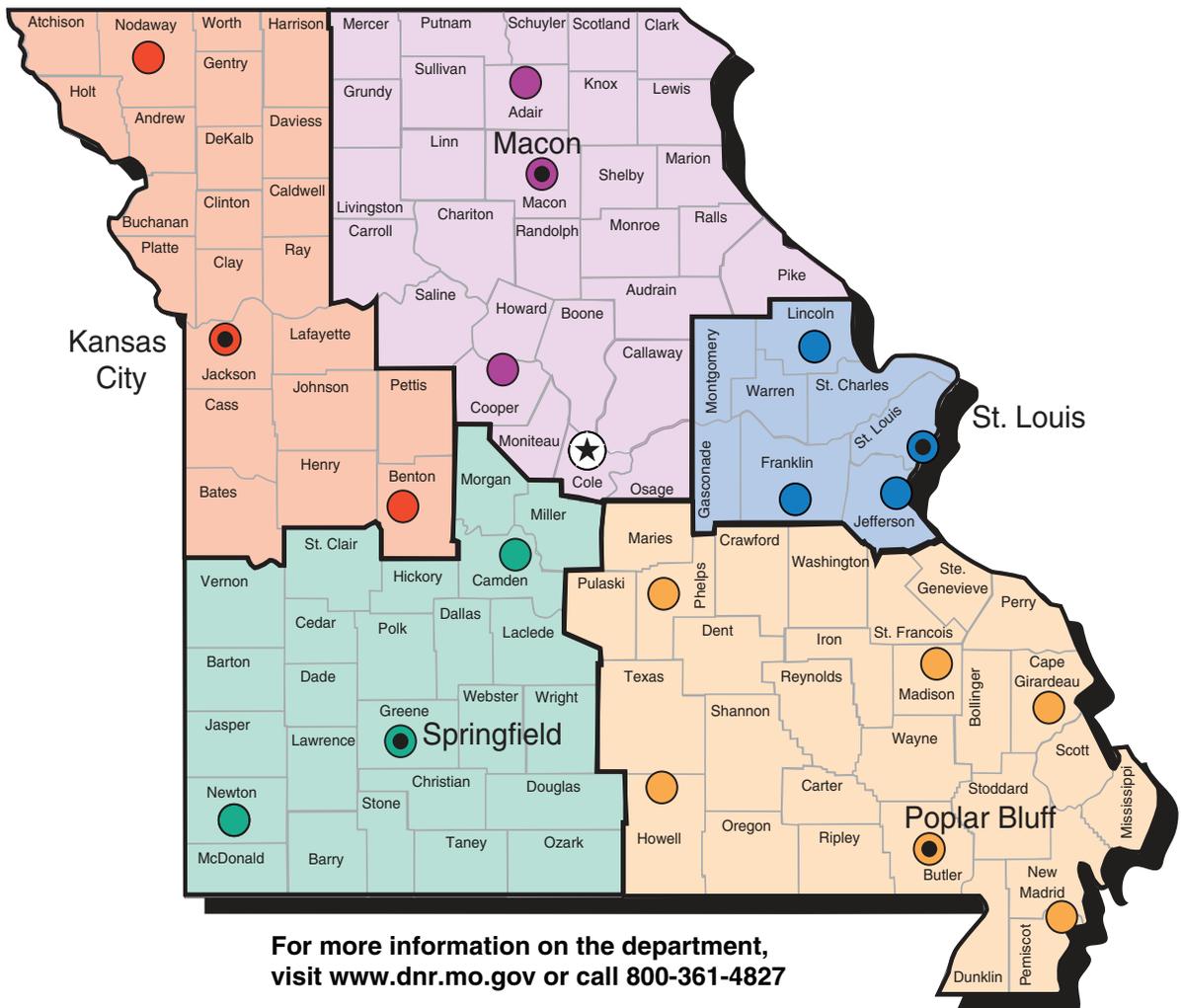
Southeast Regional Office
 2155 North Westwood Blvd.
 Poplar Bluff, MO 63901
 573-840-9750

Kansas City Regional Office
 500 NE Colburn Road
 Lee's Summit, MO 64086-4710
 816-622-7000

St. Louis Regional Office
 7545 S. Lindbergh, Suite 210
 St. Louis, MO 63125
 314-416-2960

Northeast Regional Office
 1709 Prospect Drive
 Macon, MO 63552-2602
 660-385-8000

Southwest Regional Office
 2040 W. Woodland
 Springfield, MO 65807-5912
 417-891-4300



**For more information on the department,
 visit www.dnr.mo.gov or call 800-361-4827**

In addition to filling out and submitting these forms for permit coverage, a SWPPP must be prepared specific to the project for which permit coverage is needed. Guidance for preparation for this plan is available under the heading SWPPPs, in this handbook. A good source of information about SWPPP preparation is available on EPA's website at cfpub.epa.gov/npdes/stormwater/swppp.cfm.

The general permit also requires the permittee to perform regularly scheduled inspections of the SWPPP and all best management practices on the construction site to make sure they are functioning and maintained properly to reduce or eliminate sediment and other pollutants from leaving the construction site and entering a waterway. Additional information on inspections is available in the [Inspection for Erosion, Sediment and Stormwater Control](#) section of this handbook.

If the permittee sells less than one acre of a permitted site to an entity for commercial, industrial, or residential use (unless sold to an individual for the purpose of building his or her own private residence) that is part of a common plan or sale, this land remains a part of the common sale and regulated by this permit. Therefore, the permittee is still responsible for erosion control on the sold property until termination of the permit.

After the construction project or land disturbing activity is complete and the site is stabilized to meet the requirements within the regulations, permit coverage can be terminated. To do so complete, sign and submit Missouri Department of Natural Resources' [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409. A Missouri State Operating Permit expires within five years from its effective date. If the active construction project will not be completed by the permit expiration date, it will be necessary to re-apply for coverage within 180 days of permit expiration.

Kansas Permit Requirements

For information about requirements for Construction Activity permit coverage in Kansas visit their website at www.kdheks.gov/stormwater/index.html#construct or contact:

Kansas Department of Health and Environment
Bureau of Water
Building 283, Forbes Field
Topeka, KS 66620
913-296-5557

Training and Certification Information

The Missouri land disturbance permits require that persons designated for environmental responsibility and inspections have a thorough and demonstrable knowledge of the site's SWPPP and erosion and sediment control practices in general. Although currently there are no certification requirements in Missouri for specific education or background for those persons preparing the SWPPP or conducting the site inspections, it is in the permittees' best interest to ensure all permit requirements are being met. This includes proper SWPPP preparation and inspections of controls to ensure the site is in compliance at all times. There are numerous training and certification opportunities available in the field of erosion and sediment control and stormwater pollution prevention plan preparation.

The International Erosion Control Association provides educational opportunities through their annual conferences and live and online instruction programs. Nationwide certification programs are available through [EnviroCert International](#), [National Institute for Certification in Engineering Technologies](#) and [CISEC Inc](#). Additional information about these programs are available on the Missouri Department of Natural Resources website at www.dnr.mo.gov/env/wpp/stormwater/sw-land-disturb-permits.htm.

CHAPTER 2

CAUSES AND EFFECTS OF EROSION AND SEDIMENTATION, HYDROLOGIC CHANGES AND POLLUTION TRANSPORT

The major problem associated with erosion on a construction site is the movement of soil off the site and its consequent pollution of receiving rivers, streams and lakes. In Missouri, 70 to 90 percent of the eroded soil (sediment – see [Glossary](#)) that reaches any type of channel is transported to the state’s water resources.

Types of Soil Erosion

Soil erosion is a natural process that wears away the earth’s surface. Soil particles are detached (eroded), transported (as sediment) and deposited (sedimentation) by wind, water, ice or gravity. On a construction site, the erosion process is accelerated because the soil is left bare and unprotected by vegetation. Water and wind erosion will be described in detail below.

Water Erosion

There are five types of water erosion (shown in Figure 2.1) described below and ranked from least severe to most severe. Splash and sheet erosion can best be prevented by protecting the land surface with vegetation, mulch or erosion control blankets. Sheet, rill and gully erosion can be controlled by keeping runoff velocities slow.

Splash: Splash erosion results from the direct impact of falling drops of rain on soil particles. This impact breaks the bonds between the particles, dislodges them and splashes them into the air. The dislodged soil particles can then be easily transported by the flow of surface water runoff.

Sheet: Sheet erosion is the removal of a thin layer of exposed surface soil by the action of raindrop splash and runoff. The water moves in broad sheets over the land, picks up these particles and carries them along as it flows downhill.

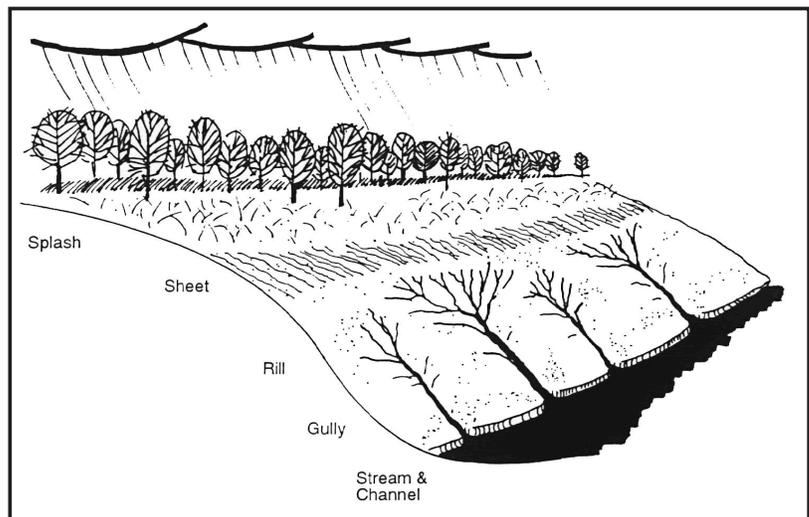


Figure 2.1 The Five Types of Soil Erosion on an Exposed Slope Source: North Carolina DEHNR, 1993

Rill: As the runoff moves down a slope, it cuts small paths or rills. In rill erosion, water flowing through these paths detaches more soil from their sides and bottoms.

Gully: Further down the slope, water tends to concentrate in channels and pick up speed. In gully erosion, soil is removed rapidly by water gushing over the headcut or uphill end of the gully, by concentrated flow scouring the sides and bottom of the gully and by water removing soils that have slumped from the sidewalls of the gully. A nearly vertical headcut allows water falling over the surface to undermine the bank so the gully moves upslope. Large earthmoving equipment is required to reshape or control gullies.

Stream and Channel: Increases in the volume, velocity and time of runoff may cause erosion of the receiving stream or channel banks and bottom.

Wind Erosion

Wind erosion is a serious environmental problem. Suspension, saltation and surface creep are the three types of soil movement that occur during wind erosion (See Figure 2.2).

Suspension: Occurs when very fine dirt and dust particles are lifted into the wind. The particles can be thrown into the air through impact with other particles or by the wind itself. Once in the atmosphere, these particles can be carried very high and be transported over extremely long distances.

Saltation: Fine particles are lifted into the air by the wind and drift horizontally across the surface increasing in velocity as they go. They travel approximately four times longer in distance than in height and when they strike the surface again they either rebound back into the air or knock other particles into the air. This is the major form of soil movement due to wind.

Creep: The large particles that are too heavy to be lifted into the air are moved through a process called surface creep. The particles are rolled across the surface after coming in contact with the soil particles in saltation.

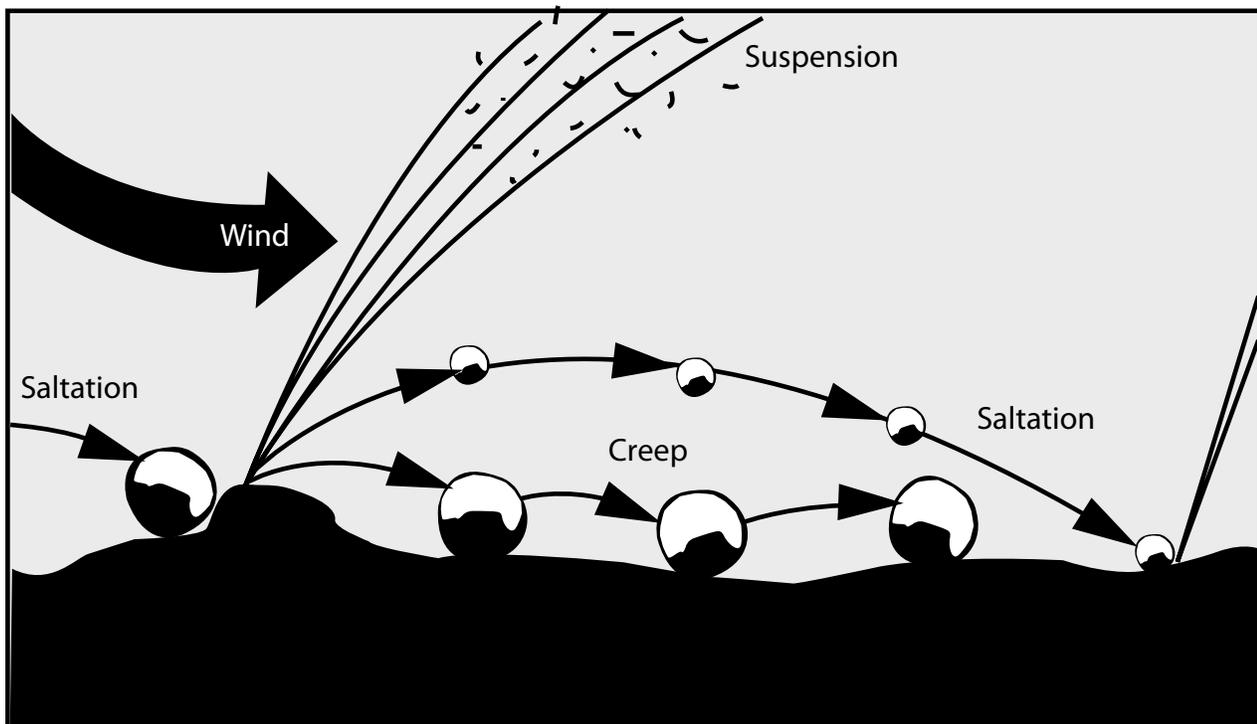


Figure 2.2 Types of Wind Erosion Source: Wind Erosion Research Unit

Factors That Influence Water and Wind Erosion

The potential for a land area to erode is determined by several key factors: climate, rainfall, soil erodibility and the length and steepness of the slope. These factors are interrelated in their effect on the potential for erosion. The variability in terrain and soils makes erosion control unique to each development site.

A site specific soils analysis and the assistance of a registered design professional (see [Glossary](#)) can aid in the development of an effective erosion, sediment and stormwater control plan.

Basic Principles of Erosion Control

Keeping soil in place when possible is the first step to erosion control. If the soil must be exposed to stormwater and wind, then it must be contained on the construction site through sediment control measures. Remember erosion controls are preventative and sediment controls are corrective.

The contractor can control erosion and sedimentation most effectively by leaving vegetation intact as long as possible, avoiding removal of streamside vegetation, leaving wetlands in place and phasing in land disturbance to minimize the amount of soil exposed at any one time. Secondly, they can protect whatever soil is exposed from the erosive force of rain, surface water runoff and, in some cases, wind. Eroded soil must be captured and retained on the construction site. In addition, it is important to keep stormwater runoff at low velocities and volumes on-site, and at or below pre-development levels going off-site. Ideally, no sediment is to leave the perimeter of the site. Reasonably, of course, some minimal amount of sediment may leave the site. The following principles will help minimize erosion on the construction site, significantly reduce soil from leaving the site and limit off-site sedimentation that result in water pollution.

Erosion from the splash of a raindrop is caused from the energy of the drop falling from the sky with a specific size and velocity. The most important part of erosion control is to design to protect the soil from the energy of the raindrop by reducing the area of bare soil at any time. Keep as much of the existing vegetation in place as possible. For those areas that were stripped of the existing, protective vegetation, cover the bare soil with erosion control measures and reestablish permanent vegetation as quickly as possible. Remember erosion controls are preventative and sediment controls are remediation.



Retain Existing Vegetation Wherever Feasible

Vegetation is the most effective form of erosion control. Try to integrate the existing vegetation including grass, trees and shrubs into the design to reduce the amount of land disturbance. For those areas where the vegetation must be removed, re-establish vegetative cover as soon as possible to reduce the potential for erosion in these areas. Retain all existing riparian corridor to waterways unless removal is absolutely necessary.

Design the Development to the Site

Reduce the amount of soil cut and fill that could occur over the site. One of the best ways to minimize the risk of erosion and sedimentation problems by construction is to disturb as little of the land as possible. The better the development fits with the topography of the site, the less the grading activity occurs, thereby minimizing the amount and intensity of land disturbance. When development is tailored to the natural topography of the land, less massive earth movement is necessary and erosion potential is greatly reduced. It is also important to avoid disturbance of sensitive areas. You should try to avoid disturbance near wetlands and within the riparian (see [Glossary](#)) corridor of perennial streams.

Reduce Surface Runoff by Increasing Infiltration

Vegetation is the most effective form of erosion control. It provides both erosion control and stormwater runoff reduction through infiltration. You can design for increased infiltration by altering the soil texture and subsoil for greater void spaces, which will increase infiltration. Try to integrate the existing vegetation including grass, trees and shrubs into the design to reduce the amount of land disturbance. Retain all existing riparian corridor to waterways unless removal is absolutely necessary. The plants dissipate the energy of the raindrop, reducing the potential for erosion and the root systems increase infiltration and decrease surface runoff.

Protect the Land Surface

Schedule and limit grading activities to minimize bare soil areas and the time of exposure. Consider the use of erosion control blankets, mulch or other erosion control measures when appropriate. Use diversions and perimeter protection to intercept runoff and divert it away from bare soil slopes. Install these practices before clearing and grading or as soon as possible. Stabilize the construction entrance and channels immediately. Establish vegetation on graded areas as quickly as possible or whenever work is interrupted. As stated in the *Missouri State Operating General Permit for Land Disturbance*, "Where soil disturbing activities cease in an area for 14 days or more, the permittee shall construct BMPs to establish interim stabilization."

Keep Runoff Velocities Low

Preserve natural vegetation where possible; mulch and vegetate exposed areas immediately after grading to allow infiltration and slow surface runoff. Use practices that shorten or "break" the slopes to reduce flow volumes and velocities, such as terraces or wattles. Convey stormwater runoff away from steep slopes to stable outlets and detain water in holding ponds before leaving the site.

Capture Sediment on the Site

Sediment traps, basins and barriers are designed to reduce runoff velocity, not filter it; allowing the water to pool and the sediment to settle out. Several sediment traps or barriers located at the border of a graded area are more effective than a single large sediment basin near the site boundary. These practices also reduce the volume and velocity of stormwater runoff.

Schedule Land Grading

The contractor can control erosion and sedimentation most effectively by coordinating the grading sequence and the installation of erosion and sediment control practices. Install key sediment control practices before site grading begins. Schedule or limit grading to small areas. Install the permanent stormwater drains early in the construction and protect all inlets from sedimentation.

Design, Install, Operate and Maintain Practices Properly

Proper design, installation, operation, inspection and maintenance are vital to the success of erosion and sediment control practices. These elements will be covered in [Chapter 5](#). Choosing the wrong practice, improper installation, improper operation and lack of maintenance are the cause of most failures. Failures of installed practices can deliver large amounts of polluted water runoff into streams and lakes. A large structure that fails, such as a detention basin, may be hazardous or damaging to people and property; just as low points in a dike can cause major gullies to form on a fill slope. Ensure the appropriate practice is selected. Also, assign an individual to be responsible for routine checks, operation oversight, repairs and maintenance of erosion, sediment and stormwater control practices.



Figure 2.3 The improperly installed check dam created significant bank erosion. Source: *ABC's of BMP's LLC*

Hydrologic Changes

Land development in urban areas causes drastic changes in the local and watershed hydrology. As land is covered with roads, buildings and parking lots, the amount of rainfall that can infiltrate into the soil is reduced. Figure 2.4 shows the reduction in rainfall infiltration into the soil as paved surface and building cover increases. Table 1.1 shows a range of runoff coefficients for different land uses. The runoff coefficient, or “C” value in the Rational Method of determining runoff, is the percentage of rainfall runoff in the watershed.

This is one reason why construction practices must work hand-in-hand with post-construction runoff controls. It is a relationship that must be well understood. Post-construction controls are designed for the long-term additional runoff from the developed areas to reduce stormwater quantity while improving stormwater quality (See [Missouri Guide to Green Infrastructure: Integrating Water Quality into Municipal Stormwater Management](#)).

The first line of defense in protecting urban water quality is to assess the entire development site for water quality protection opportunities before ever designing where roads and structures are to be located. The initial stage of site design should work to preserve and enhance the existing features.

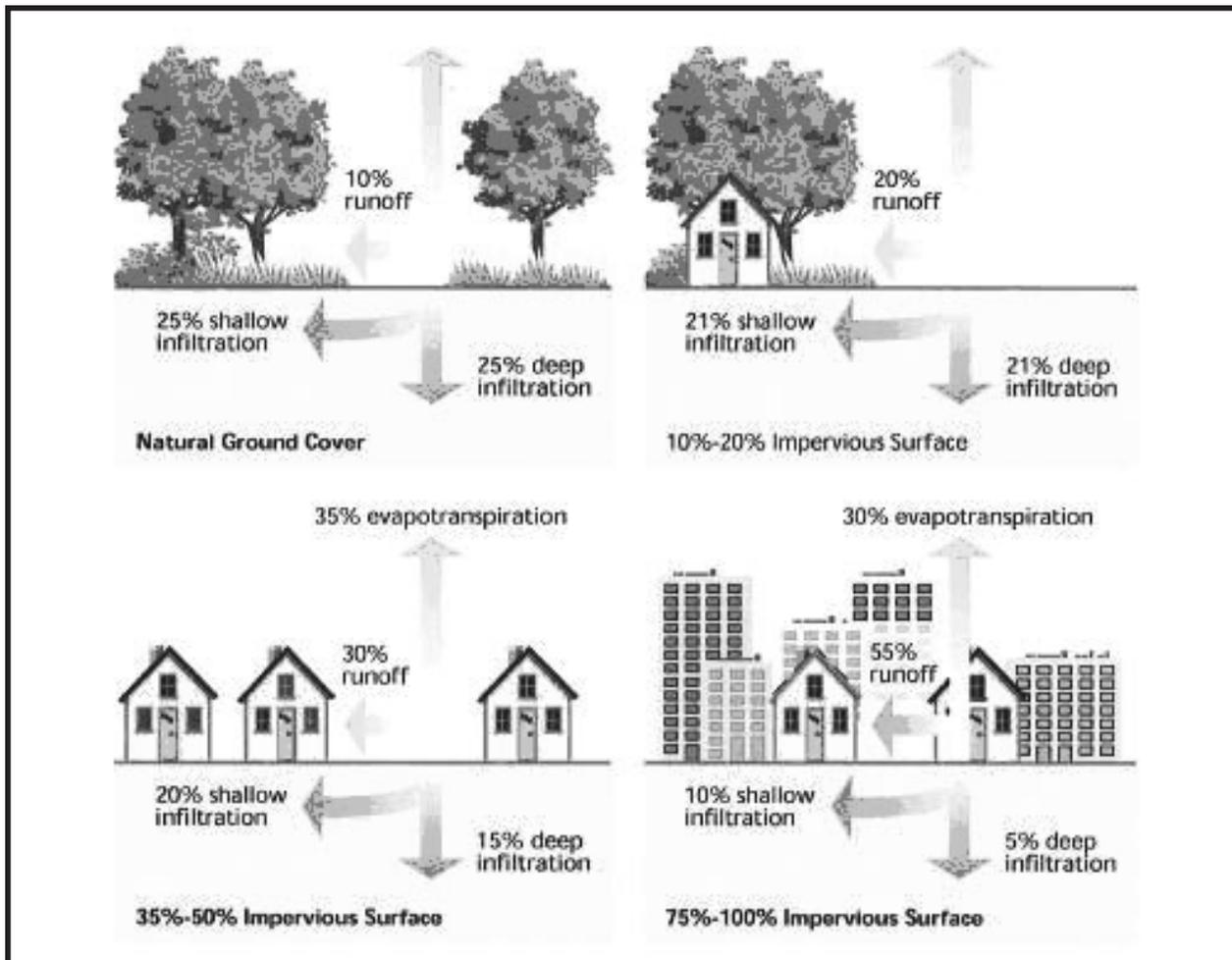


Figure 2.4 Typical changes in runoff flows resulting from paved surfaces
Source: USDA, NRCS, Stream Corridor Restoration, 2001

Land Use	Runoff Coefficient	Land Use	Runoff Coefficient
Business		Lawns	
Downtown	0.70 – 0.90	Sandy soil	0.05 – 0.20
Neighborhood	0.50 – 0.70	Heavy soils	0.13 – 0.35
Residential		Agricultural Lands	
Single Family	0.30 – 0.50	Bare packed soils	0.30 – 0.50
Multiunits, detached	0.40 – 0.60	Cultivated rows	0.30 – 0.60
Multiunits, attached	0.60 – 0.75	Pasture	
Residential, suburban	0.25 – 0.40	Heavy soils	0.15 – 0.45
Apartment	0.50 – 0.70	Sandy soils	0.10 – 0.25
Industrial		Barren slopes	
Light	0.50 – 0.80	Smooth, impervious	0.70 – 0.90
Heavy	0.60 – 0.90	Rough	0.50 – 0.70
Parks, cemeteries	0.10 – 0.25	Woodlands	0.05 – 0.25
Playgrounds	0.20 – 0.35		
Railroad yard	0.20 – 0.40		
Unimproved	0.10 – 0.30		

Table 1.1 Typical Runoff Coefficients as Percentages Source: Goldman, *Erosion and Sediment Control Handbook*, 1986

As land areas are developed, natural drainage patterns are modified when runoff is channeled into road gutters, storm sewers and paved surfaces. These changes concentrate the volume of runoff in drainageways and increase the speed of flow. This results in higher peak discharges and shorter times to reach peak discharge. Figure 2.5 shows typical pre-development and post-development discharge rates versus elapsed time for a site being developed for urban land use. The area under the curves represents the volume discharged. The increased volume and discharge rate shows how the discharge from the site is increased. The rapid rise and fall of runoff is often presented as dangerous flash flood events. Major flooding or soil erosion problems also occur often after an area has been developed.

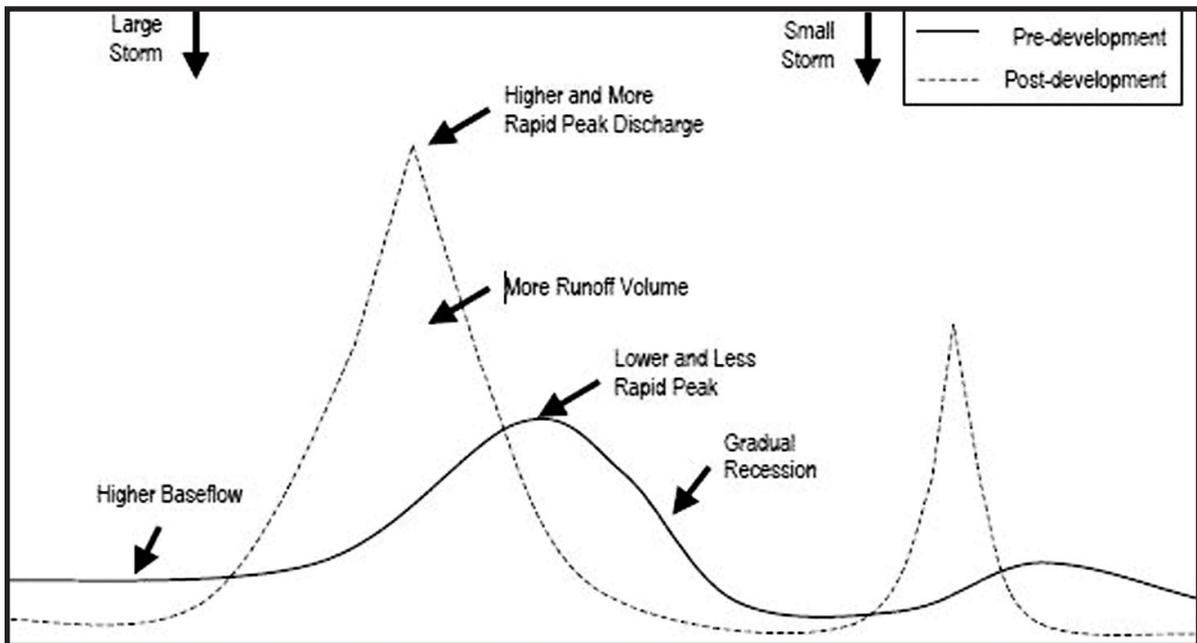


Figure 2.5 Consequences of Development to Urban Streams Source: EPA 841-B-05-004, November, 2005

Another hydrologic effect of urbanization is reduced stream flow during periods of low rainfall. This occurs because paved surfaces do not allow infiltration or retain the water in the soil that would naturally feed the streams. The result is deterioration of the aquatic ecosystem because of high pollutant loadings and low flow during periods of low rainfall.

During periods of high rainfall, the increased discharge rate and downstream flow often cause channel and streambank erosion in the receiving stream. Due to development and increase in impervious surfaces, there is less infiltration of surface water to groundwater and therefore more water arriving in stream channels and at a faster rate. This results in destabilization of streambanks and scouring of stream channels.

Removal of vegetation prior to construction activity is a major contributor to sediment moving off-site and entering nearby streams and lakes. Bare soil is highly vulnerable to erosion. Sediment movement from construction sites can range up to 35-45 tons/acre/year (ASCE and WFF, 1992). Vegetative cover is the most effective control of erosion and sediment loadings.

Pollution Transport

Water pollutants that are commonly transported by stormwater from construction sites in urban settings include sediments, nutrients, petroleum products, chemicals, metals, pesticides, fertilizers and other potentially toxic chemicals (*After the Storm*, EPA Fact Sheet 833-B-03-002, January 2003).

Sediment

Sediment, often incorrectly referred to as silt, (see [Appendix A](#)) from soil erosion is made up of soil particles and gravel washed into rivers, lakes and streams. It is the major pollutant in surface waters. Excessive sediment in waterbodies impairs aquatic ecosystems, reduces public water storage and increases drinking water treatment costs. These sediment particles are also a vehicle to transport other pollutants including nutrients, metals, petroleum products and bacteria to surface waters.

Runoff from construction sites is the major source of sediment in urban areas under development. Typical sediment loading rates from construction sites vary from 100 to 200 tons/acre/year (North Carolina DEHNR, 1993). Another major source of sediment is off-site streambank erosion, which is increased by the higher peak runoff flow rates and volumes previously discussed.

Nutrients

Phosphorus and nitrogen are the primary forms of nutrients that can cause water pollution. Lawn fertilizers used to establish and maintain vegetation can be significant sources of phosphorus. Nitrogen comes from fertilizer, too, but is also found in animal wastes, grass clippings and effluent from leaking septic systems.

Phosphorus and nitrogen are sources of food for the algae and bacteria that live in lakes, streams and rivers. Waters polluted with these nutrients develop large numbers of algae and bacteria that use up oxygen, causing fish and other beneficial organisms to die. Nitrates in drinking water are responsible for the "blue baby syndrome" that has caused illness and deaths in infants and have been linked to certain forms of cancer in adults (*Health and Environment Digest*, 1988).

Nutrient pollution can be prevented by composting grass clippings and animal wastes, and repairing leaking septic systems. Nutrient pollution from construction sites can be minimized by applying fertilizer at the rate recommended by a soil test.

Petroleum Products

Petroleum products float on water and are visible. The hydrocarbons in petroleum have a strong characteristic for attaching to sediment particles. Hydrocarbons are known to be toxic to aquatic organisms. Common sources of petroleum products at the construction site are oil storage, fuel facilities, leaks from crankcases and improper disposal of drain oil.

Chemicals

Paints, solvents, sealants, cleaning agents and caulks may be found on construction sites. These chemicals along with chemically composed or treated construction materials may enter the runoff water. Water quality is degraded and removal during water treatment processes may be very expensive.

Metals

Trace metals including lead, zinc, copper, chromium, cadmium and nickel are found on construction sites. In high concentration these metals are toxic to aquatic life. They originate from building materials, vehicle emissions and road sand or salt. Studies have shown that trace metals bioaccumulate in plants and aquatic life in areas where they are contained in sediment.

CHAPTER 3

INTERPRETING STORMWATER FEATURES IN THE SITE DEVELOPMENT PLAN

Before beginning preparation of the Stormwater Pollution Prevention Plan, the preparer needs to carefully review the site development plan, or SDP, opportunities to prevent and control stormwater pollution. The scope of stormwater controls outlined in the plan may range from minimal representation to full scale environmental site design. See Diagram 3.1 Regardless of the scope of features presented, the site development plan should be carefully examined by the preparer for ways to optimize stormwater control. The preparer’s approach to selecting and installing stormwater control measures can significantly impact benefits from their use and can lead to cost savings.

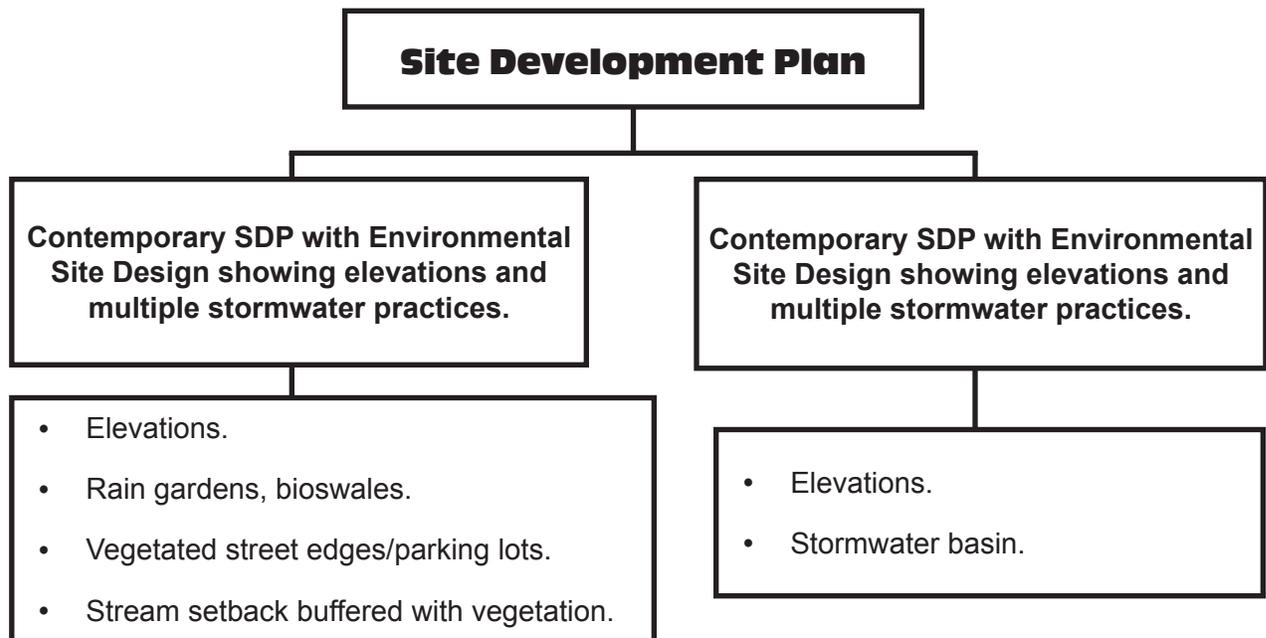


Diagram 3.1

Site development plans that contain a well constructed environmental site design should be easy to interpret. For example, Figure 3.1 demonstrates opportunities available to the Stormwater Pollution Prevention Plan preparer and contractor for enhancing stormwater control. In this example, there is no basin for permanent stormwater runoff control. Therefore, it would be less practical to build a large costly sediment basin, because it would need to be back-filled upon project completion, instead of being converted to a permanent stormwater pond. In this project, the prairie provides for sheet flow of larger storms that ultimately flow into woods along the perimeter. The woods along the southwest part of the property provide further protection of the

natural drainage areas and the stream below. Also, rain gardens and bioswales are designed into the plan to capture runoff at its source, because these practices will slow runoff and filter pollutants after the development is complete. The Stormwater Pollution Prevention Plan should explain how these permanent stormwater control features will be protected during the property development. The Stormwater Pollution Prevention Plan, is discussed in more detail in [Chapter 4](#).

The depressions for rain gardens and bioswales can be made ahead of time to catch sediment during construction, or they can be fenced off for protection during construction. If used to catch sediment, they will need to be cleaned out and converted to permanent use when the development is finished and the site is stabilized. In either case, these sites and any connecting flow paths should be protected from traffic compaction, material storage and contaminated runoff, and such protection measures should be identified in the Stormwater Pollution Prevention Plan. Fencing these protection zones will provide added protection.

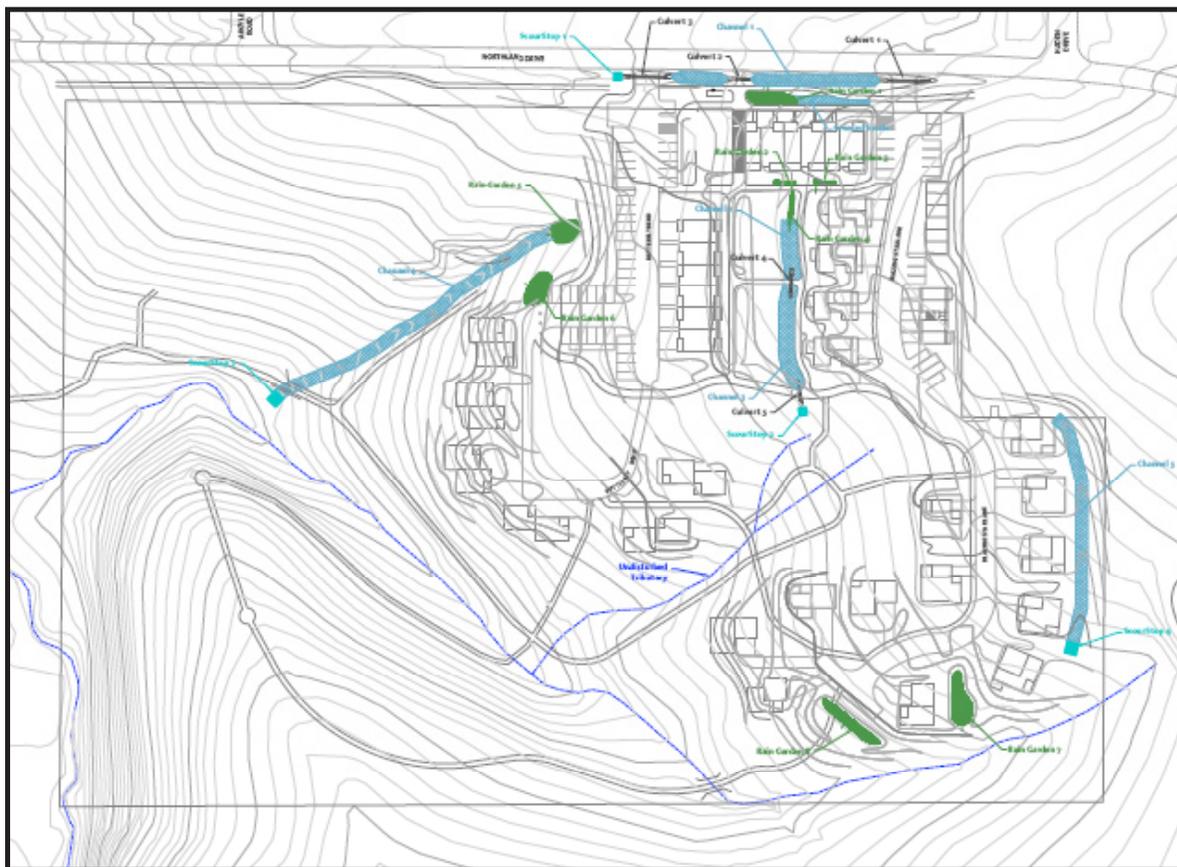


Figure 3.1 Proposed Bear Creek Prairie Project, Columbia, MO. Source: Andy Guti

Conventional Site Development Plans showing a minimum of stormwater controls can still provide opportunities for SWPPP preparers and contractors to incorporate environmental features that will enhance the protection of water resources, as well as improve the project's overall success. For example, in a conventional Site Development Plan, a choice can be made to use more than one small sediment pond or a series of other small depressions to catch sediment. Additionally phase land disturbance in order to minimize sediment-laden runoff. Better success in reducing sediment laden runoff will be achieved by focusing more effort on erosion control than on sediment capture. Regarding redevelopment projects, Environmental Site Design features may include planter boxes and street edge bioswales. Steps for incorporating these elements into the Stormwater Pollution Prevention Plan and ensuring their protection during development are described in more detail in [Chapter 4](#).

Earlier chapters explain when stormwater control practices are installed in accordance with good environmental principles, they will not only benefit the environment, but they will improve overall use and enjoyment of the development site and increase property values. Well-designed practices can also reduce project costs by reducing site maintenance requirements. Preparers and contractors can maximize these benefits when writing and executing the project's Stormwater Pollution Prevention Plan.

Increased Use of Environmental Site Designs

The number of development designs incorporating environmental features is growing. It is a trend that contractors will notice, if they are not already aware of it. The trend has led to the creation of the Environmental Site Design, used by developers to serve the growing public demand for environmental features. Environmental features are designed into the initial site development plan (concept) and carried through to the final site improvement plan. Stormwater Pollution Prevention Plan preparers and contractors familiar with these special design features are better prepared to properly select and install them. The Environmental Site Design approach is rapidly being adopted across the nation, because conventional stormwater management has been shown to significantly increase the volume and velocity of stormwater runoff, resulting in flooding, eroded properties and diminished fishing, swimming and drinking water resources.

Stormwater Pollution Prevention Plan preparers and contractors who understand the purpose and function of environmental features will be able to assist communities and developers in maximizing their benefits. For example, capital project costs can be reduced through the Environmental Site Design that employs less asphalt, fewer curbs and fewer pipes. The resulting landscape features will add value of interest to the buyer. Those benefits extend to construction contractors as well.

Contractors well versed in environmental site design goals and protection measures have an employable advantage over those who do not. And, their success in implementing Environmental Site Design features depends on an understanding of their benefits and contributions to the overall development goals. The following sections are devoted to explaining the important site development principles essential to achieving an effective Environmental Site Design. While these ideas are directed more toward a community leader or developer with environmental site design goals, the same principles apply throughout project implementation. The contractor's awareness of them will improve his or her ability to offer feasible adjustments to improve a site design at any stage of project development. An understanding of these goals will also help the contractor avoid costly mistakes. For more information about environmental site design, see references including [Missouri Guide to Green Infrastructure: Integrating Water Quality into Municipal Stormwater Management 2011](#).

Environmental Site Design Principles and Features

When projects are conceived, the business interest is usually clearly understood. Therefore, it is important to recognize the financial benefits of environmental site design such as reduced capital expenditures, lower escrow requirements and increased property values. In order to avoid costly repairs or risk environmental fines, general contractors may require written agreements that hold subcontractors and field personnel responsible for protecting environmental design components and practices.

A greater challenge in integrating environmental features may be in understanding the benefit and function of the site's natural attributes (geology, soils, vegetation, drainage patterns, etc.) toward the project's design. Through careful research and planning, natural systems, such as streams, undisturbed green space, wetlands and riparian areas, can be maintained, restored or enhanced to function as efficient stormwater management features. They are nature's stormwater management system and should be preserved and used as cost-effective measures.

Building man-made runoff control devices as opposed to preserving the natural stormwater systems not only requires additional capital investment, but also eliminates highly valued resources and can ultimately result in costly streambank restoration projects. In addition, it automatically ties the community to ongoing maintenance responsibilities that can be a source of major expense long after the developer is gone.

Communities, developers and contractors wanting to effectively implement environmental features may benefit from managing their projects after adopting these three basic goals in controlling site runoff:

- **Mimic the natural patterns and processes.** Prior to new development, the rainfall-runoff process is slow because precipitation falls on vegetation and native soils whose horizons have not been disturbed. This allows a large portion of the precipitation to infiltrate. Runoff also tends to follow relatively long pathways across vegetated areas prior to entering streams. Stormwater management practices should try to mimic these processes as land is newly developed. This practice improves water quality, but can also reduce the overall cost of managing stormwater.
- **Maximize infiltration.** Impervious surfaces, such as roadways, parking lots and rooftops, eliminate the infiltration process. Further, they tend to channelize runoff which increases runoff, volumes and rates. Conventional curb and gutter systems compound the effects. As a result, unfiltered pollutants are carried directly and rapidly to the streams. By minimizing impervious surfaces, the volume and flow rates can be curtailed, thereby reducing threats of increased flooding, channel erosion and impaired water quality.
- **Preserve natural areas.** Increasing green space in community design and connecting it where possible optimizes the opportunity for best stormwater management. Connecting these spaces to preserved natural areas adds even more value to stormwater management and recreational opportunities. If large or connected green spaces are preserved or created as in exchange for reduced lot sizes and structures, requirements for roads, sewers, water lines and other infrastructure can also be minimized.

Adopting these goals early in project planning will create the most opportunity to guide environmental design options that mesh well with development goals. A development embracing these goals will suffer less interruption or damage to infrastructure caused by stormwater during and after construction. In addition to the lower infrastructure costs, a well-designed site will hold higher value to its owner and user because of the quality and stability of its environment.

Following is a list of features that might appear in an environmental site design and its narrative plan and is intended to complement or supplement requirements to be outlined in the Stormwater Pollution Prevention Plan. These suggestions are intended to introduce the contractor to the types of Environmental Site Design stormwater controls often applied at construction sites. The contractor should consider the specific conditions at the site before implementing each practice. [Chapter 6](#) explains how various practices can be installed to complement the site conditions. The Environmental Site Design and its narrative plan may:

- Designate areas with severe limitations such as floodplains, steep slopes, drainageways, existing bodies of water and unstable soils. Leave these areas undisturbed and to be used as green space to protect water quality. Check local ordinances and permits for limitations of construction in floodplains and near waterways.

- Identify natural vegetation and trees to be left undisturbed during construction or during certain phases of construction. Existing areas of grass, shrubs and trees will provide natural erosion and sediment control while enhancing the attractiveness of the project. Check local ordinances for stream corridor setbacks. In some cases, these areas can also be enhanced to help meet water quality protection requirements for both construction and post-construction runoff control.

