Kentucky Erosion Prevention and Sediment Control Field Guide

Kentucky Erosion Prevention and Sediment Control Field Guide

Funding for this project was provided in part by a grant from the U.S. Environmental Protection Agency (USEPA) through the Kentucky Division of Water (KDOW), Nonpoint Source Section and the Kentucky Division of Conservation (KDOC) to Tetra Tech, as authorized by the Clean Water Act Amendments of 1987, Section 319(h) Nonpoint Source Implementation Grant # C9994861-01. Mention of trade names or commercial products, if any, does not constitute endorsement. This document was printed on recycled paper.

Technical Review Committee

Bruce Scott, KY Division of Water
Tom Gabbard, KY Division of Water
Joe Ferguson, KY Division of Water
Jennifer Thompson, KY Division of Conservation
Carolyn Hestand, KY Division of Conservation
David Waldner, KY Transportation Cabinet
Stephen Bowling, KY Transportation Cabinet
Ray Werkmeister, KY Transportation Center
Kurt Mason, USDA NRCS
Charles Farmer, USDA NRCS
Mary Kathryn Dickerson, Boone, Kenton, Campbell Cons. Dist.
David Uckotter, Lexington-Fayette Urban Co. Govt.
Randy Stambaugh, Metropolitan Sewer District
John Lyons, NKY Sanitation District # 1
James Kipp, KY Water Resources Research Institute
Lindell Ormsbee, Tracy Farmer Center for the Environment
Laura Wagers, KY Association of Counties
Henry Duncan, UK Cooperative Extension Service
Richard Warner, UK Cooperative Extension Service
Judy Petersen, KY Waterways Alliance
Russ Barnett, KY Institute for Sustainable Development
Michael Berthurem, KY League of Cities
Juva Sizemore Barber, Home Builders Association of Kentucky
Richard Walker, Tetra Tech
John Kosco, Tetra Tech
William Marshall, Tetra Tech
Barry Tonning, Tetra Tech

This document has been approved by the Kentucky Transportation Cabinet, and reflects Best Management Practices for erosion and sediment control for highway construction projects.

Clean runoff starts with you.

This *Field Guide* will take you through the erosion and sediment control process. The guide starts out with sections on pre-project planning and operational activities. The rest of the guide discusses erosion prevention and sediment control by starting at the top of the hill, above the project site, and proceeding down the slope through the bare soil area, ditches and channels, traps and basins, and on down to the waterways below. The drawing below summarizes this approach.