Sequence earth grading and other site preparation so these activities are minimized.

The narrative Environmental Site Design plan may also refer to the numerous resources on contemporary green infrastructure and low impact development designs. Such designs may make it easier to comply with federal, state and local requirements to protect water quality. More information is available about how these contemporary practices may even minimize project costs. See references, including [Missouri Guide to Green Infrastructure: Integrating Water Quality into Municipal Stormwater Management 2011](#).

- Specify rough grading in phases to keep disturbed areas small and to minimize the amount of time soil will be bare of vegetation. The discharge permit required for land disturbance states: "Where soil disturbing activities cease in any area for 14 days or more, the permittee shall construct and install best management practices to establish interim stabilization. If the slope of the area is greater than 3:1 or if the slope is greater than 3 percent and greater than 150 feet in length, then the permittee shall establish interim stabilization within seven days of ceasing operations on that part of the site."

Plan for the installation of best management practices (see [Chapter 6 - Practice Installation and Maintenance](#)) to control overland sheet flow, limit erosion and keep sediment and other pollutants on the site.

- When planning for best management practices near streets, ensure practices are designed and installed in a manner that prevents major flooding, sediment accumulation, traffic interruptions, road damage or other off-site impacts during significant storm (design) events.
- Require topsoil to be stockpiled and protected from erosion so it may be available for spreading over the areas to be permanently vegetated during final grading. Protecting topsoil helps maintain its organic matter, microorganisms and nutrients for successful vegetation establishment.
- Schedule the installation of control measures, such as best management practices prior to land disturbance. It is very important to understand the ultimate plan for post-construction runoff to effectively plan, prepare, schedule and coordinate conversion from construction site best management practices to permanent practices. Schedule the installation of post-construction stormwater control measures after the site is stabilized. There should be no potential for erosion on the site or sediment discharge into the post-construction stormwater control measures, unless they are intentionally designated to serve as temporary practices.
- Provide for operation and maintenance of the permanent, post-construction stormwater control measures after the site is stabilized. If selected, designed, installed and operating properly, these structures will provide storm water quantity and quality protection after the construction phase of the project is complete.

Midwest Examples of Green Infrastructure

Some developments throughout the midwest have incorporated the principles of green infrastructure and low impact development in an effort to mimic or enhance the preconstruction hydrology conditions of the area. For example:

Alberici Corporate Headquarters, Overland, MO



Figure 3.2 Alberici Headquarters Source: Alberici Headquarters

This Brownfields redevelopment project includes the reuse of a 1950s office building and a 155,633 ft² former metal manufacturing facility. The 13.6-acre site originally had 9 acres of impervious surface, including 3.7 acres under roof. The restoration process began by reducing pavements to a bare minimum. The development footprint was a fraction of that allowed by local zoning. This suburban, Brownfield site was restored with native, drought-resistant plantings, including six acres of Missouri prairie grass and wetland plants. More than 250 native trees and 4,200 perennial plants and bushes were planted, placed by type, growth rate and shade requirements. The site has become a seed bank for the St. Louis area, providing the resources to establish other native landscapes. This Brownfields site is a great example of what can be done to return an eyesore to an ecologically sensitive property in an industrial environment.

www.epa.gov/greenkit/stormwater_studies/Alberici_MO.pdf

Heifer International Headquarters – Little Rock, Arkansas



Figure 3.3 Heifer International Headquarters, Little Rock, Arkansas Source: Timothy Hursley

Located next to the Clinton Presidential Library, the Heifer International Headquarters is in walking distance of busses, a new light-rail system and a pedestrian entertainment district.

Environmental Aspects

- A restored wetland that wraps around three sides of the building collects stormwater for reuse as irrigation water.
- Rainwater collected from the roof is stored in a five-story water tower wrapped with a fire stair.
- Graywater collected from sinks and drinking fountains, condensate from outside air units, and rainwater from the water tower are reused in the toilets and cooling tower.
- Moisture removed from the building as condensate is reused to cool the building. Waterless urinals and low-flow toilets and lavatories further reduce potable water use.
- The narrow, semicircular floor plan provides daylight and views for all employees. The majority of open offices in the building offer river views and northern light, and all major gathering spaces access the exterior. Five balconies on each floor, designed as outdoor conference rooms, hang over the wetland and act as sunscreens.
- The building was designed to use up to 55 percent less energy than a conventional office building and to last for at least 100 years.
- Materials were selected for their durability, maintainability, low toxicity, recycled content, and regional availability. www.aiatopten.org/hpb/overview.cfm?ProjectID=781

The Wilderness - Overland Park, Kansas

This multi-phase development located in southern Overland Park- Johnson County, Kansas offers various housing types among trees and natural areas. A 12-acre city park is located nearby that offers a 5-acre stocked fishing lake. Paved trails lead to 400-acre deed restricted Nature Preserve with lakes, trails, land and wildlife. www.cottagesatthewilderness.com

Oakbrook - Clay County, Missouri

The Oakbrook development is the first low impact development in Clay County, Missouri. The development places emphasis on conserving the area's natural resources. The development is currently 156 acres that consist of one to two acre lots, 54 acres of dedicated open space. Walking trails and rain gardens are located throughout the development. www.oakbrookliving.com

Bear Creek Prairie - Columbia, Missouri

Bear Creek Prairie is a proposed 17-acre conservation development. The development is designed to follow the principles of the conservation community concept, where homes are generally clustered around common green spaces that everyone can use and enjoy. This encourages interaction among residents while retaining use of wooded and open areas for trails, gardens, gathering areas and other amenities.

The City of Columbia permits Planned Unit Developments, or PUD districts, which provided the vehicle for the project if it is built as planned. This zoning will allow the developers to accomplish the conservation community concept. Figure 3.4 shows the development's proposed site plan.

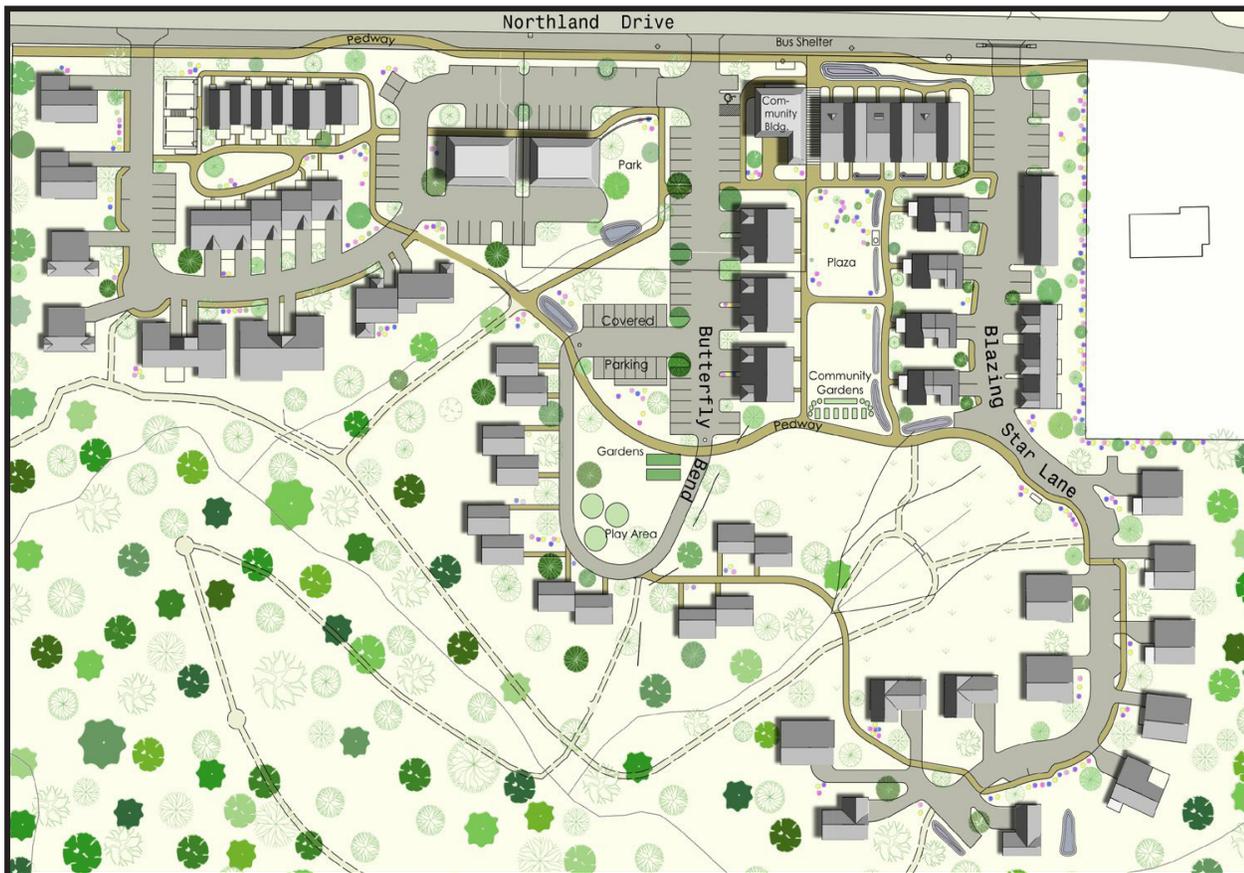


Figure 3.4: Bear Creek Prairie Proposed Development Site Plan. Source: Andy Guti www.bearcreekprairie.com

Fields Neighborhood - East Troy, Wisconsin

This development in southern Wisconsin is a new nature-based community that combines sustainable living with a strong community atmosphere and respect for the natural environment. The development offers a range of clustered condominiums integrating the latest green building technologies with designs minimizing the impact on the natural surroundings. After completion, the development will feature 74 units of clustered condominiums on 17-acres. Figure 3.5 shows a rain garden on a property in Fields Neighborhood. www.fieldsneighborhood.org



Figure 3.5: Fields Neighborhood Rain Garden Source: www.fieldsneighborhood.org

Legacy Trails, Habitat for Humanity- Springfield, Missouri

The goal of this 18-acre development is to provide homes for 56 families and to enhance the quality of life for residents as well as protect the quality of the environment, featuring:

- Native plants and grasses.
- Innovative, energy-efficient home design.
- Natural walking paths.
- A savannah-like community park.
- Curbless streets to limit stormwater runoff.
- Limited on-street parking to increase safety and reduce crime.

In December 2008 the Missouri Conservation Heritage Foundation awarded Habitat Springfield a \$5,000 grant helping fund a native plant, rain garden project at Legacy Trails. The bio-retention areas have proven successful in helping manage stormwater runoff quality. www.habitatspringfieldmo.org/legacytrail.html

Prairie Crossing- Grayslake, Illinois



Figure 3.6: Prairie Crossing Homes Source: www.planningwithpower.org

This development is one of the most popular conservation design communities in the nation, and is considered a national example of how to plan our communities to enhance the environment and support a better way of life. The development is located in Grayslake, Illinois, a suburb of Chicago. The community was designed to combine the preservation of open land, easy commuting by rail and responsible development practices.

More than 60 percent of the 677-acre site is protected open land actively used by people and wildlife. Ten miles of trails wind through a landscape of farm fields, pastures, lakes and ponds, native prairies and wetlands.

The development is well known for its beautiful native prairie landscaping. With more than 165 acres of restored prairies, 20 acres of restored wetlands and 16 acres of historic hedgerows, the Prairie Crossing landscape is contributing to the restoration of the native ecology of the region. Many Prairie Crossing residents integrate these native plant communities into their own landscaping. Figure 3.6 shows some of the homes located in the development.

www.prairiecrossing.com

Combining Stormwater Treatment Practices

Each stormwater control measure has unique characteristics and can be used to target specific pollutants. For example, some practices will collect sediment, whereas other practices are preferred for treating phosphorus. (See [Appendices C and D](#) for resources that provide specific pollution control information, such as the International BMP Database and the SUSTAIN model.)

The preferred approach for maximizing water quality improvement is a combination of stormwater control measures that collectively address the source of pollutants, the conveyance of stormwater and the infiltration and treatment of runoff. This series of measures, sometimes referred to as a “treatment train” or “string of pearls”, typically includes an integrated set of biological and physical treatment steps that successively remove pollutants from stormwater runoff. The components of a combination approach are designed to treat stormwater runoff for water quality benefits and to reduce stormwater runoff peaks and volumes. Source controls, upstream of the initial structural components are an important component to maximize benefit.

The combination approach typically follows a hierarchy of practices in a sequenced approach. The stages of a combination approach incorporate the following components:

- Preservation or restoration of open space and natural drainage areas and their native or adaptive vegetation.
- Dispersion of small-scale, on-site source controls such as rain gardens and other practices that provide infiltration and evapotranspiration (see [Glossary](#)).
- Conveyances such as swales and filter strips that connect on-site controls, dissipate energy and filter larger particles.
- Filtration stormwater control measures such as bioretention and wetland swales.
- Provisions for overflowing or rerouting large storm events.

Receiving Waters

A designer should understand the site conditions and hydrologic characteristics of the drainage area and the requirements for water quality treatment before choosing a sequence of treatment practices. The developer and site design team should select a combination of practices to meet water quality goals, while meeting local requirements and objectives. Preserving native areas or establishing vegetated open space is commonly the first step of a combination approach. Undisturbed land and areas landscaped with native plants increase stormwater infiltration and can help minimize runoff, erosion and potential for downstream pollution.

Developments may have design or site constraints limiting the amount of open space available for stormwater management. These sites may require some engineered stormwater infiltration practices and treatment.

Stormwater control measures, such as pervious vegetated areas, infiltration trenches and rain gardens, provide treatment and control of runoff near its source. Site characteristics, such as area, soil type or topography, may limit the effectiveness of open space and infiltration practices.

Engineering filtration systems are the next step of the combination approach. Filtration systems, such as bioretention and vegetated swales, have the capacity to detain smaller rain events and are designed to treat the water quality volume.

Larger scale stormwater detention practices should be the last stage of the combination approach. Detention generally applies to dense developments and provides a solution for damaging storms larger than the water quality event. Detention basins manage the rate of stormwater discharge from larger rainfall events. Some also include a treatment component sized for the water quality event. If detention basins are needed, their size may be minimized based on the combination of on-site practices that also provide for volume control.

The following examples demonstrate how a combination approach may be incorporated at three different sites:

Scenario 1: New Residential Subdivision

- Preserve a native prairie remnant or other unique landscape feature as common open space.
- Landscape with native or adaptive vegetation and incorporate rain gardens on each lot (or a group of lots) to disconnect downspouts.
- Design vegetated swales to convey and treat runoff from landscaped yards and streets.
- Limit impervious area for the development by limiting street width and the use of cul-de-sacs (provide narrower through-streets to accommodate emergency vehicles), using pervious pavement, limit on-street parking to one side, etc.

Scenario 2: Commercial Development

- Establish native or adaptive landscaping in and around buildings and parking areas.
- Use best parking lot designs to minimize impervious surface, including intra-lot bioswales or dispersed rain gardens below.
- Use bioretention cells and porous pavement to treat and infiltrate parking lot runoff.
- Use green roofs to reduce runoff from “flat” rooftops.

Scenario 3: Office Park

- Identify source controls and maintenance practices that decrease roadway salts and fertilizer use.
- Place filter strips around building downspouts and parking lots, leading to infiltration basins.
- Use dry swales to treat runoff from streets and convey to a wet pond or detention.
- Install a cistern to use for irrigation, lawn watering or other purposes.

Proper maintenance and pollution prevention practices can further limit stormwater runoff pollution. Maintenance of stormwater control measures to remove pollutants and sediment is critical to continued success. Pollution prevention strategies are specific to the site management practices and may include containment barriers around chemical storage areas, vehicle maintenance to prevent leakage or maintenance practices that reduce salt or fertilizer application.

The next chapter presents information to assist in preparing a SWPPP. Preparers should occasionally revisit this chapter while preparing the SWPPP. For more information about environmental site design, see references including [*Missouri Guide to Green Infrastructure: Integrating Water Quality into Municipal Stormwater Management 2011*](#).

CHAPTER 4

STORMWATER POLLUTION PREVENTION PLAN OR EROSION AND SEDIMENT CONTROL PLAN

Purpose

A stormwater pollution prevention plan, or SWPPP, is required under all Missouri land disturbance general permits. Some local governments also regulate land disturbance activities and therefore require a SWPPP or what they may refer to as an Erosion and Sediment Control Plan. The purpose of a SWPPP is to identify possible pollutants that may enter stormwater runoff and to identify best management practices, or BMPs, that will minimize or eliminate possible water quality impacts from stormwater runoff. BMPs are physical, structural or managerial practices that prevent or reduce pollution. Best management practices may be used when used singly or in a combination to produce the desired level of results.

A SWPPP must be developed for each construction project subject to regulations and must be prepared prior to any land disturbance. The SWPPP will define and schedule the erosion, sediment and good housekeeping control measures to be used on the construction site to prevent or minimize erosion that could occur and keep sediment and other pollutants from exiting the site.

It is stated in the Missouri land disturbance general permit: "...before disturbing earth, or submitting an application, the permittee must develop a SWPPP specific to the land disturbance activities at the site. This plan must be developed before permit coverage can be issued. The permittee must fully implement the provisions of the SWPPP required as a condition of this general permit throughout the term of the land disturbance project."

In all cases, the permittee and their representative or the contractor(s) responsible for installation, operation and maintenance of the best management practices must have a current copy of the stormwater pollution prevention plan with them when on the project site. In some cases, the permittee may be required to submit a copy of the SWPPP to the Missouri Department of Natural Resources or the local government office. The Missouri Land Disturbance General Permit requires a copy of the stormwater pollution prevention plan be provided to all contractors responsible for installation, operation or maintenance of any best management practice.

[Chapter 1](#) contains information on regulations and permits. The Missouri Department of Natural Resources' regional office may be contacted for additional information.

The Plan

The stormwater pollution prevention plan should serve as a guide for the selection, location, installation and maintenance of practices to control all anticipated erosion and prevent sediment and other pollutants from leaving the site. A SWPPP is an evolving document that includes text, site maps and forms that are maintained and updated throughout the construction project as the construction site evolves. The requirements for what information must be included in the stormwater pollution prevention plan are located within the Missouri land disturbance general permit. If a construction project is within a community that also regulates land disturbance, the contractor will need to include their SWPPP guidelines.

The following items are typical components required in a SWPPP:

- Identification of the person responsible for implementing the SWPPP.
- Physical and environmental description of the site including soils, slopes, vegetation and water resources.
- Description of the construction activity.
- Description of the potential for discharge of sediment and other pollutants from the construction site.
- Narrative, plan sheets and construction details and specifications for erosion, sediment and good housekeeping controls.
- Narrative describing the timing and schedule of installation of erosion, sediment and good housekeeping controls.
- Methods used for final stabilization of all exposed soil areas (should be coordinated with post-construction plans during the initial site design process and again before implementation).
- Information related to conformance with wetland permits (if applicable), the need for environmental review or results of such review, impacts of discharges on endangered or threatened species, and impacts of discharges on historic places or archeological sites.
- Site map showing the following information:
 - Location of areas not to be disturbed.
 - Limits of disturbed area.
 - Location and type of temporary and permanent BMPs.
 - Existing and proposed grades with direction of stormwater flow information before and after construction.
 - Impervious surfaces and soil types.
 - Location of construction phasing.
 - Location of surface waters (e.g., streams, lakes, wetlands) within 0.5 mile of the project.

Developments in an area draining to a water body that has been listed on Missouri's impaired water body list (a list required by Section 303(d) of the Clean Water Act), special measures may need to be taken to ensure conformance with the required total maximum daily load, or TMDL,

implementation plan. Contractors can determine if the stream might be included in an active TMDL restricted stream by contacting the Missouri Department of Natural Resources or by viewing EPA's approved TMDL list available on the Missouri Department of Natural Resources Web site at www.dnr.mo.gov/env/wpp/waterquality/index.html

Note: After a TMDL has been approved by EPA, the stream will ultimately be removed from the impaired water body list. While the water body may still be impaired, it is moved to the TMDL implementation list. The TMDL implementation document then becomes the governing document for addressing the impaired waters.

Understanding the Site Plan and Design

The land site should have desirable natural drainage and soils with good potential for the intended development. Detailed soil surveys and geological investigations should have been completed to assess the suitability for the intended development.

Designate areas on the site map with severe limitations such as floodplains, steep slopes, drainageways, existing bodies of water and unstable soils to be left undisturbed and used as green space to protect water quality. Check local ordinances for limitations of construction in floodplains and near waterways.

Designate natural vegetation and trees to be left undisturbed during construction. Existing areas of grass, shrubs and trees will provide natural erosion and sediment control while enhancing the attractiveness of the project. Check local ordinances for stream corridor setbacks. In some cases, these areas can also be enhanced to help meet water quality protection requirements for both construction and post-construction runoff control.

The site development should be designed so that minimum earth grading and other site preparation is required. Opportunities should be sought to speed up the design approval process by making the design meet the intentions of the municipality's comprehensive or watershed management plan to protect natural resources. Also refer to the numerous resources on contemporary green infrastructure and low impact development designs. Such designs will help the contractor comply with federal, state and local requirements to protect water quality. Much information is available on how these contemporary practices may even minimize your project costs. There are additional resources listed at the end of this chapter.

Rough grading should be completed in phases to keep disturbed areas small and to minimize the amount of time soil will be bare of vegetation. The permit states: "Where soil disturbing activities cease in any area for 14 days or more, the permittee must construct and install BMPs to establish interim stabilization. If the slope of the area is greater than 3:1 or if the slope is greater than 3 percent and greater than 150 feet in length, then the permittee must establish interim stabilization within seven days of ceasing operations on that part of the site."

The SWPPP must present a plan for the installation of best management practices (see [Chapter 6 - Practice Installation and Maintenance](#)) to control overland sheet flow, limit erosion and keep sediment and other pollutants on the site.

Topsoil should be stockpiled and stabilized to protect it from erosion and then, following final grading, spread over the areas to be permanently vegetated. Topsoil is rich in organic matter, microorganisms and nutrients for successful vegetation establishment.

The SWPPP must contain a schedule for the installation of best management practices. The installation of best management practices should occur in concert with the development

schedule. All best management practices should be in place prior to any disturbance in the area they protect. It is very important to understand the ultimate plan for post-construction runoff to effectively plan, prepare, schedule and coordinate conversion from construction site BMPs to permanent practices. Contractors should schedule the installation of post-construction BMPs after the site is stabilized. There should be no potential for erosion on the site or sediment discharge into the post-construction BMPs.

Provide for operation and maintenance of the permanent, post-construction BMPs after the site is stabilized. If selected, designed, installed and operating properly, these structures will provide stormwater quantity and quality protection after the construction phase of the project is complete.

Developing the SWPPP

Information that Goes in the SWPPP

The SWPPP, or erosion and sediment control plan, has many sections of information in it. The appropriate Missouri Department of Natural Resources general permit for land disturbance and local ordinances should be reviewed to make sure all required information is included in the SWPPP. Table 4.1 provides a checklist of information to be included in the SWPPP. The text column refers to the narrative portion of the document. The site maps are the drawings within the SWPPP. The forms are those documents created as required in the general permit. Each control measure should provide installation and maintenance information, which should be found on the detail sheet. Refer to [Chapter 6](#) for a list of all best management practices.

Table 4.1 SWPPP Checklist of Requirements

Information Required	Sections within the SWPPP			
	Text	Site Map	Forms	Detail Sheet
Site Description (e.g., soils, topography, vegetation)	X			
Discharge Points and Receiving Waters	X	X		
Limits of Disturbance – permitted boundary		X		
Temporary BMP's				
Description of installation and maintenance	X			X
Description of where and why used	X			X
Location		X		
Removal or conversion of controls with site stabilization	X			
Permanent BMPs				
Description of when to install - schedule	X	X		X
Location		X		
Good Housekeeping BMPs	X	X		X
Inspection of all BMPs – when and how	X		X	X
Sequencing and scheduling of work with BMP installation	X	X		
Amending and Updating the SWPPP	X	X	X	
Public Notification	X	X	X	
Contractor Responsibility	X			
Site Stabilization and Termination of Permit Coverage	X			

The following tables also provide questions and goals to set during the design of the construction project. Table 4.2 provides questions on the existing natural resources to be shown on the plan. Table 4.3 provides site development goals to strive for during the design of the construction project.

Table 4.2: Existing Natural Resource Considerations

Natural Resource	Questions	Actions
Wetlands	Are wetlands on-site? Are permits needed (e.g., 404/401 permits) from the Army COE or Missouri Department of Natural Resources?	Show all wetlands on map. Obtain COE/ Missouri Department of Natural Resources permits or documentation before plan approval.
Streams and Floodplains	Are major waterways on the site? Are permits needed from the Army COE or Missouri Department of Natural Resources? Is the site located within the 100- or 500-year flood plain? Is the municipal or county stream buffer (setback) shown? Is the site in a flooding or erosion prone area?	Show major waterways. Obtain COE/ Missouri Department of Natural Resources permits or documentation before plan approval. Obtain local floodplain Development Permit if applicable Show 100- and 500-year flood plains on map. Show stream buffer. Show areas prone to flooding. Show stream bank erosion areas.
Karst	Are sinkholes, springs or seeps located on the site? What is the depth to bedrock?	Local buffer requirements may apply and should be shown. Show sinkholes, springs, seeps and other karst features. Show areas with shallow depth to bedrock.
Existing Topography	What is the existing topography? Are there areas with slopes steeper than 20 percent? What are the site's soil types? What is the existing stormwater drainage area and flow path?	Show existing topography, identify areas with slopes greater than 20 percent. Show site soil type. Show areas with erodible soils. Show gullies, swales, ditches, etc.
Ponds	Are there existing ponds on or adjacent to the property? Does the pond provide recreational benefits? Does the pond provide flood detention benefits? What is the condition of existing ponds (i.e., depth of sediment in pond, bank erosion, invasive plants)?	Show all ponds on map, including any existing detention basins.
Vegetated Cover	Is the site forested? Are grassy/prairie areas on the site?	Show forest and prairie areas. Show large trees (>12" diameter).
Existing Property Use	What is the site's current use? What buildings, structures and other impervious surfaces are present? Are there utilities through the site?	Show existing impervious areas and utilities.
Surrounding Property Use	What is the surrounding property use?	Show property boundary and surrounding property uses.

Table 4.3: Site Development Goals, Questions and Methods

Goal	Questions	Methods (To the Maximum Extent Practicable)
Minimize the Generation of Stormwater Runoff	<p>Can land disturbance be minimized?</p> <p>Can additional green space be preserved?</p> <p>Can proposed development be located in already developed areas?</p>	<p>Limit clearing, grading, and earth disturbance.</p> <p>Use clustered development with open space designs.</p> <p>Use narrower, shorter streets, right-of-way and sidewalks.</p> <p>Allow smaller radii for cul-de-sacs.</p> <p>Reduce parking space requirements.</p> <p>Preserve and protect forested areas, especially areas with large trees. Show tree preservation areas on plans.</p> <p>Allow for shared driveways and parking areas.</p> <p>Provide incentives for site redevelopment.</p>
	<p>Can stormwater safely flow overland to buffer areas (i.e., avoid piping)?</p>	<p>Grade to allow stormwater to sheet flow into buffer or conservation easement areas.</p> <p>Limit use of curb and gutter streets.</p> <p>Use grass channels for street drainage and stormwater conveyance.</p> <p>Allow roof downspouts to flow overland into vegetated cover.</p>
	<p>Can stormwater be captured and infiltrated into the ground?</p>	<p>Rainwater infiltration systems. Examples include rain gardens, dry wells and other landscape infiltration methods.</p> <p>Emphasize managing stormwater at the point of generation.</p>

Determine Limits of Disturbance

The SWPPP must show the limits of disturbance by outlining all areas on the site map where soil will be disturbed or vegetative cover removed. These areas will require erosion and sediment control best management practices. The permitted limits of disturbance must include all areas of soil that will or may be disturbed to complete the construction project. This includes parking and lay down areas, equipment and material staging or storage areas and areas where the contractor will store borrow or fill material. The SWPPP must also outline areas to be left undisturbed and the locations where protective fencing needs to be installed.

Determine Drainage Areas

When beginning the erosion and sediment control design of a construction site, the contractor should first look at the drainage patterns over the site. If there is land uphill of the site with the potential to discharge stormwater onto the contractor’s site, the contractor should decide whether or not to accept the discharge and whether or not to design controls for the additional area. If the contractor wishes the design to be solely for the stormwater coming from their permitted site, then you must design diversions for the discharge above your site. These diversions are the very first controls put in place and must be totally stabilized prior to any stormwater being allowed to flow into, through or discharge from them. The diversions must not increase the amount of sediment being discharged from the site.

The SWPPP must separately outline all of the drainage areas that occur on the site. The SWPPP must also identify all of the locations where stormwater is discharged off the development site throughout the entire construction project. Furthermore, the SWPPP must identify the points where the development site will discharge stormwater into natural water ways and identify the distance from the permitted limits of the construction project to the water body.

Select Specific Control Measures

Four areas of concern should be evaluated for each drainage area: soil stabilization (erosion control), runoff control (sediment control), pollution prevention and permanent or post-construction runoff controls. Specific practices to control these areas are described in [Chapter 6 - Practice Installation and Maintenance](#). As control measures are selected, identification symbols and a symbol legend should be placed on the site map. Drawings and specifications for all structural practices and vegetation specifications should be included in the plan including information on proper installation, maintenance and inspection of each control measure. Temporary controls need additional information as to how and when the control is to be removed and the area stabilized.

Soil Stabilization/Erosion Control

Erosion control devices include vegetation, mulch and compost, rolled products such as blankets, and any other device that is laid on the disturbed soil surface to cover and protect it from raindrop impact and wind erosion. These devices dissipate the energy from the wind and rain so soil particles are not dislodged and moved in the stormwater flow.

Runoff/Sediment Controls

Sediment control devices slow the stormwater flow and/or temporarily pool the flow to dissipate the energy of the flowing water. Slowing the flow reduces the water's capacity to transport sediment off the site. Devices effective at reducing flow velocity include silt fences, wattles, inlet protection, sediment traps and ponds, check dams, etc. When using these devices for sediment control on the construction site, contractors should consider the effects that temporary pooling of water, or flooding, may have on areas adjacent to the pooling device.

Pollution Prevention

These devices and practices cover good housekeeping, construction exits, concrete washout, masons area, etc. Good housekeeping includes the management of solid waste (trash and debris), sanitary waste, petroleum-based products and hazardous waste. The SWPPP must identify controls for these possible pollutants on the construction site and their proper inspection and maintenance. The SWPPP also must identify the reportable quantities for petroleum and hazardous waste products and discuss the use of a spill kit on the construction site.

Post-Construction Control Measures

It should be stated whether the control is temporary or permanent within the description of each control device. Structural controls that are permanent must also include information on the operation and maintenance of each control after the construction project is complete and the site is fully stabilized. Maintenance requirements should be explained in the post-construction section with the SWPPP. See [Chapter 3](#) for considerations on permanent stormwater control measures.

These permanent devices are not designed for control of sediment as a post-construction device so they should not be put into permanent use until the site is fully stabilized and there is no threat of erosion or sediment discharge from the site. If devices are to be used during both stages of construction, the device must be fully cleaned of sediment deposits and retrofitted as a post-construction device after the entire site is fully stabilized and there is no hazard of soil erosion occurring. It is very important to coordinate transition from construction site best management practices to post-construction stormwater control measures, especially where newer green infrastructure and low impact development practices will be installed.

Schedule Construction, Stabilization, Inspection and Maintenance Activities

The three main scheduling items required are a construction schedule, a stabilization schedule and an inspection and maintenance schedule. A schedule should also be followed for terminating the project and closing out the permit.

Construction Schedule

The construction schedule must explain in an orderly fashion what will occur from the beginning to the end of the project. This includes both the sequence of the land disturbing activities and the sequence of controls that need to be in place before each of those activities begin. The installation sequence of control practices and structures is a critical factor in controlling erosion and sediment loss on the construction site.

Phasing of site grading is an important element of the schedule. Sediment basins, diversions and conveyance systems, whether temporary or permanent, should be installed either before grading begins or very early in the rough grading process. These practices must be stabilized immediately after they are constructed in order for them to function properly and to prevent structure failure leading to additional erosion and sediment discharge from the site. The sequence of rough grading and temporary stabilization should be indicated for each area to be graded.

The schedule should indicate the control practices to be used if grading is suspended for an extended period of time (seven to 14 days or more depending on slope and distance to waterway). In areas without sediment traps, temporary structures to divert water from cut and fill slopes, temporary seeding with mulch and tackifier or other practices should be used to stabilize the exposed soil surface.

The SWPPP must indicate the planned times and practices for final stabilization, using seed with mulch or using sod. Final stabilization should occur as soon as practicable following final grading.

Stabilization Schedule

The stabilization schedule shows the allowable times for seeding and placing sod to ensure successful vegetation establishment and soil protection (See [Temporary and Permanent Seeding](#)). An example is shown in Table 3.1. It should identify the plant species or variety, seeding dates and seeding rates. If alternate species or times are listed, this chart can be used to schedule soil surface protection activities even if the planned construction schedule falls behind. The stabilization schedule should follow closely with the construction schedule. The seeding schedule may also provide for temporary stabilization with annual ryegrass or tackified mulch, if grading is unexpectedly suspended and a permanent seeding cannot be established.

Table 4.1 Example of a Seeding Schedule

Stabilization Type	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT
Permanent Seeding with Mulch Turf fescue: 80 lbs/acre	Acceptable	Optimum	Acceptable			Acceptable	Optimum	Acceptable
Temporary Seeding with Mulch Annual Ryegrass: 75 lb/acre	Optimum	Optimum			Acceptable	Optimum	Optimum	
Mulch with Tackifier (no seed)				Optimum	Optimum			
Fescue or Zoysia Sodding*				Optimum	Optimum			

* Ground must be moistened to cool soil temperatures before sod is laid. Use only fresh, good quality sod. Irrigate to soil depth of 4 inches immediately after installation and for the first four weeks, or until sod is well established.

Table Key

	Optimum Seeding Times
	Acceptable Seeding Times

Information on seeding rates and types of vegetation is available in [Chapter 5](#) within Table 5.3. You may also contact your county soil and water conservation district for proper vegetation and seeding rates for your area. Remember, you may need to modify the seeding information provided in the SWPPP if the construction schedule changes, therefore changing the time of year you will be installing temporary or permanent vegetation.

Inspection and Maintenance Schedule

The inspection and maintenance schedule is a plan for all temporary and permanent erosion, sediment and stormwater control measures throughout the construction project. This written plan should specify the inspection programs as required in the general permit. It should indicate the work materials and equipment to be used, who is responsible and when inspections and maintenance will be provided.

Inspections are necessary immediately after each phase of construction and storm event, as well as periodic inspection and maintenance to ensure proper functioning of control measures. You should schedule inspections after every rain producing runoff for controls that detain, store or convey stormwater. Work time should be accounted for in the schedule to make immediate repairs to damaged areas and control structures.

Inspection and maintenance should be scheduled for structures such as sediment basins and ponds that require regular cleanout in order to keep them working effectively. Sediment should be removed if it has reached one-half of the designed capacity for sediment storage.

The use of vegetation for erosion control purposes also requires a regularly scheduled maintenance program to repair seeded, sodded or other vegetated areas where the desired degree of stabilization has not been achieved. All seeded areas should be checked for plant emergence and density two to six weeks after planting. Spring plantings should be inspected again during the summer or early fall so reseeded can be performed as necessary during the fall planting season.

The SWPPP inspection and maintenance section should also describe who is responsible for inspections and maintenance of all post-construction BMPs after the land disturbance permit coverage is terminated and the permanent devices are functioning as operational water quantity and quality control devices. After the project is complete, proper stabilization has been achieved according to the general permit and inspection and maintenance of permanent practices have been properly passed off to responsible parties, the project closure should include a termination of coverage of the land disturbance permit using [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 for Missouri Department of Natural Resources (see [Chapter 1: Permit Coverage Application Forms and Fees](#)).

Making the SWPPP Work

Even the best SWPPP cannot cover the specifics of each situation that will arise on a construction site during the life of a project. It is the contractor's or site operator's responsibility to make sure the site complies with the goals and intent of the SWPPP at all times. The SWPPP should show the practices to be in place at the start of construction as well as when the site design is at full build out.

The Missouri Department of Natural Resources Land Disturbance general permit states that the permittee must amend and update the SWPPP as appropriate during the term of the land disturbance activity. The SWPPP should record all land disturbance activities from the beginning of construction to the end with the date of occurrence. This would include the installation of best management practices and their removal or conversion into permanent post-construction stormwater control measures. This can be accomplished by a site activity log or notes on the site maps or a combination of both.

The site map should reflect the current activities at the site at any time throughout the construction project. The first records on the site map should include the installation locations and dates of the perimeter BMPs prior to clearing and grading and the location of the trailer, laydown and parking areas. The clearing and grading areas with appropriate dates should then be recorded. As work progresses additional notes should be made for cut areas, fill areas, utility installation, pouring footings and building pad, areas of temporary and final stabilization, etc. The last records on the site map should include the dates when temporary BMPs were removed and those areas stabilized. The last piece of record keeping at the very end of the project is for the permittee to sign and submit [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409, which will terminate coverage under the general permit. The site must be fully stabilized and all temporary BMPs removed.

The SWPPP is now complete and must be kept in the records for three years from the date the Form H was submitted to the Missouri Department of Natural Resources. Submittal of [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 is often overlooked, but is an important requirement of the permit. If coverage under the general permit is not terminated, the permittee could continue to be held accountable for activities presumably associated with the permit.

Design Do's and Don'ts

The erosion and sediment control industry is constantly evolving to meet the demands of heightened public awareness of erosion and sediment control issues and regulatory requirements. In the 1970's, ponds were used as sediment basins, geotextiles as silt fence, straw bales as sediment barriers and rock as construction exit pads. Best management practices have evolved significantly since 1992 with the Phase I and II NPDES requirements. There has been extensive research on many of the devices mentioned in this guide, as well as newer products and devices. Designing an up-to-date SWPPP may be challenging because information and technology is constantly changing. Following are three long-standing design practices for which the method of implementation has evolved and where confusion might still exist while planning the use of the BMPs on a construction project.

Straw Bales

Straw bales have been proven to be very ineffective for sediment control. They are difficult to install correctly and do not last very long. EPA does not support the use of straw bales as an effective control for sediment on a construction site. They should never be used in concentrated flow channels as check dams or as inlet protection. If used at all they may be effective if installed properly on very flat, small areas where erosion control for the soils is also incorporated over the area.

Silt Fence

Silt fence is another device that should never be used in concentrated flow channels or as an inlet protection device. Remember when using silt fence as a sediment control device, there is the potential during heavy storm events where several feet of stormwater flow may pond behind the device causing flooding of the area. This can create significant damage and cause the device to fail.

Another misuse of silt fence is in the area of perimeter control. One requirement of the construction general permit is to maintain perimeter control. Controls must be in place along the perimeter where stormwater flow exits the permitted area, not the entire perimeter. Silt fence should only be placed along the contour and not up and down slopes, at the top of the hill or any other area that does not directly discharge stormwater flows. When silt fence is not

placed directly on the contour, the storm flow will follow the fence as it travels downhill, picking up volume and velocity. This will increase the chances of a blow out at the lowest point due to the increase of concentrated flow to the area. As a SWPPP designer, remember that sediment control devices slow the flow and pond the water and should not cause flooding. Silt fence has the capability to pond two or three feet of water and sediment behind it, and damage from flooding could occur.

Short Circuiting

The discharge point of the pond should not be located near the point where sediment laden stormwater enters the pond. Pondered water is a great energy dissipation device for sediment control (as long as it does not cause flooding). When sediment laden stormwater enters pondered water, the pondered water acts as an energy dissipater and the heavier sediment particles settle out at the entrance to the pond. With additional time the lighter particles in suspension will also settle out to the bottom of the pond. For this reason the discharge point of the pond should not be located near the point where sediment laden stormwater enters the pond. If the inlet is close to the outlet particles may not have sufficient time to settle to the bottom before being discharged, creating a condition called “short circuiting”.

The longer the traveling time for the water between the inflow and outflow the better the pond will function as a control device. If the pond is short circuiting because the inflow and outflow are too close together, it will not function well as a sediment control device. If due to space and topography, there is no way to design for the inflow into the pond to be as far away as possible to the outflow then design for a baffle wall or weir to be built between the two pipes so the entire pond is used as a control device.

Additional Resources

A Builder's Guide to Low Impact Development –National Association of Home Builders Research Center www.lowimpactdevelopment.org/lid%20articles/Builder_LID.pdf

Examples of Green Infrastructure and Design Approaches – EPA
cfpub.epa.gov/npdes/greeninfrastructure/technology.cfm

Green Infrastructure Center
www.greeninfrastructurecenter.org

Low Impact Development Center
www.lowimpactdevelopment.org/

Low Impact Development for Stormwater Management – Toolbase Services
www.toolbase.org/Technology-Inventory/Sitework/low-impact-development

Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices
www.epa.gov/owow/nps/lid/costs07/

CHAPTER 5

INSPECTION FOR EROSION, SEDIMENT AND STORMWATER CONTROL

The Inspection

On-site inspections are necessary on a regular basis and after rain events to assure the proper functioning of soil erosion, sedimentation and stormwater control measures. Missouri Department of Natural Resources and certain local governments require the permittee or a representative of the permittee to conduct regular inspections every seven calendar days and within 48 hours of a rainfall event resulting in runoff from the site. The inspections shall be conducted by a person responsible for environmental matters at the site or a person trained and directly supervised by the person responsible for environmental matters at the site.

It is recommended the inspector be certified or properly trained. See training and certification information provided at the end of Chapter One in this document. If the site is also under an MS4 permit program, refer to the local inspection requirements and make sure they are also met. For a current list of regulated MS4s, visit www.dnr.mo.gov/env/wpp/stormwater/sw-phaseii-communities.pdf

All inspections should be documented by written reports, logs or checklist sheets.

These reports should contain:

- The inspector's name and qualifications.
- Date and time of inspections.
- Dates when grading the site or phase of the site began.
- Comments concerning the success of each practice.
- What corrective action may be needed.
- A list of areas where land disturbance operations have permanently or temporarily stopped.
- Any verbal communications that took place as a result of the inspection.

The inspection report shall be signed by the person designated in the SWPPP to conduct the inspections. An example of an inspection report is provided at the end of this chapter.

Site inspectors need to be knowledgeable in erosion, sediment and stormwater control principles and the installation, function and maintenance of such practices. If additional training is needed, then Missouri Department of Natural Resources' regional office, the local Soil and Water Conservation District USDA, Natural Resources Conservation Service office, or local government planning or engineering departments may be able to provide technical assistance. Also refer to the training and certification information provided at the end of [Chapter 1](#).

The inspector should have a copy of the SWPPP with drawings and specifications for all practices. This should include information on the amount of allowable sediment accumulation, design cross-sections, freeboard requirements and location of spoil areas.

The inspector may want to review the example inspection form before inspecting the site. Care should be taken to inspect all aspects of compliance with the state land disturbance permit as well as any local requirements that apply to the site. This includes all paperwork, updates and maintenance of the SWPPP or erosion and sediment control documents, public posting signage and BMPs. When listing the BMPs that are to be inspected, the inspector should include the good housekeeping practices required for trash dumpsters, designated concrete washout areas, portable toilets, petroleum and other chemical storage areas, etc.

After the inspection is complete and all deficiencies are noted on the inspection report, the inspector should document and communicate his/her findings to those responsible for each deficient BMP, explain what needs to be remedied, identify where it is located and determine a deadline for the correction. The inspector will also need to use, or provide the information necessary, in updating the SWPPP and site map on any changes that have occurred on the site since the last inspection. Most importantly, whenever an inspection notes a deficiency, the inspector should verify during the next inspection that corrections were made, and note when each previously noted deficiency was repaired.

Any deficiency noted on an inspection report must have a subsequent report which indicates that each deficiency was repaired or fixed within seven calendar days as required in the Missouri DNR and/or local land disturbance permit.

The inspector should refer to the details in the SWPPP and [Section 6](#) of this guide to evaluate BMPs for correct installation, assess whether they are functioning effectively and determine how to remedy deficiencies in the implementation of the SWPPP. The inspector should consult with the SWPPP designer to resolve observed chronic erosion or sediment issues and let the designer know about observed ineffectiveness of any hydrologic control measures such as drainage channels or swales, check dams, ponds, culverts, etc.

Regulatory Inspections

Regulatory inspectors from EPA, Missouri Department of Natural Resources or a local agency may visit a construction site that has obtained permit coverage through their respective land disturbance permit program. The regulatory inspectors are authorized to inspect the permitted site for compliance with their regulatory program. A regulatory inspection report may include any of the following information:

- The inspector's name and the agency they represent.
- Who is accompanying the inspector on the site evaluation including other regulating agency or construction site personnel.
- Notes on deficient or missing paperwork or SWPPP requirements.
- Notes on BMP deficiencies including missing controls identified in the SWPPP, those requiring maintenance, or those that appear to be ineffective in erosion and sediment control.
- Notes on any other concerns or insufficient implementation of elements required under their stormwater permit program.
- Photo documentation.

The construction personnel may obtain helpful information and education from the Missouri Department of Natural Resources to assist in performing in a compliant manner. The department may provide guides and manuals available to assist the construction personnel identifying options for achieving the best results at the site.

The permittee may also receive advice from the department on ways to enhance the use of erosion control techniques as outlined in the SWPPP designed for the site. If the SWPPP is inadequate or practices prove to be ineffective, the inspector should advise the permittee to upgrade the SWPPP to incorporate other best management practices such as those found in documents referenced in the Missouri Department of Natural Resources' land disturbance permit. If appropriate, the inspector may provide a list of alternative BMPs to consider when pursuing correction. The regulatory inspector should avoid prescribing specific practices.

Example Inspection Scenarios



Figure 5.1 Grass Planted on a Cut Slope. Source: *ASP Enterprises, Inc.*

This cut slope was planted with fescue. In this example, there are clumps of grass with erosion between the clumps. A notation of “Insufficient vegetation” in the inspection report would identify the unacceptable condition, but does not completely explain what is needed to correct the problem. Just reseeding this area will not fix the erosion occurring on the slope. The inspector needs to look to the root of the problem. There is no erosion control protecting the slope and seed. Seeding the slope and protecting with an erosion control blanket or sod might be appropriate for this slope. Minor regrading may be necessary to remove existing rills. Vegetation does not provide effective erosion control until it is fully established with a uniform density of at least 70 percent. Another revegetation problem identified in this image is the presence of hard packed gray subsoil instead of good topsoil. This is a common problem on many cut slopes. The inspector may want to note on their report to test the soil for percent organic matter and its cation exchange capacity to ensure the soil can sustain vegetative growth. In lieu of correcting any topsoil deficiencies and reseeding, the contractor may be able to achieve effective erosion control on low to moderate slopes by covering the area with mulch.