Preserve existing vegetation

Divert upland runoff around exposed soil

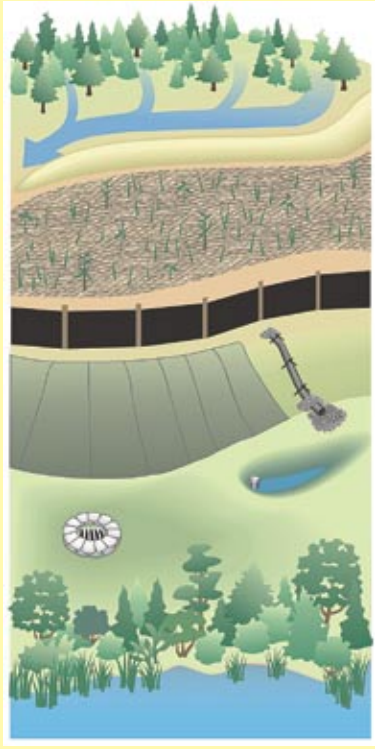
Seed/mulch/ cover bare soil immediately

Use sediment barriers to trap soil in runoff

Protect slopes and channels from gullying

Install sediment traps and settling basins

Preserve vegetation near all waterways



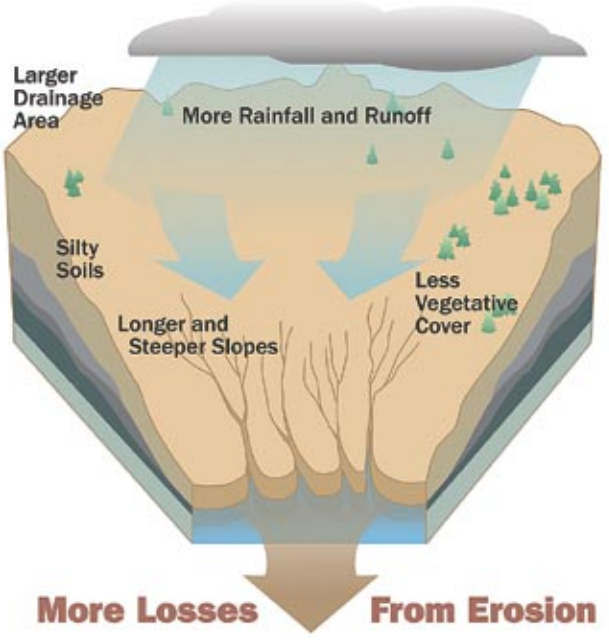
Why do we need to control erosion and sediment losses from construction sites?

Sediment washing into streams is one of the biggest water quality problems in Kentucky. Sediment muddies up the water, kills or weakens fish and other organisms, and ruins wildlife habitat. It is not difficult to reduce erosion and prevent sediment from leaving construction sites. Follow the basic approach shown above. Sites with steep slopes near waterways need more controls than flat sites farther away.

Observe basic principles such as: 1) Preserve existing vegetation as much as possible; 2) Mulch or seed bare soil immediately for the best and cheapest erosion protection; 3) Use silt fences, brush barriers, or other approaches to pond and filter sediment from runoff; 4) Install silt check dams made of rock, brush, or other products to prevent ditch erosion and remove sediment; 5) Protect inlets and outlets; and 6) Settle out soil particles in sediment traps and basins.

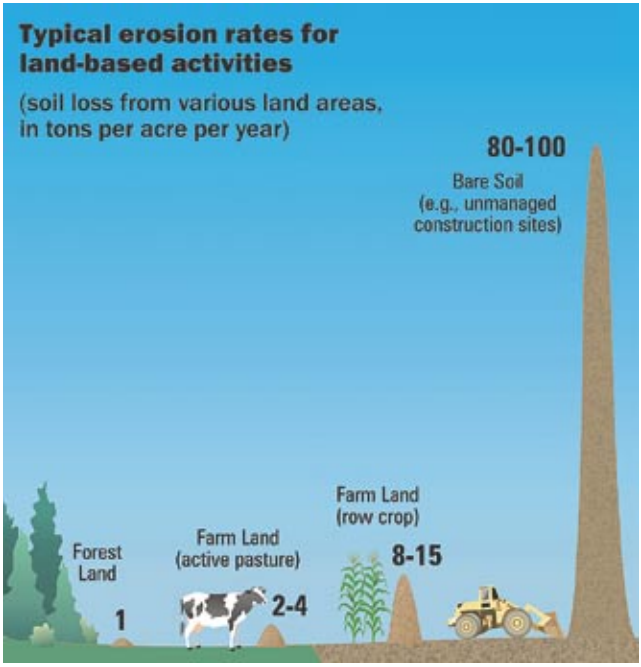
Table of Contents

What contributes to erosion?



Factors influencing erosion. Heavy rainfall, steep slopes, removal of most existing vegetation, and erodible soils result in higher soil losses from erosion.

Lower rainfall amounts, flatter slopes, preserving existing vegetation, and less erodible soils result in lower soil losses from erosion.



What contributes to erosion?

- Removing vegetation
- Removing topsoil and organic matter
- Reshaping the lay of the land
- Exposing subsoil to precipitation
- Failure to cover bare soil areas
- Allowing gullies to form and grow larger
- Removing vegetation along stream banks

What other factors affect erosion?

Rainfall frequency and intensity

Slope (steep = more; flat = less)

Soil structure and type of soil (silty = more erosion)

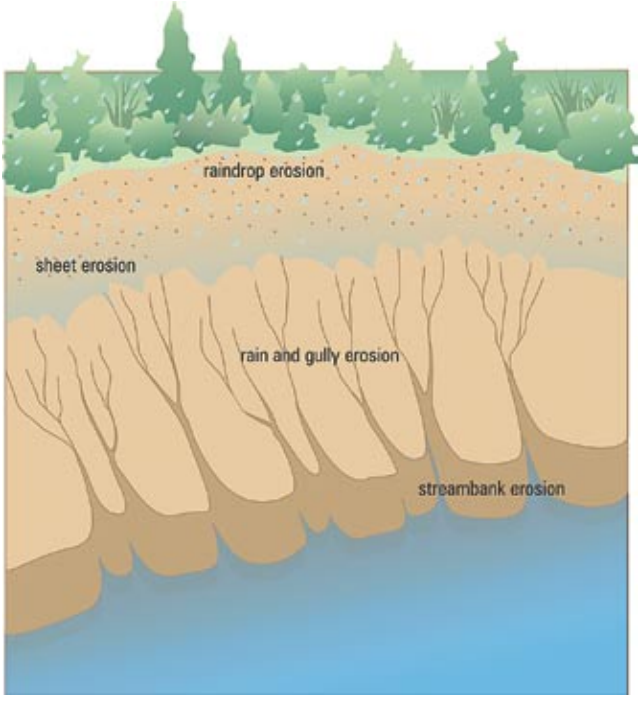
Vegetation (more vegetation = less erosion)

Erosion and sediment controls for muddy runoff:

- Soak it in—maximize seeding and mulching
- Sift it out—use silt fences or other filters
- Slow it down—don't let gullies form
- Spread it around—break up concentrated flows
- Settle it out—use sediment traps and basins

Types of Erosion

Types of erosion. Raindrop erosion (top) breaks down soil structure. Slope runoff creates sheet erosion, which can lead to the formation of small rill channels and larger gullies (below). Erosion of unprotected stream banks can be caused by removing vegetation and higher flows caused by runoff from pavement, sidewalks, and roofs in newly developed areas.



SECTION 1

Pre-Construction Planning

Planning your construction project can help you avoid costly mistakes in controlling erosion and sediment loss to nearby waterways. Follow the steps below before you begin clearing, grading, and excavation work. If your project is one acre or larger, you will need a storm water permit from the Kentucky Division of Water (502-564-3410, or see http://www.water.ky.gov/permitting/wastewaterpermitting/KPDES/storm/).

Assess soils and slopes on the construction site

If your construction site has highly erodible soils and steep slopes, you will need maximum erosion and sediment control protection. See the table below.

Need for erosion and sediment controls for various slope and soil conditions

	Soil Type		
Slope Angle	**Silty**	**Clays**	**Sandy**
Very Steep (2:1 or more)	*Very high*	*High*	*High*
Steep (2:1–4:1)	*Very High*	*High*	*Moderate*
Moderate (5:1–10:1)	*High*	*Moderate*	*Moderate*
Slight (10:1–20:1)	*Moderate*	*Moderate*	*Lower*

Identify nearby streams and drainage control points

Walk over the site and find where ditches or other concentrated flows leave the site. These are the final sediment control points. Sediment traps or basins should be installed just above these control points. Your site may drain to an underground storm sewer system. In this case, the storm drain inlets that drain runoff from your site are the control points and must be protected (see Section 7). These are also the compliance points for any permits issued for the site. Low spots—where rain water ponds—are good places for sediment traps (see Section 9).

Install clean water diversions, sediment traps/basins, grassed ditches, silt check dams, and sediment barriers such as silt fences *before* clearing and excavation work begins!

Preserve existing vegetation wherever possible

Only dig or grade where necessary. Existing trees, bushes, and grass help keep erosion to a minimum. Protect large trees by marking off a no-dig root protection zone that is twice as large as the outer perimeter of the branches. Plan your project to limit the amount of bare soil area exposed to the weather, and limit the amount of exposure time. Do not clear vegetation or excavate areas near streams, rivers, lakes, or wetlands without getting the required state and federal permits!

Design projects to fit the lay of the land

Minimize clearing and grading to preserve mature vegetation and save money. Identify natural landscape features you want to keep, like large trees, wildflower areas, grasslands, streams, and wetlands. Plan ways to fit your project around these features, so they remain in place after construction is completed. Be sure to mark off these areas with colored ribbon or stakes and warn equipment operators of their location!

Minimize impervious surfaces

Keep the amount of roof area, parking lots, driveways, and roads to a minimum. Design these hard surfaces so that rain water they collect is directed onto landscaped or yard areas, not into ditches or streams. For example, design roads slightly higher than adjacent lawn areas, and use rain infiltration ditches (swales) rather than curbs along roadways. Porous pavement can also help soak up runoff.

Promote infiltration in project design

Moving storm water runoff from hard surfaces to landscaped or yard areas helps runoff soak into the soil. This promotes groundwater recharge, filters sediment and other pollutants from runoff, and helps to prevent flooding.