This inlet protection device has been damaged and is in need of repair. A notation in the inspection report such as “repair inlet”, does not identify the source of the problem. The inlet was damaged by an uninformed contractor so the root of the problem is education and communication with the contractors at the site. Education about the importance of the devices and an understanding of the shared liability when non-compliance issues arise would help deter damage to the devices. It would at least increase the chance that the device would be repaired immediately.



Figure 5.2 Broken Inlet Protection. Source: ABC's of BMP's

Here is an inlet device that was properly installed. So what is the problem? Remember that inlet devices are designed to block the flow of stormwater from entering the storm sewer system. They will pond the flow, dissipate the energy, settle out the sediments and allow the cleaner stormwater to leave the site. This is good, however, the silt fence has a low porosity and during a heavy rain event may pond up to two feet of water around the inlet. If that happens at this location it will create flooding in the



Figure 5.3 Inlet Protection Results and Consequences Source: ABC's of BMP's, LLC

street because the device is located at an intersection. The problem with the implementation of this BMP has nothing to do with installation and maintenance but rather the choice of control devices. With additional erosion control and soil stabilization around the inlet, especially in the roadside ditch or swale to the inlet, the contractor could remove the silt fence and only block the lower half of the inlet with a wattle type product. There are many control choices when it comes to inlet protection but the contractor should think about the consequences of the device chosen. When the flow through an inlet is restricted, more ponding will occur resulting in better sediment removal but at greater risk of the possible flooding. Conversely, a device that ponds less stormwater, but provides less treatment of the stormwater prior to discharge and increases the risk of releasing sediment off-site.

Stormwater Construction Site Inspection Report

As an inspector it is critical to understand not only the deficiency but also what caused it so the problem can be corrected. The following examples will look at deficiencies and what needs to be done to correct them.

General Information		
Project Name		
Permit Tracking No.		
Date of Inspection		
Inspector's Name(s)		
Inspector's Title(s)		
Inspector's Contact Information		
Inspector's Qualifications ¹		
Describe present phase of construction		
Type of Inspection: <input type="checkbox"/> Routine <input type="checkbox"/> Pre-storm event <input type="checkbox"/> During storm event <input type="checkbox"/> Post-storm event		
Weather Information		
Has there been a storm event since the last inspection? <input type="checkbox"/> Yes <input type="checkbox"/> No		
If yes, provide: Storm Start Date & Time: Duration (hrs): Approximate Amount of Precipitation (in):		
Weather at time of this inspection? <input type="checkbox"/> Clear <input type="checkbox"/> Cloudy <input type="checkbox"/> Rain <input type="checkbox"/> Sleet <input type="checkbox"/> Fog <input type="checkbox"/> Snow <input type="checkbox"/> High Winds <input type="checkbox"/> Other:		
Temperature:		
Discharge Information		
Have any storm water discharges occurred since the last inspection? <input type="checkbox"/> Yes <input type="checkbox"/> No		
If yes, describe:		
Are there any storm water discharges occurring at the time of inspection? <input type="checkbox"/> Yes <input type="checkbox"/> No		
If yes, describe:		

Documentation

On-Site Documentation			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Is the SWPPP on-site and up-to-date?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the SWPPP properly signed and certified?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is a copy of the LD permit available at the site?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is a copy of the signed permit authorization or coverage available on site?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Are all applicable documents available and readable on the public posting sign near the entrance of the site?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Are the clearing, grading or excavating activities recorded and kept with the storm water plan?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the SWPPP site map, being updated with dates and locations of grading activity and locations of port-a-potties, trash dumpsters, stockpiles, fuel tanks, etc.?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Have all BMPs action items, identified in the last inspection report, been addressed?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Structural Controls

Silt Fence or Other Perimeter Type Device			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Properly installed (tied, trenched and jointed correctly)?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Stakes installed correctly and properly spaced?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is maintenance or repair required? (holes, tears, fabric off stakes, fence down or removed, etc.)	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Does the accumulated sediment exceed the level allowed in the permit?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is silt fence receiving concentrated flows? If yes, alternate BMP proposed?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Wattles			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Properly installed by being trenched and jointed correctly?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Stakes installed correctly and properly spaced?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is maintenance or repair required?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Does the accumulated sediment exceed the level allowed in the permit?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Structural Controls

Diversion/Swale/Channel Conveyance			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Properly stabilized with erosion control blanket, turf reinforcement mat, or vegetation?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Velocity of flow through channel is not causing erosion or scour? If scour or erosion due to high velocity, consult designer.	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is maintenance or repair required?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Check Dam			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Installed, spaced and operating properly? (no cutting around edges or scour due to high velocity)	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is maintenance or repair required?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Does the accumulated sediment exceed the level allowed in the permit?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Storm Drain Inlet			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Selected, installed and maintained correctly? Identify storm drains that require cleaning or maintenance.	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the device creating a flooding situation during rain events? Consider alternative solutions.	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Sedimentation Pond or Trap			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Are ponds located and built according to the SWPPP?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Are the banks of the pond stabilized?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is accumulated sedimentation below the max level allowed in the permit?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the overflow structure installed per design?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is there evidence of sediment discharge?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Energy Dissipation Outlet From Pipe, Pond, Trap or Dewatering			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Properly installed and working correctly with no visible scour or erosion?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Has rock been dislocated downstream?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Active Treatment System			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Is there sufficient polymer material?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Do deposited sediments need to be removed?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Pipe Slope Drain			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Properly installed according to the plan?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Working correctly?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is maintenance or repair required?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is there any scour or piping at top, around or at discharge of the pipe?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Soil Stabilization

Buffer Requirements			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Are any buffer zones required by the SWPPP being preserved?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the vegetation healthy, dense and effective?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is there sediment deposition within the buffer zone?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Temporary Stabilization			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Has temporary stabilization been completed within timeframe specified in the permit?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the vegetation established sufficiently to reduce or eliminate erosion?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Are the stabilized banks, stockpiles and borrow areas on/offsite being maintained and/or repaired?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Has temporary seeding been mulched or otherwise protected?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Temporary Stabilization			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Has temporary stabilization been completed within timeframe specified in the permit?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the vegetation established sufficiently to reduce or eliminate erosion?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Are the stabilized banks, stockpiles and borrow areas on/offsite being maintained and/or repaired?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Has temporary seeding been mulched or otherwise protected?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Rolled Erosion Control Devices			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Is the device installed correctly with proper overlap, toed in, and staples?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the device laid on a smooth soil surface with no clods or tenting?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is there evidence of soil movement below the device?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Has the device been moved, torn out or become dislodged?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Mulch or Compost			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Is the soil completely covered and protected?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Has the product been moved or displaced by the storm water flow?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Pollution Prevention

Concrete Washout			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Located according to the SWPPP and location shown on site map?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Built according to SWPPP?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the washed concrete being contained and area maintained?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is the washout pit or device full and in need of clean out?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Stabilized Construction Exit			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Is there evidence of off-site tracking?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Built according to SWPPP?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is maintenance or repair required?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Wash water properly contained, treated and disposed of?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Good Housekeeping and Waste Disposal Practices

BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Are fuels and other chemicals being properly stored and contained?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Material storage BMPs functioning correctly?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Trash and debris cleaned up, stored in appropriate containers and disposed of properly when removed from site?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Porta-potties or other sanitary waste receptacles properly managed?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is mason's area properly maintained?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Paint wash properly managed?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Truck and other equipment fueling area properly managed?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is there any evidence of or have there been any spills of petroleum or hazardous waste?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
If so, is the spill at or above the reportable quantity noted in the SWPPP?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is dust control being performed according to SWPPP?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Stormwater Discharge Evaluation

Off-site Accumulation of Sediment or Any Non-Storm Water Discharges

BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Is there evidence of sediment in storm water discharge?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is there evidence of sediment in the waters downstream from the construction site?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Are the number and location of outfalls consistent with the SWPPP? Update SWPPP as needed.	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Are velocity dissipation devices at discharge locations preventing erosion of stream banks and receiving waters?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Checklist for Terminating Permit Coverage

Termination Requirements			
BMP/activity	Implemented?	Required Maintenance	Corrective Action Needed and Notes
Is site stabilized in accordance with the SWPPP and LD permit?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Has 70 percent density of vegetative cover been achieved?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Is there any evidence of erosion?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Have temporary erosion control measures been removed and that area stabilized?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Have permanent ponds been cleaned of sediment accumulation and sediment properly disposed of?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Have all fuel and waste containers been removed and/or properly disposed of?	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

Inspection Report certification Statement

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.”

Print name and title: _____

Signature _____ Date: _____

CHAPTER 6

INSTALLATION AND MAINTENANCE OF BEST MANAGEMENT PRACTICES

Introduction

Changes made to the land during construction have far reaching effects, both on and off the construction site. Contractors can make important contributions to protecting water quality by installing the appropriate practices. Because of the many potential effects on the local ecosystem, the services of qualified engineering, design and environmental professionals are necessary in the land grading and construction activities associated with developing a site.

This chapter describes practices to help prevent or minimize erosion and sediment movement and pollutant discharge from a construction site. Remember also that pollutants can move through the soil on the construction site, enter shallow groundwater directly and contaminate drinking water supplies. This can be prevented by cleaning up the site before construction begins and by preventing pollutants from entering the site.

Use of Sections in This Chapter

This chapter provides general information on practices and controls. (For more detailed BMP design criteria, refer to the design manuals listed below.) This chapter is organized in sections by the type of controls and the practice or the function they provide.

The first section is Site Preparation, it covers practices and procedures that should be operational prior to land clearing and grading, such as construction exit pads and wheel wash structures as well as practices to install as topsoil is removed and grading begins.

The second section, titled Pollution Prevention and Good Housekeeping, includes those types of devices and site practices employed to reduce or eliminate pollutants other than sediment from discharging from the construction site. This would include solid waste, sanitary waste, petroleum or hazardous waste, concrete wash water and other pollutants.

The third section discusses surface stabilization or erosion control techniques that are necessary as soon as possible following land disturbing activities. Most erosion control devices work by dissipating the energy in the raindrop to reduce the potential for soil to be dislodged during a storm event. However, there are a wide range of surface stabilization options available depending on the function they need to perform.

Remember that erosion controls are preventive measures to keep soil in place, whereas sediment control devices are remediation measures for sediment that is moving with the stormwater flow.

Section four discusses runoff or sediment controls. These types of controls work primarily by slowing the flow and ponding the stormwater. This dissipates the energy in the flowing water so suspended sediment can settle out of the water and not leave the construction site. This results in treated or cleaner stormwater leaving the site.

Section five of this chapter includes any practice installed during construction that is designed as a permanent feature to control the stormwater discharge for quantity and/or quality once the site is fully stabilized and operational (post construction stormwater control). These permanent devices are built during the construction phase of the project but are not typically put into use until after construction is complete and the site is stabilized. Today's stormwater management goals require permanent practices that control stormwater quality as well as quantity. The site manager or job foreman should be aware of all planned post-construction measures designed for this purpose.

The site superintendent can refer to [Section 5](#) of this chapter for a better understanding of permanent water quality devices shown on site plans, in addition to understanding placement of stream buffers and the placement of stormwater control measures. To differentiate from temporary (during construction) controls, permanent/post construction controls will be referred to as Stormwater Control Measures, or SCMs, and not BMPs which refer to temporary controls. This section will also discuss how to retro-fit controls from use as a sediment control during construction to a post-construction operational or SCM control. This discussion will include timing of the construction and functioning of these types of control devices.

Each section in this chapter has an index tab, so that finding the practice is easier. To help the contractor, site manager, job foreman or inspector, each section is broken into the following six basic components.

Practice Description

Defines the practice, describes where and for what it is used, and may include other basic information.

Recommended Minimum Requirements

Gives some suggested specifications or requirements for the practices that should be respected as minimums. However, this is only a guide and any required design standards should be followed. This part also suggests either a qualified or registered design professional (see [Glossary](#)) be the designer of the practice. Note: Site specific designs for the watershed, topography and soils may dictate more restrictive requirements.

Construction Installation

Gives step-by-step procedures for installing the practices, with a construction verification checklist at the end. For some practices, several options are given. (e.g., Soil Bioengineering for Slope Protection covers nine different practices).

Maintenance, Inspection and Removal

Designed to help the site manager or a designated employee ensure that needed inspections and maintenance activities are completed.

Common Problems and Solutions

Lists problems that are often found on sites and recommendations for solutions. Many of the common problems can be avoided by using the recommended minimum requirements and following the construction sequence. This tips can also be used to troubleshoot problems and when the design professional may need to be contacted.

Design Manual References

Reference manuals to be followed for design plans and specifications include but are not limited to the following:

Georgia Stormwater Management Manual, Atlanta Regional Commission, August 2001.
www.georgiastormwater.com/

Kansas City APWA Standards and Specifications BMP Manual
kcmetro.apwa.net/chapters/kcmetro/specifications.asp

Low Impact Development Manual for Michigan: A Design Guide for Implementers and Reviewers
SEMCOG 2008 www.semcog.org/lowimpactdevelopmentreference.aspx

Manual of Best Management Practices for Stormwater Quality March 2008, Mid America Regional Council. kcmetro.apwa.net/chapters/kcmetro/specs/APWA_BMP_Manual_Mar08.pdf

Maryland Stormwater Design Manual, Volumes I & II, Maryland Department of the Environment, 2000. 2009 Revised. Maryland Department of the Environment, Baltimore, MD.
www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp.

Springfield Storm Drainage Criteria Manual draft 2007. Wright Water Engineers,.
www.springfieldmo.gov/stormwater/developer.html

The Minnesota Stormwater Manual, Version 2 November 2005, Minnesota Pollution Control Agency, <http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html>

SECTION 1: SITE PREPARATION

Before construction begins, the construction manager, site superintendent or job foreman should meet with the design professionals and be supplied with a complete SWPPP or Erosion, Sediment and Stormwater Control Plan including a narrative description of the site and environmental conditions, detailed site map, construction/grading schedule, seeding schedule and maintenance/inspection schedule.

The construction manager, site superintendent or job foreman should review all federal, state and local regulations and understand completely the consequences of violations including but not limited to fines and imprisonment. Invite a local Missouri Department of Natural Resources representative to a preconstruction meeting if there are questions regarding the regulations. Invite all land disturbing contractors to the meeting.

Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.

Caution should be given to placing BMPs near streets. The drainage patterns in the vicinity of and around streets in new developments should be carefully studied so that the design or construction of BMPs will both meet local requirements and prevent any major flooding, sediment accumulation, traffic interruptions, or road damage during significant storm (design) events.

Post-construction practices today do not mean what they did in the 1970s when it was mostly about water quantity. Refer to [Section 5](#) of this chapter for a complete discussion about post-construction measures that address both quantity and quality. The site manager or job foreman should also be aware of all planned post-construction measures. Many of today's state-of-the-practice post-construction features such as rain gardens, infiltration trenches and bioswales are incorporated into the initial site design. Their ultimate placement and function need to be considered throughout the construction phase in order to avoid roadblocks to implementation. See [Section 5](#) for more detail.

For more information on environmental site design for the development plan and operation and maintenance considerations, see [Missouri Guide to Green Infrastructure: Integrating Water Quality into Municipal Stormwater Management 2011](#).

Temporary Rock Construction Exit Pad



Figure 6.1 A temporary rock construction exit can reduce sediment and resulting safety hazards on public streets. This pad needs maintenance due to sediment filling the void spaces between the rocks making the rock exit pad ineffective. Source: ABC's of BMP's, LLC

Practice Description

A temporary rock construction exit is a stone base installed to provide an exit area where construction vehicles can drop the mud and caked soil from their tires to avoid transporting it onto public roads. The mud and dirt that ends up on the street is called “track out” and is the number one complaint associated with construction projects. The rock will jar and flex the tire treads so dirt and mud on the tires will become dislodged and collect in the voids of the rock exit pad. This device should be incorporated anywhere traffic will be leaving a construction site and moving directly onto a public road or other paved area.

The rock exit pad is often not effective by itself and requires a lot of maintenance. High-clay content soils may not adequately separate from the tires, and the rocks must be reconditioned as void space is filled with sediment. You may need to install additional practices, some of which are described below. Superior practices may be available in the construction industry, although the temporary rock construction exit pad is most commonly used.

Prior to the start of construction, temporary rock construction exit pads should be designed by a qualified professional. The site superintendant and field personnel should refer to plans and specifications through the construction process.

The design professional should give consideration to the following:

- Limit the points of entrance and exit to the site.
- Designate combination or single purpose access points to the construction site, and require all employees, subcontractors and others to use them.
- Properly grade each construction entrance and exit to prevent runoff from leaving the construction site.
- Route runoff from a stabilized pad through a sediment-trapping device before discharge.
- Design the pad to support the heaviest vehicles and equipment that will use it.
- Avoid placing the exit pad in low areas where stormwater accumulates or discharges off-site.

Recommended Minimum Requirements

Aggregate Size

2- to 3-inch washed stone.

Pad Design

- Thickness: 6 inches minimum.
- Width: 12 feet minimum or full width of roadway, whichever is greater.
- Length: 50 feet minimum.

Signage

Clearly designate these areas to be used for exiting the construction site and make sure everyone involved with the project is aware that track out is not tolerated.

Wheel Wash (Optional)

Level the area with a minimum of 3 inches of washed stone. Remember if a wheel wash station is installed, all wash water must be collected and treated before it is discharged from the construction site. A simple sediment trap can be added next to the rock pad to collect the wash water and allow it to discharge over a check dam and into the road ditch. See additional information on wheel wash devices later in this section.

Geotextile Fabric

An underliner of woven geotextile (fabric) should be used under the rock to provide stability.

Construction

Avoid locating on steep slopes or at curves on public roads. If possible, locate where permanent roads will eventually be constructed. Limit the number of access roads to limit the inspection and maintenance of these devices and areas where sediment could be tracked onto public roads.

Site Preparation

Remove all vegetation and other unsuitable material from the foundation area; grade and crown for positive drainage. If wheel washing is indicated, provide a sediment trap adjacent to the rock pad to collect the discharged wash water for treatment before it is released off-site.

Grading

- If the slope towards the road exceeds 2 percent, construct a 6- to 8-inch high ridge with 3:1 side slopes across the foundation approximately 15 feet from the entrance to divert runoff away from the public road.
- Place geotextile filter fabric on the graded foundation to improve stability.

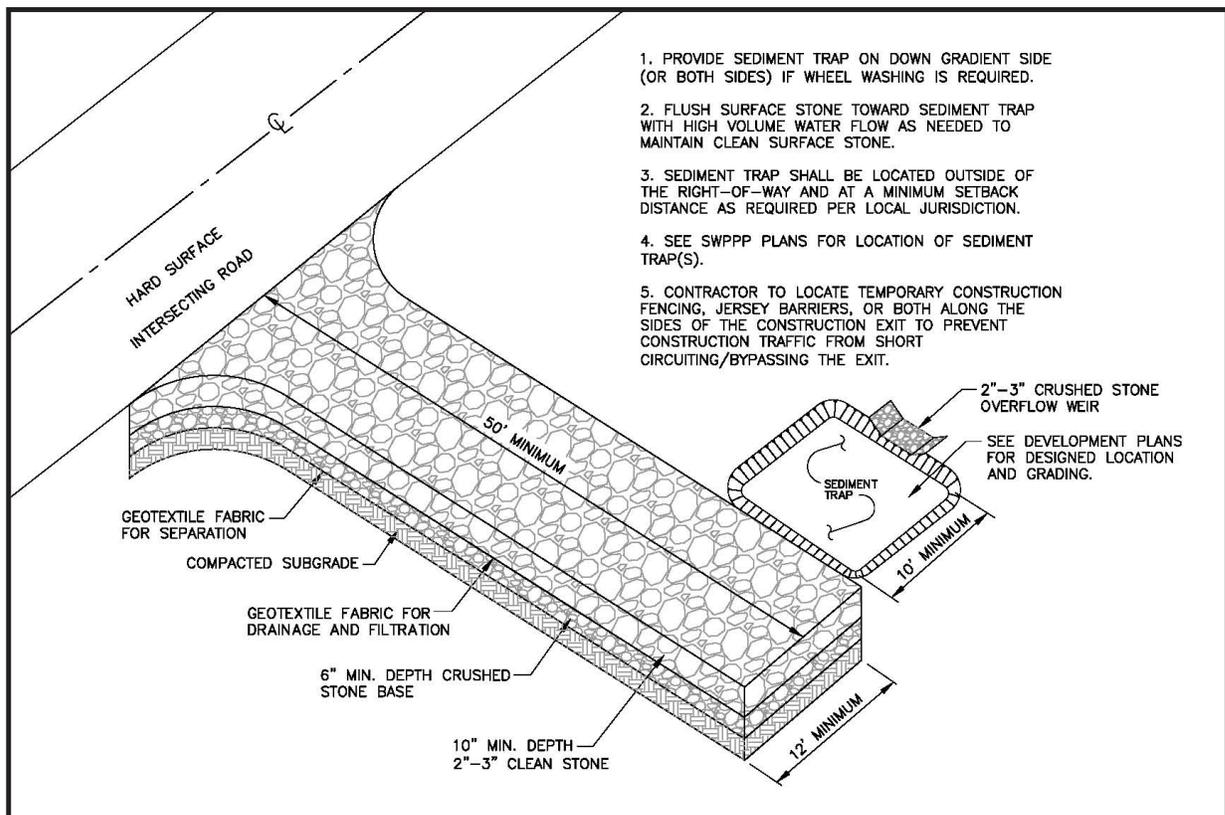


Figure 6.2 Typical Temporary Rock Construction Exit. Source; BFA Inc.

- Place stone to dimensions and grade shown on plans. Stone size should not be less than 2 inches or greater than 3 inches. Stones in the dimensions of 4- to 6-inches may become trapped between the dual tires on some construction vehicles and be transported off-site to later be thrown from the trucks tires and cause damage to vehicles or their drivers. Leave the surface smooth and sloped for drainage.
- Divert all surface runoff and drainage from the stone pad to a sediment trap or basin.

Maintenance, Inspection and Removal

- Inspect stone pad and sediment disposal areas weekly and after storm events or heavy use. When the voids between stones are filled with sediment or the pad becomes smooth and does not function to jar the truck and flex the rubber, it is not functioning properly and should be repaired. Add more rock or turn the existing stone over to move sediment below the stone so the stone pad will again have proper roughness and void spaces.
- Reshape pad as needed for drainage and runoff control.
- Topdress with clean 2- to 3-inch stone as needed.
- Immediately remove mud or sediment tracked or washed onto public road within 24 hours.
- Keep all temporary roadway ditches clear.
- Repair any broken road pavement immediately.
- Remove this temporary device and stabilize the site stabilized prior to filing [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Inadequate runoff control; sediment washes onto public road.	Install diversions or other runoff control measures.
Stone too small, pad too thin or geotextile fabric absent; results in ruts and muddy conditions as stone is pressed into soil.	Increase stone size or pad thickness, or add geotextile fabric. Stone should not be more than 4-inches in diameter, to avoid rocks being caught and thrown from dual tires.
Pad too short for heavy construction traffic.	Extend pad beyond the minimum 50-foot length as necessary.

Wheel Wash



Figure 6.3 Industrial wheel wash unit with self contained and recycled wash water. Source: *Innovative Equipment Solutions*.

Practice Description

A wheel wash device can consist of a range of tools from a simple compressor, hose and water source to a large scale industrial truck wash system. A wheel wash is designed to complement the rock construction exit pad to reduce the amount of sediment that might leave the construction site via construction vehicle traffic. Several portable wheel wash systems are available on the market today.

Recommended Minimum Requirements

While the installation of a wheel wash on the construction site will minimize mud tracking onto the roads, it is necessary to collect and treat the wash water to keep it from discharging off-site. Whatever type of wheel wash device is used at the construction site, a collection of the wash water is required in the form of a sediment trap or other such device. The water must be allowed to settle so the sediment is retained on-site and the treated water is allowed to discharge.

The size of the device and quantity of wash water will depend on the quantity and size of trucks treated. Some devices such as the one pictured above have self contained wash water collection systems that do not discharge the runoff.

Construction

Whether you install a portable wheel wash, or construct one on-site, you will need a water source and a collection system for the wash water. How the wheel wash is constructed and installed will depend on the type of system used. Make sure the installation of the system allows for a drip area between the device and public road so as little as possible of the wash water is transported to the public road to decrease wetting of the road. This is extremely important in cold weather when freezing is a possibility and the wash water could create hazardous conditions.

Maintenance, Inspection and Removal

- Capture all sediment from the wash water on-site and dispose of it in an appropriate manner.
- Clean out wash water capture device when sediment fills it to greater than 50 percent.
- Removal of this temporary device must be performed and the site stabilized prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One-Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Sediment laden water drops onto the public road from the trucks exiting the construction site.	Increase the amount of washing to remove sediment from truck and increase the distance from wash area to road to provide a drip/dry pad for trucks. This will reduce water getting onto the public road.
Sediment-laden wash water from the trucks leaving the site drips onto the public road creating slick conditions.	Increase the washing of the vehicle on the site and allow the truck to drip-dry before driving onto the public street. Provide a sediment trap for wheel wash run-off as necessary.
Temperatures are near or below freezing creating ice from the wash water.	Discontinue the use of water to remove sediment from the construction vehicles before they enter the public street.

Rumble Plate



Figure 6.4 Prefabricated rumble plate, which produces a vibration of the tires and vehicle to dislodge dirt and mud from the construction equipment. Source: *Track out Control, LLC*

Practice Description

A rumble plate is a device that provides rough vibration to construction vehicles exiting the construction site. The vibration dislodges dirt and mud from the tires and undercarriage of the vehicles so sediment does not leave the construction site and drop onto a public road.

The rumble plates can be constructed of many types of material including, but not limited to, pipe or wood poles.

Recommended Minimum Requirements

Size the plate for maximum efficiency and allow for void space and sediment collection under the plate. Create a width so construction vehicles can not drive around and avoid the device.

Construction

Many rumble plate devices are prefabricated and shipped by the manufacture to the construction site. To construct your own device, remember the objects you construct it with need to be different diameters and spacing to create the vibration effect. The size and spacing of material should not be such as to cause harm or destruction to the vehicles driving over it.

The device should sit up on a frame with a void space below so the sediment drops from the trucks is trapped under the device. Then you can lift the device and scrape out the dropped sediment for easy clean out. Dispose of the sediment in an appropriate manner.

Maintenance, Inspection and Removal

- Clean sediment from under the device when it is close to filling the void area underneath. Dispose of the sediment on the construction site in an area that is stabilized and protected with a sediment control device.
- Remove the temporary device and stabilize the site stabilized prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One-Missouri Permit Requirements](#)) for termination of permit coverage.

Common Problems and Solutions

Problem	Solution
Device is ineffective.	Build the device longer and wider so construction vehicles can not exit without traveling over the device.
Device does not create a rough vibration.	Redesign the device with varied sizes of pipe and spaces between pipes.
After vehicles drive over the device, sediment is dropped onto the public street – device is not long enough to be effective or does not create a rough enough vibration.	Increase the length of device, clean out sediment from under the device and if necessary, redesign to increase vibration to vehicles driving over it.

Bamboo Mats



Figure 6.5 Bamboo mats placed at the exit of the construction site to contain dirt and mud falling from the construction vehicles before they exit the site. Source: *Brock White, LLC*

Practice Description

Bamboo mats are flexible fabric or mesh sewn together with pockets that hold bamboo reinforcing members. This alternative to rock construction exits is portable, reusable and can be joined with other mats to increase width and length as necessary. This device is not recommended for heavy truck traffic and should be considered for smaller construction projects only such as house lots or small construction sites. The bamboo can break down with excessive traffic from heavy construction equipment.

Recommended Minimum Requirements

Mats should be put together to meet design standards as well as state and local permit requirements. Mats can be effective until the reinforcing members break down. They are not designed for long periods of heavy use.

Construction

These mats are manufactured and shipped to the buyer to be installed on-site. They are reusable.

Maintenance, Inspection and Removal

- Inspect the mats weekly and after rain events.
- Clean sediment from mats and replace broken down mats as needed.
- Remove this temporary device and stabilize the site prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 of permit coverage (see [Chapter One-Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Sediment fills area between reinforcing members.	Will need to be cleaned as necessary.
Reinforcing members may break down with extended heavy traffic.	Individual mats will need to be replaced if this occurs.

Streambank Setback



Figure 6.6: Homes too Close to Streambank Source: K. Grimes, SWCD, St. Charles County.

Practice Description

A streambank setback limits how close structures can be placed to the stream, and it restricts vegetation removal and grading of the riparian area along flowing waters. This practice is intended to protect the banks of natural streams from damage due to development, lessen the risk of flooding in developed areas and provide a buffer between the developed area and the stream. A properly maintained streambank setback will help maintain channel capacity and stability, reduce the sediment load in the channel and reduce the movement of pollutants into the stream. Setbacks help preserve natural channel meander and protect homes and other buildings from damage due to bank erosion and flooding.

The following recommended minimum requirements may not be adequate to protect water quality. Many communities have stream setback requirements up to 300 feet, depending on the quality of the stream to be protected. As a good example of a stream buffer ordinance, see the ordinance for the City of Kansas City or the City of Lenexa, Kansas at www.ci.lenexa.ks.us/LenexaCode/codetext.asp?section=004.001.015.

Streambank setbacks can also apply to areas adjacent to excavated open channels used for site drainage, drainage ways and watercourses that route runoff to streams. Consult your local government for ordinance requirements.

Recommended Minimum Requirements

Prior to the start of construction, the 100-year floodplain established by the Federal Emergency Management Agency and the streambank setback area should be shown on the design plan prepared by a registered design professional. Plans should be referred to by the site superintendent, job foreman and field personnel throughout the construction process. The streambank setback should be established according to the planned alignment and grade. Vegetation should be inventoried and flagged for retention.

Channel

Ensure that the channel is stable before determining the width of streambank setback.

Streambank Setback in Developed Areas

The greater of the following is recommended:

- A minimum of 50 feet from the top of the streambanks (larger setbacks will be needed where channels are downcutting, hydrology is shifting and in large drainage areas - if sufficient land is available, a 100-foot setback is encouraged to protect the stream from degradation and to protect property) beyond the 100-year floodplain.

Vegetation

If possible, preserve desirable natural vegetation within the setback area, especially on steep slopes. Establish vegetation on all areas without sufficient cover (see Vegetative Protection in the Streambank Protection section). Overall fish and wildlife habitat requirements and landscape character should be considered in determining the scope of streambank setback.

Street Setback

Streets in new developments should be constructed so that they remain usable during runoff from the design storm or according to local requirements.

Water Surface Elevation

A minimum of 1 foot below the ground floor of private dwellings and commercial buildings in a new development during the 100-year frequency, 24-hour duration storm.

Permits

Contact the Corps of Engineers and local authorities for permit requirements; permits may be needed if placing fill in wetlands or streams.

Construction

Site Preparation

- Follow all federal, state and local regulations for channel improvements required to increase stream capacity (due to development).
- Open channel cross sections should not be reduced in order to increase streambank setback. The use of levees within small watersheds is discouraged.
- Locate all underground utilities.

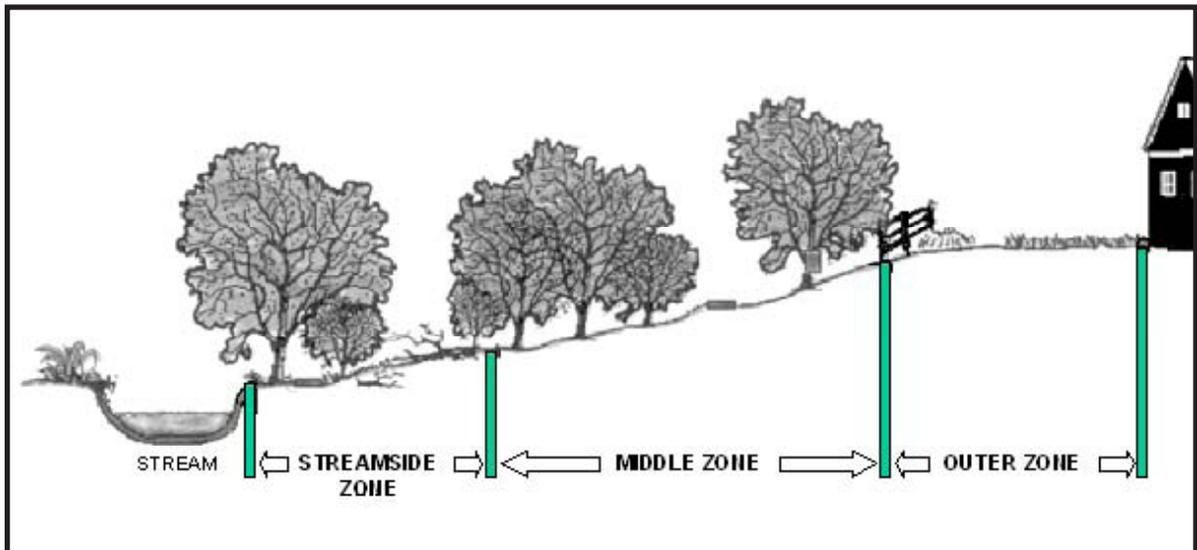


Figure 6.7 Three-Zone Stream Buffer System *Minnesota Stormwater Manual*. November 2005.
Source: Adapted from Schueler, 1995.

Natural Channels

- Natural channel side slopes should not be disturbed. When disturbance is necessary to develop a site, reestablish vegetation on channel side slopes as soon as possible after excavation or improvement.
- Consider the natural zones of a streambank community when placing vegetation. Use native plant materials for establishment and long term success. Lists of suitable species may be obtained from the Missouri Department of Conservation or NRCS. (See [Streambank Protection](#).)
- Existing woody vegetation adjacent to the stream should not be disturbed.
- Leave any right-of-ways in the best condition feasible, consistent with the project purposes and adjacent land uses. A permit will be required to work in the right-of-way from the governing authority.
- Preserve or plant adapted trees to provide shade to prevent thermal pollution in the stream, help stabilize banks and provide wildlife habitat in those areas of perennial flow or where woody cover exists.

Erosion Control

- Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete.
- Establish vegetation on all disturbed areas immediately after construction.
- The streambank setback area should not be used as a buffer strip during construction. This is important – if it is used as a sediment buffer, it could become contaminated with sediment and kill all the natural vegetation.
- Use temporary diversions to prevent lateral surface water from running onto the streambank setback area.
- After construction, if overland flow is required to go through the streambank setback area, velocities should be low (5 feet per second or less).

Safety

- At the completion of each day's work, move all construction equipment away from the streambank setback area in anticipation of flooding.
- Temporary stream crossings should be used by construction equipment to prevent destruction of the streambank setback areas.
- Construction materials and waste material should not be stored in the stream channel or streambank setback area.
- Provide temporary fencing and post warning signs until vegetation is established in areas that are disturbed.
- Provide site drainage.

Construction Verification

The alignment and width of the setback should be maintained during all construction activities. The final grades and elevations of the setback area should be checked to insure compliance with plans and specifications.

Maintenance, Inspection and Removal

- Check the streambank setback area after every storm event during the period of construction. In the setback area immediately adjacent to the stream (a minimum 10 foot width), reseed bare areas of soil greater than one square foot upon discovery and protect from soil erosion.
- Protect new plantings in the streambank setback area from livestock or wildlife.
- Mulch, spray (with an herbicide approved for aquatic use) or chop out undesirable vegetation periodically to prevent its growth.
- Keep inlets to side drainage structures open.
- Keep subsurface drain outlet pipes open and protected.
- Prohibit certain activities in the stream setback area, such as clearing and grading, drainage ditching, filling or dumping; and storage of motorized vehicles.
- Streambank setback vegetation maintenance after construction is the responsibility of the land owner. Make sure the landowner knows and understands their responsibility and the state and local requirements in their area.

Common Problems and Solutions

Problem	Solution
Variations in topography on site indicate setback or channel is inadequate or will not function as intended.	Changes in the plans may be needed.
Design specifications for seed variety, trees, mulch and fertilizer cannot be met.	Substitution may be required. Unapproved substitutions could result in additional flooding and erosion of the streambank.
Erosion of streambank setback; caused by disturbed land in setback area, inadequate vegetation or concentrated flow	Establish adequate vegetation in all areas or install measures to reduce flow concentrations.
Slumping failure or slides in streambank; caused by steep slopes.	Repair by excavating failed material and replacing with properly compacted fill. Consider reducing slope or installing streambank protection measures.
Reduction in stream capacity; caused by overgrowth of vegetation on the streambank.	Selectively cut overgrown vegetation.

Tree Protection

Practice Description

Tree protection preserves and protects trees during construction. Trees provide aesthetic and economic value, and aid in energy conservation, landscaping, air purification and erosion control. This practice applies to any construction site where desirable trees are present and need to be protected.

Trees can be damaged or killed by direct contact with construction equipment, compaction of the soil within the root zone of the tree, changes in the elevation of the water table due to site grading, and by construction chemicals and refuse. Although damage may be unseen, it can result in tree death within three or four years. Damage to the root zone is the leading factor in the unintentional destruction of trees.

Recommended Minimum Requirements

Prior to start of construction, desirable trees (including sensitive species) should be selected and marked for protection by a registered design professional. A grading plan that indicates the location of protected trees, utility trenches and other protected areas (e.g., floodplains, steep slopes, wetlands and streambanks) should be made available to field personnel. Areas for parking equipment should be designated away from the canopy (drip line) to protect the root zones of desired trees, shrubs, stream buffer vegetation and other protected areas. The root zone of plants is generally as broad as the drip line.

Temporary Fences

Placement

Around the dripline or tree canopy perimeter to restrict traffic, excavation, parking, storing materials and filling under the tree canopy. (For tree species sensitive to root damage, place the fence at the critical root radius to ensure tree's survival.)

Materials

Snow, board, plastic or cord fence.

Restricted Activities

Use temporary fence to restrict traffic, excavation, parking, storing materials and filling under the tree canopy (or at the critical root radius to ensure survival of sensitive species).

Permanent Drains

Install permanent drains in areas where site grading may be expected to cause water table saturation of the root zone (See Subsurface Drain).

Grading

Minimize cut and fill near trees by following the natural contours, and locating roadways, storage areas and parking pads away from desired tree stands.

Trenching

Minimize trenching near tree canopy perimeter and place several utilities in one trench when possible.

Up to 90 percent of trees' roots may be in the top 12 inches of soil. Typically, roots spread out from two to three times the width of the canopy or tree's branches.

Build a barrier at the dripline (or at the critical root radius for sensitive species) to prevent damage from soil compaction, cut and fill operations physical wounds.

To calculate the critical root radius: measure the tree's diameter in inches at breast height (4.5 feet above the ground), multiply that number by 1.5 feet. This will provide you with the critical root radius in feet.

For example, a tree with a diameter (breast height) of 20 inches will have a critical root radius of 30 feet (60 foot diameter).

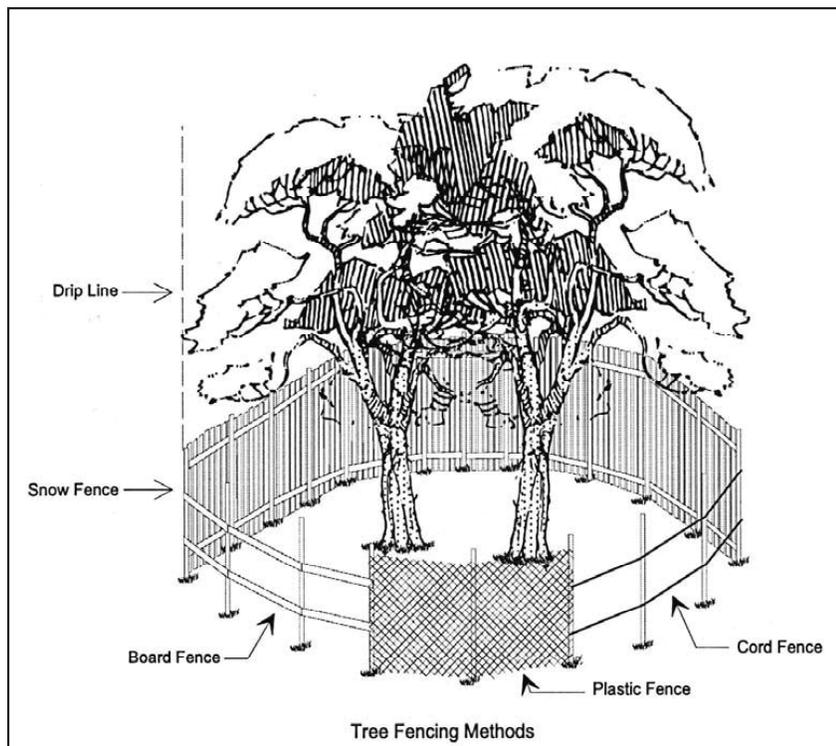


Figure 6.8 Erecting Barriers for Tree Protection Source: Adapted from MU Guide 6885

Construction

- Install temporary fences at tree driplines (at the critical root radius for sensitive tree species). To avoid compaction of the soil around desired trees, keep traffic, equipment and supplies off of the root systems. Figure 6.8 shows the correct method of erecting barriers for tree protection.
- Route the underground utilities according to plan. If possible, combine in one trench and route away from trees and potential planting sites.
- Use a brush cutter, rotary axe, or cut by hand instead of grading off brush to maintain the area within the tree canopy perimeter.

Note: If grading beneath a tree's canopy is indicated on the plan:

- Prior to construction activities, prune low hanging branches that may be damaged by equipment. To avoid tearing the bark from the tree while pruning, remove large branches with a stub-cut method. Figure 6.9 illustrates correct methods of pruning.
- Minimize grading beneath the tree canopy. Avoid placing fill, or removing leaf litter or soil in the ungraded areas. Cut large roots instead of tearing them with equipment.

Stub-cut Method

First, make an undercut about one foot from the trunk. Then, cut through the branch near the first cut. Leave the tree's branch collar intact during the final cut to promote healing. Source: *Adapted from MU Guide 6866*

Construction Verification

Check the construction site to verify protective measures are being observed.

Troubleshooting

Consult with registered design professional such as an arborist or silviculturist if any of the following occur:

- A protected tree is accidentally injured by construction activities.
- If grade around a protected tree must be raised.

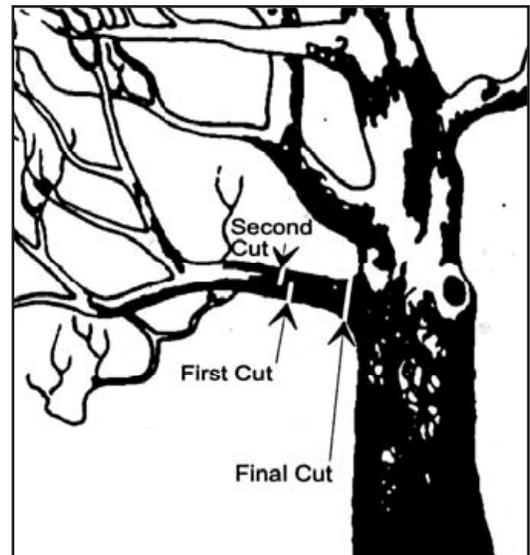


Figure 6.9 Proper Method of Pruning
Source: *Adapted from MU Guide 6866*

Maintenance, Inspection and Removal

- Remove fence around protected trees only after all construction is complete and all disturbed soil is stabilized.
- In spite of these precautionary steps some damage may occur to desired trees. If minor damage occurs, repair it immediately. Repair damage to limbs or roots by cutting off the damaged areas. Repair damage to bark by trimming the perimeter of the damaged area. If there is any question about the correct course of action, enlist the service of a professional arborist or silviculturist.
- Inspect trees for signs of stress, such as insect, disease and drought damage. Stressed trees should be watered during dry periods. Soak area under the canopy to a depth of 12- to 18-inches. Avoid fertilizing severely stressed trees until they become reestablished a year or two later. Treat insect and disease problems with a pesticide, if necessary, but be sure to follow instructions on the label. Or, employ a certified pesticide applicator to treat the problem.
- Remove temporary devices and stabilize the site prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Trees show signs of damage such as wilting, early leaf drop in the fall or slow growth often caused by compaction.	Aerate the soil by pulling 12- to 18- inch deep cores in the soil within the dripline to assist movement of moisture and oxygen into the soil, then backfill with compost.
Trees killed during construction.	Remove after site completion and replace with new trees.

Parking and Material Laydown Areas



Figure 6.10 Laydown and storage areas should be neat and fully stabilized. Source: *ABC's of BMP's*

Practice Description

Many construction sites have a designated area for a construction trailer, parking and storage of construction material usually referred to as a laydown area. The area itself is not considered a best management practice but management of the area is.

Recommended Minimum Requirements

This area should be within the permitted area to be disturbed and should be located no closer than 100 feet from streams, wetlands, natural drainageways or other environmentally sensitive areas. Although the tendency is to park vehicles in shaded areas, this area should not be placed within the canopy of plants expected to remain on-site. The root zone of plants is generally as broad as the canopy. The area should be stabilized with vegetation or a small rock and gravel base depending on the amount of traffic in the area and should not contribute pollutants to the stormwater discharge. The area should be clearly marked on the SWPPP site map.

Construction

The parking and laydown areas as well as the traffic paths into and out of these areas should be stabilized. They are most often placed near the exit of the construction site and therefore can contribute to off-site sediment tracking if not managed properly.

Troubleshooting

Keep the area free and clear of trash and debris. Provide a location for trash disposal (e.g., dumpster) in an appropriate location. See the Solid Waste section under [Pollution Prevention](#).

Maintenance, Inspection and Removal

- Inspect the area on a weekly basis and after rain events.
- Ensure that materials are properly stored and contained with Material Safety Data Sheets, or MSDS, information readily available.
- Removal of this temporary device must be performed and the site stabilized prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One-Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Sediment is being transported onto a public street when exiting the parking or laydown area; the area is eroding or traffic carries mud to the street.	Add rock over the area to stabilize it.
Vehicles sink into the soil caused by a soft subgrade.	Lay a geotextile membrane over the area and add a layer of small rock or gravel.

Temporary Stream Crossing

Practice Description

A temporary stream crossing is a short term crossing constructed over a stream for use by construction traffic. Temporary stream crossings can be designed as low water crossings, as an embankment with a culvert, or as a bridge with or without embankment approaches. Properly constructed, they prevent on going turbidity and streambed disturbance caused by construction traffic. Improperly designed and constructed stream crossings can cause upstream flooding, channel erosion during increased flows and failure of temporary crossings.

Temporary stream crossings may be subject to applicable federal, state and local regulations for in-stream modifications. Contact the U.S. Corps of Engineers and local authorities for possible permit regulations.

Recommended Minimum Requirements

Prior to start of construction, temporary stream crossings should be designed by a registered design professional. Plans and specifications should be referred to by the site superintendent and field personnel throughout the construction process.

Drainage Area

Any size, however most temporary stream crossings occur on smaller headwater stream located within smaller drainages.

Slopes

Low Water Crossing

- 3:1 or flatter for downstream slope.
- 2:1 or flatter for upstream slope.

Culvert Crossing

- 2:1 or flatter for downstream and upstream slope.

Low Water Crossings

Water Flow

Shallow (less than 3 inches deep) or intermittent.

Traffic Usage

Light

Bank Height

Less than 5 feet.

Approaches

Slope of 5:1 or flatter.

Culverts

Minimum Diameter

- 18 inches or according to design plan.
- Large enough to pass the peak flow from the 2-year 24-hour rainfall event of the design storm.

Minimum Height of Fill Over Culvert

1 foot or 1/2 the pipe diameter, whichever is greater.

Culvert Length

Sufficient to extend the full length of the driving surface and the side slopes.

Construction

Locate the temporary stream crossing where erosion potential is low. Riffle locations within the channel generally are preferable locations to stream pools. Where practical, locate and construct stream crossings to serve as both temporary and permanent crossings to keep stream disturbance to a minimum.

Site Preparation

- Plan stream crossing in advance and attempt to construct them during dry periods to minimize stream disturbance.
- Follow all federal, state and local requirements on temporary road crossing.
- Ensure that all necessary materials are on the site before any work begins.
- Construct a bypass channel before undertaking other work. Refer to plans.
- Scarify the creek bed before placing fill.

Dewatering Site

- Stabilize the bypass channel with riprap or other suitable material when stream velocity exceeds that allowed for existing soil material.
- Divert the stream to the bypass channel.

Low Water Crossing

- Locate low water crossings only where normal flow is shallow (less than 3 inches deep) or intermittent, and where traffic is light. See Figure 6.11.
- Excavate the foundation for the temporary crossing. Place crossing straight across stream.
- Excavate roadways through the abutment approaches (bank) to the crossing according to the design plan.
- Place large rock riprap across the channel. Construct a wearing course of gravel or crushed rock over the riprap. Use geotextile between crushed rock and the riprap.
- Remove gravel and excess rock riprap as soon as it is no longer needed. Restore original contours to the channel, leaving rock riprap level with the streambed.

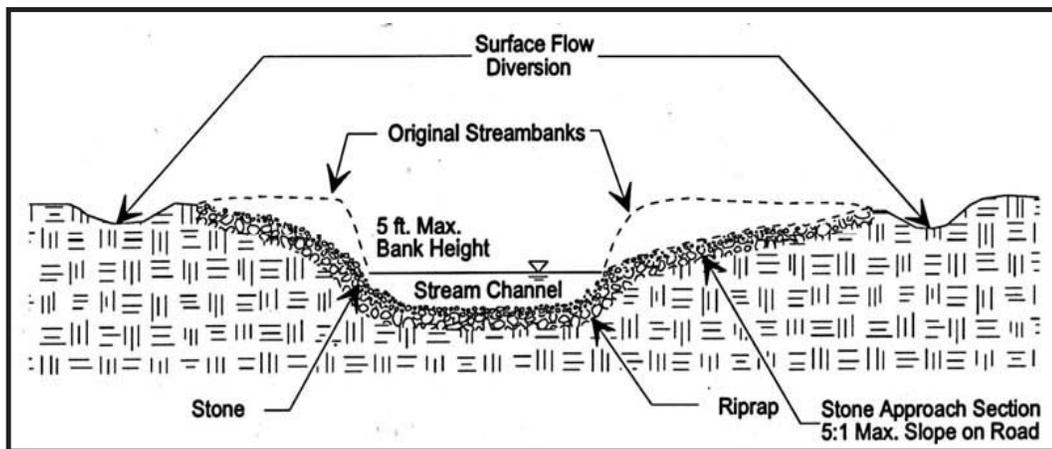


Figure 6.11 Typical low water stream crossing.

Culvert Crossing

- Excavate the foundation for the temporary stream crossing.
- Divert the stream flow. Prepare the pipe bedding. Situate the culvert pipe on a firm, even foundation and keep the culvert parallel to the direction of flow. See Figure 6.12.
- Place a 4-inch layer of moist, clayey, workable soil (not pervious material such as sand, gravel or silt) around the culvert. Compact by hand to at least the density of the embankment soil. (Don't raise the culvert from the foundation when compacting under the culvert haunches.)
- Extend the end of the culvert beyond the toe of the fill slope or install a riprap apron at least 5 feet wide and 10 feet long to a stable grade.
- Remove culvert as soon as it is no longer needed. Restore streambed to original contour.

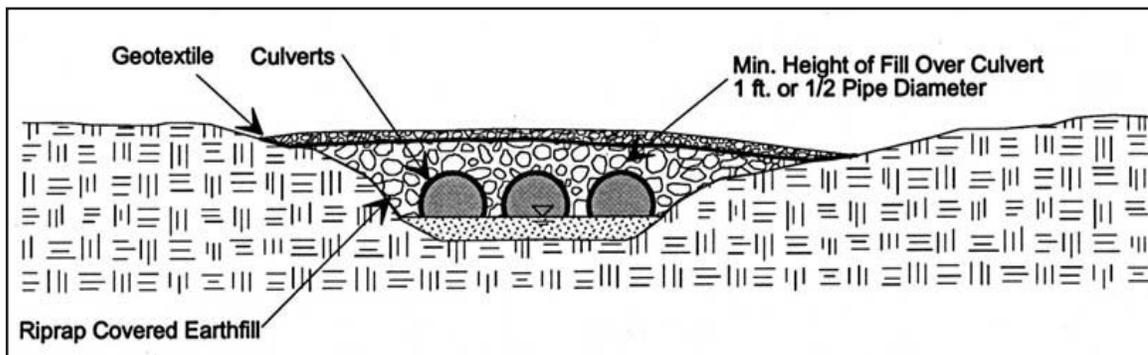


Figure 6.12 Typical temporary culvert stream crossing.

Bridges

- Properly designed bridges cause the least disturbance to the stream bed, banks and surrounding area. They are the preferred method for temporary stream crossings.
- Disadvantages to constructing temporary bridges include:
 - They are the most expensive option to construct
 - They are the greatest safety hazard if not adequately designed, constructed and maintained.
 - They cause a longer construction delay if washed out.
- Bridges must have stable abutments. It is recommended that a cable be tied to one corner of the bridge frame with the other end fastened to a secure object to prevent flood flows from carrying the bridge downstream where it may cause damage to other property.

Embankment for Bridges and Culverts

- Use fill from predetermined borrow areas. It should be clean, stable mineral soil free of roots, woody vegetation, rocks and other debris and must be wet enough to form a ball without crumbling yet not so wet that water can be squeezed out.
- Compact the fill material in 6- to 8-inch continuous layers over the length of the embankment. (One way is by routing construction equipment over the embankment so that each layer is traversed by at least one wheel of the equipment.)
- Protect the culvert with 2 feet of hand-compacted fill before traversing over the pipe with equipment.
- Construct and compact the temporary road crossing embankment to 10 percent above the design height to allow for settling.

Erosion Control

- 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 stockpiled fill located flood plains to a minimum to prevent upstream flooding and reduce erosion potential.
- Minimize the size of all disturbed areas and vegetate as soon as each phase of construction is complete. Riprap or establish vegetation on the slopes of the embankment in the temporary stream crossing.
- Direct all overland flow to the ditches along the approach roads at low velocity.

Safety

Because temporary stream crossings are potentially hazardous, take the following precautions:

- If site conditions warrant, construct guardrails or axle berms along the sides of the temporary stream crossing.
- Avoid steep slopes on the embankment; slopes should be kept as flat as possible (3:1 or flatter).
- Approach road slopes should be 5:1 or flatter.

Construction Verification

Check finished grade and both the size and orientation of culvert within the stream. Check to see if culverts are free of obstructions.

Troubleshooting

Consult with registered design professional if any of the following occur:

- Variations in topography and stream conditions on-site indicate crossing will not function as intended; changes in plan may be needed.
- Design specifications for fill or conduit cannot be met; substitution may be required. Unapproved substitutions could result in the crossing being washed out.

Maintenance, Inspection and Removal

- Inspect the temporary stream crossing on a weekly basis and after each storm event. Pay close attention to the condition of the entrance and exit sections of the culvert pipe, the culvert joints, the abutment supports for bridges, all bridge connections and the amount of erosion on low water crossings.
- Add riprap to the culvert entrance and exit as necessary to protect the crossing.
- Periodically check the embankment for erosion damage, settling or slumping and repair immediately.
- Correct any problems immediately upon observing them. Do not wait until a scheduled weekly inspection to address a failure or potential hazard noted during routine activities.
- Remove debris, trash and other materials that restrict flow from the culvert or bridge.

Common Problems and Solutions

Problem	Solution
Piping failure along culvert caused by improper compaction, leaking pipe joints or use of unsuitable soil.	Repair piping damage and ensure culvert joints are sealed before properly compacting suitable soil around the culvert to prevent reoccurrence of the problem.
Erosion of embankment slopes caused by inadequate vegetation or improper grading and sloping.	Repair erosion damage and reevaluate erosion protection measures.
Slumping or settling of embankment; caused by inadequate compaction or use of unsuitable soil.	Return embankment to original configuration using properly compacted soil as specified in the original plans.
Slumping failure; caused by steep slopes.	Remove slide debris and replace with properly compacted soil.
Erosion and streambank caving below culvert; caused by inadequate outlet velocity protection.	Repair erosion damage and provide adequate outlet velocity protection.
Difficult and costly maintenance; caused by culvert not set in direction of flow in stream.	Consult registered design professional for other options.
Overtopping of roadway, ponding upstream of the culvert and erosion beneath the culvert caused by culvert entrance elevation set too high.	Repair erosion damage, and either reevaluate size and elevation of the culvert or raise the roadway elevation.
Frequent overtopping of roadway and increased erosion potential caused by the culvert or bridge opening being too small.	Repair erosion damage, and either resize the culvert or raise the roadway elevation.
Downstream scour and undermining of structure during flooding caused by roadway elevation too high.	Repair damage and resize or lower culvert.

Slope Breaks and Surface Roughening



Figure 6.13 Lot benching can shorten slope length and prevent erosion while improving the homeowner's yard. Source: C. Rahm, NRCS, St. Charles County

Practice Description

Slope breaks and surface roughening are practices that reshape the ground surface during construction to slow the surface overland stormwater flow and reduce slope length to reduce surface runoff velocities, therefore minimizing soil erosion and sedimentation during construction. Slope breaks and surface roughening are inexpensive ways to provide erosion control during construction prior to establishment of permanent vegetative cover.

Slope breaks, such as diversions or benches, can be used to reduce the length of continuous slopes and reduce erosion (See [Diversions](#)).

Recommended Minimum Requirements

Prior to start of construction, the site grading plan should be designed by a qualified professional. The grading plan should show disturbed areas, cuts, fills and finished elevations for all graded areas. The site superintendent and field personnel should refer to plans and specifications throughout the construction process. During construction and reshaping of the topography a slope can be roughened once it has been graded out and prior to reaching final grade and vegetation establishment.

Schedule construction activities so the least amount of area is disturbed at one time.

Slope Breaks

Refer to plan. Table 6.1 provides suggested guidelines for spacing of slope breaks.

Soil Surface Roughening

There are many types of surface roughening techniques such as track walking with a dozer up and down a slope or using a sheep's foot to create dimples in the soil surface. This increases infiltration and slows overland flow.

Table 6.1 Guidelines for Spacing Slope Breaks

Slope	Spacing (ft.)
33-50%	20
25-33%	40
15-25%	60
10-15%	80
6-10%	120
3-6%	200
< 3%	300

Source: Adapted from North Carolina Field Manual, 1991

Surface Runoff

Avoid disturbing natural drainage ways, if possible. At each slope break, intercept runoff and channel it to storm drains or stabilized watercourses. If runoff contains sediment, protect drain inlets with a filter or divert water to a sediment trap or basin according to the site grading plan (See [Inlet Protection](#), [Temporary Sediment Trap](#) and [Sediment Basin](#)).

Erosion Control

Graded areas should be stabilized with mulch, vegetation, crushed stone, riprap or other measures as soon as work is completed, or if work is interrupted for 14 or more working days. Soil surface roughening is both an erosion and sediment control technique and should not be combined with devices such as erosion control blankets. Blankets should be applied to smooth, fine-graded soil surfaces and will fail if used to cover roughened soil surfaces.

Slopes to be Vegetated

2:1 or flatter; 3:1 or flatter where maintained by tractor or other equipment. Slopes should be roughened during grading operations to retain water, increase infiltration and promote vegetative growth. Slopes should be protected from surface runoff while vegetation is being established (See [Diversion](#), [Perimeter Protection](#)).

Borrow and Disposal Areas

As shown on the grading plan; these should be no closer than 100 feet to a streambank or sensitive area (e.g., wetland, spring, cave, sinkhole) in the absence of a specification and should not be placed in an area of stormwater conveyance. Stockpiles should be stabilized if not being used for 14 or more days according to the state and local regulatory requirements. If borrow or disposal locations are off-site, they should also be permitted and have a copy of the permit authorization on-site at all times. This is necessary if the off-site borrow or disposal area is used for this construction project only and disturbs one acre or greater requiring permit coverage.

Outlets for Breaks and Diversions

Stabilized outlets should be provided for runoff from the disturbed area in order to retain sediment on-site.

Construction Site Preparation

- Erosion and sedimentation control measures should be installed as specified and in the sequence shown on the design plan.
- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Remove and stockpile topsoil (see [Topsoiling](#)) if subsoils will not support plant growth.
- Clear and grub areas to be filled and remove trees, vegetation, roots and other debris.
- Check fill to make sure it does not contain brush, rubbish, oversized rocks or other objectionable material.
- Place fill in layers and compact as specified by the grading plan. Do not use frozen, excessively soft or high organic content material.
- Do not place fill on frozen subgrade, as it may cause an unstable condition due to potential differential settlement when the soil thaws.

Grading

- Construct slope breaks as shown on the grading plan, or in accordance with the recommendations of Table 6.1. A typical slope break is illustrated in Figure 6.14.
- Keep diversions and other water conveyance measures free of sediment during all phases of development.
- Avoid grading and building in areas of seepage. If this cannot be avoided, then install subsurface drains (See Subsurface Drains) in areas where seepage interferes with the grading operations, or where required to improve slope stability or soil bearing capacity.
- Permanently stabilize graded areas immediately after final grading is complete. Use temporary stabilization measures on graded areas when work is to be interrupted or delayed for 14 working days or longer.

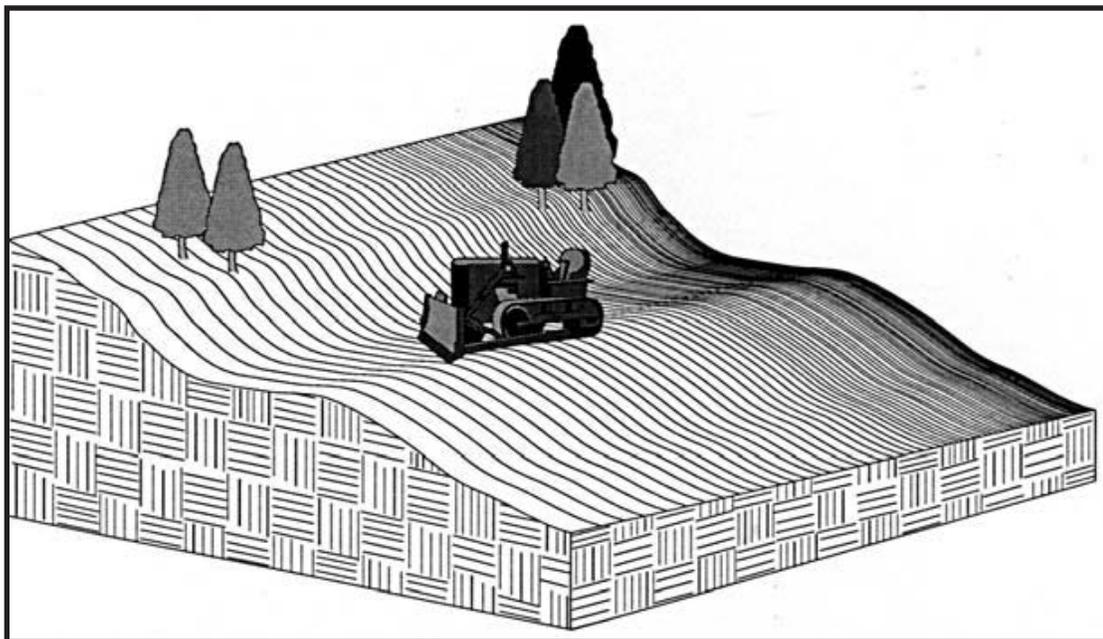


Figure 6.14 Typical Slope Break

Construction Verification

Check all finished grades for conformance with grading plan and correct as necessary.

Maintenance, Inspection and Removal

- Periodically inspect all graded areas and the related erosion and sedimentation control practices, as required by the construction general permit, especially after heavy rainfalls. Clean sediment out of diversions and other structures as needed. If washouts or breaks occur, repair them immediately.



Figure 6.15 Track walking with a dozer up and down the slope provides horizontal grooves to reduce stormwater flow volumes and velocity therefore reduces potential for erosion of the slope. Source: ABC's of BMP's, LLC

- Remove this is a temporary device and stabilize the site [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Variations in topography on-site indicate grading plan will be ineffective or unfeasible.	Consult with design professional
Seepage is encountered during construction.	It may be necessary to install drains. Dewatering shall be performed in accordance with regulatory requirements.
Design specifications for seed variety, seeding dates, erosion control materials or timeframes cannot be met.	Substitutions may be required. Unapproved substitutions could result in erosion and lead to failure of erosion control measures.
Prominent rill and gully erosion caused by slope breaks being too far apart.	Construct intermediate slope breaks.
Difficulties achieving proper compaction of fill caused by subgrade being soft, contains oversized rocks or has high organic content.	Undercut and replace unsuitable subgrade soil.
Slope is unstable or has reduced bearing capacity caused by a high water table	Install subsurface drains to lower water table.

Topsoiling: Removal, Stockpiling and Replacement



Figure 6.16 It's important to mix or incorporate topsoil with the underlying subsoil to prevent sloughing on sloping soils.
Source: C. Rahm, NRCS, St. Louis Co.

Practice Description

Topsoiling is a method of preserving the topsoil prior to construction, stockpiling it and using it after construction to help establish vegetation on a construction site. Stockpiling is also used for storage of other soils and construction material such as fill material. These practices apply to areas on a site to be disturbed by excavation, compaction or filling, and where vegetation is to be reestablished.

Recommended Minimum Requirements

Prior to the start of construction, topsoiling should be designed by a qualified professional. The existing soil should be tested to ensure the material to be saved is topsoil and helps with vegetation establishment and long-term, permanent growth. The location of other material to be stockpiled on the site should be shown on the site map and stabilized according to the regulations. Refer to the plans and specifications throughout the construction process.

Topsoil

- Surface soil or top layer of undisturbed soil, usually richest in organic matter and nutrients.
- Should be free of debris, trash, stumps, large rocks, roots and noxious weeds. It should contain no substance potentially toxic to plant growth.

Minimum Soil Depth

- 24 inches of total soil depth over bedrock (combined topsoil and subsoil); from 8- to 12-inches of total soil depth over loose sand or rock.
- The top 4- to 6-inches of soil must be good topsoil, rich with organic matter, microorganisms and not more than 50 percent clay content to ensure good vegetation establishment and growth on a permanent basis.

pH Range

- From 6.0 to 7.5.
- If the pH is less than 5.2, lime should be incorporated in accordance with soil test results.

Construction

Site Preparation

- Establish all perimeter erosion and sediment control practices, (e.g., sediment barriers, diversions, grade stabilization structures, berms, dikes, sediment basins) before stripping.

Stripping

- Strip topsoil from areas that will be disturbed by excavation, filling or compaction by equipment.
- Determine depth of stripping by taking soil cores at several locations within each area to be stripped.
- Make sure the soil being saved is topsoil. It should have a minimum of five percent organic material and a clay content of less than 50 percent.

Stockpiling

- Do not place topsoil or other stockpiles near areas of water (e.g., conveyances, ditches, swales).
- Do not place stockpiles on impervious surfaces or within 50 feet of storm drain inlets.
- Avoid placing topsoil or stockpiling other material on steep slopes. Side slopes of stockpile should not exceed 2:1.
- Use sediment fences or other barriers where necessary to retain sediment.
- Protect topsoil and other stockpiles with temporary seeding or other soil stabilization techniques as soon as possible, but not more than 14 working days after formation of the stockpile. If stockpiles will not be used within 12 months, they should be stabilized by permanent vegetation to control erosion and weed growth.

Grading

Established grades should be maintained according to the approved plan and should not be altered by adding topsoil.

Liming of Subsoil

Where the pH of the existing subsoil is below 5.2, incorporate agricultural limestone in amounts indicated by soil tests or specified for the seeding mixture to be used (See [Temporary or Permanent Seeding](#)). Incorporate lime into the subsoil to a depth of at least two inches by disking. Retest the soil to determine the pH and if pH is not 5.2 or higher, repeat the process.

Roughening

Immediately prior to spreading topsoil, loosen the subgrade by disking or scarifying to a depth of at least two inches to ensure bonding of the topsoil and subsoil.

Spreading Topsoil

- Spreading frozen or muddy topsoil can prevent proper grading or seeding. Uniformly spread topsoil to a minimum compacted depth of four inches. For long-term growth of vegetation without irrigation, minimum soil depth (subsoil and topsoil) should be 8- to 12-inches over loose sand or rock fragments, and 24 inches over bedrock.
- Prior to the establishment of final vegetation, the topsoil should be final graded so it is smooth with no clods greater than one inch in diameter.

Construction Verification

Verify that topsoil was spread evenly and incorporated with underlying subsoil.

Maintenance and Inspection

- Maintain erosion control devices over topsoil until vegetation is fully established with a density of 70 percent over the entire area.
- Inspect topsoiled areas frequently until vegetation is established.
- Repair eroded or damaged areas and revegetate.

Common Problems and Solutions

Problem	Solution
Poor or no vegetation establishment caused by topsoil pH too low.	Add agricultural limestone to adjust pH.
Poor or no vegetation establishment caused by topsoil containing sterilants or toxic chemicals.	Remove contaminated topsoil and replace.
Poor or no vegetation establishment caused by topsoil being too high in clay content or too low in organic material and microorganisms.	Add organic material.
Poor vegetation establishment caused by topsoil being compacted too much during application.	Loosen by disking or scarifying and reseed.
Poor drainage and possible sloughing on steep slopes caused by topsoil not properly bonded to subsoil.	Remove topsoil, roughen subgrade and respread topsoil.
Inadequate vegetation establishment caused by topsoil removed during construction and not replaced.	Add topsoil with a minimum of 5 percent organic material, a clay content under 50 percent, fertilize according to soil test results, reseed or sod site, and apply water to establish vegetation.

SECTION 2: POLLUTION PREVENTION AND GOOD HOUSEKEEPING

Pollution prevention includes best management practices that need to be set up at the beginning of the project. Pollution prevention practices consist of site management considerations that do not fit into other categories of erosion or sediment controls, such as materials management, good housekeeping, spill prevention, spill clean up and concrete washout.

Good housekeeping entails keeping the site clean and reducing water and air-borne pollutants. Best management practices include effective control of solid waste, sanitary waste, petroleum, hazardous waste and material storage.

This section addresses general components of pollution prevention at the construction site. Each site should be evaluated for more specific pollution prevention needs. Some protection measures are required by federal, state or local regulations. For example, any project disturbing an acre or more of land requires a land disturbance permit. The permit in turn requires a Stormwater Pollution Prevention Plan, or SWPPP (See [Chapter 1](#)).

The Stormwater Pollution Prevention Plan should contain sections for each of the following issues on a construction site. In addition, these practices should be routinely inspected with all other best management practices to ensure pollution sources are contained on the construction site and that pollutants do not mix with soil or stormwater.

Materials Management

Material delivery, handling and storage can generate significant pollution. The site superintendent needs to ensure best management practices are followed to minimize or eliminate the discharge of material pollutants to the storm drain system or watercourse.

Inventory

The site superintendent should develop and maintain an inventory of materials that will be stored outside on the site during construction. For example:

- Pipe, fittings and joint compounds for underground utility piping.
- Gravel and stone bedding material.
- Concrete forming materials.
- Other. (Specify) _____

Delivery

Locations for delivery should be determined and clearly marked. Where beneficial, visibly place signs with delivery instructions for the drivers. Employees trained in emergency spill clean-up procedures need to be present when dangerous materials or liquid chemicals are unloaded.

Storage

Fuels, oils and other petroleum products (e.g., forming oils and compounds; fertilizers; pesticides) or any other hazardous or toxic compounds should be stored under cover and not allowed to come in contact with stormwater on the site. On-site storage should meet all local, state and federal secondary containment rules and regulations. Additionally, local ordinances may require fencing and security measures for storage of these products.

Do not store hazardous chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and under cover in secondary containment.

Do not store incompatible materials, such as chlorine and ammonia in the same temporary containment facility.

Solid Waste Management



Figure 6.17 This dumpster is in need of routine maintenance and the trash and debris around the area must be disposed of in a proper manner. Source: ABC's of BMP's, LLC

The general contractor is responsible for disposing of all solid waste from the site in accordance with state and local laws and regulations. Dumpsters or other collection containers should be provided as needed and should be covered at all times to reduce the spread of litter and avoid public nuisance and vector concerns. Solid waste may not be buried on the site and may not be open burned except in conformance with the Missouri Air Conservation Law and regulations. Open burning violations are also a violation of the Missouri Solid Waste Management Law.

All solid wastes removed from the construction site must go to a permitted transfer station or landfill and cannot be taken to another unpermitted location for consolidation or processing. Material may be sorted on-site and diverted to acceptable reuse or recycling.

Deconstruction Waste Recycling

Recycling deconstruction waste is one way to minimize solid waste disposal costs and pollution. For information about local outlets for deconstruction materials, contact your area Solid Waste Management District.

There are 20 Solid Waste Management Districts in the State of Missouri. Search their contact information at:

- Solid Waste Management District Contacts located at www.dnr.mo.gov/env/swmp/swmd/swmdinfo.htm or by calling 800-361-4827.
- Missouri Construction and Demolition Waste Guidance www.dnr.mo.gov/env/cdwaste.htm.
- Additional information is available at:
 - Mid America Regional Council (Kansas City region) at 816-474-4240 or www.recyclespot.org.
 - Construction Industry Compliance Assistance Center at www.cicacenter.org/
 - Toolbase Services: Construction Waste Management at www.toolbase.org/Best-Practices/Construction-Waste/construction-waste-management.

Recommended Minimum Requirements

- Solid waste management procedures and practices are designed to minimize or eliminate the discharge of pollutants to the drainage system or to watercourses as a result of the creation, stockpiling or removal of construction site wastes.
- Construction projects should be designed and implemented to minimize the amount of wasted materials.
- Materials should be purchased with minimal packaging.
- Solid waste management procedures and practices must be implemented on all construction projects that generate solid wastes. Solid wastes that are commonly found on construction and demolition sites include but are not limited to:
 - Construction wastes (e.g., lumber, wood sheeting products, steel and metal scraps, sawdust, pipe and electrical cuttings, non-hazardous equipment parts, polystyrene (Styrofoam), wall board, miscellaneous types of insulation, roofing materials, empty containers and other materials used to transport and package construction materials).
 - Landscaping vegetation waste and landscape plant containers.
 - Packaging materials.
 - Litter, including food containers, beverage cans, coffee cups, paper bags, plastic wrappers and smoking materials, including litter generated by the public.

Employee Training

Employees should be trained and educated as part of good housekeeping and pollution prevention on a construction site.

- Instruct employees and subcontractors about identification of solid waste and hazardous waste.
- Educate employees and subcontractors about solid waste storage and disposal procedures.
- Hold regular meetings to discuss and reinforce disposal procedures. incorporate procedures into regular safety meetings.

- Require employees and subcontractors follow solid waste handling and storage procedures.
- Prohibit littering by employees, subcontractors and visitors.
- Minimize production of solid waste materials wherever possible.

Collection, Storage, Recycling and Disposal

- Construction and landscaping material waste should be recycled and reused as much as possible.
 - Landscaping vegetation should be shredded and used as mulch when possible.
 - Materials from demolished structures should be recovered for reuse or recycling when possible.

Note: Any separating of recoverable materials for reuse or recycling must occur on the property of origin. Solid waste cannot be removed to another location for sorting or separating without a permit from the Department of Natural Resources' Solid Waste Management Program.
- Salvage or recycle useful vegetation debris, packaging or surplus building materials when practical. For example, trees and shrubs from land clearing can be converted into wood chips, and then used as mulch on graded areas. Recycle wood pallets, cardboard boxes and construction scraps.
- Provide dumpsters of sufficient size and number to contain the solid waste generated by the project. Dumpsters should be covered at all times and be properly serviced.
- Provide trash receptacles in the permittee's yard, field trailer areas and at locations where workers congregate for lunch and break periods.
- Locate solid waste storage areas at least 50 feet from drainage facilities and watercourses and should not be located in areas prone to flooding or ponding of water.
- Collect construction debris and litter from work areas within the construction limits of the project site on a daily basis and place in watertight dumpsters, regardless of whether the litter was generated by the permittee, the public or others.
- Empty dumpsters weekly from the site. Dispose of the contents in accordance with Missouri State solid waste regulations. While demolition and construction debris typically do not emit a lot of odors, food waste from workers can cause an odor problem and attract public complaints.
- Properly dispose of the waste at a permitted solid waste transfer station or a permitted sanitary or demolition landfill.
- Do not place collected litter and debris in or next to drain inlets, stormwater drainage systems or watercourses.
- Prohibit littering on the project site and perform periodic litter removal from the area to reduce public nuisance concerns from airborne and waterborne litter.
- To prevent clogging of the storm drainage system, litter and debris removal from drainage grates, trash racks, and ditch lines should be a priority.
- Remove construction debris and waste from the site as necessary to maintain a safe environment and to avoid public nuisance issues related to airborne and waterborne trash or vectors.

- Store or stack construction material visible to the public in an orderly manner and manage it to protect the value of the material. Materials stored in a waste like manner are regulated by the Missouri Department of Natural Resources' Solid Waste Management Program or Kansas Department of Health and Environment's Bureau of Waste Management.
- Prevent stormwater run-on from contacting stored solid waste through the use of covered containers. Recovered or recycled materials should be covered, or the area in use should include berms, dikes, other temporary diversion structures or the use of measures to elevate waste from site surfaces to avoid contact with stormwater.
- Construction and highway planting waste not stored in watertight dumpsters need to be securely covered from wind and rain by covering the waste with tarps or plastic sheeting or protected in conformance with the applicable disturbed soil area protection section.
- Dumpster washout on the project site is typically not allowed by the permits.
- Notify trash hauling contractors that only watertight dumpsters are acceptable for use on-site.
- Store potentially hazardous waste from non-hazardous construction site waste.
- Keep the site clean of litter debris.
- Make sure that toxic liquid wastes (e.g., used oils, solvents, and paints) and chemicals (e.g., acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.
- Dispose of non-hazardous waste in accordance Missouri State solid waste regulations.
- Remove this temporary device and stabilize the site prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter 1 -Missouri Permit Requirements](#)) for termination of permit coverage.

Maintenance, Inspection and Removal

- Inspect all dumpsters on a weekly basis and after rain events.
- Remove full dumpsters from the project site and dispose the contents in accordance with Missouri Solid Waste Management Law and regulations.
- Handle and dispose litter stored in collection areas and containers properly.
- Remove construction debris and waste from the site as necessary. The debris and waste cannot cause a public nuisance or health hazard.

Common Problems and Solutions

Problem	Solution
Trash and debris blowing out of dumpster caused by lack of a cover or overfilling.	Cover dumpster and debris with a tarp or other waterproof cover until the dumpster service provider can bring a new dumpster or empty the existing one. Insist on a unit with a properly working lid or cover, if not provided.

Sanitary Waste Management



Figure 6.18 Typical port-a-potty with secondary containment and tie downs. Source: BFA Inc.

Sanitary waste management consists of procedures and practices to minimize or eliminate the discharge of sanitary or septic waste materials to the storm drain system or watercourses. The general contractor is responsible for providing sanitary facilities appropriate to the number of employees on the site. Sanitary and septic waste management practices are to be implemented on all construction sites that use temporary or portable sanitary or septic waste systems. Sanitary waste may only be disposed of in accordance with the Missouri Clean Water Law.

Recommended Minimum Requirements

Written Procedures and Practices

Written procedures and practices should be referenced in the stormwater pollution prevention plan, or SWPPP. Plans should be posted on the portable facilities and at the office. The site superintendent and field personnel should ensure procedures and practices are followed at all times.

Documentation

Log all education, maintenance, inspection and removal activities in case questions arise during inspections and for reference when troubleshooting problems.

Education

- Educate employees, subcontractors and suppliers about potential dangers to humans and the environment from sanitary or septic wastes.
- Instruct employees, subcontractors and suppliers in identification of sanitary and septic waste.
- Educate employees, subcontractors and suppliers about sanitary and septic waste storage and disposal procedures.
- Hold regular meetings to discuss and reinforce disposal procedures. Incorporate procedures into regular safety meetings.
- Establish a continuing education program to update new employees.

Location, Storage and Disposal Procedures

- In order to reduce the risk of tipping and spillage, temporary sanitary facilities should be firmly anchored to the ground and located where they are protected from high winds.
- Temporary sanitary facilities should be located a minimum of 50 feet away from drainage facilities, watercourses and traffic circulation. Avoid locating sanitary facilities on an impervious surface. Secondary containment may be required for sanitary facilities located on impervious surfaces.
- Wastewater must not be discharged onto or buried within the construction site.
- If sanitary and septic systems discharge directly into sanitary sewer systems, where permissible, the contractor needs to comply with applicable city, county or sewer district requirements. Use of portable toilet facilities on the construction site may require a permit from the local municipality or health department.
- If using an on-site disposal system, such as a septic system, the contractor may need to comply with county health department requirements.
- Properly connect temporary facilities that discharge to the sanitary sewer system to avoid illicit discharges.
- Ensure sanitary and septic facilities are maintained in good working order. It is recommended that a licensed contractor be used or consulted.
- It is recommended to use reputable, licensed sanitary and septic waste haulers.

Maintenance, Inspections and Removal

- Inspect all sanitary waste management devices weekly and after each rainfall event that results in stormwater runoff – and as strong wind conditions occur. Discuss maintenance issues and requirements with the sanitary facility provider before installation.
- Make sure routine and timely disposal of waste materials is occurring.
- Respond immediately to correct problems caused by damage to or tipping of portable units. Clean up and dispose of spills in accordance with state and local regulations. Determine response times for waste haulers and adjust the callout routine to ensure timely disposal of waste is occurring.

- Anticipate fluctuations in facility usage based on the number and location of concurrent construction activities as well as variations in the total number of workers present on the site. Relocate facilities, add units, or increase the frequency of maintenance calls to waste haulers as necessary to make sure the units are convenient for use and do not overfill.
- Remove this temporary device and stabilize the site prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter 1 -Missouri Permit Requirements](#)) for termination of permit coverage.

Common Problems and Solutions

Problem	Solution
Waste management device falls over or is blown over by wind, caused by improper anchoring.	Anchor or otherwise tie down the device securely.
The sanitary or septic system facility is overflowing, caused by failure to routinely empty and dispose of the waste.	Call the sanitary facility provider to empty the waste immediately and dispose of it properly. Ensure the person in charge of the facility is clearly aware of their responsibility to oversee proper inspection and maintenance. Implement additional education for all involved.

Petroleum and Hazardous Waste Management



Figure 6.19 This site has a designated vehicle maintenance area with all petroleum products located within secondary containment areas. Source: BFA, Inc.

Petroleum and hazardous wastes must be managed and controlled on a construction site to ensure they do not contaminate the stormwater flow and discharge from the site. The site superintendent and field personnel must ensure proper management of petroleum and hazardous waste by providing secondary containment of petroleum and hazardous substances, and by ensuring proper use, containment and disposal. Site superintendents and field personnel should strive to reduce, reuse and recycle materials as much as possible and avoid purchasing, storing and using more petroleum and hazardous waste material than necessary.

While this is a guidance document, some of the information in this section might actually be required under federal, state or local regulations. The general contractor and site superintendent need to ensure they have a clear understanding of federal, state and local requirements, and they should ensure all field personnel are properly educated and trained in these areas.

Recommended Minimum Requirements

Ensure hazardous waste management practices are implemented on construction projects that generate any waste from the use of:

- Petroleum products.
- Asphalt products.
- Concrete curing compounds.
- Pesticides.
- Acids.
- Paints.
- Stains.
- Solvents.
- Wood preservatives.
- Roofing tar.
- Soil binders
- Any materials deemed a hazardous waste according to federal and state laws and regulations.

More information about federal and Missouri laws and regulations is available on the Missouri Department of Natural Resources' Hazardous Waste Program Web page at www.dnr.mo.gov/env/hwp/lawsregs.htm or by calling 800-361-4827 or 573-751-3176

More information about Kansas laws and regulations is available on the Kansas Department of Health and Environment Web page www.kdheks.gov/waste/ or by calling 785-296-1600.

Documentation

Log all education, maintenance, inspection and removal activities in case questions arise during inspections and for reference when troubleshooting problems.

Education And Training

- Educate employees and subcontractors about potential dangers to humans and the environment from hazardous wastes.
- Train employees and subcontractors about hazardous waste delivery, handling, storage and disposal procedures.
- Instruct employees and subcontractors about:
 - Identification of hazardous and solid waste.
 - Safety procedures for common construction site hazardous wastes.
- Hold regular meetings to discuss and reinforce hazardous waste management procedures along with safety procedures.

Petroleum Products

All vehicles kept on-site need to be monitored for leaks and receive regular preventive maintenance to reduce the chance of leakage. Leaking vehicles and construction equipment should be removed from service until the problem has been corrected. Petroleum products should be stored in tightly sealed containers are clearly labeled. Any asphalt substances used on-site should be applied according to the manufacturer's specifications and recommendations. Empty containers should be disposed of per manufacturer's recommendations and meet all federal, state and local regulations.

Fueling and Servicing

No fueling, servicing, maintenance or repair of equipment or machinery should be done within 100 feet of a stream, or within 150 feet of a classified stream, losing stream or sinkhole. Tarps or drop cloths and drip pads should be used when servicing, repairing or performing maintenance on construction equipment in the field. When work is complete, the contaminated materials should be disposed of appropriately.

Disposal of Petroleum and Hazardous Materials

No fuels, oils, lubricants, solvents, coolant, washer fluid or other hazardous materials can be disposed of on-site. All hazardous material must be properly disposed of in accordance with State law.

- For guidance, contact 800-361-4827 in Missouri or 785-296-1667 in Kansas.

Setup, Storage, Maintenance, Inspection and Removal

- Do not store hazardous chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and under cover in secondary containment.
- Incompatible materials, such as chlorine and ammonia, must not be stored in the same temporary containment facility.
- The site superintendent should keep an accurate, up-to-date inventory of material delivered and stored on-site.
- Minimize material inventory when stored on-site (e.g., only a few days supply).
- Employees trained in emergency spill clean-up procedures need to be present when dangerous materials or liquid chemicals are unloaded.
- Locate temporary storage areas away from vehicular traffic and in upland areas.
- Spill containment is highly recommended for chemical storage and transfer areas. (See [Spill Prevention and Control](#)).
- Locate an ample supply of appropriate spill clean-up materials near storage areas.
- Keep storage areas clean, well organized and equipped with ample clean-up supplies as appropriate for the materials being stored.
- Post proper storage instructions at all times in an open and conspicuous location. Storage areas should be clearly marked, directing placement of containers and materials.
- Store materials in their original containers. Maintain original product labels on the container where they can be easily seen. Damaged or otherwise illegible labels should be replaced immediately.
- Store bagged and boxed materials on pallets. Do not allow materials to accumulate on the ground. Cover bagged and boxed materials during non-working days and prior to rain events.
- Store materials exposed to precipitation in watertight, structurally sound, closed containers. All chemicals should be stored in approved containers and not exposed to stormwater.

Secondary Containment

Materials such as fuel (e.g., gasoline, diesel, kerosene), oil products (e.g., motor oil, transmission fluid, hydraulic oils, grease), miscellaneous liquids (e.g., windshield washer fluid, antifreeze, paint, concrete cure, liquid fertilizer, concrete sealer, calcium chloride, salt brine) should be stored in secondary containment. This represents a partial list.

- Throughout the rainy season, each secondary containment facility should have a permanent cover. The facility should at least be covered during non-working days, prior to rain events and during rain events. The cover should include side wind protection. The cover should be securely fastened to be effective during all rain events, overnight and during any extended period of time when the site will be left unattended.

- No not allow rainwater to collect within the secondary container. Remove any rainwater waste that does collect within the structure immediately so it does not reduce the capacity to contain spills or leaks. Collect and properly dispose contaminated rainwater, spills and leaks in accordance with local, state and federal regulations. (See [Spill Prevention and Control](#)).
- Provide Adequate cover to the secondary container to prevent the entry of rainwater. Depending on the type of secondary container used, adequate cover could include a tarpaulin, fitted lid or roof.
- Provide a temporary containment facility for a volume able to contain precipitation from a 24-hour, 25-year storm event, plus the greater of 10 percent of the aggregate volume of all containers or 100 percent of the capacity of the largest container within its boundary, whichever is greater.
- A temporary containment facility should be impervious to the materials stored therein for a minimum contact time of 72 hours.

Provide sufficient separation between stored containers, secondary or otherwise, to allow for spill cleanup and emergency response access. (See [Spill Prevention and Control](#)).

Inspection

- Inspect all construction equipment prior to use each day for leaks or spills.
- Inspect all areas where petroleum and hazardous waste materials are stored.
 - Inspect weekly and after each rainfall event that results in stormwater runoff.
 - Repair or replace perimeter controls, containment structures, covers and liners as needed to maintain proper function.
- Collect and clean up spills, leaks or accumulated rainwater and dispose of appropriately.
- If a rain event causes secondary containment devices to fill with water, dewater the containment system in the appropriate manner.
- Make sure routine and timely disposal of waste materials occurs.

Removal

- Collect, remove and dispose hazardous waste only at authorized disposal areas.
- Remove and stabilize petroleum and hazardous materials stored on the construction site prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (See [Chapter 1 -Missouri Permit Requirements](#)) for termination of permit coverage.

Common Problems and Solutions

Problem	Solution
Temporary containment device is full or overflowing after a rain event due to failure to dewater or lack of adequate storage volume.	Contain the discharge and ensure it does not leave the site. Ensure dewatering occurs in a timely manner following storm events. If necessary, enlarge the containment system to allow additional storage volume, and maintain the system appropriately.
Sheen shows up in dewater discharge, due to failure to remove sheen prior to dewatering.	Ensure there is no visible sheen on rainwater prior to dewatering. Use appropriate absorbents to recover materials to the extent possible. Properly dispose of absorbent materials and then finish dewatering.

Spill Prevention and Control

Spill prevention and control procedures and practices are necessary to prevent and control spills in a manner that minimizes or prevents the discharge of spilled material to the drainage system or watercourses. This includes calling the spill hot line to report the spill.

It is not the intent of this guidance to supersede or replace normal site assessment and remediation procedures concerning hazardous materials. (See [Petroleum and Hazardous Waste Management](#)). Significant spills, releases or contamination warrant an immediate response by trained professionals.

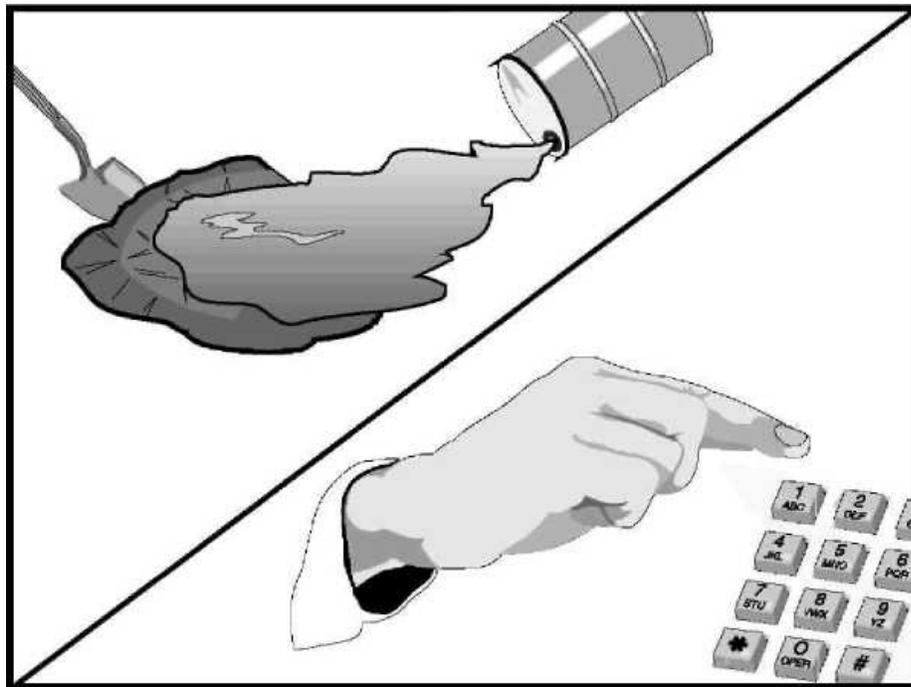


Figure 6.20 Contain spills and report them to the appropriate agency .

In Missouri, contact the department's emergency spill hot line at 573-634-2436.
In Kansas, contact the KDHE 24-hour spill hotline at 785-296-1679.

Recommended Minimum Requirements

Documentation

Log all education, maintenance, inspection, clean up and removal activities in case questions arise during inspections and for reference when troubleshooting problems.