Develop an erosion and sediment control plan

Develop a written site plan for your project that shows the drainage patterns and slopes, areas of disturbance (cuts/fills, grading), location of erosion and sediment controls, location of surface waters and wetlands, and the location of storm water drainage control points. Your site plan must be updated as conditions change at the site. **If your construction site is one acre or more, erosion protection and sediment control plans must be on file to assure compliance with storm water regulations** (see Appendix A). Plans related to state road projects must be filed with the Transportation Cabinet; some counties also require that plans be filed with local agencies (see Section 12 and Appendices).

Design specifications for erosion and sediment controls (i.e., "Best Management Practices" or BMPs) are available from the Kentucky Division of Water, Division of Conservation, the Louisville-Jefferson County Metropolitan Sewer District, and the Lexington-Fayette Urban County Government.

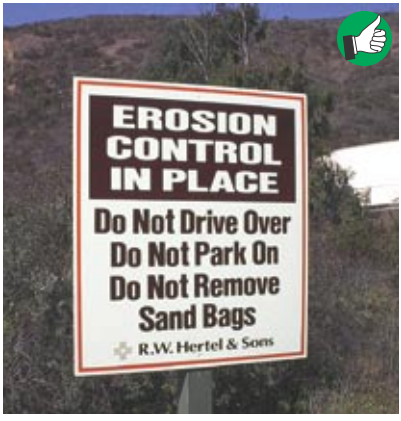
Prioritization of erosion and sediment controls for construction sites

Practice	Cost	Effectiveness
Limiting disturbed areas through **phasing**	$	
Protecting disturbed areas through **mulching and revegetation**	$ $	
Installing diversion around disturbed areas.	$ $ $	
Sediment removal through **detention** of all site drainage	$ $ $ $	
Other **structural controls** to treat sediment-laden flow	$ $ $ $ $	

The cheapest erosion and sediment controls are the most effective. For example, limiting the amount of bare soil by phasing your project and preserving existing vegetation are less expensive and work better than installing large storm water control basins or ponds.

Limiting the amount of bare soil exposed to the weather by working in phases reduces erosion and sediment control expenses.

Preserving existing vegetation at the site makes the final development more attractive and saves money by reducing clearing, excavation, and erosion control expenses.



Erosion and sediment controls are required for all construction sites one acre or larger under new federal, state, and local regulations. Storm water pollution prevention plans (also called Best Management Practice Plans) must be written up before the project begins. Permit coverage is also required before clearing, grading, or other cut/fill activities start.

Storm water pollution prevention (BMP) plans and KPDES permit coverage are required for all construction sites one acre or larger under 2003 regulations. Plans must be kept on site and available for inspection.

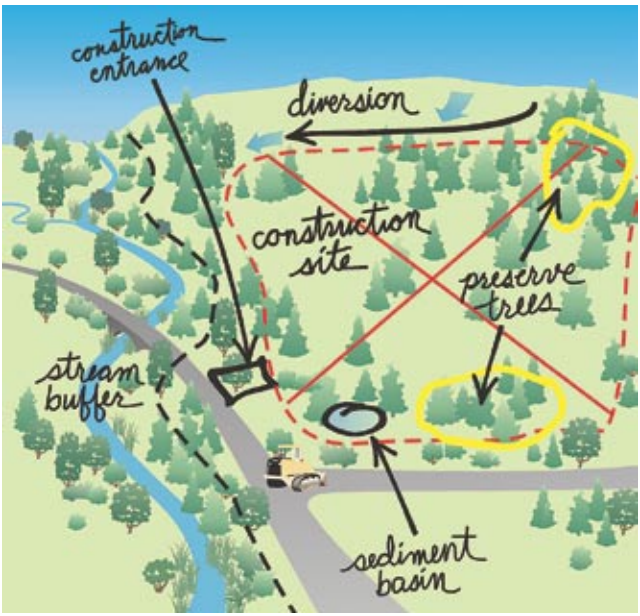
Providing primary and secondary containment for fuel and other hazardous materials at the work site helps prevent problems. Controlling non-storm water runoff, trash and other wastes, and post-construction runoff are also required under the new storm water permit program.

SECTION 2

Construction Phase Operations

Divide your construction site into natural drainage areas, so you can deal with each one individually. You will be controlling erosion on bare soil areas by applying seed, mulch, or sediment filters, and minimizing the time bare soil is exposed to the weather. Control points for sediment in runoff will be at the curb inlets or in the ditches, channels, or sediment traps/basins installed where concentrated flow leaves the site.

Install clean water diversions, sediment traps/basins and stabilize drainage channels with grass, liners, and silt check dams *before* excavation, fill, or grading work begins (see Sections 8 and 9). Install silt fences and other sediment barriers downhill from bare soil areas before clearing or excavation work begins (see Section 5).



Identify drainage areas and drainage ditches and channels. Install diversions, grassed channels, sediment traps/basins, downslope sediment barriers, and rock construction entrance before beginning work.

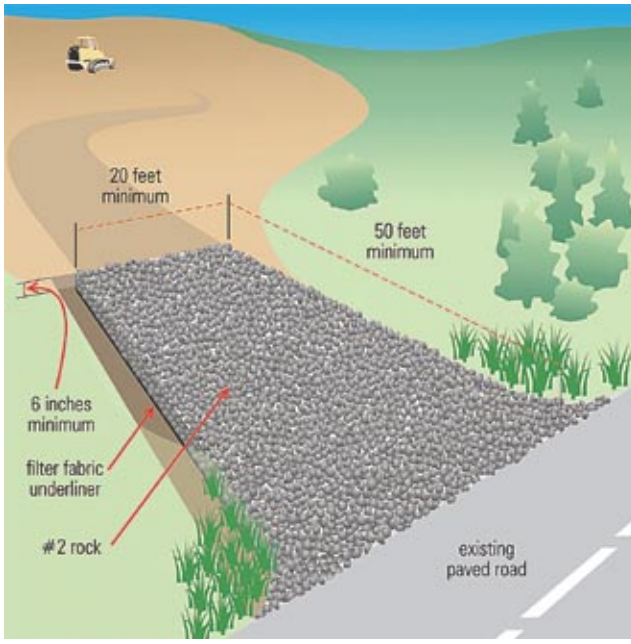
Phase your construction work to minimize exposed soil areas

Excavate or place fill material at the site in stages, to avoid exposing large areas of bare soil to the elements. Establish final grade quickly, then seed, mulch, or cover bare soil. Require utilities and sub-

contractors to grade their work sites and seed, mulch, or cover excavated areas promptly. You should require subcontractors to sign a form assuring compliance with your erosion and sediment control plan if their work is covered under your permit.

If work will proceed over several weeks or months, apply temporary seeding or mulch until final grade work is completed. **New regulations require seeding or mulching all bare soil areas that are not being worked after 21 consecutive days.**

Excavation and grading work should be done during dry weather if possible. Prepare for rainy weather forecasts by making sure sediment controls are in place and that mulch or grass is on bare areas that are at final grade.



Construction entrance detail. Entrance/exit pad must keep mud from tracking onto paved roads.

Install construction entrances and control dust

Mud tracked onto paved roads is the number one complaint from citizens regarding construction site operations. Use #2 (4- to 8-inch) rock—not 57s or 410 "traffic bound"—for entrance/exit pads leading to paved roads. Pads should be 20 feet wide, 50 feet long, and 6" thick. Install filter fabric under the rock to keep it from sinking into the soil below. Rake rock

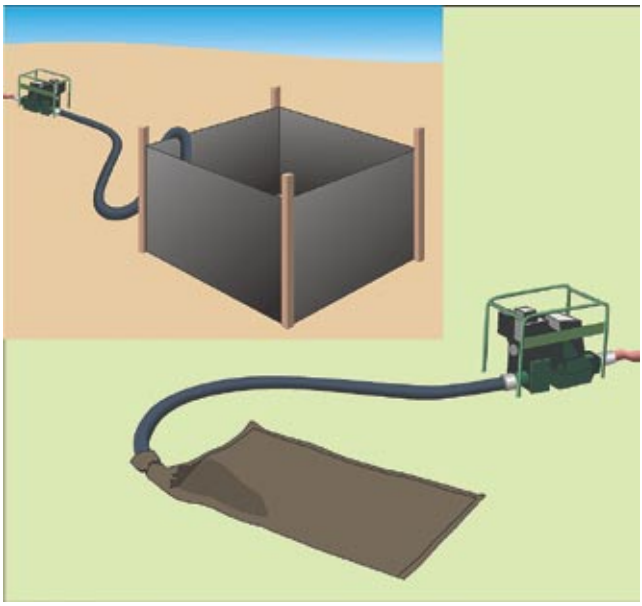
with a grubbing attachment or add new rock if the pad fills with sediment.