Education and Training

- Ensure the contractor provides adequate training to the site superintendent and all field personnel about the proper protocol for reporting and cleaning up spills.
- Educate employees and subcontractors about potential dangers to humans and the environment from spills and leaks.
- Educate employees and subcontractors about what a “significant spill” is for each material they use and what is the appropriate response for “significant” and “insignificant” spills.
- Hold regular meetings to discuss and reinforce appropriate disposal procedures. Incorporate disposal procedures into regular safety meetings.
- Establish a continuing education program to train new employees.

In addition to good housekeeping and material management practices listed previously, the following practices need to be followed for spill prevention and clean-up:

- The spill response plan should be documented and its availability should be referenced in the written stormwater pollution prevention plan or SWPPP.
- Clearly post methods on-site for storage and spill cleanup, including manufacturer’s recommendations.
- Make site superintendent and field personnel aware of the procedures and the location of material safety data sheets, or MSDSs, information and cleanup supplies. For federal requirements for Spill Controls and Countermeasure Plans, or SPCC, see 40 CFR Part 112 on the Web at www.campuserc.org/virtualtour/grounds/WasteOils/Pages/SPCCDetails.aspx.
- Keep material and equipment necessary for spill cleanup in the material storage area on-site. Equipment and materials include, but are not be limited to, brooms, dust pans, mops, rags, gloves, goggles, kitty litter, sand, sawdust and plastic and metal trash containers specifically for this purpose.
- Clean up all spills immediately after discovery and properly containerize spills for proper disposal. Burial is not acceptable.
- Keep the spill area well ventilated. Personnel need to wear appropriate protective clothing to prevent injury from contact with a hazardous substance.

Reporting

Spills of toxic or hazardous material must be reported immediately to the appropriate state or local government agency, pursuant to reportable quantity regulations for specific materials or if a waterway is, or may be, impacted. Each county should have a Local Emergency Planning Committee, or LEPC. If you are unable to contact the committee directly, contact your local fire department, city hall or county courthouse. When permits are applicable, the permittee or authorized representative is required to notify the Missouri Department of Natural Resources or Kansas Department of Health and Environment’s Environmental Emergency Response in accordance with 40CFR117 and CFR302 as soon as they have knowledge of the discharge of any hazardous substance or petroleum product in excess of the reportable quantity.

- In Missouri, contact the 24-hour emergency spill hotline at 573-634-2436.
- In Kansas, contact the 24-hour emergency spill hotline at 785-296-1679.

In Missouri, state law requires the responsible party (spiller) to report petroleum product releases greater than 50 gallons to the Missouri Department of Natural Resources at 573-634-2436 at the earliest practical moment after discovery. If the release is from an underground storage tank, or UST, or piping, the reportable quantity is 25 gallons or more. Reports are also required for above ground storage tanks, or AST, that have released 50 gallons or greater. Further, federal law requires the responsible party to report any release of oil if the oil reaches or threatens any waterway. The definition of waterway includes sewers, groundwater, wetlands, lakes, creeks, streams, rivers and areas that may not have running water in them at the time, such as road ditches that drain into other waterways.

Adjust spill prevention plan to include measures to prevent this type of spill from being repeated. The plan needs to show how to clean up the spill if another one does occur.

Hazardous Products

- Keep products in original containers unless they are not resealable. If product is transferred to a new container, mark and label properly.
- Retain original labels and material safety data sheets. (See [Petroleum and Hazardous Waste Management](#)).

Disposal

If surplus product or a container must be disposed of, disposal must be done in accordance with State law. For local disposal information, contact your solid waste district, your local emergency planning committee or:

- In Missouri call 800-361-4827.
- In Kansas call 785-296-1667.

Maintenance, Inspections and Removal

- Inspect spill kits on a weekly basis and after each rainfall event that results in stormwater runoff. Inspect the spill kit anytime after material from the kit is utilized and note what material will need to be replaced.
- Maintain the appropriate contents of the spill kit as necessary. List contents of spill kit and attach it to the underside of the spill kit lid or some other readily accessible location. Include on the list the name and phone number of the person or company to contact to replace spill kit items.
- Remove this temporary device and stabilize the site prior to filing [Form H - Request for Termination of a General Permit](#), Form--MO 780-1409 (See [Chapter 1 -Missouri Permit Requirements](#)) for termination of permit coverage.

Common Problems and Solutions

Problem	Solution
Spills are not handled properly, due to site personnel being unaware of spill kit or its location.	Educate all contractors and subcontractors as they begin work on the site. Ensure they know the location of the spill kits and how to use them.
Spill went undetected for a significant period or was not reported, caused by lack of education, lack of inspections or inattention.	Educate all site personnel that all spills are to be reported to the site superintendent immediately and the spill should be contained and cleaned up immediately. Ensure all site personnel are properly trained.

Emergency Numbers

- **In Missouri:** Contact the department's emergency spills hotline at 573-634-2436. More information about federal and Missouri laws and regulations is available on the Missouri Department of Natural Resources' Hazardous Waste Program webpage at www.dnr.mo.gov/env/hwp/lawsregs.htm or by calling 800-361-4827 or 573-751-3176
- **In Kansas:** Contact the department's 24-hour spill hotline at 785-296-1679. More information about Kansas laws and regulations is available on Kansas Department of Health and Environment webpage at www.kdheks.gov/waste or by calling 785-296-1600

Concrete Washout



Figure 6.21 Concrete washout pit with signage. Source: ABC's of BMP's, LLC

Concrete washout water is a pollutant due to the high pH solution of the wash water. Concrete wash water must be contained on a construction site, and the high pH water cannot be allowed to exit the site and enter a waterway. Alkalinity and chemical additives could be harmful to fish, stream bottom macro invertebrates and wildlife.

Washing waste concrete into waters of the state or in a location where it is likely to enter waters of the state, such as a drainage ditch, is prohibited by State Law and Regulations (644.051 RSMo, 10 CSR 20-6.010). As long as state and local regulations allow, a concrete washout area can be as little as a depressional area where the concrete truck drivers can empty their trucks after use. This may not be allowed in areas of karst topography where cracks and fissures in the rock would allow the wash water to enter ground water easily. Lined pits may need to be used or other containment systems.

Recommended Minimum Requirements

- Procedures for concrete washout should be documented and referenced in the stormwater pollution prevention plan. The site superintendent and field staff should be trained on the procedures and should ensure they are practiced. Construct the concrete washout area to contain the concrete washout so the solids may harden. In approved locations, locate the washout area so the liquid portion of the washout may soak into the ground. The hardened material can then be disposed of properly with construction waste.
- Concrete washout area(s) need to be clearly marked with proper signage, and locations must be shown on the site map within the stormwater pollution prevention plan. The concrete washout area or device should not be placed within 50 feet of a stream or within 100 feet of a classified stream, losing stream or sinkhole.

Construction

- Unless otherwise noted by state and local requirements, the concrete washout can be contained in an excavated pit or bermed area and then buried on-site a minimum of 24 inches below finished grade. The depth must provide a minimum of 24 inches of topsoil over the disposed concrete to allow proper vegetative growth in the area. In areas where concrete wash water is not allowed to be disposed of in the soil, a lined container must be used and after the concrete hardens and there is no liquid as a possible pollutant, the material can be disposed of properly along with other construction waste.
- The number of washout facilities installed should depend on the expected demand for storage capacity. On large sites with extensive concrete work, place washouts in multiple locations for ease of use.
- Install signage adjacent to each washout facility to inform concrete equipment operators to use the proper facilities. Also locations of the washout facilities should be shown on the stormwater pollution prevention plan site map.
- Locate concrete washout on-site at least 100 feet from storm drains, water bodies (wet or dry), open ditches, etc.

Maintenance, Inspections and Removal

- Concrete washout pits must be inspected on a weekly basis and after each rainfall event that results in stormwater runoff. Cover the washout area before predicted rainfall events to prevent overflows. When the concrete reaches 75 percent of the storage capacity of the pit, the hardened concrete must be disposed of in an approved manner.
- These devices are temporary and should be removed from the site after all concrete has been poured and they are no longer necessary.



Figure 6.22 Concrete washout bag.

Common Problems and Solutions

Problem	Solution
Concrete wash water is hosed into a storm drain or directly to the creek due to lack of education or inattention to compliance.	Ensure all employees understand it is illegal to wash concrete water into storm drains and streams.
Concrete trucks are hosed out onto areas considered “in need of rip-rap”, due to a lack of education about the environmental harm caused by concrete wash water, the use of current engineering methods preferred over rip-rap or the thoroughly regulated nature of washout disposal.	<p>Ensure employees and concrete truck operators are well informed of the requirement to properly dispose of concrete washout.</p> <p>Discuss concrete management techniques with the concrete supplier before and after deliveries are made.</p> <p>Make sure concrete truck drivers are aware of the presence of concrete waste management facilities.</p>
Concrete wash water is not contained within the system due to inadequately sized storage area.	Ensure the wash water does not enter a water body. Clean dried material out of the system as needed to ensure adequate storage, or enlarge the system so wash water is fully contained until dry.



Figure 6.23 Concrete washout system that can be installed and maintained by vendor. Source: Concrete Washout Systems Inc.

Dust Control and Air Emissions

Prohibited Open Burning Under State Regulations

In Missouri, any waste generated by a business, trade, industry, salvage or demolition operation cannot be burned without a permit issued by the Department of Natural Resources or its delegated local agency. Permits will only be considered for untreated wood wastes. Wastes that may not be burned include but are not limited to tires, rubber products, hazardous materials, styrofoam, plastics, petroleum based products, demolition waste, treated wood and any asbestos containing material.

Required Open Burning Permits

In Missouri, the open burning of certain trade wastes, primarily untreated wood wastes such as pallets or crates, throughout the state, and vegetation from land clearing operations in the Springfield-Greene County area and the Kansas City and St. Louis Metropolitan areas, may be permitted only when it can be shown open burning is the only feasible method of disposal and disposal is in the public interest. In the St. Louis nonattainment area, permits will not be issued unless it can be shown emissions from open burning would be less than any other waste management or disposal method. The open burning permit requires the facility, in most cases, to use an air curtain destructor.

For more information in Missouri contact the Missouri Department of Natural Resources at 800-361-4827, or:

- Contact your nearest Missouri Department of Natural Resources' Regional Office. Contact information located on the Web at www.dnr.mo.gov/regions/regions.htm.
- See *Facts on Open Burning Under Missouri Regulations* fact sheet at www.dnr.mo.gov/pubs/pub2047.pdf.
- Visit the Missouri Department of Natural Resources' Air Pollution Control Program website at www.dnr.mo.gov/env/apcp/publications.htm or call 573-751-4817.
- Visit the Missouri Department of Natural Resources' Solid Waste Management Program webpage at www.dnr.mo.gov/env/swmp/index.htm, or call 573-751-5401.

In Kansas, open burning is regulated by the Kansas Department of Health and Environment. Any open burning of tree and brush typically requires a permit. For more information:

- *Open Burning of Wood Waste* - Technical Guidance Document BAR2000-01.
- *Open Burning for Tree and Brush Sites* - Technical Guidance Document 2002.
- Technical Guidance Document (burning of waste).

For more information in Kansas, contact your Kansas Department of Health and Environment district office, or call 785-296-1550.

Note: Local governments may have stricter laws and policies regarding burning or disposal of wastes.

Dust Control Regulations

In Missouri, state regulation places limits on the amount of visible dust that can leave a property boundary. The general contractor is responsible for implementing control measures as necessary when handling, transporting or storing any material; construction, repair, cleaning or demolition of a building or its appurtenances; construction of use of a road, driveway or open area; or operation of a commercial or industrial installation without applying reasonable measures to prevent visible dust from leaving the property boundary.

For more information about this regulation:

- See 10 CSR 10-6.170 Restriction of Particulate Matter to the Ambient Air Beyond the Premises of Origin at www.sos.mo.gov/adrules/csr/current/10csr/10csr.asp.
- Visit the Missouri Department of Natural Resources' Air Pollution Control Program website at www.dnr.mo.gov/env/apcp/publications.htm or call 573-751-4817.

Dust control measures used to protect air quality must not cause a violation of the water quality standards, permit conditions or other regulations. For more information about dust control measures, see [Surface Stabilization – Erosion Controls](#).

General Housekeeping Reminders

Some general reminders of information provided in this pollution prevention and good housekeeping section, include:

- An effort should be made to store only enough product to do the job. All materials stored on-site should be stored in a neat, orderly manner in their appropriate containers and, if applicable, under a roof or other enclosure.
- Products should be kept in their original containers with the original manufacturer's label. If a replacement container is used, it must be clearly labeled and the original label retained.
- Whenever possible, all of a product should be used up before disposing of the container.
- Manufacturer's recommendations for proper use and disposal of contents and containers must be followed. Refer to the [Material Safety Data Sheets](#).
- The site superintendent should inspect daily to ensure proper usage, storage and disposal of materials.
- Fertilizers need to be applied only in the minimum amounts recommended by the manufacturer.
- All paint containers need to be tightly sealed and stored when not required for use. Excess paint may not be dumped into the storm sewer system but should be properly disposed of according to manufacturer's instructions, Material Safety Data Sheets and State and local regulations. (See [Petroleum and Hazardous Waste Management](#)). Non hazardous non bulk household products are allowed by regulation to be disposed of sanitary landfills. However, landfill operators may impose more stringent restrictions. Contact the local government for more information and refer to [Solid Waste Management](#).
- Disposal of waste oil. If used oil has come into contact with hazardous materials, it is considered to be waste oil. It must be disposed of according to hazardous waste regulations. (See [Petroleum and Hazardous Waste Management](#)).
- Used oil (non hazardous) should be disposed of at the nearest used-oil recycling center. For more information, check with the local government and refer to the Missouri Solid Waste Management webpage at www.dnr.mo.gov/env/swmp/index.html or call 800-361-4827.
- Mudtracking is a common problem at construction sites. Refer to [Site Preparation](#) for proper exit pad installation and maintenance.

SECTION 3: SURFACE STABILIZATION - EROSION CONTROLS

Temporary Seeding



Figure 6.24 Temporary vegetation is a relatively inexpensive way to stabilize construction sites in a hurry. As grass grows, the roots hold soil in place and the plant protects the soil surface from raindrop impacts. Source: N. Klopfenstein, NRCS. St. Charles Co.

Practice Description

Temporary seeding is the establishment of fast-growing annual vegetation to provide economical erosion control for up to 6 months and reduce the amount of sediment moving off the site.

Annual plants that germinate rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover.

This practice applies where short-lived vegetation needs to be established before final grading or in a season not suitable for permanent seeding.

Recommended Minimum Requirements

A qualified professional should specify plant materials, seeding rates and times of planting. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. To ensure emergence, vigorous growth of seedlings and continued plant growth, prepare the seedbed and add soil amendments according to soil tests. Protect the soil and seed with mulch or other erosion control until the vegetation is fully established to a density of 70 percent over the entire vegetated area.

Soil

Make sure there is a minimum of three inches of topsoil with a sufficient percentage of organic material to sustain vegetative growth.

Seedbed Preparation

Loosen soil to depth of 3-inches for broadcast seeding or drilling. If compacted, loosen soils for no till drilling. Avoid excessively wet conditions.

Amendments

Incorporate fertilizer and lime (if soil pH is less than 5.3) incorporated 3- to 6-inches into the soil. See Table 6.2.

Seed Quality

Use certified seed, tested within the past nine months.

Plants

Select recommended temporary erosion control plant species. Rate of application and seeding dates are listed in Tables 6.3 and 6.4.

Erosion Control

Cover the seeded area with approved mulching materials or other erosion control devices to protect the soil and seed until vegetation is fully established.

General

Inspect seeded areas 2 to 4 weeks after seeding for seed germination, vegetation establishment, erosion control and weed control. Repair and reseed as necessary.

Reseed

After six months if the site is not in permanent vegetation over the entire disturbed area to a density that impedes erosion.

Installation

Successful vegetative establishment is directly dependent on the nutrients in the soil. For optimum results, take soil samples from the top 6-inches in each area to be seeded. Submit samples to a soil testing laboratory for liming and fertilizer amendment recommendations.

Seedbed Preparation

- Seedbed preparation is essential for the seed to germinate and grow.
- For broadcast seeding and drilling, loosen the soil to a depth of approximately 3-inches.
- For no-till drilling, the soil surface does not need to be loosened unless the site has surface compaction.
- Use a disk, ripper, chisel, harrow or other acceptable tillage equipment to loosen compacted, hard or crusted soil surfaces. Avoid preparing the seedbed under excessively wet conditions.

Liming

- Acid soils with an extremely low pH can prevent seeding success. However, most of the recommended temporary vegetation is tolerant of low pH soils and will establish on all but the lowest pH soils.
- If soil pH in the region is known to be extremely low, conduct a soil pH test to determine if limestone is necessary for temporary seeding. Amend soils with lime according to information in Table 6.2. Soils with a pH above 7.0 should not be limed.

Table 6.2 Liming Requirements for Temporary Sites

pH Test	Plant Response	Recommended Application of Agricultural Limestone
Below 6.0	Poor growth	Lime according to soil test
6.0 - 6.5	Adequate growth	No lime recommended
Greater than 6.5	Optimum	No lime recommended

Fertilizer

- The soil will most likely be deficient in nutrients required for growth. A soil test will provide the best guide for the amount and types of fertilizer to apply for optimum plant growth.
- A general recommendation is to broadcast Nitrogen, Phosphorus and Potassium at 90 lbs./acre for areas receiving more than 30 inches of precipitation and 50 lbs./acre in areas receiving less than 30 inches of precipitation.

For example, to compute the bulk pounds of product to use - For 100 pounds of a 10-10-10 fertilizer mix you have 10 percent or 10 pounds of actual Nitrogen, Phosphorus and Potassium. The remaining 70 percent or 70 pounds of product in the bag is inert material that improves application consistency. You would need to apply 900 pounds of product per acre to provide 90 pounds of actual Nitrogen per acre.

- For best results incorporate the fertilizer into the top 3- to 6-inches before seeding.

Seeding

- Apply seed evenly with a broadcast seeder, drill, cultipacker seeder or hydroseeder. Plant small grains no more than 1½ inches deep. Plant grasses and legumes no more than ½ inch deep.
- Prior to mulching, harrow, rake or drag a chain to lightly incorporate broadcast seed into the soil to enhance germination. Cover applied seed with mulch (See [Mulching](#)).

Table 6.3 Temporary Seeding Plant Materials and Minimum Seeding Rate *

Species	Seeding Rate		Plant Characteristics
	lbs. per Acre	lbs. per 1,000 ft. ²	
Oats	80 lbs.	2 lbs	Not cold tolerant, height up to 2 feet
Cereals: Rye/Wheat	90 / 120	2 / 2.5	Cold tolerant, height up to 3 feet, low pH tolerant
Millet, Sudangrass	45 / 60	1 / 1.25	Warm season annual, aggressive growth, height up to 5 feet
Annual Ryegrass	75	2	May be added to mix, not heat tolerant, height up to 16 inches
Annual Lespedeza** plus Tall Fescue	15 plus 45	0.5 plus 1	Warm season annual legume, makes own nitrogen, tolerated low pH

* In areas receiving less than 30 inches of precipitation, use 75 percent of these rates.

** If there is any possibility the seeding will be required to control erosion for more than one year, then consider the addition of fescue or another permanent species as part of a mixture when seeding.

Planting Dates

- Plant according to the design plan. In absence of a plan, choose a recommended temporary species or mixture appropriate for the season from Tables 6.3 and 6.4.
- Plant during optimum seeding dates if at all possible. Always use mulch or other erosion control practices to cover and protect seed and soil during vegetation establishment. Roll and cultipack broadcast seed for good soil-to-seed contact.
- Use high quality seed and for best results, use certified seed. When using uncertified seed, use the highest recommended seeding rate.

Table 6.4 Seeding Dates for Temporary Seeding

Species	Seeding Dates Optimum and Acceptable											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oats												
Cereals: Rye/Wheat												
Millet, Sudangrass												
Annual Ryegrass												
Annual Lespedeza plus Tall Fescue ¹												

¹ If site may not be developed within one year, consider permanent species listed in Table 6.5.

Table Key	
	Optimum Seeding Times
	Acceptable Seeding Times

Mulching

- Mulching conserves moisture and reduces erosion during seed germination and vegetation establishment.
- Evenly cover a minimum of 75 percent of the ground surface with mulch material specified in the design plan. Tack or tie down the mulch according to plan (See [Mulching](#)).

Construction Verification

Check materials and installation for compliance with specifications.

Maintenance and Inspection

- Check temporary seeding during each weekly inspection to monitor germination, growth and to see if stands are of adequate thickness (more than 70 percent density of the ground surface vegetation over the entire area to be stabilized). Stands should be uniform and dense for best results. Fertilize, reseed and mulch bare and sparse areas immediately to prevent erosion.
- Mowing is not recommended for cereals seeded alone. Cereals seeded with a grass can be mowed when height is greater than 12-inches. However, to prevent damage to grasses, do not mow shorter than 4-inches.
- Mow millets and sudangrass before height is greater than 6-inches to allow regrowth and continued erosion protection.
- Annual lespedeza and tall fescue may be mowed after height exceeds 8-inches. Do not mow shorter than 4-inches.
- Replant temporary or permanent vegetation within 12 months as annual plants die off and no longer provide erosion control (see [Permanent Seeding](#)). Consider no-till planting

where possible.

Common Problems and Solutions

Problem	Solution
Design specifications for seed variety, seeding dates or mulching cannot be met.	Substitutions may be required. Unapproved substitutions could lead to failure.
Vegetation is not sustainable as a permanent cover caused by a lack of topsoil resulting in a lack of organic material, nutrients and water holding capacity.	Add topsoil with a minimum of three percent organic material.
Poor seedling emergence and growth with erosion of the soil caused by inadequate seedbed preparation.	Repair gullies, prepare seedbed, fertilize, lime (if necessary), mulch and reseed.
Unsuitable choice of plant materials; resulting in poor germination or inadequate stand (less than 70 percent of the ground surface covered).	Choose plant materials appropriate for season, prepare seedbed and replant.
Poor or spotty stands of vegetative cover caused by inadequate mulching, washing away of the seed and erosion of the soil surface.	Poor plant vigor, yellow color and short height caused by a lack of nitrogen - add 50 lbs. of nitrogen fertilizer per acre. Do not apply over the top of existing plants from June 1 to Aug. 15 or on frozen ground.
Poor plant vigor, yellow color and short height caused by a lack of nitrogen.	Add 50 lbs. of nitrogen fertilizer per acre. Do not apply over the top of existing plants from June 1 to Aug. 15 or on frozen ground.
Dying plants caused by a lack of topsoil or soil compaction that limits root growth and water availability to plants.	Add organic material and loosen soil if reseeding is necessary or before seeding permanent vegetation.

Permanent Seeding



Figure 6.25 Permanent vegetation can be used to stabilize many structures, such as this grassed waterway, ensuring that runoff is relatively sediment-free.

Practice Description

Permanent seeding is the establishment of perennial vegetation on disturbed areas for periods longer than 12 months. Permanent vegetation provides economical long-term erosion control and helps prevent sediment from leaving the site. This practice is used when vegetation is desired to permanently stabilize the soil or if future phases of a construction site will remain dormant for a significant period of time after grading. It is necessary to protect earthen structures such as dikes, channels and embankments. Particular care is required to establish a good, thick cover of permanent grass.

Recommended Minimum Requirements

A qualified professional should specify plant materials, seeding rates and times prior to start of construction. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. To ensure germination and growth, prepare seedbed, add soil amendments according to soil tests, mulch all seeded areas and follow the seeding dates.

Seedbed Preparation

For broadcast seeding or drilling, loosen soil to depth of 3-inches. For no till drilling, loosen the soil if it's compacted. Avoid excessively wet conditions.

Soil Amendments

Incorporate fertilizer and lime (if soil pH is less than 6.0) incorporated 3- to 6-inches into the soil.

Seed Quality

Use certified seed, tested within the past 9 months.

Planting Dates

Coordinate the construction schedule with planting dates appropriate for region and species (See Table 6.5).

Plants

Select from recommended erosion control plants (grass or grass/legume mixtures) as shown in Tables 6.5 and 6.6. Rate of application and seeding dates are shown in Tables 6.4, 6.7 and 6.8.

Mulch

Cover a minimum of 75 percent of the ground surface with approved material (See [Mulching](#)).

Inspection

Inspect seeded areas during each weekly inspection. Repair and reseed as necessary.

Installation

During final grading, take soil samples from the top 6-inches in each area to be seeded. Submit sample to a soil testing laboratory for liming and fertilizer recommendations.

Seedbed Preparation

- Seedbed preparation is essential for the seed to germinate and grow.
- For broadcast seeding and drilling, loosen the soil to a depth of approximately 3-inches.
- For no-till drilling, the soil surface does not need to be loosened unless the site has surface compaction.
- Loosen compacted, hard or crusted soil surfaces with a disk, ripper, chisel, harrow or other tillage equipment.
- Avoid preparing the seedbed under excessively wet conditions.

Liming

- Follow the recommendations resulting from the soil test. Apply ground agricultural limestone unless a soil test shows a pH of 6.5 or greater.
- Incorporate lime into the top 3- to 6-inches of soil.
- Do not add lime if the pH is 7.0 or greater.

Fertilizer

Remember: Phosphorus helps roots grow and develop to get the grass plants established. Nitrogen will only be taken up after the seed has germinated and the vegetation is growing. It may wash down stream if applied heavily during seeding.

Note: Fertilizer can be blended to meet exact fertilizer recommendations. Take soil test recommendations to local fertilizer dealer for bulk fertilizer blends. This may be more economical than bagged fertilizer.

For establishment and long-term growth, apply a complete fertilizer at rates recommended by soil tests or as specified in the design plan. In the absence of soil tests, use the following as a guide:

- A typical fertilizer blend for lawn grass mixes: Apply 10-24-18 which represents 10 percent of actual nitrogen – 24 percent of actual phosphorus and 18 percent of actual potassium within the fertilizer compound. If you had 100 pounds of a 10-24-18 blend you would have 10 pounds of actual nitrogen, 24 pounds of actual phosphorus and 18 pounds of actual potassium within the bag.

- A typical application rate of fertilizer for initial establishment of vegetation after seeding is approximately 1 pound of actual nitrogen per 1,000 square feet. With the 10-24-18 fertilizer this would require the application of approximately 435 pounds of this fertilizer mix per acre since there are 43,500 square feet in an acre. This fertilizer would also provide more than 2 pounds of phosphorus per acre.
- Incorporate lime and fertilizer to a depth of 3- to 6-inches by disking or chiseling on slopes of up to 3:1.
- Grade soil to a smooth firm surface to enhance rooting of seedlings and reduce rill erosion.
- Subsequent fertilization with an additional 2 pounds per 1,000 square feet of actual Nitrogen approximately one month after initial seeding will help grass growth after germination to achieve the density of vegetation to prevent or minimize erosion. A typical fertilizer for a second application once vegetation is established would be a 20-10-5 mix at 435 pounds of fertilizer per acre.

Plant Selection

If not specified in the design plan, choose a suitable species of grass or a grass/legume mixture from Tables 6.5 and 6.6 appropriate for the season. Consider site conditions including soils, plant characteristics, region of the state and desired level of maintenance. The species shown are adapted for lawns and erosion control. If there are questions on species selection and how they may be adapted in wildlife habitat or wetland applications, contact your local Natural Resources Conservation Service or Extension office.

Developing a Mixture

A pure stand of grass provides the best erosion control. The advantage of a grass/legume mix is the legume provides nitrogen to the grass and often grows during hotter and drier months when the grass is dormant. Usually one grass and one or two legumes is sufficient in a mixture. More grasses can be mixed together, but may be of little use. Refer to Tables 6.5 and 6.6 for information about each grass and legume to determine the correct species for your site.

Nurse Crops (Temporary or Annual Species)

Nurse crops are temporary grains that have one growing season such as wheat, rye and oats and are sometimes used in a seeding mixture. These annuals can reduce weeds, control erosion and provide protection to young seedlings until the perennial species become established.

Plant nurse crops about 1-inch deep. Most permanent grasses and legumes are sown 1/4 inch deep. Permanent seedings should not be planted deeper than 1/4 to 1/2 inch.

Aesthetic Plantings

A wide variety of native forbs and grasses are available that add diversity and beauty to permanent plantings (e.g., switchgrass as an accent). Contact your local Natural Resources Conservation Service office for species selection and seeding rates.

Planting Dates

If seeding dates are not specified in the design plan or construction has not proceeded according to schedule, use the seeding calendar shown in Table 6.5.

Plant during optimum seeding dates if at all possible. Always use mulch or other erosion control measures to protect the seed and reduce erosion until the vegetation is established. For dormant seeding dates, broadcast seed and immediately roll and cultipack for good soil-to-seed contact.

If unable to seed according to schedule, use temporary seeding until the preferred date for permanent seeding.

Seeding Rates

If seeding rates are not specified in the design plan, use rates in Table 6.8 for grasses alone. Use rates in Table 6.9 for a grass or legume mixture. These rates are based on the poor growing conditions that typically exist on a development site, a need for dense growth and high germination rates.

For best results use certified seed. When using uncertified seed, use the highest recommended seeding rate. Higher seeding rates will not substitute for good seedbed preparation.

- Apply seed uniformly using a cyclone seeder, drop-type spreader, drill, cultipacker seeder or hydroseeder.
- When using a drill seeder, plant rye or other grains about 1-inch deep; plant grasses and legumes no more than ½ inch. Calibrate equipment in the field.
- Cover seed by raking, or dragging a chain, brush or mat. Then firm the soil lightly with a roller. Seed can also be covered with hydro-mulched wood fiber and tackifier or a rolled erosion control product.
- Legumes require inoculation with nitrogen-fixing bacteria to ensure good growth. Purchase inoculum from seed dealer and mix with seed prior to planting.

Table 6.5 Planting Dates Optimum and Acceptable* Planting Dates

Species	Seeding Dates Optimum and Acceptable											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Turf Fescue												
Tall Fescue												
Kentucky Bluegrass												
Perennial Ryegrass												
Ryetop												
Reed Canary												
Bermuda - Common												
Bermuda- Hybrid												
Buffalograss ¹												
Zoysia ²												
Birdsfoot Trefoil												
Common Lespedeza												
Red Clover												
White Clover												
Wheat/Rye ³												
Oats ^{3,4}												

¹ Can also be sprigged.

² Usually sprigged. Space plugs every 6-, 8- or 12-inches; with 4,000, 2,250 or 1,000 sprigs/1000 ft² respectively.

³ Check with your local Noxious Weed Department before planting.

⁴ Nurse crop only.

⁵ Provides a quick temporary cover or nurse crop even if planted in the fall.

Table Key	
	Optimum Seeding Times
	* With Mulch Cover - Acceptable Seeding Times

Table 6.6 Plant Characteristics

	Species	Kansas Adaptation	Missouri Adaptation	Maintenance	Fertility Needs	Establishment Ease
				L - M - H	L - M - H	P - M - G
Cool Season Grasses	Perennial ryegrass	E, C, W*	N, S	L	M	M
	Canada wildrye	E, C, W	N, S	M	L	G
	Tall fescue	E, C, W*	N, S	M	L - H	G
	Crested wheatgrass	E, C, W	N	M	L	M - G
	Kentucky bluegrass	E, C, W*	N, S	H	M - H ¹	M - G
	Bromegrass	E, C, W*	N, S	M	M - H ¹	M - G
	Redtop	S ¹ / ₂ E	N, S	L	L	M
	Reed canary ¹	E, C, W*	N, S	H	L - M ³	P
Warm Season Grasses	Common Bermuda	E, C, W*	S	L	L - M	M
	Hybrid Bermuda	E, C, W*	-	L	L - M	M
	Buffalograss ³	E, C, W*	N, S	L	L	M
	Blue grama	E, C, W*	N, S	L	L	M
	Zoysia ⁴	E, C, W*	-	M	M - H	M
	Sideoats grama	E, C, W*	N, S	M	L	G
	Little bluestem	E, C, W*	N, S	M	L	M
	Big bluestem	E, C, W*	N, S	M	L	M
	Indiangrass	E, C, W*	N, S	M	L	M
	Switchgrass	E, C, W*	N, S	M	L	M
Legumes ⁵	Birdsfoot trefoil	E, C, W*	N, S	L	M	P - M
	Crownvetch	E, C, W*	N, S	M	M	P - M
	Annual lespedeza ⁶	E, C, W*	N, S	M	M	P - M
	Red clover	E, C, W*	N, S	M	M	G
	White clover	E, C, W*	N, S	L	M	M - G
	Alfalfa	E, C, W*	N, S	M	L	P
Companion Crops/Cereal Grains	Wheat	E, C, W*			M	M
	Rye (cereal)	E, C, W*			M	M
	Oats	E, C, W*			M	M

* Adaptation limited to areas that receive additional moisture enhancement by irrigation, subirrigation or overland flow.

¹ Will be high maintenance in lawn – type or low rainfall (<30") settings.

² Adapted to shorelines, wet or frequently flooded areas.

³ Responds well to fertilizer, but doesn't necessarily require it.

⁴ Usually seeded, by can be sprigged.

⁵ Usually sprigged, plugged or sodded.

⁶ Legumes alone will not provide adequate erosion protection: use with a grass in a mixture.

⁷ Will reseed each year if not mowed until after seed shatter in September.

Table Key

L = low
M = moderate,
H = high.
P = poor,
G = good.

Table 6.7 Species Tolerance for Environmental Conditions

Species		Tolerance				
		Shade	Drought	Flooding	Traffic	Soil Wetness
Cool Season Grasses	Perennial ryegrass	L	L	M	M	M
	Canada wildrye	M	M	L	M	P
	Tall fescue	M	M	M	M	P
	Crested wheatgrass	L	H	M	M	G
	Kentucky bluegrass	L	L	M	H	G
	Bromegrass	L	M	L	H	M
	Redtop	L	L	M	H	G
	Reed canary	L	M	H	H	G
Warm Season Grasses	Common Bermuda	L	H	H	H	M
	Hybrid Bermuda	L	H	H	H	M
	Buffalograss	L	H	H	H	G
	Blue grama	L	H	L	M	P
	Zoysia	L	H	M	H	P
	Sideoats grama	L	H	M	H	M
	Little bluestem	L	H	L	L	P
	Big bluestem	L	H	M	L	M
	Indiangrass	L	M	L	M	P
	Switchgrass	L	M	M	M	G
Legumes ¹	Birdsfoot trefoil	L	H	L	M	G
	Annual lespedeza	L	L	M	L	M
	Red clover	L	L	L	M	P
	White clover	L	L	L	H	M
	Alfalfa	L	L	L	L	P

¹ Legumes alone will not provide adequate erosion protection: use with a grass in a mixture.

Table Key
L = Low
M = Moderate
H = High
P = Poor
G = Good

Table 6.8 Seeding Rates

Species		Kansas: Full Seeding Rate ¹	Missouri: Full Seeding Rate ¹
		lbs./acre (PLS) ²	lbs./acre (PLS) ²
Cool Season Grasses	Perennial ryegrass	150	150
	Canada wildrye	21	24
	Tall fescue	150	150
	Crested wheatgrass	20	16
	Kentucky bluegrass	120	120
	Bromegrass	100	100
	Redtop	8	8
	Reed canary ¹	40	40
Warm Season Grasses	Common Bermuda	2	4
	Hybrid Bermuda	20 bu./acre	-
	Buffalograss ³	8 (grain)	8 (grain)
	Blue grama	3	6
	Zoysia ⁴	20 bu./acre	-
	Sideoats grama	15	15
	Little bluestem	9	13
	Big bluestem	17	16
	Indiangrass	12.5	16
	Switchgrass	8	9
Legumes ⁵	Birdsfoot trefoil	5	10
	Annual lespedeza ⁶	14	16
	Red clover	8	12
	White clover	3	4
	Alfalfa	9	9
Companion Crops	Wheat	1 bu./acre	1 bu./acre
	Rye (cereal)	1 bu./acre	1 bu./acre
	Oats	1.5 bu./acre	1.5 bu./acre

¹ Note: Rates based on typical construction site conditions where seedbed is normally less than ideal. Planned future use or specific site conditions may dictate an increase or a decrease in rates. Contact your local Natural Resources Conservation Service office or consulting agronomist for specific seeding rates within your county.

² PLS or Pure Live Seed = the amount of seed guaranteed to grow.

³ Legumes alone will not provide adequate erosion protection: use with a grass in a mixture.

Table 6.9 Example Seeding Mixtures for Critical Area Seeding

Grass - Legume Mixture	Seeding Rate (PLS) *	
	lbs./1000 ft. ² ***	lbs./acre
Reed canarygrass / White clover	5 + 0.1	40 + 1
Reed canarygrass / Red clover	5 + 0.25	40 + 2
Tall fescue** / Birdsfoot trefoil	10 + 0.25	80 + 2
Tall fescue** / White clover	10 + 0.1	80 + 1
Tall fescue** / Lespedeza	10 + 0.5	80 + 4
Tall fescue** / Lespedeza / White clover	10 + 0.25 + 0.1	80 + 4 + 1
Tall fescue** / Red clover	10 + 0.25	80 + 2
Tall fescue** / Red clover / White clover	10 + 0.25 + 0.1	80 + 2 + 1
Kentucky bluegrass / White clover	3 + 0.1	25 + 1
Kentucky bluegrass / Red clover	3 + 0.25	25 + 2
Kentucky bluegrass / Birdsfoot trefoil	3 + 0.25	25 + 2
Kentucky bluegrass / Lespedeza	3 + 0.5	25 + 4
Perennial ryegrass / Red Clover	8 + 1	70 + 10
Perennial ryegrass / Birdsfoot trefoil	8 + 0.5	70 + 5
Perennial ryegrass / Lespedeza	8 + 3	70 + 25
Big bluestem / Indiangrass / Switchgrass / Sideoats grama / Western Wheatgrass	-	3.4 + 2.5 + 2 + 3 + 4
Wheat / Rye (as nursery crop)	1.5	60
Oats (as nursery crop)	0.75	30

* PLS or Pure Live Seed = the amount of seed guaranteed to grow. To calculate amount of bulk seed needed: Read seed tag and multiply % purity X % germination = % PLS; then divide lbs of PLS recommended by % PLS. Example: 30 lbs of Reed canary is needed to seed a 1 acre waterway; 90% pure X 90% germination = 81% PLS; 30 lbs PLS / .81 = 37 lbs. bulk seed needed.

** Turf fescue may be substituted for fescue at the same rates.

***Note: Use lbs. / 1,000 ft.² rate to establish dense vegetation for lawns.

Erosion Control

- Mulching or a rolled erosion control product is recommended to conserve moisture, reduce erosion and protect the seed.
- Cover at least 75 percent of the area with approved mulch materials. Crimp, tack or tie down mulch with netting. Mulching is extremely important for successful seeding (See [Mulching](#)).

Construction Verification

Check materials and installation for compliance with specifications.

Maintenance and Inspection

- Inspect seeded areas weekly and after rain events. Check for erosion and seed wash out.
- Expect emergence of grasses and legumes within 28 days after seeding, with legumes following grasses.
- Check permanent seeding at each regular weekly inspection. Look for:
 - Germination.
 - Vigorous seedlings.
 - Uniform density with at least 70 percent of the ground surface covered.
 - Uniformity with nurse plants, legumes and grasses well intermixed.
 - Green, not yellow, leaves. Perennials should remain green throughout the summer, at least at the plant bases.

Reseeding

- Inspect seedings for die out for at least a year. Inspect the soil for erosional areas. To repair bare and sparse areas, fill gullies, refertilize, reseed and mulch. Consider no-till planting where possible.
- If stand is inadequate or plant cover is patchy, identify the cause of failure and take corrective action (e.g., choice of plant materials, lime and fertilizer quantities, poor seedbed preparation, lack of topsoil or weather.) If vegetation fails to grow, have the soil tested to determine whether pH is in the correct range or nutrient deficiency is a problem.
- Depending on stand conditions, repair with complete seedbed preparation, then overseed or reseed.
- If it's the wrong time of year to plant desired species, overseed with cereal grain or millets to thicken the stand until timing is right to plant perennials or use temporary seeding.

Fertilization

Satisfactory establishment may require refertilizing the stand in the second growing season.

- Do not fertilize cool season grasses in late May through July.
- Grass that looks yellow may be nitrogen deficient. An application of 500 lbs of 10-10-10 Nitrogen, Phosphorus, and Potassium per acre in early spring will help cool season grasses compete against weeds or grow more successfully.

Remember to convert actual pounds of nutrient needed when determining how many pounds of commercial fertilizer to buy.

- Do not use nitrogen fertilizer if stand contains more than 20 percent legumes.

Mowing

- Consider mowing after plants reach a height of 6- to 8-inches.
- Mow grasses tall, at least 3-inches in height and minimize compaction during mowing process.
- Monitor the late winter and early spring growth of nurse crops to be sure that they do not smother the permanent seeding. Mowing in April may reduce the competitiveness of the nurse crop and open the canopy to allow more sunlight to permanent seedlings that are beginning to grow.
- Vegetation on structural practices such as embankments and grass-lined channels need to be mowed only to prevent woody plants from invading.

Troubleshooting

Consult with design professional if the following occurs:

- Design specifications for seed variety, seeding dates or mulching cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.

Common Problems and Solutions

Problem	Solution
Poor stand of vegetation caused by inadequate topsoil.	Apply good topsoil with a minimum of 5 percent organic material and reseed.
Poor stand of vegetation caused by inadequate seedbed preparation.	Prepare well-tilled, limed and fertilized seedbed and reseed.
Vegetative stand failures caused by unsuitable choice of plant materials such as seeding Bermuda grass in the north or in the fall.	Select an appropriate species based on plant characteristics in Tables 6.8 and 6.9 and time of seeding.
Perennial vegetation overtaken by nurse crop with too high seeding mixture.	Limit rates to those shown in Table 6.9; eliminate old nurse crop, prepare seedbed and reseed.
Inadequate stand of vegetation caused by seeding at the wrong time of the year.	Consult Table 6.5 and reseed. If timing is not right, use temporary seeding to stabilize soil until preferred seeding dates.
Inadequate stand of vegetation, bare spots or eroded areas caused by inadequate mulching.	Prepare seedbed, reseed, cover seed evenly and tack or tie down mulch, especially on slopes, ridges and in channels (see Mulching).

Hydroseeding



Figure 6.26: Hydroseeding over matt armoring on a steep slope to promote vegetation growth and prevent erosion.
Source: *Florida Erosion and Sediment Control Designer and Reviewer Manual*, June 2007

Hydroseeding is the application of a mixture of water, wood fiber (this could be paper or a 70/30 blend of wood fiber and paper), seed, fertilizer, and a soil stabilizer to temporarily and permanently protect exposed areas of soil from erosion due to wind, rain, and runoff. It is a way to establish grass where grass is the desired cover. This method is most often used in large-scale projects such as highway projects or steep slope areas where straw, sod and blankets are more challenging to use.

Hydroseeding is applied with a mechanical machine. Highway departments often use a boom machine with hoses that can shoot up to 100 feet or more, using soil stabilizers in the seed mix.

For most effective coverage, exposed soil surface should be loose (uncompacted) at time of application. Soil areas can be roughened by rolling the surface with a crimping or punching-type roller or by track walking to increase the soil surface area available for seeding. For best results, cover hydroseed layer (seed with soil stabilizer if used) with a mulch layer to keep applied seeds in place, retain soil moisture, and control soil temperature during seed establishment. The mulch acts as a blanket to protect the seed from wind and erosion.

Fertilizers should be included only when soil tests indicate a lack of adequate nutrients to establish and sustain the selected vegetation. However, there is much debate about whether starter fertilizers should be used at time of seeding. The important factor is to have adequate organic matter in the soil bed so that fertilizing is not necessary. Typically by time the seed

germinates and starts to develop a root system, about 25 percent of the fertilizer has leached out or washed away except when one is using a “cross-linked polymer” or so called “water retention polymer”. The other exception is when you are using a growth stimulator that will increase germination therefore allowing more of the starter fertilizer to still be in the soil. There are also other options to using fertilizers, such as guar, biostimulants and other root inoculants.

- The application of a soil binder may be necessary to further stabilize hydraulic mulch and seed to allow for germination and continued growth of vegetation. Soil binders in this case are sold as a tackifier and dust palliative all in one – not soil specific. The soil binder reacts with the soil, binding the mulch, seed, fertilizer, and other additives to the soil, holding it together until vegetation is established. Open weave matting can be applied before hydroseeding areas, especially in areas with steep slopes or sandy conditions, to provide additional structural support, creating a highly erosion-resistant surface to support vegetation establishment. There are also additive products available that have a fibrous material in them to create the same high performance bonding of soil, seed and mulch which is may be cheaper and more efficiently applied through the hydroseeder. See precautions on WCCs under [Chemical Application for Turbidity Reduction](#).

Loading of soil binders and other additives should be done in accordance with machine manufacturer procedures. The hydroseed mix should be applied to the soil as soon as possible following the loading of additives. Otherwise, slurry may become too thick, and the machine could become clogged – wasting time, product and money. Straw, mulch, matting, or jute cover may be applied over the hydroseed application to further promote the vegetation and prevent erosion, but if too thick, the sun, oxygen and water cannot penetrate into the seed/soil.

Installation

- While construction activities are occurring.
- After construction activities are completed.
- Avoid application of hydroseed on existing vegetation, water bodies, sidewalks and roadways. Hydroseeding should not be used in areas where re-disturbance is expected within four to six weeks.
- In a manner that avoids overspray into water bodies, on sidewalks, and on roadways, where the products can end up polluting the water ways.
- Using appropriate hydroseeder equipment.
- Contact the local street department or the state transportation department for more information.

Inspected

- Inspect area at installation to ensure area is properly covered, and receiving waters are properly protected.
- Inspect area after a precipitation event and/or heavy wind for any removal of vegetation, mulch, or other stabilization material.

Maintenance Activities

- Repair coverage and re-apply hydroseed material as needed to maintain maximum protection against erosion.
- If plant seeds fail to germinate, or established plants die, area must be re-seeded. Consult with product distributor or SWPPP preparer for troubleshooting application problems.
- If the desired permanent seeding type is different from the temporary seed, temporary seeding may have to be removed prior to the application of permanent seeding

Common Problems and Solutions

Problem	Solution
In some cases, grass has low germination percentage due to poor contact with soil.	Additives used in hydroseeding can enhance germination and root development, but cautions should be taken to ensure the additives do not make their way to the drainage system.
Hydroseeding application does not cover soil completely and erosion occurs.	Ensure initial application of hydroseeding is done in two directions for proper coverage. Ensure proper products and application rates are used correctly.