Control dust during hot, dry weather by seeding or mulching bare areas promptly, wetting haul roads as needed, or applying approved chemical soil binders.

Dewatering operations and discharges

Muddy water pumped from collection basins or other areas must not be pumped into storm sewers, streams, lakes, or wetlands unless sediment is removed prior to discharge. **Discharges to streams, lakes, or wetlands, or storm sewers must be covered by a KPDES permit issued by the Division of Water.**

Use sock filters or sediment filter bags on discharge pipes, discharge muddy water into silt fence enclosures installed in vegetated areas away from waterways, or discharge muddy water into a de-silting basin. Remove accumulated sediment after water has dispersed and stabilize or seed the discharge area. Dispose of sediment in areas where it won't wash into waterways, then grade the area and seed.



Pump muddy water from dewatering operations away from waterways into a silt fence enclosure or use a bag filter or other device to remove sediment. Allow discharge to soak into the ground if possible. Do not pump discharger from dewatering operations into curb inlets, storm sewers, creeks, lakes, or rivers without a KPDES permit from the Division of Water.

Inspection and maintenance of erosion and sediment controls

For sites one acre or larger, new state and federal regulations require that you inspect and repair/replace silt fences, vegetated buffers, berms, silt check dams, channels, and other erosion and sediment controls every 7 days and after each rainfall of 0.5 inch or more (0.1 inch for KYTC projects). Remove accumulated sediment from behind silt fences before it reaches ½ the silt fence height. Remove sediment from pipe or curb inlet ponding dams or filters as it accumulates. Clean mud off paved roads immediately. Your inspection reports must be in writing, and kept on file at the site.

Silt check dams in ditches and sediment traps/basins also require periodic sediment removal. Remove sediment from traps and basins before they are halfway full. Dispose of removed sediment in areas where it will not wash into waterways. Seed or mulch bare soil areas as soon as possible.

Keep written records of these inspections, including dates, observations and corrective actions taken, with your erosion and sediment control plan and *Storm Water Pollution Prevention Plan, or BMP Plan*. See Section 5 for information on installing and maintaining overland sheet flow sediment filters. See Sections 7, 8, and 9 for information on handling concentrated flows in ditches, channels, and other areas.

Rock pad was installed properly with right sized rock, but lack of filter fabric underliner is causing rock to spread and sink into the soil. Note tracking of mud onto paved road. Mud tracked on roadways violates BMP standards, and is a potential legal liability.

Rock sizing, placement, and pad sizing are good, but sediment from unprotected slopes and ditches is washing onto paved highway. Serious liability issue.

Poor construction entrance. Rock pad is poorly constructed; rock is too small. Use filter fabric under rock and larger sized rock, such as #2. No mud should be tracked onto paved roads open for traffic.

Rock sizing and placement look OK for a residential site, and very little mud appears on the pavement. The pad is a little thin, however, and it looks like some drivers are not using it—note track marks near curb. Entire area needs seed and mulch.

SECTION 3

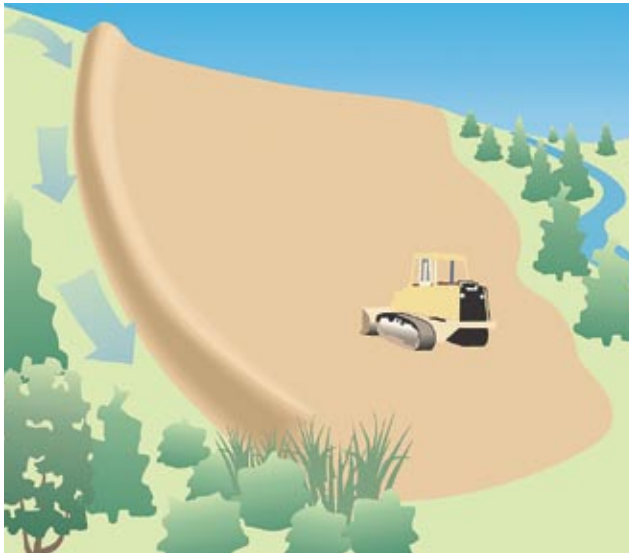
Diverting Upland Runoff Around Exposed Soils

Keep clean upland runoff from flowing through your construction site, or route it through stable ditches so it won't get muddy. Below are some simple approaches for dealing with uphill sources of runoff.