Mulch and Hydromulch



Figure 6.27 It takes about two tons per acre of straw mulch to cover at least 75 percent of the ground surface. To prevent erosion and provide the best microclimate for seed establishment, straw mulch should be physically anchored (crimped) or tied down with a tackifier.

Practice Description

Mulch and hydromulch are the application of plant residues such as straw or other suitable materials to the soil surface to reduce erosion. Mulch protects the soil surface from the erosive force of raindrop impact and reduces the velocity of overland flow. It helps seedlings germinate and grow by conserving moisture, protecting against temperature extremes and controlling weeds. Mulch also maintains the infiltration capacity of the soil.

Hydraulic mulch consists of applying a mixture of shredded paper, wood fiber or a hydraulic matrix and a stabilizing emulsion or tackifier with hydroseeding equipment, which temporarily protects exposed soil from erosion by raindrop impact or wind.

Mulch should always be applied to seeded areas to help establish plant cover and protect the seed during establishment.

Recommended Minimum Requirements

Prior to start of construction, mulch requirements should be determined by a qualified professional. The site superintendent and field personnel should refer to plans and specifications throughout the construction process..

Material

As specified in the approved site plan. If not specified, select from mulch materials listed in Table 6.10. Base the choice upon soils, slope steepness and length, flow conditions and time of year (See Figure 6.29).

Coverage

At least 75 percent of the soil surface.

Anchoring

Anchor the light materials, such as hay and straw mechanically using a crimping disc or with hydraulic tackifiers or netting. Heavy material mulches such as wood chips will not require anchoring unless on slopes of 4:1 or greater.

Installation

Site Preparation

- Divert runoff water away from areas above the site that will be mulched.
- Remove large dirt clods, stumps, roots and other debris from the construction area.
- Grade area as needed to permit the use of equipment for seeding, mulching and maintenance. Shape area so it is relatively smooth.
- If the area will be seeded, follow seeding specifications in the design plan (See [Temporary and Permanent Seeding](#)) and apply mulch immediately after seeding.

Mulching

Spread straw or cereal grain mulch uniformly over the area with a power blower or by hand. No more than 25 percent of the ground surface should be visible after spreading.

Apply at the rates shown in Table 6.10. Use higher rates for steep slopes and other erosive areas.

Anchor straw mulch by one of the following methods:

- Crimp with a weighted, straight, notched disc or a mulch anchoring tool to punch the straw into the soil.
- Tack with a liquid tackifier designed to hold mulch in place. Use suitable spray equipment and follow manufacturer's recommendations.
- Cover with netting, using a degradable natural or synthetic mesh to hold mulch materials in more erosive areas. Anchor the netting according to manufacturer's specifications (See [Erosion Control Blankets](#)).
- Anchor wood cellulose mulch with a liquid tackifier.

Figure 6.28 shows straw that has been crimped with a disc blade as in Figure 6.27. Notice when the blade cuts the straw into the soil to anchor it, some of the straw may become vertical and thereby exposing the soil surface to raindrop impact. The vertical straw acts more like a sediment control and you lose some erosion protection. This can be remedied by increasing the amount of mulch used to 3 or 4 tons per acre if crimping will take place. Table 6.10 provides the application rates of different mulch materials.

Use heavy natural nets without additional mulch, synthetic netting with additional mulch or erosion control mats/blankets to control erosion on steep slopes and in areas needing a higher degree of protection such as waterways, swales and diversion channels. These commercial materials vary greatly in longevity, strength, heaviness and the rate of water flow they can handle.

Install netting and mats/blankets according to manufacturer's specifications making sure materials are properly anchored (See [Erosion Control Blankets](#)).

Construction Verification

Check materials and installation for compliance with specifications.



Figure 6.27 Crimping disc. Source: ABCs of BMPs, LLC.



Figure 6.28 Crimped straw. Source: ABCs of BMPs, LLC.

Table 6.10 Typical Mulching Materials and Application Rates

	Rate per Acre	Requirements	Installation Uses	Longevity
Organic Mulches				
Straw	3,000 - 4,500 lb./acre	Dry, unchopped, unweathered; free of weed seeds and rot	Spread by hand or machine, 1.5 to 2.5 inches deep; must be crimped or tacked with vegetative overspray	2 - 4 weeks
Paper, wood fiber, recycled newsprint	2,000 lb./acre	Can use paper on flatter areas, increase percentage of wood fiber as slopes steepen	To be used with hydroseeder, refer to seeding chart for dates to seed	2 - 4 months
Stabilized Fiber Matrix	Refer to manufacturers recommendations - usually 1,500 - 3,000 lb./acre	Typically requires wood fiber mulch to reduce rainfall impact. Requires 24-hour cure time-not used in concentrated flows	To be used on more erodible slopes, molecularly binds soil particles for improved erosion protection, can be used without seed for temporary soil protection	4 - 5 months
Bonded Fiber Matrix	Refer to manufacturers recommendations - 3,000 - 4,000 lb./acre depending on steepness of slope	24-hour cure time, can be used on slopes as steep as 2:1, not used in concentrated flows	Does not require smooth finish grade, can be used in soils with high rock content, can be used with out seed for temporary soil protection	4 - 6 months
Flexible Growth Medium	Refer to manufacturers recommendations - 3,000 - 4,500 lb./acre depending on steepness of slope	No cure time, can be used on slopes steeper than 1:1, not used in concentrated flows without TRM combination	Does not require smooth finish grade, can be used in soils with high rock content, molecularly binds soil particles, equivalent to short term erosion control blankets in many cases	up to 1 year
Wood Chips	10-20 Tons	Air dry, add nitrogen fertilizer	Apply with blower...	6 - 9 months
Bark	35 cubic yds.	Air dry...	Apply with...	6 - 9 months
Tackifiers				
Mulch tackifiers	Rates vary-refer to manufacturers specifications	Powders, liquids, crystals, etc.; most are water soluble	Mix with organic mulches to hold together, heavier rates required for steeper slopes	1 - 3 months
Straw Tackifiers	750 lb./acre	Recycled newsprint with tackifier	Spray ovetop of vegetative mulching to hold together for extended time.	1 - 3 months
Soil Binders				
Chemical and Biodegradable products: Many Trade Names	Follow manufacturers specifications	Use for temporary and longer term stabilization of non-vegetative soils	Some may be harmful to plant growth, check manufacturers recommendations for seeding limitations	30 days to 6 months depending upon rate

Source: ASP, Enterprises, 2009

* See Temporary Erosion Control Blanket section for nettings and mats.

**Enlist the assistance of a Certified Professional in Erosion and Sediment Control for specific recommendations.

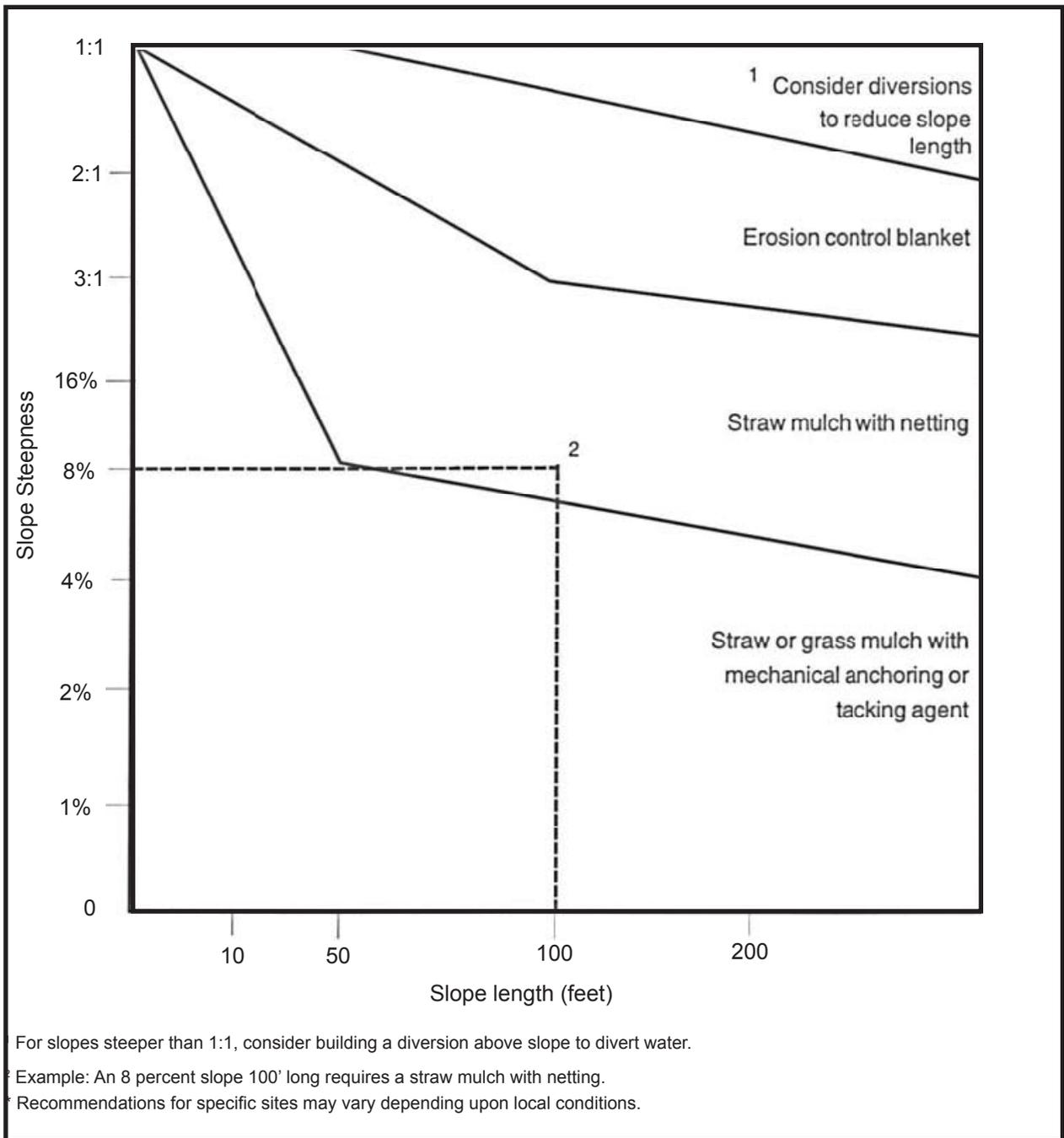


Figure 6.29 General mulch recommendations to protect from splash and sheet flow. Source: Adapted from *Minnesota Protecting Water Quality in Urban Areas, 1991*

Troubleshooting

Consult with a qualified design professional if any of the following occur:

- Variations in topography on-site indicate the mulching materials will not function as intended; changes in the plan may be needed.
- Design specifications for mulching materials or seeding requirements cannot be met; substitution may be required. Unapproved substitutions could result in erosion or seeding failure.

Maintenance and Inspection

Inspect all mulched areas on a weekly basis and after rainstorms for erosion and damage to the mulch. Repair promptly and restore to original condition. Continue inspections until vegetation is well established. Keep mower height high if plastic netting is used to prevent netting from wrapping around mower blades or shaft.

Common Problems and Solutions

Problem	Solution
Erosion, washout and poor plant establishment.	Check for proper topsoil, repair eroded surface, reseed, remulch and anchor mulch.
Mulch is lost to wind or stormwater runoff.	Reapply mulch and anchor by crimping, netting or tacking.
Mulch not anchored in channel; resulting in channel bottom eroding	Repair damage, replace mulch and anchor or install appropriate turf reinforcement mat channel liner.
Mulch deteriorates before plant establishment.	Check for proper topsoil, reapply mulch, do not hydromulch in winter.

Erosion Control Blankets



Figure 6.30 Follow manufacturer's recommendations to successfully install erosion control blankets or matting. The manufacturer of this high velocity blanket called for stapling every two feet and a check slot wherever two sections were joined. This blanket was used to protect soil and establish grass in a waterway on the August Busch Memorial Conservation Area

Practice Description

Erosion control blankets are used to aid in controlling erosion on critical areas by providing a protective cover made of straw, jute, wood or other plant fibers; plastic, nylon, paper or cotton. This practice is best used on slopes and channels where the erosion hazard is high and plant growth is likely to be slow to provide adequate protective cover for the seed and soil until germination. Erosion control blankets are typically used as an alternative to mulching but are also used to provide structural erosion protection.

Some important factors in the choice of a blanket are: soil conditions, steepness of slope, length of slope, type and duration of protection required to establish desired vegetation, and probable shear stress. (See [Compost](#) for compost blanket considerations.)

Recommended Minimum Requirements

Prior to the start of construction, the application of erosion control blankets should be designed by a qualified professional and plans and specifications should be available to field personnel. The field inspector should verify that installation is in accordance with the plans and specifications.

Numerous products designed to control erosion are available. Product installation procedures for manufactured erosion control blanket products should always be available from the manufacturer. Tables 6.11 and 6.12 list some of the more common temporary and permanent products available.

Table 6.11 Types of Temporary Erosion Control Blankets

ULTRA SHORT-TERM - Typical three month functional longevity						
Type	Product Description	Material Composition	Slope Applications*		Channel Applications*	Minimum
			Maximum Gradient	C Factor ^{2, 5}	Max. Shear Stress ^{3, 4, 6}	Tensile Strength ¹
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	5:1 (H:V)	< 0.1 @ 5:1	0.25 lb./ft. ² (12 Pa)	5 lb./ft. (0.073 kN/m)
1.B	Netless Rolled Erosion Control Blankets	Natural or polymer fibers mechanically interlocked or chemically adhered together to form a RECP.	4:1 (H:V)	< 0.1 @ 4:1	0.5 lb./ft. ² (24 Pa)	5 lb./ft. (0.073 kN/m)
1.C	Single-net Erosion Control Blankets and Open Weave Textiles	Processed degradable natural or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	< 0.15 @ 3:1	1.5 lb./ft. ² (72 Pa)	50 lb./ft. (0.73 kN/m)
1.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	2:1 (H:V)	< 0.2 @ 2:1	1.75 lb./ft. ² (84 Pa)	75 lb./ft. (1.09 kN/m)
SHORT-TERM - Typical 12 month functional longevity						
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	5:1 (H:V)	< 0.1 @ 5:1	0.25 lb./ft. ² (12 Pa)	5 lb./ft. (0.073 kN/m)
2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked or chemically adhered together to form a RECP.	4:1 (H:V)	< 0.1 @ 4:1	0.5 lb./ft. ² (24 Pa)	5 lb./ft. (0.073 kN/m)
2.C	Single-net Erosion Control Blankets and Open Weave Textiles	An erosion control blanket composed of processed degradable natural or polymer fibers mechanically bound together by a single degradable synthetic or natural fiber netting to form a continuous matrix or an open weave textile composed of processed degradable natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	< 0.15 @ 3:1	1.5 lb./ft. ² (72 Pa)	50 lb./ft. (0.73 kN/m)
2.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two degradable, synthetic or natural fiber nettings.	2:1 (H:V)	< 0.2 @ 2:1	1.75 lb./ft. ² (84 Pa)	75 lb./ft. (1.09 kN/m)

EXTENDED-TERM - Typical 24 month functional longevity.						
3.A	Mulch Control Nets	A slow degrading synthetic mesh or woven natural fiber netting.	5:1 (H:V)	< 0.10 @ 5:1	0.25 lb./ft. ² (12 Pa)	25 lb./ft. (0.36 kN/m)
3.B	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5:1 (H:V)	< 0.25 @ 1.5:1	2.00 lb./ft. ² (96 Pa)	100 lb./ft. (1.45 kN/m)
LONG-TERM - Typical 36 month functional longevity.						
4	Erosion Control Blankets and Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1:1 (H:V)	< 0.25 @ 1:1	2.25 lb./ft. ² (108 Pa)	125 lb./ft. (1.82 kN/m)

Source: *Erosion Control Technology Council.*

* "C" factor and shear stress for Types 1.A., 2.A. and 3.A mulch control nettings must be obtained with netting used in conjunction with pre-applied mulch material.

¹ Minimum Average Roll Values, Machine direction using ECTC Mod. ASTM D 5035.

² "C" Factor calculated as ratio of soil loss from RECP protected slope (tested at specified or greater gradient, h:v) to ratio of soil loss from unprotected (control) plot in large-scale testing.

³ Required minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in) soil loss) during a 30-minute flow event in large-scale testing.

⁴ The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 - 0.05.

⁵ Acceptable large-scale test methods may include ASTM D6459, or other independent testing deemed acceptable by the engineer.

⁶ Per the engineers discretion. Recommended acceptable large-scale testing protocol may include ASTM D6460, or other independent testing deemed acceptable by the engineer.

TABLE 6.12 Types of Temporary Erosion Control Blankets - For applications where vegetation alone will not sustain expected flow conditions or provide sufficient long-term erosion protection.

PERMANENT¹ - All categories of TRMs must have a minimum thickness of 0.25 inches (6.35 mm) per ASTM D 6525 and U.V. stability of 80 percent per ASTM D 4355 (500 hours exposure).					
Type	Product Description	Material Composition	Slope Applications	Channel Applications*	Minimum
			Maximum Gradient	Max. Shear Stress ^{4, 6}	Tensile Strength ^{2, 3}
5.A	Turf Reinforcement Mat	Turf Reinforcement Mat – A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. Mats that may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: Mats are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.	0.5:1 (H:V)	6.0 lbs/ft ² (288 Pa)	125 lbs/ft (1.82 kN/m)
5.B	Turf Reinforcement Mat		0.5:1 (H:V)	8.0 lbs/ft ² (384 Pa)	150 lbs/ft (2.19 kN/m)
5.C	Turf Reinforcement Mat		0.5:1 (H:V)	10.0 lbs/ft ² (480 Pa)	175 lbs/ft (2.55 kN/m)

Source: *Erosion Control Technology Council.*

- ¹ For mats containing degradable components, all property values must be obtained on the non-degradable portion of the matting alone.
- ² Minimum Average Roll Values, machine direction only for tensile strength determination using ASTM D6818 (Supercedes Mod. ASTM D5035 for RECPs)
- ³ Field conditions with high loading or high survivability requirements may warrant the use of a mat with a tensile strength of 44 kN/m (3,000 lb./ft.) or greater.
- ⁴ Required minimum shear stress mat (fully vegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in.) soil loss) during a 30-minute flow event in large scale testing.
- ⁵ Acceptable large-scale testing protocol may include ASTM D6460, or other independent testing deemed acceptable by the engineer.

Construction Site Preparation

- Grade the site in accordance with the approved design to a smooth and uniform surface, free of debris.
- Add and incorporate topsoil where needed.
- Make sure seed bed is firm yet friable.
- Seed and fertilize as shown on the design plan.

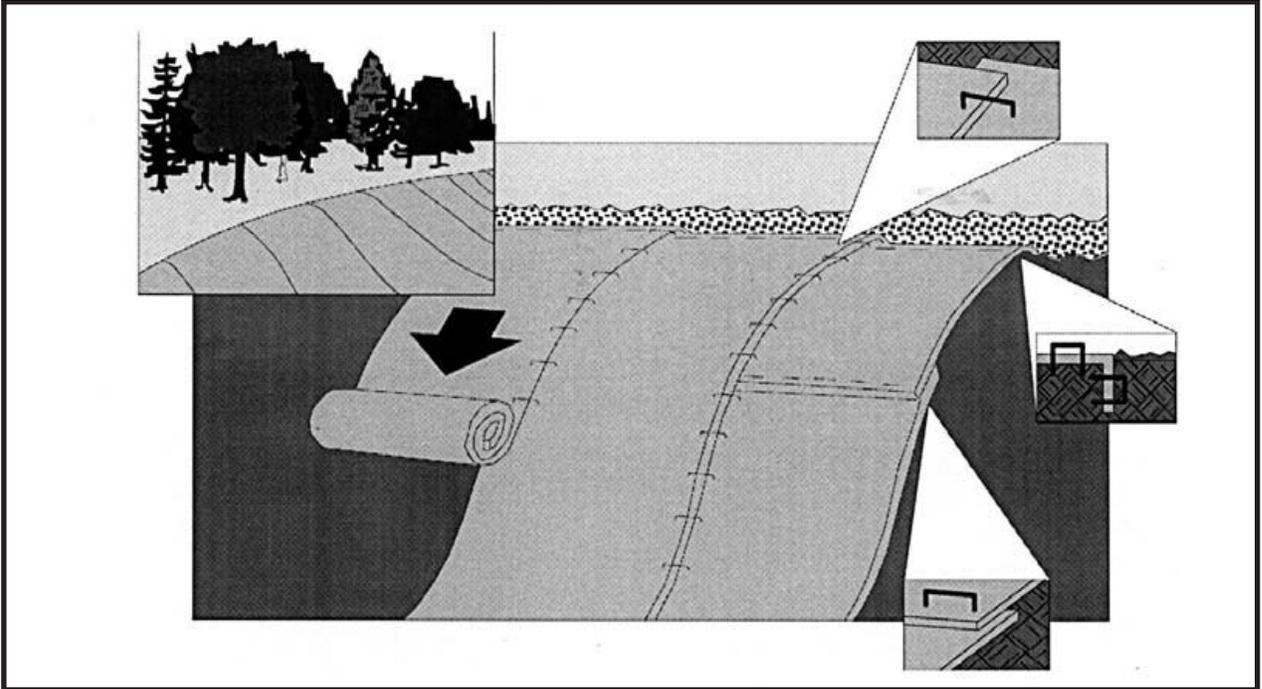


Figure 6.31 Typical installation of erosion control blankets on a slope - Consult manufacturer for recommendations on proper installation of staple patterns, overlap and keying edges.

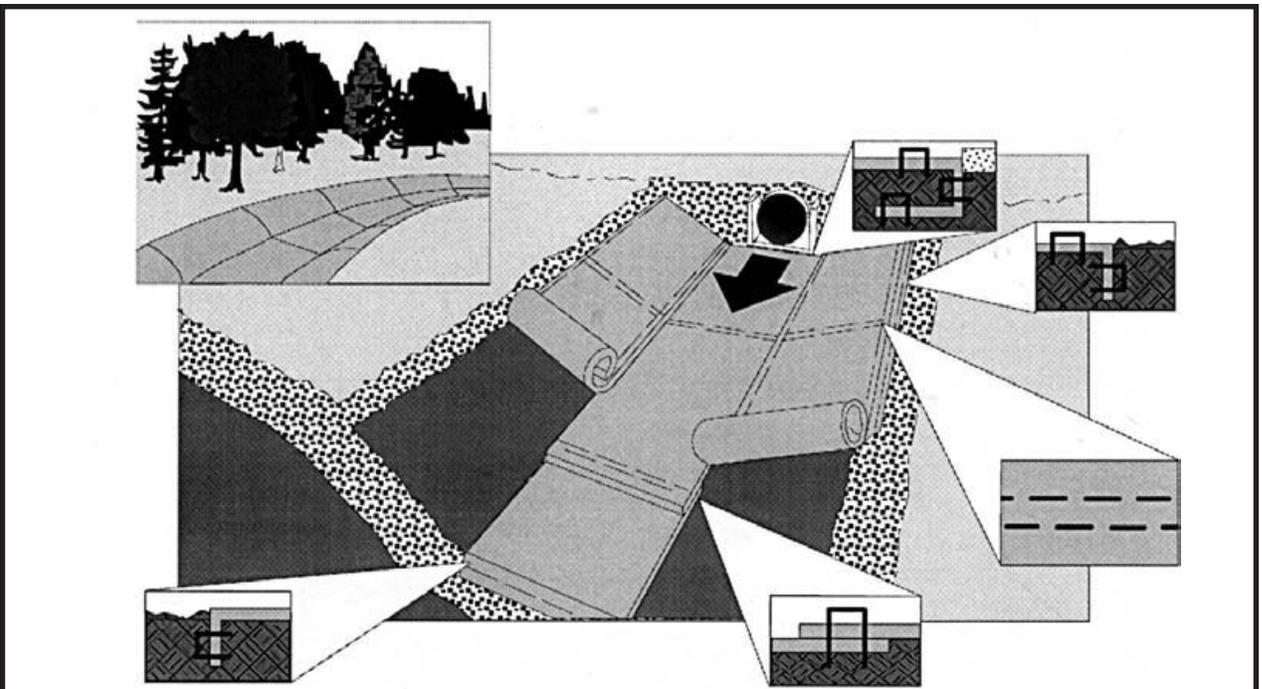


Figure 6.32 Typical installation of erosion control blankets in a channel - Consult manufacturer for recommendations on proper installation of staple patterns, overlap and keying edges.

Erosion Control Blankets

Blanket Installation

Install erosion control products in accordance with the manufacturer's recommendations and specifications, including check slots and stapling materials.

Anchor product so a continuous, firm contact (no tenting) with the soil surface/seed bed is maintained. Soil must be fine graded with no clods.

Note: Failure to do the above could result in soil erosion, which would require regrading and reseeding.

Construction Verification

Check finished grade, dimensions and staple spacing of erosion control blankets. Check materials for compliance with specifications.

- Movement of the blanket or erosion under the blanket is observed.
- Variations in topography on-site indicate erosion control mat will not function as intended; changes in the plan may be needed, or a blanket with a shorter or longer life may be needed.
- Design specifications for seed variety, seeding dates or erosion control materials cannot be met; substitution may be required. Unapproved substitutions could result in failure to establish vegetation.

Maintenance, Inspection and Removal

Inspect weekly and after storm events, until vegetation is established, for erosion or undermining beneath the blankets. If any area shows erosion, pull back that portion of the blanket, add tamped soil and reseed; then resecure the blankets.

If blankets become dislocated or damaged, repair or replace and resecure immediately.

Although some erosion control blankets are temporary, they are left in place to decompose and are not to be removed prior to filing [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Surface water flows under rather than over the blanket, causing erosion. This may be caused by poor contact between soil and the erosion control blanket.	Smooth grade or remove large clods and retrench or reanchor to direct water over blanket.
Tenting (air pockets under blanket), blanket movement or displacement is caused by blanket inadequately or improperly stapled.	Reinstall and ensure blanket is properly anchored.
Blanket or slope failure caused by unstable slope.	Determine cause of slope failure, stabilize slope and reinstall blanket.

Dust Control



Figure 6.33 Spraying water is effective for dust control on haul roads, although it must be frequently repeated during hot days or heavy traffic periods. Source: C. Rahm, NRCS, St. Charles Co.

Dust Control

In Missouri, the contractor is required by State law to control fugitive dust blown from the site. Kansas does not have specific regulations for fugitive dust emissions; however, the Kansas Department of Health and Environment encourages contractors to implement measures to reduce such emissions. Dust can be minimized by stabilizing areas with mulch as soon as possible. Provide watering in unstabilized areas. Contact Missouri Department of Natural Resources or Kansas Department of Health and Environment for guidance.

Practice Description

Dust control includes a wide range of techniques that reduce movement of wind-borne soil particles (dust) from disturbed soil surfaces. This practice applies to construction routes and other disturbed areas where on-site and off-site damage or hazards may occur if dust is not controlled.

Recommended Minimum Requirements

Dust control measures should be designed by a qualified professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. Whenever possible, leave undisturbed vegetated buffer areas between graded areas.

Scheduling

Plan and schedule construction operations so the smallest area is disturbed at one time.

Erosion Control

Install surface stabilization measures immediately after completing land grading.

Construction

Any combination of the following may be used to help reduce dust and air pollution at a construction site.

Vegetative Cover

For areas not subjected to traffic, vegetation provides the most practical method of dust control (See [Temporary or Permanent Seeding](#)).

Sprinkling

The site can be sprinkled with water until the surface is moist. This practice is effective for dust control on haul roads or other traffic routes, but constant repetition is required for effective control.

Soil Stabilizers and Binders

Soil stabilizers are polymers that bind the soil particles together so they are less likely to be transported in the air from the energy of the wind.

Limitations

- Soil binders are temporary in nature and may need reapplication.
- Soil binders require a minimum curing time until fully effective, as prescribed by the manufacturer, which may be 24 hours or longer. Soil binders may need reapplication after a storm event.
- Soil binders will generally experience spot failures during heavy rainfall events. If runoff penetrates the soil at the top of a slope treated with a soil binder, it is likely the runoff will undercut the stabilized soil layer and discharge at a point further down slope.
- Some soil binders do not hold up to pedestrian or vehicular traffic across treated areas. Consult manufacturers' representatives for specific applications and limitations of materials.
- Soil binders may not penetrate soil surfaces made up primarily of silt and clay, particularly when compacted. Some soil binders may not perform well with low relative humidity. Under rainy conditions, some agents may become slippery or leach out of the soil.
- Soil binders may not cure if low temperatures occur within 24 hours of application.

General Considerations

- Site-specific soil types will dictate appropriate soil binders to be used.
- A soil binder must be environmentally benign (non-toxic to plant and animal life), easy to apply, easy to maintain, economical and shall not stain paved or painted surfaces.
- Some soil binders are compatible with existing vegetation.
- Performance of soil binders depends on temperature, humidity and traffic across treated areas.
- Avoid over-spray onto the traveled way, sidewalks, lined drainage channels, and existing vegetation.

Dust Control

Water clarifying compounds may be used on mineral soils for dust control. Traffic must be kept off treated areas to prevent the product from becoming ineffective. The manufacturer or supplier shall provide written application methods for the water clarifying compounds and mixtures. The application method shall ensure uniform coverage to the target and avoid drift to non-target areas including waters of the state. The manufacturer or supplier shall also provide written instructions to ensure proper safety, storage and mixing of the product.

Mulching

This practice offers a fast and effective means of controlling dust when properly applied. Use binders or tackifiers to tack organic mulches (See [Mulch and Hydromulch](#)). Mulching is not recommended for areas with heavy traffic.

Barriers

Board fences placed perpendicular to the prevailing winds at intervals of 15 times the barrier height can control blowing soil. In areas of known dust problems, windbreak vegetation should be preserved.

If the following materials or any other chemicals are used for dust control, contact the Missouri Department of Natural Resources, Water Pollution Control Program, or the Kansas Department of Health and Environment for permit requirements.

- Calcium Chloride - This material is best used on road surfaces. It can be applied by a mechanical spreader at a rate that keeps the surface moist.

Note: This method may cause restrictions for vegetation establishment.

Maintenance and Inspection

- Maintain dust control measures continuously throughout dry weather periods until all disturbed areas have been stabilized.
- If using a soil binder, it may need to be reapplied for proper maintenance.
- High traffic areas shall be inspected daily, and lower traffic areas shall be inspected weekly.
- After any rainfall event, the permittee is responsible for maintaining all slopes to prevent erosion.

Troubleshooting

Consult with a qualified professional if the following occurs:

- Spray-on adhesives are specified. A permit may be needed.

Common Problems and Solutions

Problem	Solution
Dry soils and increase in dust problems caused by drought conditions.	Use greater precautions during these periods.

Sodding



Figure 6.34 A team is laying sod strips so the seams are not aligned and the ends and sides are against each other to reduce drying out of the roots. Source: N. Klopfenstein, NRCS. St. Charles Co.

Practice Description

Sodding is the use of a vegetative cover that includes both the grass plants as well as an established root system to provide immediate erosion control in disturbed areas. Sodding is well suited for stabilizing erodible areas such as grass-lined channels, stormwater detention basins, diversions, swales, slopes and buffer strips.

Recommended Minimum Requirements

Prior to start of installation, plant materials and amendments should be specified by a qualified professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process..

Plant Selection

Select high quality, healthy, moist, fresh sod. Select a variety that is well-adapted to the region, supports its intended use, and is appropriate for the desired level of maintenance.

Soil Amendments

Fertilizer and lime (if soil pH is less than 6.0) incorporated to a depth of 3- to 6-inches into the soil.

Soil Surface

Clear of clods, rocks, etc.; smooth and firm; not compacted clay or pesticide-treated soil.

Irrigation

Temporary irrigation is required to ensure rooting and plant establishment.

Timing

Anytime of the year, except when the soil is frozen. Check with local sod farms for availability.

Installation

Soil supplied nutrients are critical to sod establishment and continued plant growth. Test soil for nutrients and pH. Soil testing can be done at University Extension offices and private labs.

Site Preparation

Apply amendments according to soil test recommendations.

In the absence of a soil analysis, apply fertilizer amendments at the following maximum rates:

- Fertilizer: Apply 500 pounds of a 10-10-10 Nitrogen, Phosphorus and Potassium.
- Consult a qualified professional who specializes in soils and soil amendments.

Apply ground agricultural limestone unless a soil test shows a pH of 6.0 or greater.

If soil test recommendations are not available and soil pH is less than 6.0, use:

- Ground agricultural limestone: 20 lb. ENM or ECC* /1,000 ft² or 800 lb. ENM or ECC/acre (approx. 2 tons/acre). Missouri state agricultural lime laws require ag lime be sold as units of Equivalent Neutralizing Material (ENM)/ton. For example, soil test requires 800 lbs ENM and lime producer's material tests at 400 lb. ENM. $800/400 = 2$ tons to be applied. See [MU Guide #9107](#) for details. In Kansas, ECC (Effective Calcium Carbonate) = ENM. (See [Glossary](#) for definition.)
- Incorporate amendments to depth of 4- to 6-inches with a disk or chisel plow.
- Rake or harrow to achieve a smooth, final grade on which to lay the sod. Surface should be loose, and free of plants, trash and other debris.
- Moisten the soil immediately prior to laying sod during high temperatures to cool the soil and reduce burning and dieback.

Table 6.13 Sod Species Adaptation to Regions of the State

Species	Kansas	Missouri
Kentucky Bluegrass	East and Central	Statewide
Turf Fescue	East and Central	Statewide
Bermuda		
common	South half, east, central	Southern half
improved	South half, east, central	Southern third
Zoysia	South half, east, central	Southern half
Buffalograss	Statewide	Statewide

Laying Sod

- For best results, place the sod as soon as possible after being cut. Ideally, sod is cut and laid the same day.
- To prevent roots from drying out, moisten the soil surface and lay sod joints tightly against each other.
- Lay the first row of sod in a straight line with subsequent rows placed parallel to and laying tightly against each other. Stagger joints to create a brick-like pattern and promote more uniform growth and strength. Ensure sod is not stretched or overlapped and that all joints are butted tight to prevent spaces which cause drying of the roots. (See Figure 6.35).

- Do not lay sod on frozen soil surfaces.
- On slopes 3:1 or steeper, or wherever erosion may be a problem, lay sod with staggered joints and secure by stapling or pegging. Install sod with the length perpendicular to the water flow (on the contour).

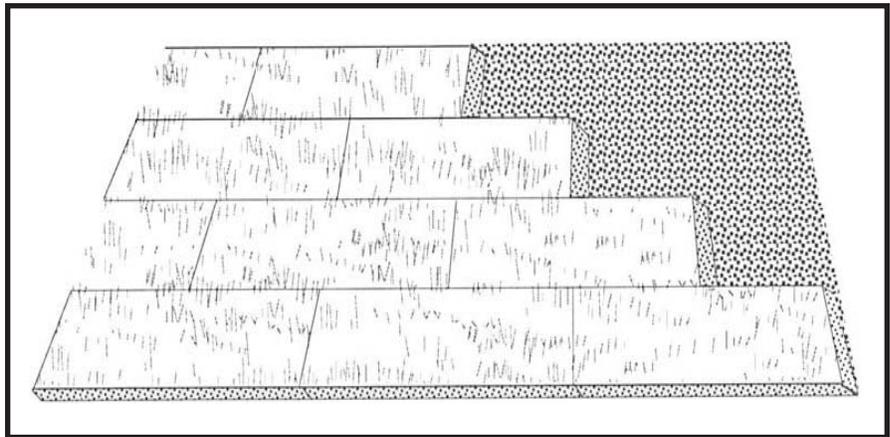


Figure 6.35 Typical installation of grass sod - lay sod in a staggered pattern with strips tightly against each other.

- Immediately after laying the sod, roll or tamp it to provide firm contact between roots and soil, then irrigate sod deeply so the underside of the sod pad and the soil 4-inches below the sod is thoroughly wet.
- Until a good root system develops, water sod as often as necessary to maintain moist soil to a depth of at least 4-inches.
- Wait until the sod is firmly rooted before mowing for the first time, usually two to three weeks. Not more than 1/3 of the grass leaf should be removed at any one cutting.

Sodded Waterways

- Sod provides quicker protection than seeding and may reduce the risk of early washout unless turf reinforcement mats are used.
- When installing sod in waterways, use the type of sod specified in the channel design.
- Lay sod strips perpendicular to the direction of water flow and stagger in a brick-like pattern. See Figure 6.36.
- Staple sod firmly at the corners and middle of each strip. Jute or synthetic netting may be pegged over the sod for further protection against washout during establishment.
- Channel velocity should not exceed 1.5 feet per second in a sodded waterway. Seek guidance from a qualified professional for additional control measures in high flow channels.

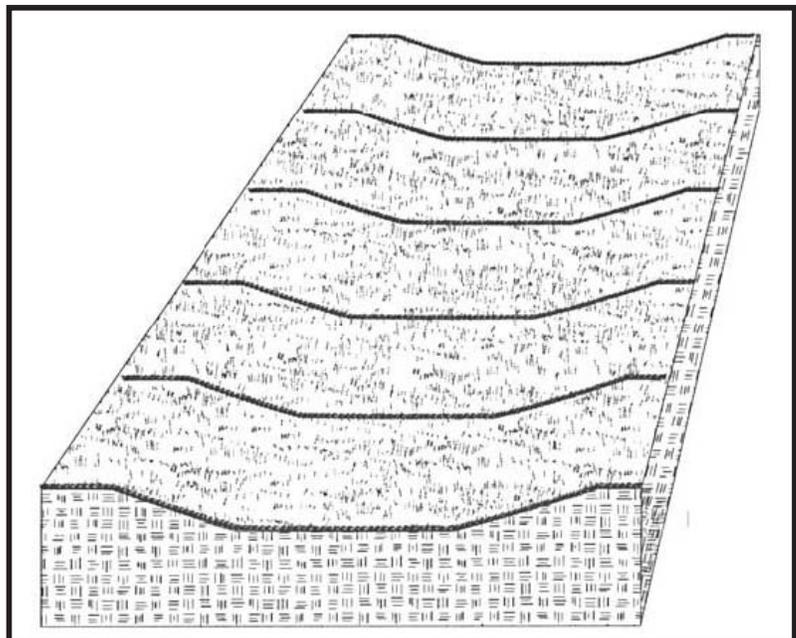


Figure 6.36 Installation of sod in waterways - lay sod across the direction of flow. Use pegs or staples to fasten sod firmly at the corners and in the center.

Construction Verification

Check materials and installation for compliance with specifications.

Maintenance and Inspection

- Inspect the sod each week and after rain events.
- Keep sod moist until it is fully rooted. Lay the sod in place at least two weeks prior to filing a Notice of Termination to allow time for sod to take root. If sod can be pulled up by hand, it has not rooted sufficiently and the site land disturbance permit can not be terminated.
- Mow to a height of 2- to 3- inches after sod is well-rooted, in two to three weeks. Do not remove more than 1/3 of the leaf blade in any mowing.
- Permanent, fine turf areas require yearly fertilization. Fertilize warm-season grass in late spring to early summer; cool-season grass in late winter and again in early fall.

Troubleshooting

Consult with a qualified design professional if any of the following occur:

- Variations in topography on-site indicate the sodding materials will not function as intended; changes in the plan may be needed.
- Design specifications for sod variety cannot be met or irrigation is not possible; substitution or seeding may be required. Unapproved substitutions could result in erosion or the sods inability to establish a root system.

Common Problems and Solutions

Problem	Solution
Grass dies because it is unable to root caused by the sod being laid on poorly prepared soil or unsuitable surface.	Remove dead sod, prepare surface and resod.
Root dieback or grass does not root rapidly and is subject to drying out caused by sod not adequately irrigated after installation.	Irrigate sod and underlying soil to a depth of 4-inches and keep moist until roots are established.
Sod may be loosened by runoff during a rain event caused by not being properly anchored.	Replace damaged areas and anchor sod.
Yellowing of leaf blades and slow growth caused by a lack of nitrogen.	Fertilize sod, but avoid fertilizing cool season grasses from late May through August.
Sod picked up and removed from soil surface caused by the hydraulic limitations of sod that may have been exceeded in the waterway.	Evaluate actual hydraulic conditions and use alternative erosion control practice, (e.g., rip rap, turf reinforcement mat, transition mats).

Soil Bioengineering for Slope Protection



Figure 6.37 Willows and other live stakes will root and sprout rapidly to protect slopes. The roots form an interlocking mat to hold soil in place, while the foliage protects the soil surface. These willows, planted along Hinkson Creek in Columbia, were 3- to 5-feet tall within six months. Source: Doug Wallace. NRCS. Boone Co.

Practice Description

Soil bioengineering consists of the use of live woody and mixed plant material to provide erosion control, slope and streambank stabilization, landscape restoration and wildlife habitat. These techniques are used alone or in conjunction with conventional engineering techniques. Soil bioengineering has the benefits of establishing permanent vegetation for decreased erosion, reduced off-site sedimentation lower runoff velocity and increased infiltration. Also, as the vegetation grows, the roots mechanically reinforce the soil and provide greater protection than just grass or a mechanical practice alone.

There are two approaches that can be used:

- Woody vegetation systems.
- Woody vegetation systems combined with reinforcing structures.

The structural part of the system helps establish vegetation on steep slopes or in areas subject to extreme erosion. Both systems provide immediate protection and grow stronger with time as the vegetation becomes established.

Soil bioengineering is advantageous where there is minimal access for equipment and workers, and in environmentally sensitive areas where minimal site disturbance is required. It is particularly suited for small, highly sensitive or steep sites. Most techniques can also be used for stream channel or bank protection. Once established, woody vegetation becomes self-repairing and needs little maintenance.

One of the best resources for soil bioengineering and slope protection is the U.S. Department of Agriculture's Natural Resources Conservation Service *Part 650: Engineering Field Handbook*. The handbook is broken into and published as many individual chapters. Chapter 16 is titled *Streambank and Shoreline Protection* and was published December 1996. Chapter 18 is titled *Soil Bioengineering for Upland Slope Protection and Erosion Reduction* and was published October 1992 with a reprinting December 1995. The *Engineering Handbook* provides standards and specifications, drawings and details of the different practices mentioned in this section. More information about bioengineering practices is available from your local National Resources Conservation Service/Soil and Water Conservation District and the Missouri Department of Conservation.

Recommended Minimum Requirements

Prior to start of construction, bioengineering practices should be designed by a registered design professional or an interdisciplinary team with knowledge of mechanical, biological and ecological concepts. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Plant Species

Native species that root easily, such as willow. Use plants suitable for the intended use and adaptation to site conditions. While willow is one of the most common groups of plants used in bioengineering, there are several other native plants that offer function and aesthetics. Plants are usually harvested from a nearby local area. Contact your local conservation office for more information.

Cutting Size

Normally ½- to 2-inches in diameter and from 2- to 6-feet long (length will depend on project requirements).

Harvesting

Cut plant materials at a blunt angle, 8- to 10- inches from the ground, leaving enough trunk so that cut plants will regrow.

Transportation and Handling

Bundle cuttings together on harvest site, removing side branches. Keep material moist. Handle carefully during loading and unloading to prevent damage. Cover to protect cuttings from drying out.

Installation Timing

Deliver to construction site within 8 hours of harvest and install immediately, especially when temperatures are above 50° F. Store up to two days if cuttings are "heeled in" moist soil, shaded and protected from wind.

Season

Install during plants' dormant season, generally late October to March.

Soil

Must be able to support plant growth with good topsoil (see [Topsoiling and Stockpiling](#)). Compact to fill voids and maintain good branch cutting-to-soil contact.

Velocities

Up to 6 feet per second for woody vegetation alone. Include simple structures with woody vegetation for velocities more than 6 feet per second. Use the velocity associated with the peak discharge of the design storm (see [Streambank Protection](#) section for structural protection alternatives).

Erosion Control

Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete. Seed and mulch bare areas on 3:1 or flatter slopes. Use netting, tackifiers or blankets with seeding on slopes steeper than 3:1.

Construction

Site Preparation

- Observe applicable government regulations especially the U.S. Army Corps of Engineers permits for work in and around waterways.
- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Locate source of live rooted plants or cuttings as specified in design plan. Local sources of native plants are ideal to use. Purchase of materials from commercial sources may be necessary to comply with local regulations. Specifically, if a bioengineering project is taking place within the riparian corridor, requirements may be required under a Section 404 permit administered by the Army Corps of Engineers. In addition, local governments may also have a stream buffer ordinance requirement.
- Prepare the site by clearing, grading and shaping according to the design plan. Stockpile topsoil to be used as backfill. Stabilize the soil and slope base before any structural or streambank work is done.

Installation

- If required by the design, prepare trenches or benches in cut and fill slopes and construct structural components such as cribwalls, walls or riprap according to the plan (See [Structural Protection](#) in this section).
- Install live cuttings, checking angle of placement. Secure cuttings with stakes or as specified in plan. Schedule the work so that plants are in a dormant state to enhance the success of establishment.
- Fertilize and lime according to soil test results as specified in the design plan.
- Install filter fabric if specified in the design plan. Backfill over the vegetative cuttings, compacting the soil to achieve good live branch cutting-to-soil contact. Fill any voids around the plant materials.
- Check to see adequate soil moisture is present to encourage rooting and growth. Water, if necessary.

Woody Vegetative Protection Installation

Live staking, live fascines, brushlayers, branchpacking and live gully repair are soil bioengineering practices that use the stems or branches of living plants as a soil reinforcing and stabilizing material. Eventually the vegetation becomes a major structural component of the bioengineered system.

Live Stake

Live staking is the use of live, rootable vegetative cuttings, inserted and tamped into the ground. As the stakes grow, they create a living root mat that stabilizes the soil. Use live stakes to peg down surface erosion control materials. Most native willow species root rapidly and can be used to repair small earth slips and slumps in wet areas.

Installation

- To prepare live material, cleanly remove side branches, leaving the bark intact. Use cuttings ½- to 1½-inches in diameter and 2- to 3-feet long. Cut bottom ends at an angle to insert into soil. Cut the top of the stake square.
- Tamp the live stake into the ground at right angles to the slope, starting at any point on the slope face. Buds should point up. Install stakes 2- to 3-feet apart using triangular spacing with from two to four stakes per square yard.
- Use an iron bar to make a pilot hole in firm soil. Drive the stake into the ground with a dead blow hammer (hammer head filled with shot or sand).
- Four-fifths of the live stake should be underground with soil packed firmly around it after installation. Replace stakes that split during installation.

Live Fascine

Live fascines are long bundles of branch cuttings bound together into sausage-like structures. Place them in shallow contour trenches on dry slopes and at an angle on wet slopes to reduce erosion and shallow face sliding. This practice is suited to steep, rocky slopes, where digging is difficult.

Installation

- To prepare live materials, make cuttings from species such as young willows or shrub dogwoods that root easily and have long, straight branches.
- Make stakes 2½ feet long for cut slopes and 3 feet long for fill slopes.
- Make bundles of varying lengths from 5- to 30-feet or longer, depending on site conditions and limitations in handling. Use untreated twine for bundling.
- Completed bundles should be 6- to 8-inches in diameter. Place growing tips in the same direction. Stagger cuttings so root ends are evenly distributed throughout the length of the bundle.
- Install live fascine bundles the same day they are prepared.
- Prepare dead stakes such as 2½-foot long, untreated 2- by 4-inch lumber, cut diagonally lengthwise to make two stakes. Live stakes will also work.
- Beginning at the base of the slope, dig a trench on the contour large enough to contain the live fascine. Vary width of trench from 12- to 18-inches, depending on angle of the slope.
- Trench depth will be 6- to 8-inches, depending on size of the bundle.
- Place the live fascine into the trench.
- Drive the dead stakes directly through the bundle every 2- to 3-feet. Use extra stakes at connections or bundle overlap. Leave the top of the stakes flush with the bundle.
- Install live stakes on the down slope side of the bundle between the dead stakes.

Brushlayer

Brushlayering is similar to live fascine systems. Both involve placing live branch cuttings on slopes. However, in brushlayering, the cuttings are placed at right angles to the slope contour. Use on slopes up to 2:1 in steepness and not over 15 feet in vertical height.

Installation

- Starting at the toe of the slope, excavate benches horizontally, on the contour, or angled slightly down the slope to aid drainage. Construct benches 2- to 3-feet wide. Slope each bench so that the outside edge is higher than the inside.
- Crisscross or overlap live branch cuttings on each bench. Place growing tips toward the outside of the bench.
- Place backfill on top of the root ends and compact to eliminate air spaces. Growing tips should extend slightly beyond the fill to filter sediment. Soil for backfill can be obtained from excavating the bench above.
- Space brushlayer rows 3- to 5-feet apart, depending upon the slope angle and stability.

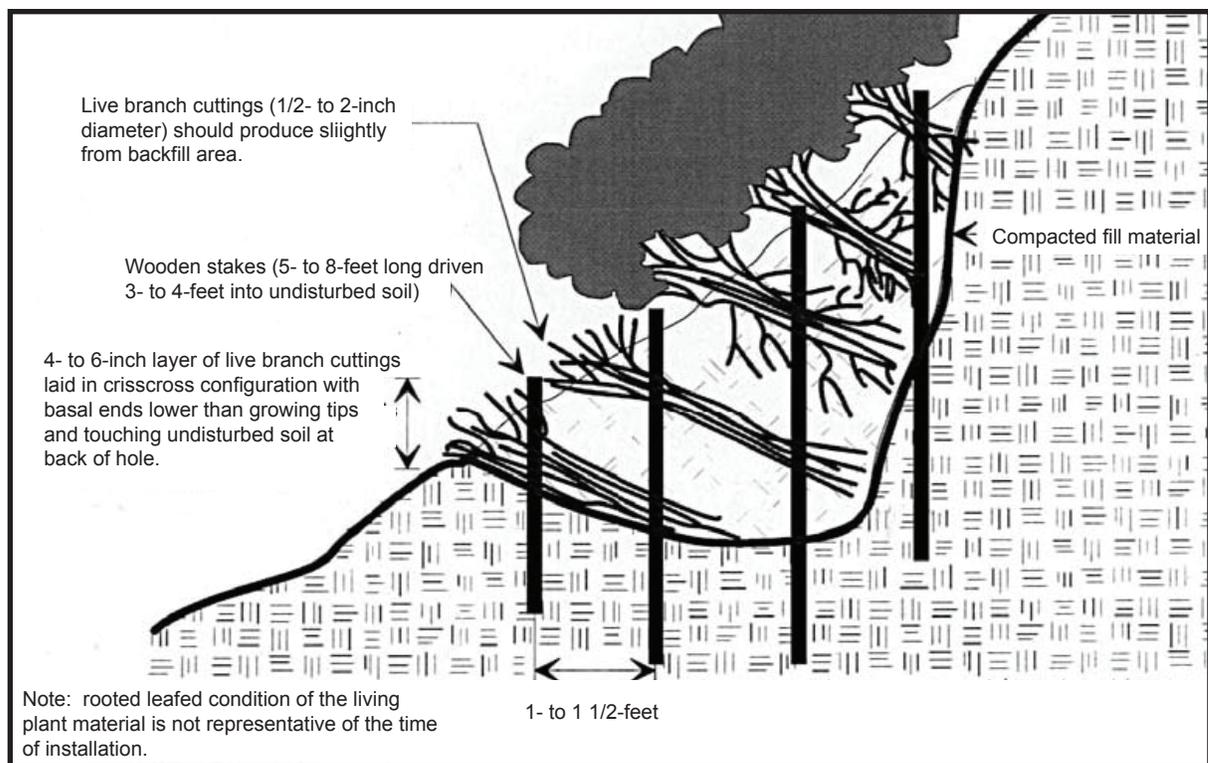


Figure 6.38 Typical branchpacking cross section. Source: NRCS Engineering Field Handbook, 1992.

Branchpacking

Branchpacking (see figure 6.38) consists of alternating layers of live branch cuttings and compacted backfill to repair small localized slumps and holes in slopes (no greater than 4 feet deep or 5 feet wide). Use for earth reinforcement and mass stability of small earthen fill sites.

Installation

- Make live branch cuttings from 1/2- to 2-inches in diameter and long enough to reach from soil at the back of the trench to extend slightly from the front of the rebuilt slope face.
- Make wooden stakes 5- to 8-feet long from 2 by 4 inch lumber or 3- to 4-inch diameter poles.
- Start at the lowest point and drive wooden stakes vertically 3- to 4-feet into the ground. Set them 1- to 1 1/2-feet apart.

- Place a layer of living branches 4- to 6-inches thick in the bottom of the hole, between the vertical stakes, and at right angles to the slope face. Place live branches in a crisscross arrangement with the growing tips oriented toward the slope face. Some of the root ends of the branches should touch the back of the hole.
- Follow each layer of branches with a layer of compacted soil to ensure soil contact with the branch cuttings.
- The final installation should match the existing slope. Branches should protrude only slightly from the rebuilt slope face.
- Ensure that the soil is moist or moistened to ensure live branches do not dry out.

Live Gully Repair

Live gully repair uses alternating layers of live branch cuttings and compacted soil to repair small rills and gullies. This practice is limited to rills or gullies less than 2 feet wide, 1 foot deep and 15 feet long.

Installation

- Make live branch cuttings ½- to 2-inches in diameter and long enough to reach from the soil at the back of the gully and extend slightly from the front of the rebuilt slope face.
- Starting at the lowest point of the slope, place a 3- to 4-inch layer of branches at the lowest end of the rill or gully and at right angles to the slope. Cover with a 6- to 8-inch layer of fill soil.
- Install the live branches in a crisscross fashion. Place the growing tips toward the slope face with root ends lower than the growing tips.
- Follow each layer of branches with a layer of compacted soil to ensure soil contact with the live branch cuttings and root ends.

Structural Protection Installation

Live cribwalls, vegetated rock gabions, vegetated rock walls and joint plantings are soil bioengineering practices that combine a porous structure with vegetative cuttings. The structures provide immediate erosion, sliding and washout protection. As the vegetation becomes established, the structural elements become less important.

Live Cribwall

A live cribwall consists of a hollow, box-like interlocking arrangement of untreated logs or timber. Use at the base of a slope where a low wall may be required to stabilize the toe of the slope and reduce its steepness or where space is limited and a more vertical structure is required. It should be tilted back if the system is built on a smooth, evenly sloped surface.

Installation

- Make live branch cuttings ½- to 2-inches in diameter and long enough to reach the back of the wooden crib structure.
- Build constructed crib of logs or timbers from 4- to 6-inches in diameter or width. The length will vary with the size of the crib structure.
- Starting at the lowest point of the slope, excavate loose material 2- to 3-feet below the ground elevation until a stable foundation is reached.
- Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability.
- Place the first course of logs or timbers at the front and back of the excavated foundation, approximately 4- to 5-feet apart and parallel to the slope contour. Place the next set of logs or timbers at right angles to the slope on top of the previous set.

- Place each set of timbers in the same manner and nail to the preceding set.
- Place live branch cuttings on each set to the top of the cribwall structure with growing tips oriented toward the slope face.
- Backfill crib, compacting soil for good root-to-soil contact, seed and mulch.

Vegetated Rock Gabions

Vegetated gabions combine layers of live branches and gabions (rectangular wire baskets filled with rock). This practice is appropriate at the base of a slope where a low wall is required to stabilize the toe of the slope and reduce its steepness. It is not designed to resist large, lateral earth stresses. Use where space is limited and a more vertical structure is required. Overall height, including the footing, should be less than 5 feet.

Installation

- Make live branch cuttings from ½- to 1-inch in diameter and long enough to reach beyond the rock basket structure into the backfill.
- Starting at the lowest point of the slope, excavate loose material 2- to 3-feet below the ground elevation until a stable foundation is reached. Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability and ensure rooting.
- Place the gabions in the bottom of the excavation and fill with rock. Backfill between and behind the gabions.
- Place live branch cuttings on the gabions at right angles to the slope with the growing tips placed away from the slope and extending slightly beyond the gabions. Root ends must extend beyond the backs of the gabions into the fill material. Put soil over the cuttings and compact it.
- Repeat the construction sequence until the structure reaches the required height.

Vegetated Rock Wall

A vegetated rock wall is a combination of rock and live branch cuttings used to stabilize and protect the toe of steep slopes. This system is appropriate at the base of a slope where a low wall may be required to stabilize the toe of the slope and reduce its steepness. It is useful where space is limited and natural rock is available. Height of the rock wall, including the footing, should be less than 5 feet.

Installation

- Make live branch cuttings from ½- to 1-inch in diameter and long enough to reach the soil behind the rock structure.
- Rock should range from 8- to 24-inches in diameter. Use larger boulders for the base.
- Starting at the lowest point of the slope, remove loose soil until a stable base is reached, usually 2- to 3-feet below ground elevation. Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability.
- Seat rocks firmly on the foundation material. Place rocks so that their center of gravity is as low as possible, with their long axis slanting inward toward the slope, if possible. Also attempt to imbricate the rock as much as possible for streambank application.
- Provide for drainage when a rock wall is constructed adjacent to an impervious surface or in locations subject to deep frost penetration.
- A sloping bench behind the wall can provide a base on which to place live branch cuttings during construction. Tamp or place live branch cuttings into the openings of the rock wall during construction. The root ends should extend into the soil behind the wall. Place cuttings at right angles to the slope contour with growing tips protruding from the wall face.

Joint Planting

Joint planting (see Figure 6.39) or vegetated riprap involves tamping live cuttings into soil between the joints or open spaces in rocks previously placed on a slope. Use this technique where rock riprap is required. Joint planting is used to remove soil moisture, to prevent soil from washing out below the rock and to increase slope stability over riprap alone.

Installation

- Make live branch cuttings from ½- to 1½-inches in diameter and long enough to extend into soil below the rock surface. Remove side branches from cuttings leaving the bark intact.
- Tamp live branch cuttings into the openings of the rock during construction. The root ends should extend into the soil behind the riprap. Mechanical probes may be needed to create pilot holes for the live cuttings.
- Place cuttings at right angles to the slope with growing tips protruding from the finished face of the rock.

Note: A detailed description, applications, effectiveness and construction guidelines for all types of bioengineering practices are discussed in

Chapter 18, *Soil Bioengineering for Upland Slope Protection and Erosion Protection*, in the *USDA NRCS Part 650: Engineering Field Handbook*.

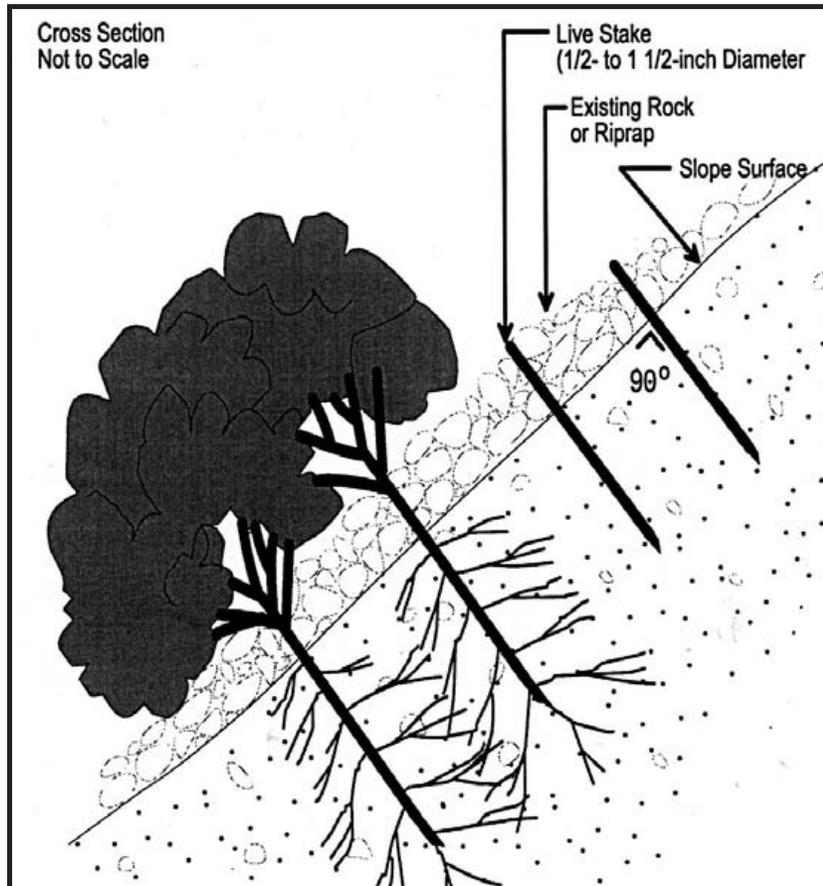


Figure 6.39 Typical Joint Planting Cross Section Source: *NRCS Engineering Field Handbook*, 1992.

Erosion Control

Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete. Seed and mulch bare areas on 3:1 or flatter slopes. Use netting, tackifiers or blankets with seeding on slopes steeper than 3:1 (see [Temporary or Permanent Seeding, Mulching and Erosion Control Blankets](#)).

Construction Verification

For woody vegetative protection alone, check that live stakes were installed according to the design specifications. For structural protection, check that cross section of the improvements, thickness of protection and live stake installation meet with the design specifications.

Maintenance and Inspection

- For the first two months, check the treated area weekly for insects, soil moisture and other conditions that could cause failure. Water or treat with insecticide, if needed. Follow applicable federal, state and local guidelines for using insecticides next to a waterbody.
- From four to six months, check monthly and note areas where the vegetation is not growing acceptably.
- Every six months for the first two years, replace dead plants with the same species and sizes as originally specified. Install during the dormant season.
- Check the treated area after heavy rains or during drought. Fix gaps in the vegetative cover with structural materials or new plants. Make needed repairs to structural systems with similar material.
- Protect new plantings from grazing livestock or wildlife, if needed.
- After two year establishment period, maintenance requirements should be minimal. Heavy pruning may be required to reduce competition for light or stimulate new growth. Remove undesirable vegetation every 3 to 7 years.

Common Problems and Solutions

Problem	Solution
Variations in topography on-site indicate protection will not function as intended.	Changes in plan may be needed.
Design specifications for vegetative or structural protection cannot be met.	Substitution may be required. Unapproved substitutions could result in erosion damage to the disturbed area.
There is any indication of undermining of structural elements at their sides or base.	Consult with registered design professional.
Pressure behind the structure due to slope instability is causing any deformation to the structural elements.	Consult with registered design professional.
Erosion of treated areas; caused by inadequate vegetation or improper structural protection.	Repair erosion, replace vegetation or structural protection and consider methods to reduce or divert surface runoff from the slope, including but not limited to slope drains.
Slumping failure or slides in slope; caused by steep slopes.	Repair slide by excavating failed material, replacing vegetation and properly compacting fill. Consider flattening slope.
Sinkholes in riprap; caused by failure of the filter beneath the riprap.	Remove riprap, repair filter and reinstall riprap.
Death of vegetation; caused by drought, insect damage, cuttings damaged during installation, or poor cutting/soil contact.	Repair and replace vegetation during dormant season, maintain biweekly or monthly inspection schedule and water or treat with insecticide as needed. Follow applicable federal, state and local guidelines for using insecticides next to a waterbody.

SECTION 4: SEDIMENT CONTROLS

Fabric Drop Inlet Protection



Figure 6.40 Filter fabric is only one way of protecting storm water inlets from siltation early in the grading process.

Practice Description

A fabric drop inlet protection is a temporary woven geotextile barrier placed around a drop inlet to reduce the amount of sediment entering the storm drains during construction operations. This practice applies where early use of the storm drain system is necessary.

Recommended Minimum Requirements

Prior to start of construction, fabric drop inlet protection structures should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Drainage area

Less than 1 acre per inlet.

Capacity

Ten year or design storm should enter inlet without bypass flow.

Height of Fabric

One and one-half feet maximum, 1-foot minimum; base of fabric should be buried at least 6-inches below the ground surface.

Approach

Less than 1 percent slope.

Sediment Storage

Generally 35 yard³/disturbed acre/year for watershed slopes of under 8 percent;
100 yard³/disturbed acre/year for slopes more than 8 percent.

Support Posts

Steel fence posts or 2 x 4 inch wooden posts. Minimum length of the stakes should be 3-feet; maximum spacing of stakes should be 3-feet.

Fabric

Durable, high-strength synthetic woven fabric.

Framing

Use frame cross members to connect the tops of the posts to stabilize the structure.

Stakes

Close to the drop inlet so overflow will fall directly into the structure and not onto unprotected soil.

Approach

Less than 1 percent slope.

Sediment Storage

Generally 35 yard³/disturbed acre/year for watershed slopes of under 8 percent;
100 yard³/disturbed acre/year for slopes more than 8 percent.

Support Posts

Steel fence posts or 2 x 4 inch wooden posts. Minimum length of the stakes should be 3-feet; maximum spacing of stakes should be 3-feet.

Fabric

Durable, high-strength synthetic woven fabric.

Framing

Use frame to connect the tops of the posts to stabilize the structure.

Stakes

Close to the drop inlet so overflow will fall directly into the structure and not onto unprotected soil.

Safety

Provide protection to prevent children from entering the inlet and outlet.

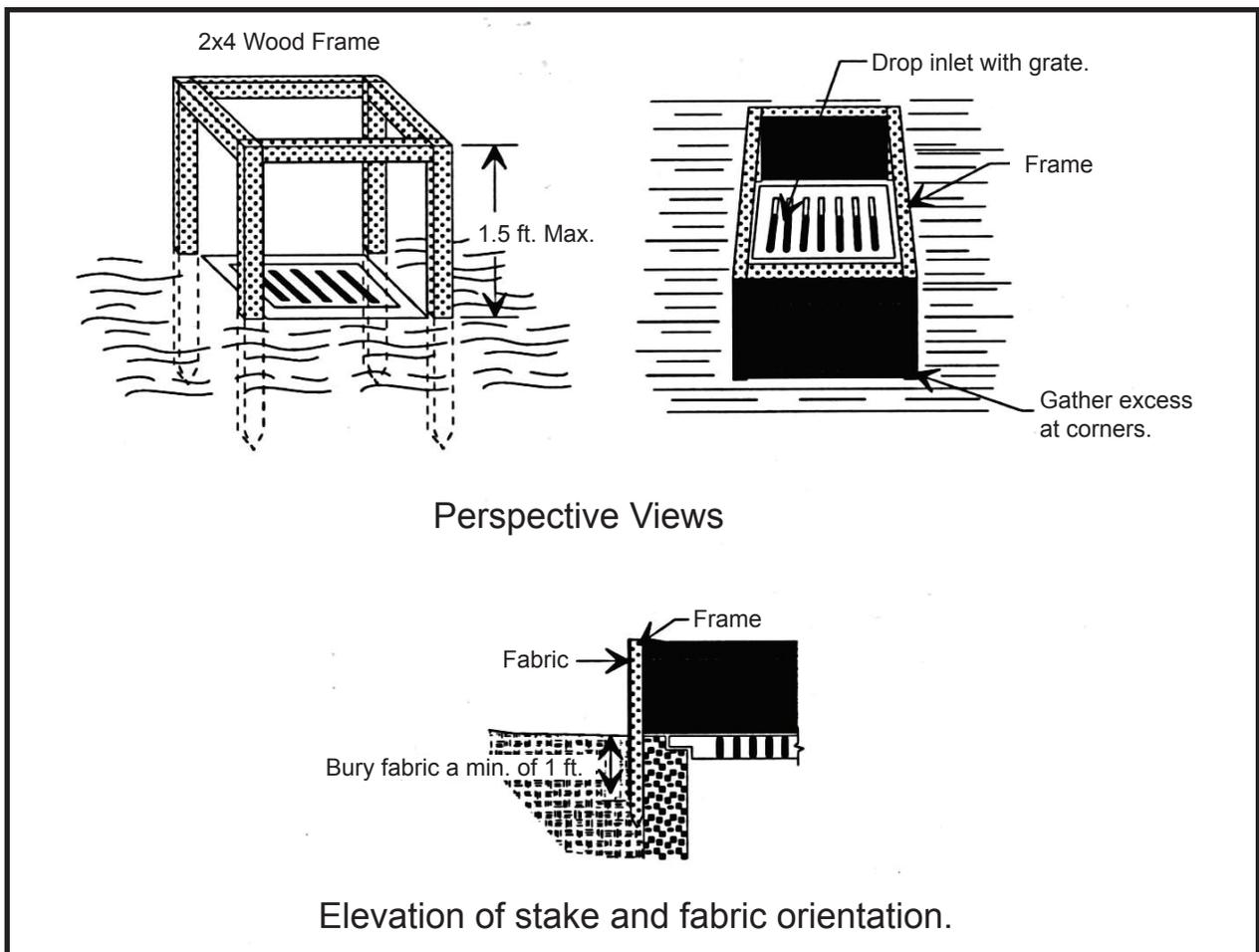


Figure 6.41 Fabric Drop Inlet Protection

Construction

- Space stakes evenly around the perimeter of the inlet a maximum of 3-feet apart and securely drive them into the ground, approximately 18-inches deep.
- To provide needed stability to the installation, frame with 2 x 4 inch wood strips or other suitable materials around the crest of the overflow area at a maximum of 18-inches above the drop inlet crest.
- If possible, cut fabric from one continuous roll to eliminate joints.
- Place the bottom 12-inches of the fabric in a trench and backfill the trench with crushed stone or compacted soil.
- Fasten the fabric securely to the stakes and frame. Joints should be overlapped to the next stake.
- Optional: Wire fence may be used to support the fabric. The wire should be 14-gage minimum with maximum mesh spacing of 6-inches. The top of the fence should be level, and the bottom should be buried at least 6-inches below ground surface.
- The top of the frame and fabric must be well below the ground elevation downslope from the drop inlet to keep runoff from bypassing the inlet. It may be necessary to build a temporary dike on the downslope side of the structure to prevent bypass flow. Material from within the sediment pool may be used for dike construction.

Stabilization

Stabilize all bare areas around the inlet.

Construction Verification

Check finished grades and dimensions of fabric drop inlet protection structures.
Verify sturdiness of frame construction.

Troubleshooting

Consult with a registered design professional if any of the following occur:

- Variations in topography on-site indicate fabric drop inlet protection will not function as intended; changes in plan may be needed.
- Design specifications for posts, fabric or fencing cannot be met; substitution may be required. Unapproved substitutions could result in failure of the structure.
- Fabric clogs or creates flooding due to ponding of storm water flows.

Maintenance, Inspection and Removal

- Inspect fabric barrier and frame weekly and after each rainfall event and make needed repairs immediately.
- Remove sediment from the pool area as necessary to restore required storage volume for the next rain. Take care not to damage or undercut the fabric during the sediment removal.
- When the contributing drainage area has been adequately stabilized, remove all materials and unstable sediment and dispose of properly in an upland area to dry and be stabilized. Bring the disturbed area to the grade of the drop inlet; smooth and compact it.
- Remove the temporary fabric drop inlet protection stabilize the site prior to filing [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Overtopping of fence; caused by posts and fabric unsupported at top.	Repair frame as necessary and use frame to support tops of post and fence to support fabric.
Undercutting of fence; caused by fabric not properly buried at bottom.	Use proper installation to bury fabric (see Figure 5.44)
Inadequate storage volume for the next storm; caused by sediment not being removed from pool.	Remove sediment as needed to prevent build-up.
Flow bypassing the inlet; caused by top of fabric set too high.	Lower top of fabric or select other inlet protection device.
Erosion and undercutting of inlet; caused by fence not close enough to inlet.	Relocate fence adjacent to inlet.
High flow velocity and poor trapping efficiency; caused by steep slopes at drain inlet.	Flatten slope at inlet.
Flooding; high water ponding around inlet; caused by improper selection of best management practice.	Reevaluate appropriate best management practice inlet protection device.

Excavated Drop Inlet Protection

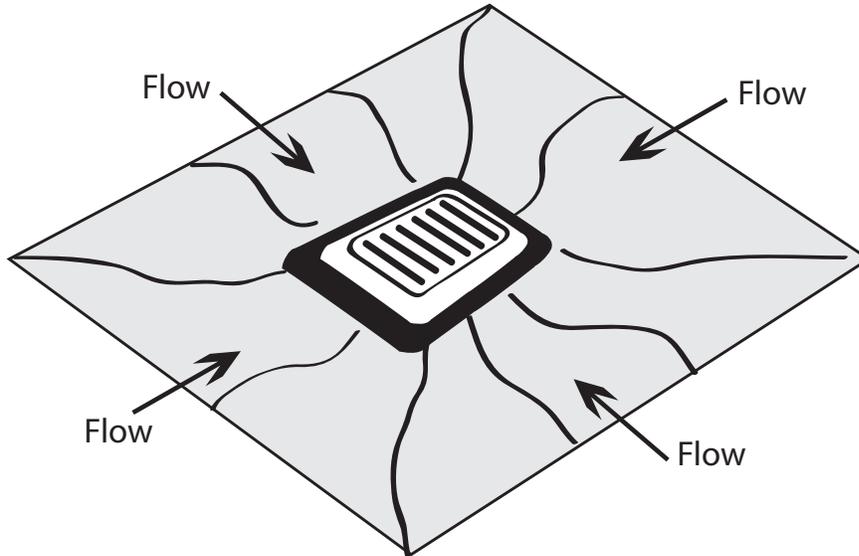


Figure 6.42 Perspective of Excavated Drop Inlet Protection

Practice Description

An excavated area in the approach to a storm drain drop inlet or curb inlet. The purpose is to trap sediment at the approach to the storm drainage system and not permit sediment to flow into the storm drain. This practice applies where early use of the storm drain system is necessary.

Recommended Minimum Requirements

Prior to start of construction, excavated drop inlet protection structures should be designed by a registered design professional. The site superintendent and field personnel should refer to plans and specifications throughout the construction process.

Drainage Area

Less than 1 acre per inlet.

Capacity

Ten year or design storm should enter inlet without bypass flow.

Minimum Depth

One foot, as measured from the top of the drop inlet.

Maximum Depth

Two feet, as measured from the top of the drop inlet.

Side Slopes

Side slopes at 2:1 or flatter around the excavation.

Dewatering

Place drain holes in drop inlet, covered with wire screen and gravel.

Gravel

Use clean gravel, 1/2- to 3/4-inches in diameter.

Sediment Storage

Keep the minimum volume of excavated material around the drop inlet at approximately 35 yd³/disturbed acre.

Basin Shape

To fit site conditions, with the longest dimension placed toward the longest inflow area to provide maximum settling efficiency. Try to keep the slopes less than 2:1 and allow access for excavation equipment for sediment removal, if possible.

Drain

Install provision for draining the temporary pool to improve trapping efficiency for small storms and to avoid problems from standing water after heavy rains.

Safety

Provide protection to prevent children from entering the inlet or outlet.

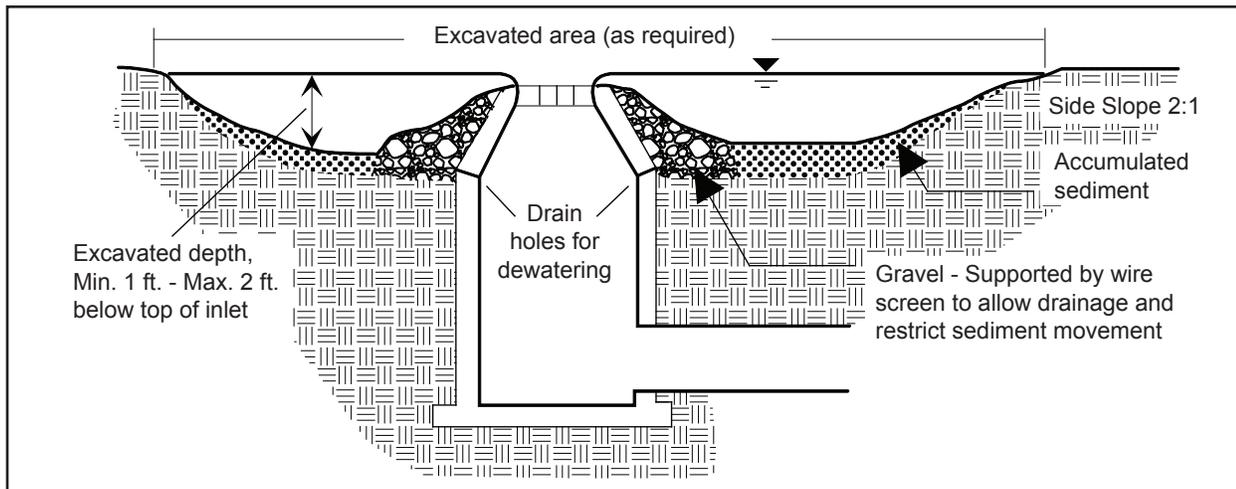


Figure 6.43 Cross section of Excavated Drop Inlet Protection

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Clear the area of all debris that might hinder excavation and disposal of spoil.
- Excavate the basin to the depth, side slopes and dimensions shown on the plans.
- Grade the approach to the inlet uniformly.
- Install drain holes in the drop inlet to drain pool slowly. Cover holes with wire screen and place gravel around sides of inlet.
- When necessary, spoil may be placed to form a dike on the downstream side of the excavation to prevent bypass flow.

Erosion Control

Stabilize disturbed areas, except the excavated pool bottom, in accordance with vegetation plan.

Construction Verification

Check finished grades and dimensions of excavated drop inlet protection structures.

Troubleshooting

Consult with a registered design professional if the following occurs:

- Variations in topography on-site indicate excavated drop inlet protection will not function as intended; changes in plan may be needed.

Maintenance, Inspection and Removal

- Inspect, clean and properly maintain the excavated basin after every storm as needed until the contributing drainage area has been permanently stabilized. While removing sediment from around inlet, do not allow accumulated sediment to discharge into unprotected inlet.
- Remove sediment when the excavated volume is approximately one-half full.
- Spread all excavated material evenly over the surrounding land area or stockpile and stabilize it appropriately.
- When the contributing drainage area has been permanently stabilized, seal drain holes, fill the basin with stable soil to final grading elevations, compact it properly, and establish vegetation or provide other means of protection.
- Remove the temporary excavated drop inlet protection stabilize the site prior to filing [Form H: Request for Termination of a General Permit, Form--MO 780-1409](#) (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Sediment entering drain; caused by sediment producing area too large for basin design or inlet not properly maintained.	Enlarge basin and maintain inlet (remove sediment, refresh filter fabric and rock).
Excessive ponding; caused by gravel over drain holes plugged with sediment.	Remove debris, clear sediment and replace gravel.
Flooding and erosion; caused by blockage of the storm drain from debris entering inlet.	Install trash rack around inlet.

Block and Gravel Inlet Protection

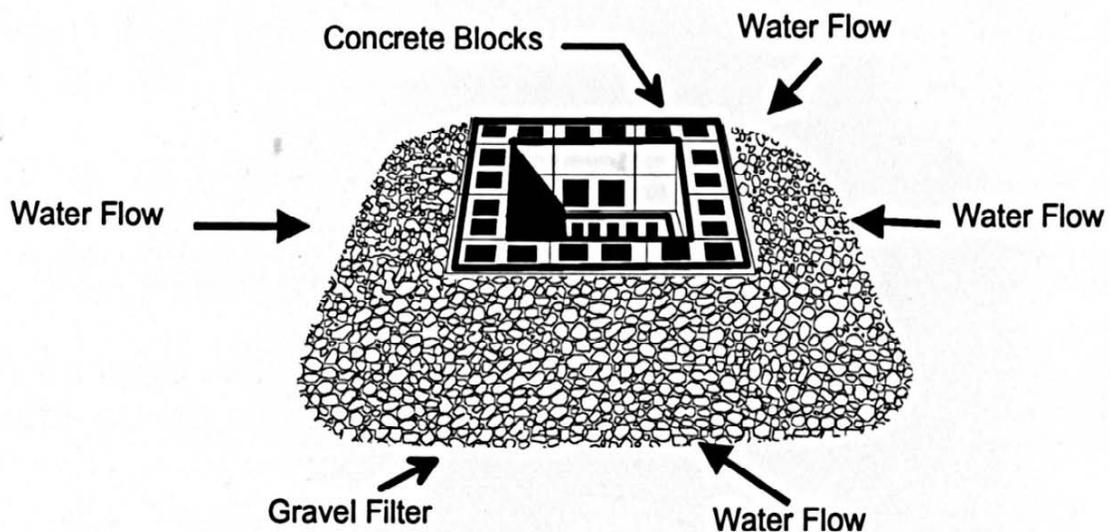


Figure 6.44 Detail of block and gravel drop inlet

Practice Description

Block and gravel inlet protection is a sediment control barrier formed around a storm drain inlet by the use of standard concrete block and gravel. The purpose is to help prevent sediment from entering storm drains before the disturbed construction area is revegetated and stabilized. This practice applies where early use of the storm drain system is necessary.

Recommended Minimum Requirements

Prior to start of construction, block and gravel inlet protection structures should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Drainage Area

Less than 1 acre.

Capacity

Ten year or design storm should enter inlet without bypass flow.

Height

Height of barrier should be between 1 and 2 feet. Be aware of potential ponding issues and provide emergency overflows to prevent possible excessive flooding.

Side Slopes

Gravel placed around the concrete block structure should have side slopes of 2:1 or flatter.

Dewatering

Some blocks in bottom row should be placed on their side for drainage.

Gravel

Use clean gravel, 1/2- to 3/4-inches in diameter. Place hardware cloth or comparable wire mesh with half inch openings over all block openings to hold gravel in place.

Safety

Provide protection to prevent children from entering the pipe inlet.

The top elevation of the structure must be at least 6-inches lower than the ground elevation downslope from the inlet. It is important that all storm flows pass over the structure and into the storm drain and not past the structure. Temporary dikes below the structure may be necessary to prevent bypass flow. Material may be excavated from inside the sediment pool for this purpose.

Construction

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Clear area of all debris that might hinder excavation and disposal of spoil.
- Grade the approach to the inlet uniformly.
- Lay one block on its side in the bottom row on each side of the structure to allow pool drainage. The foundation should be excavated at least 2-inches below the crest of the storm drain. Place the bottom row of blocks against the edge of the storm drain for lateral support and to avoid washouts when overflow occurs. If needed, give lateral support to subsequent rows by placing 2 x 4 inch wood studs through block openings.
- Carefully fit hardware cloth or comparable wire mesh with half inch openings over all block openings to hold gravel.
- Place gravel around blocks on a 2:1 slope or flatter, 2-inches below the top of the blocks, and smooth to an even grade.

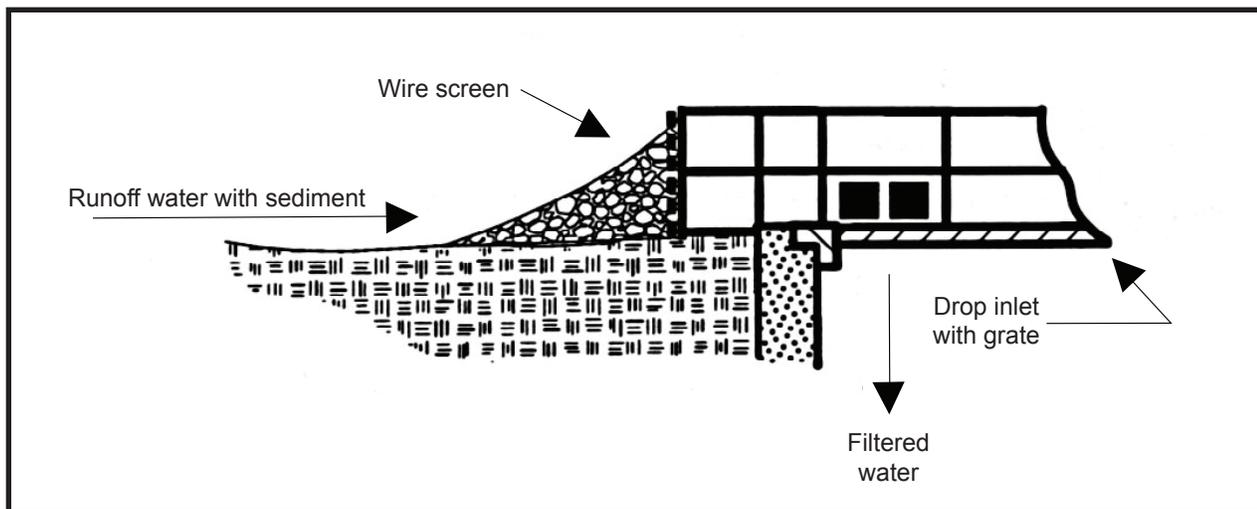


Figure 6.45 Cross section detail of block and gravel drop inlet.

Erosion Control

Stabilize disturbed areas in accordance with the vegetation plan.

Construction Verification

Check finished grades, material sizing and dimensions of block and gravel drop inlet protection structures.

Troubleshooting

Consult with registered design professional if variations in topography on-site indicate block and gravel drop inlet protection will not function as intended; changes in plan may be needed.

Maintenance, Inspection and Removal

- Inspect the barrier after each rain and make repairs as needed.
- Remove sediment as necessary to provide adequate storage volume for subsequent rains and replace gravel surrounding the inlet as it fills with sediment.
- When the contributing drainage area has been adequately stabilized, remove all materials and any unstable soil, and salvage or dispose of it properly. Bring the disturbed area to proper grade, then smooth and compact it. Appropriately stabilize all bare areas around the inlet.
- Remove the temporary block and gravel inlet protection stabilize the site prior to filing [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Bypass flow and erosion; caused by top of structure being too high.	Lower height of structure.
Scour; caused by blocks not placed firmly against the storm drain inlet.	Reset blocks firmly against drain inlet.
Poor trap efficiency or sediment overload; caused by too large of a drainage area.	Increase size of temporary sediment pool.
Poor trap efficiency; caused high flow velocity due to too steep of an approach to the drain.	Use excavated basin (see Excavated Drop Inlet Protection).
Sediment entering the storm drain; caused by sediment not being removed promptly.	Remove sediment promptly following storms.

Domed Inlet Protection



Figure 6.46 These are the two parts to this domed inlet device. Here it is secured to the ground weighted with gravel.
Source: Silt Saver Inc.

Definition and Purpose

This domed inlet protection device has two parts. There is a reusable HDPE (high-density polyethylene) frame and a hat that fits over the frame made primarily of two fabrics, a non-woven geotextile on the lower part and an open weave geotextile on the upper part. The open weave will allow for stormwater discharging quicker and reducing depth of ponded water. The frame has super stress crack resistance combined with high impact strength and rigidity. The base can be either round or square depending on the configuration of your storm sewer inlet openings.

Recommended Minimum Requirements

These inlet protection devices should be installed immediately after the storm sewer is constructed so stub openings can be protected before the next storm event.

Construction

These devices are manufactured and purchased from area distributors. The device should be installed over the opening and small stone or sand bags placed in the pockets at the bottom of the geotextile cover to keep the cover in place over the rigid cap.

Maintenance, Inspection and Removal

- Inspect each inlet protection device weekly and after rain events. Clean any sediment accumulation and dispose of sediment in a proper manner.
- Replace the geotextile cover if it is torn or damaged.
- While inspecting and cleaning inlet, do not allow accumulated sediment to discharge into unprotected inlet.
- Removal of this temporary domed inlet protection must be performed and the site stabilized prior to filing [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Any inlet protection device has the potential to create ponding. Protection devices that completely block the inlet or reduce the flow to the inlet can cause flooding or bypass of the storm flow to the next inlet down stream of the protected inlet.	Choose the inlet protection device according to the specific situation on your construction site.
Flooding during storm event; caused by the inlet device being completely blocked.	Choose the appropriate inlet protection device according to the situation on your site and provide routine and adequate maintenance.

Inlet Bag or Insert



Figure 6.47 Inlet Bag goes around grate.
Source: Dandy Products Inc.

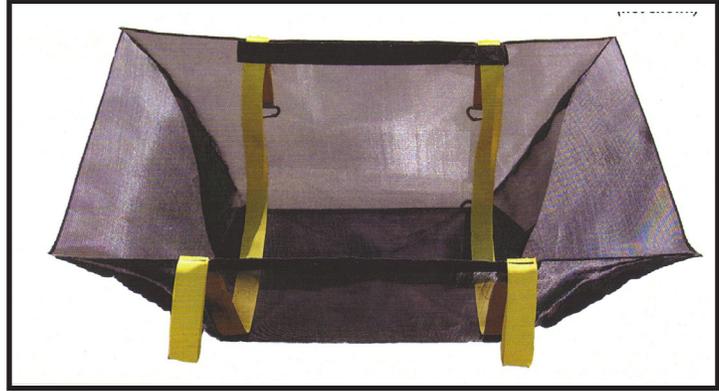


Figure 6.48 Inlet protection insert goes inside the storm drain.
Source: Pollution Solution Inc.

Practice Description

Inlet bags or inserts are inlet protection devices that are manufactured in a bag or sack form and completely cover or surround the inlet grate or fit around the grate and are suspended below the grate to collect the sediment within the storm sewer pipe. Most often the material is a geotextile but can be made of many types of materials. Some of these products are inlet bags that go around the grate or inserts that go inside the storm drain.

To provide some protection against excessive ponding, some manufacturers incorporate overflow tubes in their design that allow storm water to bypass through the bag or insert if the ponding level reaches a certain height.

Recommended Minimum Requirements

All storm sewer inlets that discharge stormwater off-site must be protected to treat the storm water discharge before it exits the construction site. Partially or completely blocking the inlet with a sediment control device will create ponding and possible bypasses or flooding. Keep this in mind when selecting which protection device you choose.

Construction

These products are manufactured and you must follow manufactures requirements for installation and maintenance.

Maintenance, Inspections and Removal

- Inspect each device weekly and after each storm event. Remove accumulated sediment around or in device and then wash device to clear it of sediment and replace it on or into the storm sewer inlet. While cleaning device, do not allow sediment to discharge into the unprotected inlet.
- Remove the temporary inlet bag or insert and stabilize the site prior to filing [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Troubleshooting

Bypass and flooding are the two largest issues with inlet protection devices. Select the device that best fits the situation you have on your construction site knowing you may need to change devices during different stages of construction.

Common Problems and Solutions

Problem	Solution
Flooding during storm event; caused by the inlet device being completely blocked.	Choose the appropriate inlet protection device according to the situation you have on your site and provide routine and adequate maintenance.



Figure 6.49 Inlet cover with opening for overflow.

Sediment Fence

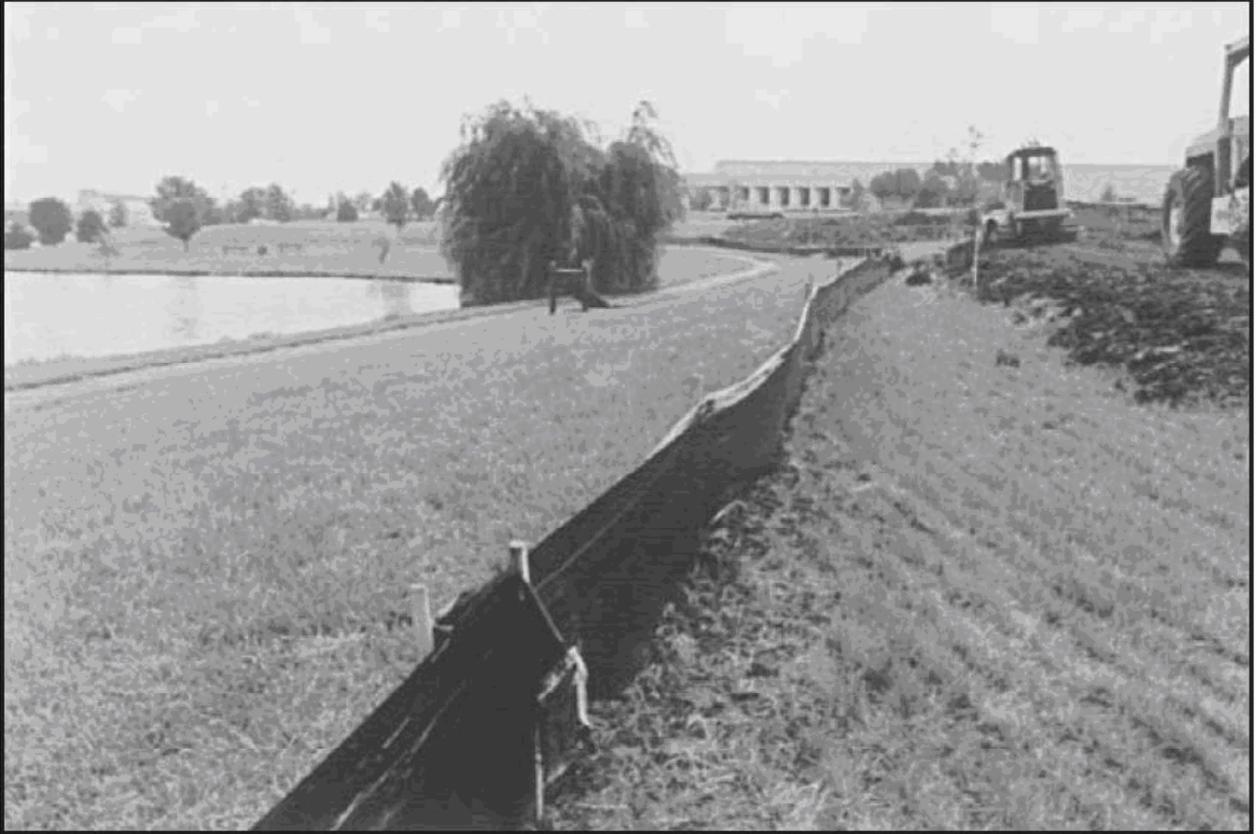


Figure 6.50 A properly installed sediment fence slows water flow long enough for the sediment to settle out. There should be no gaps under fence if heeled in properly. Source: C. Rahm, NRCS, Platte Co.

Practice Description

A sediment fence (often called a silt fence) is a temporary sediment barrier consisting of a geotextile fabric that is attached to supporting posts and trenched into the ground. Sediment-laden runoff ponds uphill from the sediment fence and runoff is temporarily stored to allow sediment to settle out of the water.

This practice applies where sheet erosion occurs on small disturbed areas. Sediment fences are intended to intercept and detain small amounts of sediment from disturbed areas in order to prevent sediment from leaving the site. Sediment fences can also prevent sheet erosion by decreasing the velocity of the runoff. Silt fence is not intended to be used in concentrated flow paths.

Recommended Minimum Requirements

Prior to start of construction, sediment fence placement and installment methods should be designed by a qualified professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Drainage Area

Limit to $\frac{1}{4}$ acre per 100 feet of fence. Further restrict the area by slope steepness as shown in Table 5.16.

Location

Fence should be built on a nearly level grade and at least 10 feet from the toe of the slope to provide a broad shallow sediment pool. Install on the contour, where fence can intercept runoff as a sheet flow; not located crossing channels, waterways or other concentrated flow paths; not attached to existing trees; and not located vertically up the slope (at a right angle to the slope.)

J-Hook

Silt fence should not be used around the entire perimeter of the site unless it is a small, flat site. It should only be located at areas where stormwater flow discharges with overland or sheet flow. You can use silt fence to create small catchments of stormwater flow by creating a small J-hook shape with the silt fence. The drainage area should be less than $\frac{1}{4}$ acre with little or no slope (see Figure 3.83).

Length

Maximum of 600 feet; flare ends of fence uphill to temporarily impound water as shown in Figure 5.32.

Geotextile

Commercially available silt fence fabric is almost exclusively woven geotextile fabric. Non-woven material has better flow through but poorer strength. A higher porosity geotextile would be a mono-filament fabric with larger voids between the woven threads.

Table 6.14 Typical Land Slope and Distance for Sediment Fence

Land Slope (percent)	Maximum Slope Distance* above Fence (feet)
Less than 2	100
2 to 5	75
5 to 10 greater than 10	50*

* Follow manufacturers' recommendations for proper spacing.

Spacing of Support Posts

A good minimum stand is 6-feet maximum for geotextile fabric supported by wire and 5-feet maximum for geotextile fabric without supportive wire backing. Follow the local design standards in your area and the site SWPPP.

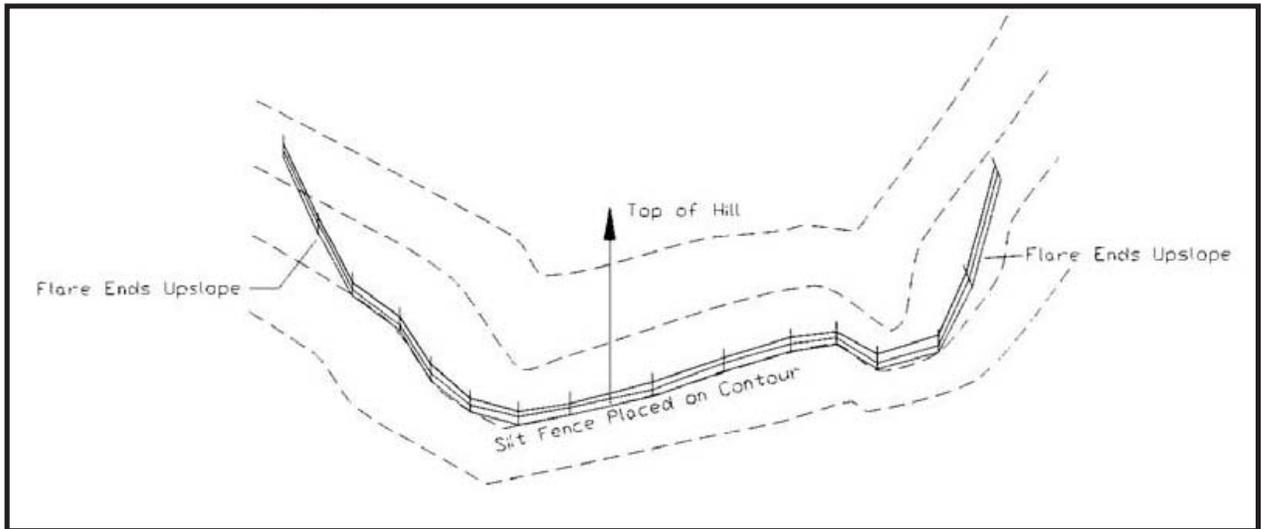


Figure 6.51 Placement of sediment fence

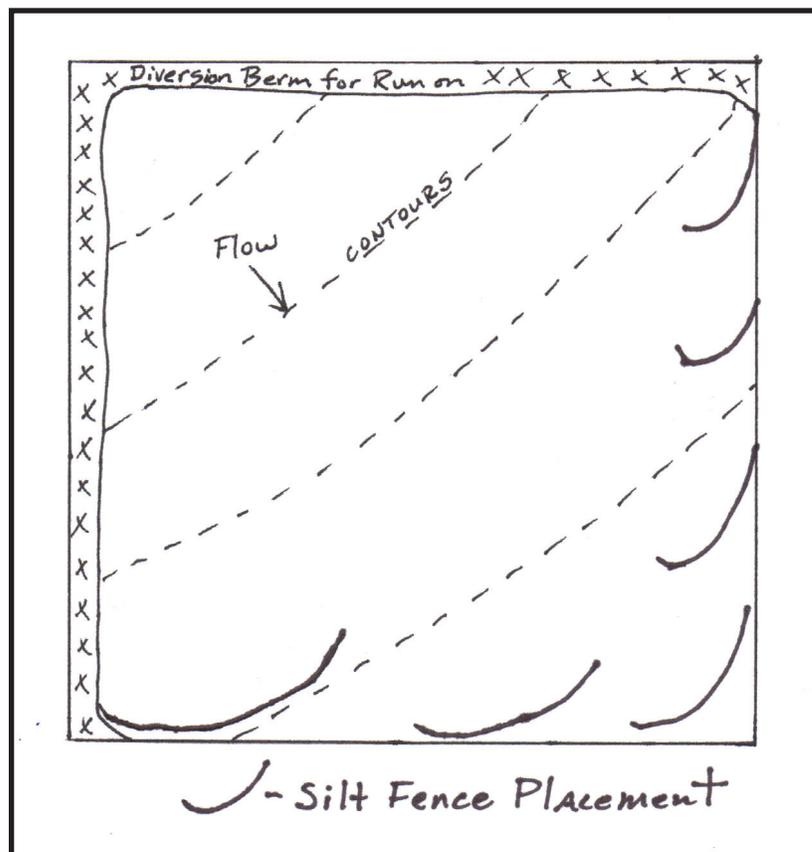


Figure 6.52 Placement of J-hook silt fence along the perimeter of a construction site to slow and pond small areas of stormwater runoff.

Proper Installation of Silt Fence

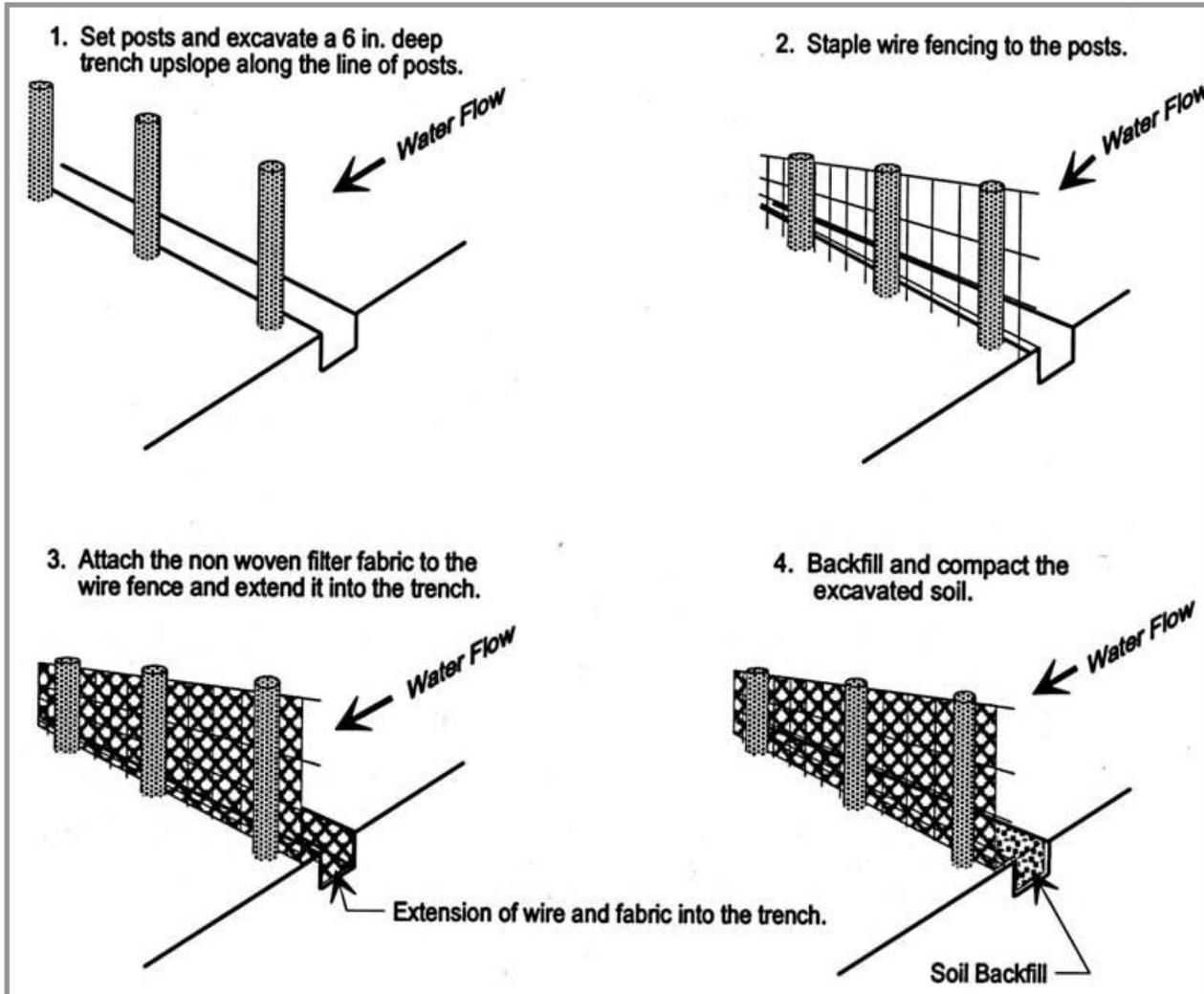


Figure 6.53 Proper Installation of silt fence

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Grade alignment of fence as needed to provide broad, nearly level area upstream of fence.

Fence Installation

- Dig a trench at least 6-inches deep along the fence alignment as shown in Figure 5.84.
- Drive hard wood or steel posts at least 24-inches into the ground on the downslope side of the trench. Space posts a maximum of 6-feet if fence is supported by wire, or 5-feet if no reinforcing wire fence is used.
- Fasten support wire fence to upslope side of posts, extending 6-inches into the trench as shown in Figure 5.84.
- Attach continuous length of fabric to upslope side of fence posts. Try to minimize the number of joints. Avoid joints at low points in the fence line. Where joints are necessary, fasten fabric securely to support posts and overlap to the next post.

- Place the bottom 1-foot of fabric in the 6-inch deep trench (minimum), lapping toward the upslope side. Backfill with compacted earth or gravel as shown in Figure 5.85.
- To reduce maintenance, excavate a shallow sediment storage area in the upslope side of the fence.
- Provide good access in areas of heavy sedimentation for clean out and maintenance.

Reinforced Stabilized Outlet Installation

- Allow for safe bypass of storm flow to prevent overtopping failure of fence.
- Set outlet elevation so water depth cannot exceed 1.5 feet at the lowest point along the fence.
- Drive posts securely at least 24 inches into the ground, at a spacing of 5- to 6-feet depending on the use of wire fence reinforcement or not. Install a horizontal brace between the support posts to serve as an overflow weir and to support the top of the fabric.
- Immediately downslope of the fabric, excavate foundation for splashpad a minimum of 5-feet wide, 5-feet long and 1-foot deep. Place 1-foot of riprap in the excavated foundation. The surface of the riprap should be flush with the undisturbed ground (no outfall).

Erosion Control

Stabilize disturbed areas in accordance with landscape plan.

Construction Verification

Check finished grades and dimensions of the sediment fence. Check materials for compliance with specifications.

Maintenance, Inspection and Removal

Inspect sediment fences at least once a week and after each rainfall as dictated by your permit. Make any required repairs immediately.

- Immediately replace the fabric of the sediment fence should it collapse, tear, decompose or become ineffective.
- Remove sediment deposits as necessary to provide adequate storage volume for the next rain event and to reduce pressure on the fence. Take care to avoid damaging or undermining the fence during cleanout.
- Remove all fencing materials and unstable sediment deposits and bring the area to grade and stabilize it after the contributing drainage area has been properly stabilized.
- Remove the temporary sediment fence and stabilize the site prior to filing [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

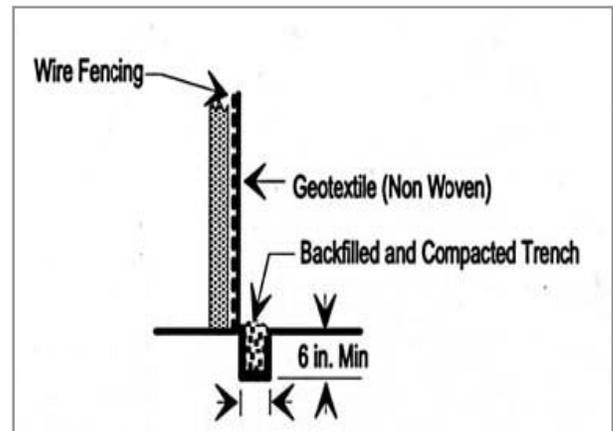


Figure 6.54 Detail of sediment fence installation

Troubleshooting

Consult with registered design professional if any of the following occur:

- Variations in topography on-site indicate sediment fence will not function as intended; changes in the plan may be needed.
- Design specifications for geotextile fabric, support posts, support fence, gravel or riprap cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.
- Fence is not installed on the contour or is installed across channels or other concentrated flow areas.
- Installation of sediment fence as designed appears to create a potential flooding hazard or directs runoff overflows into sensitive ecological areas.

Common Problems and Solutions

Problem	Solution
Overtopping, sagging or collapse of fence occurs; caused by the drainage area too large or too much sediment accumulation allowed before cleanout.	Increase sediment storage capacity upslope of fence or remove accumulation more frequently, then repair fence.
Collapse of fence due to high velocity or undercutting of fence; caused by approach too steep.	Reduce slope of approach area, or consult with a registered design professional.
Sagging or collapse of fence; caused by fence not adequately supported.	Add additional supports.
Undercutting of fence; caused by the bottom of fence not buried properly.	Reinstall fence using proper method of trenching.
Sagging, collapse or undercutting of fence; fence installed across drainage way.	Relocate fence away from drainage way. Silt fence should only be used adjacent to drainageway; other devices should be used across or within drainageway (see Rock Check Dam or Ditch Check).
Water runs on both sides of fence; fence installed vertically or at right angle to contour.	Relocate fence along contours.

Fence should never be used as a check dam or in concentrated flow paths.

Temporary Diversions



Figure 6.55 An unfinished temporary diversion routes sediment-laden storm water to a sediment basin. Temporary diversions should be shaped and protected with a turf reinforcement mat or rock. Establish permanent vegetation if the diversion will be used for one year or more. Source: K. Grimes, Soil and Water Conservation District, St. Charles Co.

Practice Description

A temporary diversion is a temporary ridge or excavated channel or combination ridge and channel. It is designed to either prevent runoff from flowing across the active construction site work areas and discharge it through stable, protected outlets or to divert sediment laden water to sediment traps. Temporary diversions are usually constructed by excavating a channel and using the excavated material to construct a ridge on the down slope side of the channel.

This practice applies wherever storm water runoff must be temporarily diverted to protect disturbed areas and slopes or to retain sediment on-site during construction. When a diversion is needed to direct runoff from undisturbed areas above the construction site around a disturbed area, it must be routed to a stabilized outlet. The diversion must be fully stabilized and non-erodible prior to receiving storm water flows. Check dams may be installed within the diversion to reduce velocities and control flows better. A diversion of clean storm water flow should never be allowed to flow over disturbed areas and create erosion or pick up sediment in the flow. If the untreated flow mixes with sediment laden storm water on the construction site, it must be treated through a control device before it discharges off-site.

Recommended Minimum Requirements

Prior to start of construction, temporary diversions should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. Temporary diversions should be constructed to minimize erosion at the design flow.

Drainage Area

Less than 5 acres.

Ridge Design

- Side Slope: 2:1 or flatter; 3:1 or flatter where vehicles must cross.
- Top Width: 2.0 ft.
- Freeboard: 0.3 ft.
- Settlement: 10 percent of fill height.

Channel Design

- Side Slope: 2:1 or flatter; 3:1 or flatter where vehicles must cross.
- Grade: Stable, positive grade towards outlet, but not exceeding 2 percent.

Construction

Site Preparation

- Locate and mark the alignment of the diversion as shown on the plans. The alignment should maintain a stable, positive grade toward the outlet. Minor adjustments to the grade and alignment may be required by site conditions. Realign or elevate the diversion as needed to avoid reverse grade.

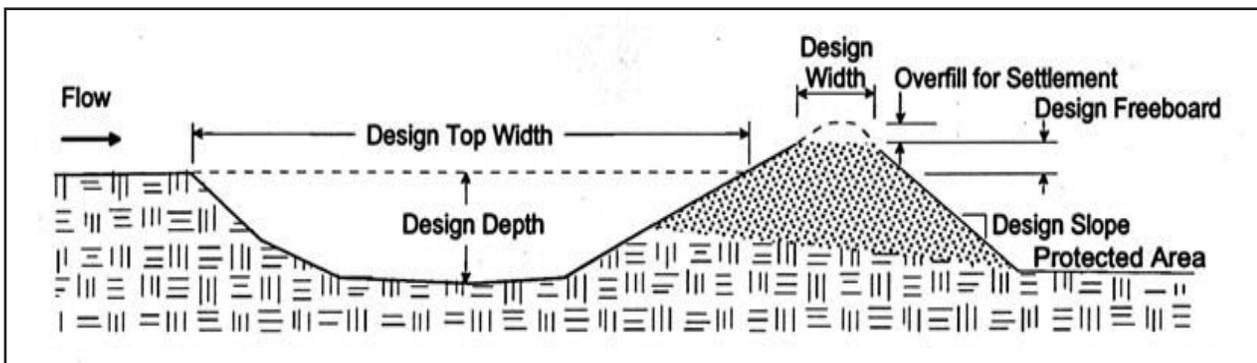


Figure 6.56 Typical temporary combination diversion.

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Remove trees, brush, stumps and other unsuitable material from the site.
- Disk the base of the ridge before placing fill.

Grading

- Construct the diversion to the dimension and grades shown on the design.
- Build the ridge 10 percent higher than designed for settlement and compact with wheels of the construction equipment or sheep foot roller.
- Leave sufficient area along the diversion to permit clean out and regrading.

Erosion Control

- Stabilize the outlets in accordance with design plans during construction of the diversion.
- Vehicles should not be allowed to drive across through diversions.
- Stabilize ridges, side slopes and channels with vegetation or synthetic erosion control measures as specified in the design. Do not allow storm water flows to enter the channel until it is fully stabilized especially if it is being used to direct clean storm water around a disturbed area.
- Outlet should be nonerosive for design flow. Divert flow containing sediment to sediment trap or basin.
- Stabilize ridge with vegetation if in place more than 30 working days.
- Diversions should not be installed on slopes greater than 15 percent or where diversion flows are calculated to be greater than 3-feet per second over vegetation. If the diversion is constructed above a steep slope, install temporary slope drains or other stable outlet to control runoff and prevent erosion of the slope (see [Temporary Slope Drains](#), [Grass-lined Channel](#), [Riprap-lined Channel](#) or [Turf Reinforcement Mats](#)).

Construction Verification

- The field inspector should verify the dimensions shown on the plans for the following: depth, bottom width, top width, side slopes of channel and ridge, grade of channel bottom, ridge height and channel stabilization techniques.
- Check all of the finished grades and configuration of all channels to eliminate constrictions to flow and to ensure final discharge flows to sediment basins or stabilized outlets. Also check all ridges for low spots and stability.

Grading

- Construct the diversion to the dimension and grades shown on the design.
- Build the ridge 10 percent higher than designed for settlement and compact with wheels of the construction equipment or sheep foot roller.
- Leave sufficient area along the diversion to permit clean out and regrading.

Erosion Control

- Stabilize the outlets in accordance with design plans during construction of the diversion.
- Vehicles should not be allowed to drive across through diversions.
- Stabilize ridges, side slopes and channels with vegetation or synthetic erosion control measures as specified in the design. Do not allow storm water flows to enter the channel until it is fully stabilized especially if it is being used to direct clean storm water around a disturbed area.
- Outlet should be nonerosive for design flow. Divert flow containing sediment to sediment trap or basin.
- Stabilize ridge with vegetation if in place more than 30 working days.
- Diversions should not be installed on slopes greater than 15 percent or where diversion flows are calculated to be greater than 3-feet per second over vegetation. If the diversion is constructed above a steep slope, install temporary slope drains or other stable outlet to control runoff and prevent erosion of the slope (see [Temporary Slope Drains](#), [Grass-lined Channel](#), [Riprap-lined Channel](#) or [Turf Reinforcement Mats](#)).

Construction Verification

- The field inspector should verify the dimensions shown on the plans for the following: depth, bottom width, top width, side slopes of channel and ridge, grade of channel bottom, ridge height and channel stabilization techniques.
- Check all of the finished grades and configuration of all channels to eliminate constrictions to flow and to ensure final discharge flows to sediment basins or stabilized outlets. Also check all ridges for low spots and stability.

Maintenance, Inspections and Removal

- Inspect weekly and following each storm event.
- Remove debris and sediment from the channel and rebuild the ridge as needed.
- Check outlets and make necessary repairs immediately.
- Remove sediment from traps or check dams when they are 50 percent full.
- When the work area has been stabilized, remove the ridge and fill in the channel to blend with the natural ground. Remove temporary slope drains and stabilize all disturbed areas with permanent vegetation or other erosion control practices.
- Remove the temporary diversion and stabilize the site stabilized [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).
- Maintain vegetation in channel as shown in the design plan.

Common Problems and Solutions

Problem	Solution
Seepage is encountered during construction.	It may be necessary to install drains.
Variations in topography on-site indicate diversion will not function as intended.	Consult with a registered design professional.
Design specifications for seed variety, seeding dates or erosion control materials cannot be met.	Substitutions may be required. Unapproved substitutions could result in erosion and lead to diversion failure.
Final discharges from diversion channels cause ongoing erosion at the outlets.	Modifications to the diversion system need to be made or energy dissipation devices installed.
Overtopping of channel; caused by sedimentation in channel resulting in grade decreasing or reversing.	Realign or deepen the channel to maintain grade.
Overtopping of ridge due to low point in ridge where diversion crosses a natural depression.	Build up ridge.
Erosion and scour of the channel; caused by high velocity in channel.	Consult a design professional and install velocity dissipators such as check dams.

Breach of ridge caused by uneven channel grade and leading to erosion in channel before vegetation is established.	Repair channel and add more effective erosion control option-erosion control blanket, turf reinforcement mat, transition mat, etc.
Poor vegetation establishment caused by seepage or poor drainage in channel.	Install subsurface drains or stone channel bottom.
Erosion in channel caused by excessive grade in channel.	Consult design professional, repair channel, install an erosion resistant lining and velocity dissipators such as check dams or realign to reduce the grade.
Erosion; caused by excessive velocity at outlet.	Consult a design professional, install an outlet stabilization structure (see Rock Outlets or Energy Dissipators).
Runoff from a storm event causes blow out failure; caused by ridge not being compacted.	Repair and use construction equipment to compact.

Right-of Way/Diversions Bars

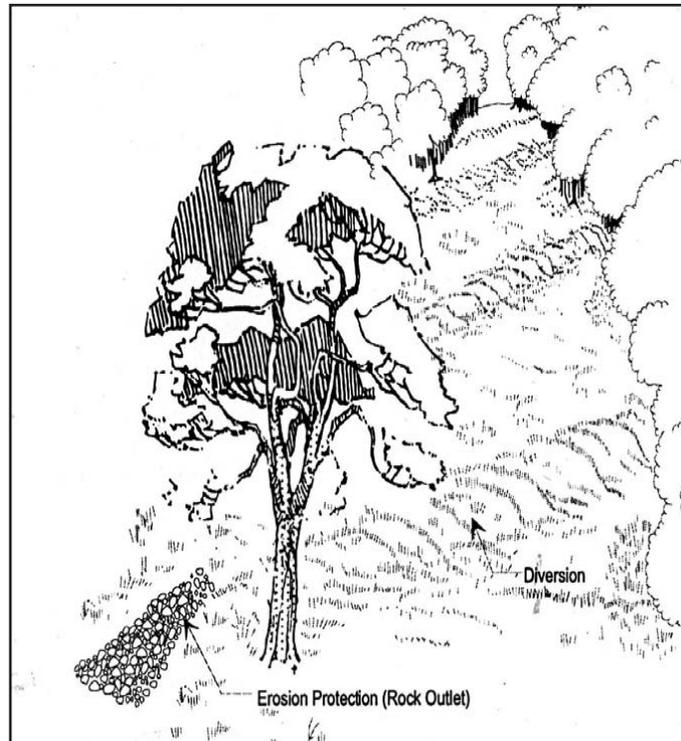


Figure 6.57 Typical Right-of-Way Diversion.

Practice Description

A right-of-way diversion, also known as a water bar, is a temporary ridge or combination of a ridge and excavated channel designed to shorten the flow length within a sloping right-of-way. The diversion thereby reduces the erosion potential by diverting storm runoff to a stabilized outlet. This practice applies to sloping right-of-ways or other long, narrow sloping areas such as utility access clearings.

Recommended Minimum Requirements

Prior to start of construction, right-of-way diversions should be designed by a qualified professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. The diversions should be built according to planned alignment, grade and cross section.

Height

18-inches.

Side Slopes

Side slopes are 2:1 or flatter; 3:1 or flatter where vehicles cross.

Base Width of Ridge

6-feet.

Spacing

Spacing as given in Table 5.14.

Grade

Stable, positive grade towards outlet, but less than 2 percent.

Outlet

Right-of-way diversion must cross full access width and extend to a stable outlet.

Table 6.15 Recommended Spacing of Water Bar Diversions

Slope	Diversion Spacing (ft.)
Less than 5%	125
5 to 10%	100
10 to 20%	75
20 to 35%	50
Greater than 35%	25

Source: *North Carolina Field Manual*, 1991

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Clear the access right-of-way and grade as necessary.
- Construct sediment traps or outlet stabilization structures as needed.
- After utilities have been installed in the corridor, locate the first bar at the required distance from the slope crest depending on steepness of the right-of-way slope (Table 5.14). Set the crossing angle so as to maintain a positive grade of less than 2 percent.
- Set the direction of the right-of-way diversions to use the most stable outlet locations. If necessary, adjust length of or spacing between bars to prevent runoff from upslope bars from merging with downslope water bar outlets.

Grading

- Mark the location and width of the ridge, and scarify the entire length.
- Excavate, fill and shape the diversion to planned alignment, grade and cross section.
- Fill the ridge to above the design height, then compact with rubber-tired equipment down to the design height.

Erosion Control

- Establish vegetation on the ridge and channel immediately following construction.

Construction Verification

- Verify the dimensions shown on the plans for height, base width, channel depth, grade and side slopes.
- Check all of the finished grades and configuration of all channels to eliminate constrictions to flow and to ensure the final discharge flows to sediment basins or stabilized outlets. Also check all ridges for low spots and stability.

Maintenance, Inspections and Removal

- Inspect right-of-way diversions weekly and after storm events for erosion and sediment deposition and periodically for vehicle wear.
- Remove debris and sediment from channels and sediment traps or basins.
- Repair ridges to grade and planned height.
- Add rock at crossing areas and stabilize outlets as needed.
- Repair and establish vegetation on right-of-way diversions immediately after installation of additional utilities in the right-of-way.
- To remove temporary right-of-way diversions, grade the ridge and channel to blend with the natural ground, compact the channel fill and establish vegetation on disturbed areas. (Do not remove right-of-way diversions until all disturbed areas draining to them are stabilized).
- Remove the temporary right-of-way diversion and stabilize the site prior to filing [Form H: Request for Termination of a General Permit](#), Form--MO 780-1409 (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Gully erosion occurs between right-of-way diversions caused by diversion spacing being too wide for slope.	Install additional bars.
Ridge is worn down and channel is filled where vehicles cross caused by unstable surface.	Stabilize surface by using gravel or other surface treatment and reduce vehicle traffic.
Erosion at outlets caused by unstable outlet structures.	Install an outlet stabilization structure or extend the upslope bars so runoff will not converge on the lower outlets.
Erosion in channel caused by too steep of a grade.	Realign the right-of-way diversion to reduce grade.

Temporary Slope Drains



Figure 6.58 Temporary slope drains can be used almost immediately to carry surface runoff down a steep slope, allowing vegetation a chance to become established. Source: North Carolina Department of Environment and Natural Resources

Practice Description

A temporary slope drain is a pipe or other conduit designed to convey concentrated runoff down the face of a cut or fill slope without causing erosion. This practice applies wherever storm water runoff must be conveyed down a steep slope.

Prior to start of construction, temporary slope drains should be designed by a registered design professional. Plans and specifications should be referred to the job foreman and field personnel throughout the construction process.

Recommended Minimum Requirements

Material

Strong, flexible pipe, such as heavy-duty, non-perforated, corrugated plastic.

Design Life

18 months or less.

Inlet Section (optional).

Standard “T” or “L” flared-end section with metal toe plate.

Inlet to Pipe at Top of Slope

Compacted fill over pipe with minimum dimensions of 1.5-foot depth, 4-foot top width and 6-inches higher than ridge.

Outlet

Pipe should extend beyond toe of slope and discharge into a sediment trap or basin unless the contributing drainage area is stable or undisturbed. The pipe could also “T” with a perforated horizontal pipe discharging into a stable, vegetated area acting as a level spreader, turning concentrated flow into sheet flow.

Pipe Size

Refer to the appropriate design manual for your area (see [Design Manual Reference](#)).

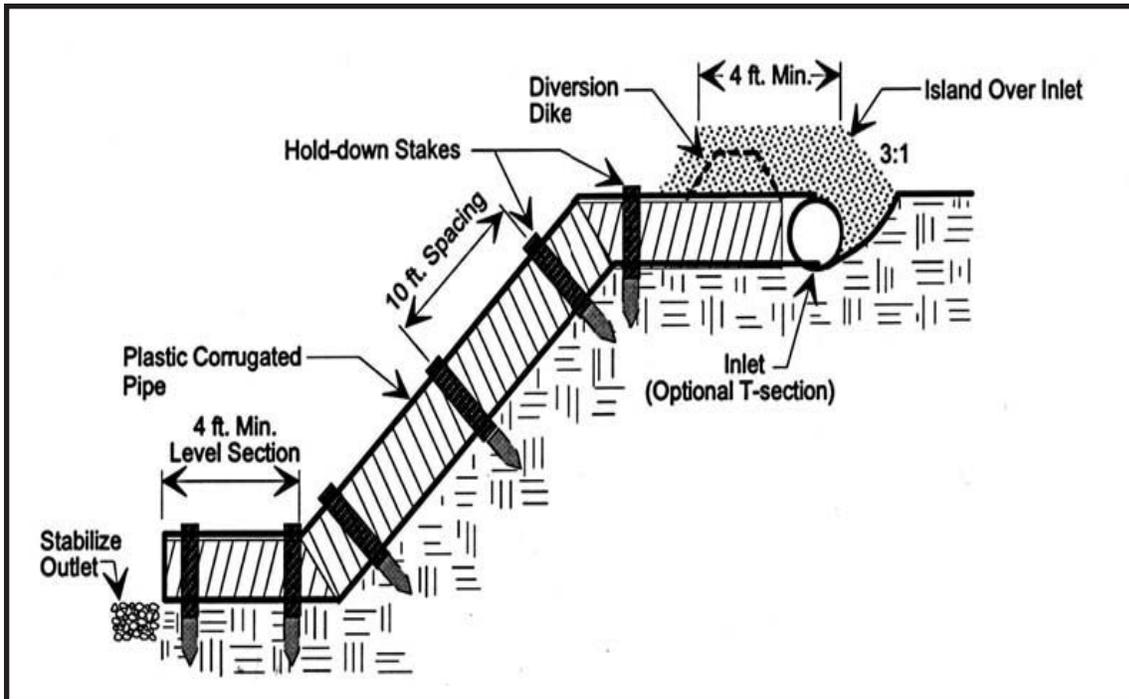


Figure 6.59 Typical Cross Section of Temporary Slope Drain with Optional T-section Inlet

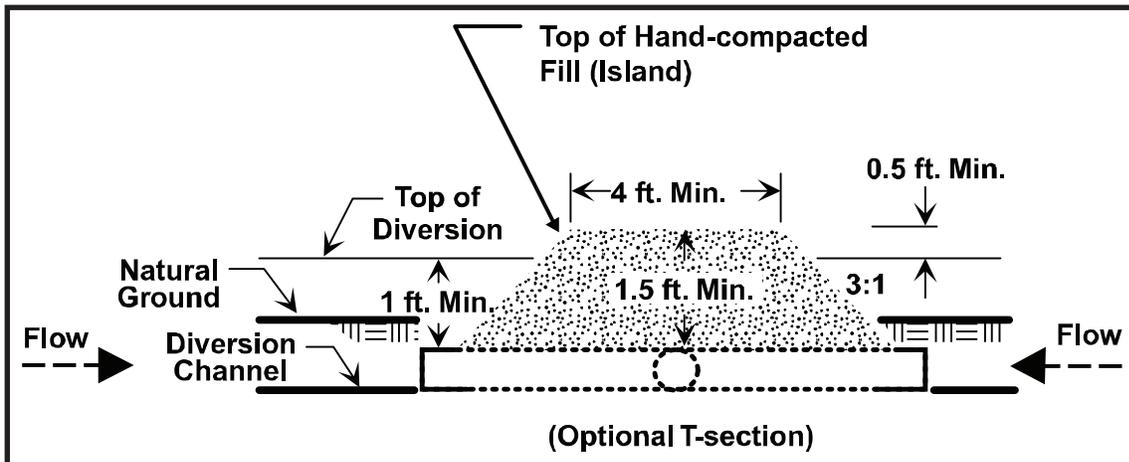


Figure 6.60 Detail of Inlet to a Temporary Slope Drain

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Place temporary slope drains on undisturbed soil or place well-compacted fill at locations and elevations shown on the plans.
- Grade the diversion channel at the top of the slope toward the temporary slope drain. A stable, positive grade not exceeding 2 percent is needed. Slightly slope the section of pipe under the ridge.
- Hand tamp the soil under and around the pipe in lifts not to exceed 6-inches.
- Ensure fill over the drain at the top of the slope has minimum dimensions of 1.5-foot depth (above top of pipe) and 1-foot top width.
- Ensure all slope drain connections are secure and watertight.
- Ensure all fill material is well-compacted. Securely anchor the exposed section of the drain with grommets or stakes spaced no more than 10 feet apart.
- Extend the drain pipe beyond the toe of the slope and adequately protect outlet from erosion.

Erosion Control

- Make the settled, compacted diversion ridge no less than 1 foot above the top of the pipe at every point.
- Immediately stabilize all disturbed areas following construction with vegetation or other appropriate means of protection.
- Provide for energy dissipation at the outlet of the pipe (see [Energy Dissipators](#) section.).

Construction Verification

- Verify the dimensions shown on the plans for the following: diameter of pipe, inlet, outlet elevations, orientation relative to how flow will enter the existing drainage pattern and diversion specifications (see [Temporary Diversions](#)).
- Joints should be carefully inspected for separations or looseness.

Troubleshooting

Consult with a registered design professional if any of the following occur:

- Variations in topography on-site indicate temporary slope drains will not function as intended.

Maintenance, Inspection and Removal

- Inspect slope drains and supporting diversions once a week and after every storm event.
- Check the inlet for sediment or trash accumulation; clear and restore to proper condition.
- Check the fill over the pipe for settlement, cracking or piping holes; repair immediately.
- Check for holes where the pipe emerges from the ridge; repair immediately.
- Check the conduit for evidence of leaks or inadequate anchoring; repair immediately.
- Check the outlet for erosion or sedimentation; clean and repair, or extend if necessary.

- After slopes have been stabilized, remove the temporary diversions and slope drains, and stabilize all disturbed areas.
- Remove the temporary slope drains stabilize the site prior to filing [Form H: Request for Termination of a General Permit, Form--MO 780-1409](#) (see [Chapter One - Missouri Permit Requirements](#)).

Common Problems and Solutions

Problem	Solution
Overtopping of the drain caused by undersized or blocked pipe; drainage area may be too large.	Install additional pipes and remove debris frequently.
Overtopping of the drain caused by improper grade of channel and ridge.	Regrade to provide positive drainage.
Overtopping of the drain caused by poor entrance conditions and trash buildup at pipe inlet.	Deepen and widen the channel at the pipe entrance; inspect and clear inlet frequently.
Erosion at outlet caused by focused erosive flow being released at too high an elevation.	Extend pipe to a stable grade or an outlet stabilization structure as needed.
Pipe separates or is displaced caused by lack of securement.	Tie the pipe down and secure the joints.
Animals going into the pipe outlet caused by open-ended pipe.	Install a free swinging animal guard.

Subsurface Drains



Figure 6.61 A gravel-filled trench is one of several ways to solve subsurface drainage problems. Note safety barrier around the trench. Source: Bob Clay, Missouri Department of Natural Resources, Nodaway County

Practice Description

A subsurface drain is a perforated pipe or continuous layer of porous material installed below the ground surface that intercepts, collects and carries excessive groundwater to a stable outlet. Subsurface drains by themselves do not provide erosion control.

The purpose of a subsurface drain is to reduce storm water runoff volumes, and improve soil moisture conditions, vegetation growth and ground stability. Subsurface drains also prevent wet, soft ground from interfering with construction activities. Drains may be constructed using a gravel-filled trench, perforated pipe in gravel bedding or manufactured drain panel products. This practice applies where groundwater is at or near the ground surface or where adequate drainage cannot be provided for surface runoff.

Recommended Minimum Requirements

Prior to start of construction, subsurface drains should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Drainage system layout, depth, construction details and specifications should be included in the design plans. Some aspects of the design may depend on-site specific conditions not known or only estimated prior to installation and will need to be verified or modified during construction.

The timing of construction of these devices is critical. They should not be installed prior to final stabilization of the area where they will collect sediment laden runoff. Subsurface drains are not intended to collect sediment. If they do, they may become blocked or clogged and need to be reconstructed.

During the construction process, prior to final stabilization, infiltration trench excavations shall be completely protected from storm water runoff. These protection methods may include diversions, berms and other approved runoff barriers. Final placement of subsurface drain fill material and connection to the storm sewer system shall take place after the drainage area from which it receives water is completely stabilized.

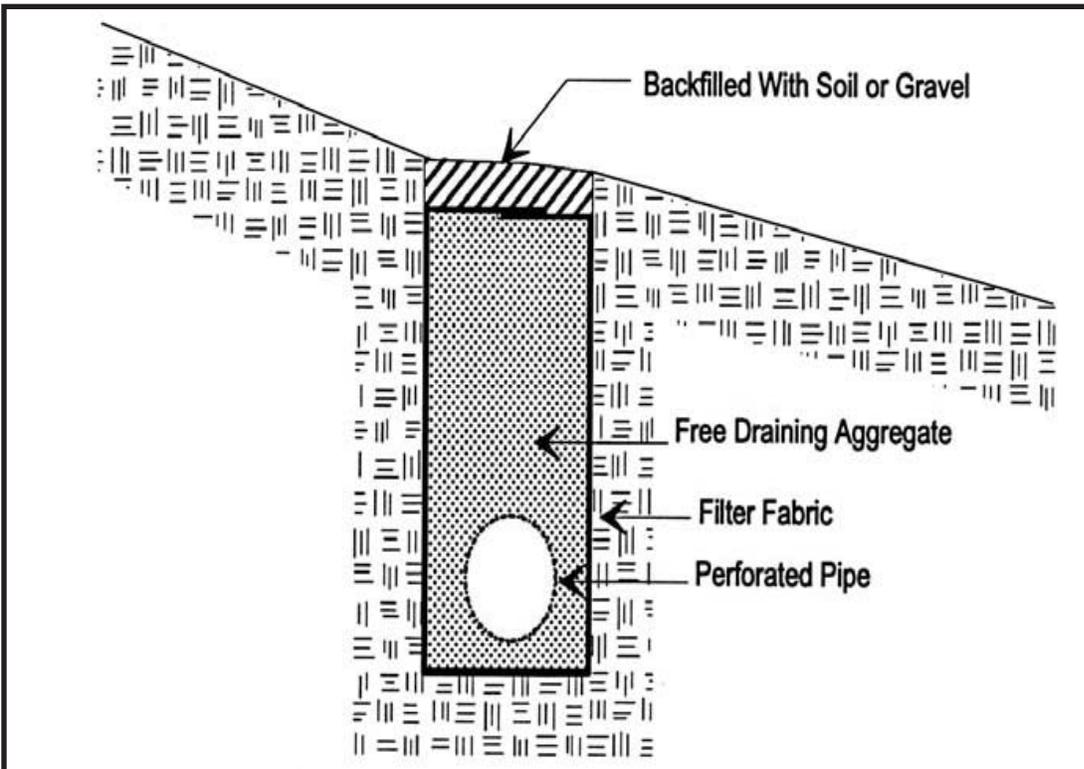


Figure 6.62 Typical Detail for Installation of Subsurface Drain

Layout and Depth

Generally, a depth of 3-feet and a spacing of 50 feet will be adequate.

Depth

Depth of the drain will determine how much the water table is lowered.

- Maximum: Limited by the impenetrable layer, and if pipe is used, by the allowable load on the pipe.
- Minimum: 2-feet under normal conditions.
- Spacing: Dependent on soil permeability and the depth of the drain.
- Multiple Drains: Determining the required spacing can be difficult. Install the first drain. Install an additional drain if seepage or high water table problems occur.

Location

Over 50 feet from the dripline of any trees.

Grade

Grade trench according to the design plan to prevent siltation within the drain. Steep grades should be avoided.

Gravel Bedding

Three inches or more of gravel placed completely around the drain and graded to prevent the infiltration of fine-grained soils into the drain.

Filter

As specified in design plan; determined by soil permeability. Usually filter fabric, although gravel bedding may be designed as a filter to prevent migration of fines.

Outlet

To a stable watercourse, with outlet above the mean water level in the receiving channel. Protect drains from erosion, undermining, damage from periods of submergence and the entry of small animals.

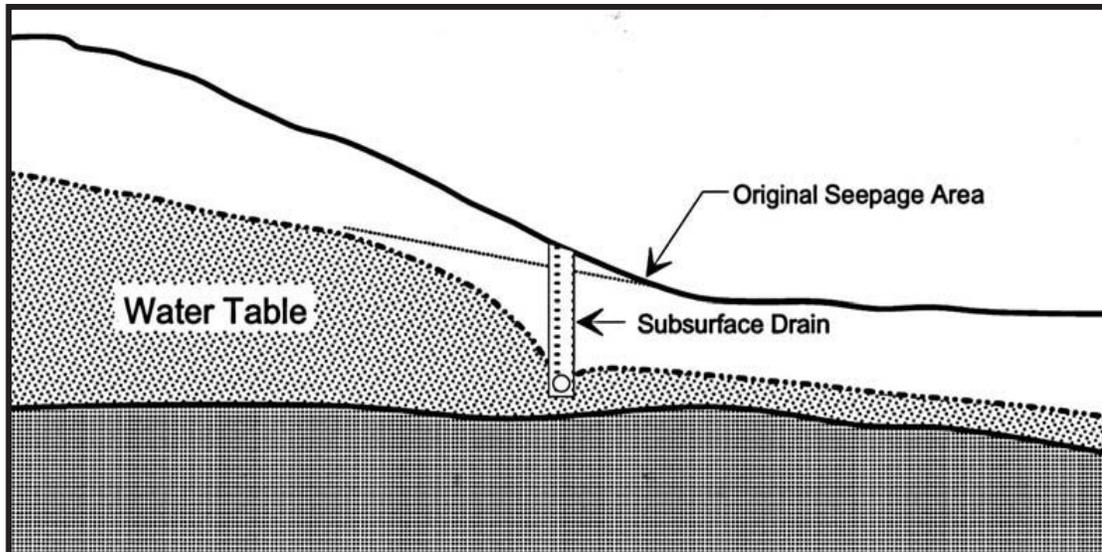


Figure 6.63 Detail of typical subsurface drain construction

Clean-outs

Required for long sections of drain.

Materials

Perforated, continuous closed-joint pipes of corrugated plastic, concrete, corrugated metal or bituminous fiber.

Strength and Durability

Should meet the requirements of the site in accordance with the manufacturer's specifications.

Construction

Installation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Dig a trench to specified grade at least 3-inches (or as shown on the design) below the design bottom elevation of the pipe to accommodate the gravel bedding or filter material.
- Line trench with filter cloth, providing enough material to fold it back over the top of the finished gravel bedding. This helps prevent movement of soil into the gravel.
- Lay pipe on the design grade and elevation avoiding reverse grade or low spots. Do not use damaged, deformed, warped or otherwise unsuitable pipe.