Diversion berms

A diversion berm is a long, mounded "collar" of compacted soil located uphill from the excavated area. The berm is designed to intercept overland runoff and direct it around the construction site. This prevents "clean" water from becoming muddied with soil from the construction site. Berms can be temporary or permanent landscape features of the site.

Berms should be located so that storm water flowing along their uphill face follows a gently sloping path (i.e., less than 5 percent channel slope). Turf reinforcement mats, erosion control blankets, or rock protection might be needed for berms that channel water at a slope of 5 percent or more (see Section 4). Berm side slopes should be 2:1 or flatter, 10 to 14 inches high, and seeded immediately after construction.



Berms and ditches diverting clean upland runoff around construction sites reduce erosion and sedimentation problems. Seed berms and ditches after construction.

Extend the downhill end of the berm so it directs overland flow to areas of thick vegetation or flat surfaces to promote dispersal and infiltration. Seed and mulch berms after construction to minimize erosion.

Diversion ditches

Diversion ditches are similar to berms—they are designed to intercept and divert upland runoff around bare soil areas. Ditches are cut above cleared or fill areas and designed with a gentle slope to carry water away from work areas. Ditches should be 8 to 12 inches deep and seeded. Side slopes should be 2:1 or flatter.

Stabilized, lined ditches can also be used to move upland water through your site without getting muddy. Construct and line "pass-through" ditches before general clearing or grading work begins.

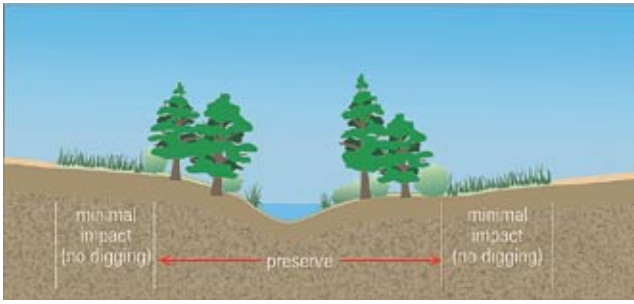
Ditches should discharge to areas with thick vegetation or flat surfaces to promote dispersal and infiltration. Gullies must be repaired as soon as they appear. Ditches with slopes less than 5 percent may be heavily seeded, mulched, and maintained without additional protection if stabilized quickly after construction. Ditches with slopes of 5 percent or more need erosion control blankets, turf mats, or rock liner protection.

Diversion ditches should be lined with grass at a minimum, and blankets if slopes exceed 10:1 (10%) (see Section 8).

Vegetated buffers

Grass, shrubs, trees, and other vegetation located above or below excavated areas should be preserved if possible. Vegetation above construction sites prevents high volume sheet runoff flows from moving across cut or fill areas. Vegetation below the construction site helps filter and trap sediment before it can move into ditches, channels, and streams. All vegetated areas help to promote infiltration of storm water, which is a key objective in preventing erosion and controlling sediment movement off the construction site. Vegetated buffers along channels, streams, and other waterways must not be cleared unless proper permit coverage is provided by KDOW.

Vegetated buffers above or below your work site are always a plus. They trap sediment before it can wash into waterways, and prevent bank erosion.



Vegetated waterways help move upland water through or past your site while keeping it clear of mud. Do not disturb existing vegetation along banks, and leave a buffer of tall grass and shrubs between stream bank trees and disturbed areas.

Good construction, seeding, and stabilization of diversion berm. Note that diversion ditch is lined with grass on flatter part of slope, and with rock on steeper part.

Good installation of rock-lined berm to divert rain runoff around residential construction site on steep slope near a river. Diversion ditches can be lined with grass if channel slopes are 20:1 or less, and with blankets or turf mats if they are steeper.

Well built vegetated berm diverting runoff from wooded stream. Diversion berms and ditches should be seeded after construction. Use blankets if slopes are steep.

SECTION 4

Protecting Soils With Seed, Mulch, or Other Products

Seeding or covering bare soil with mulch, blankets, mats, or other products as soon as possible is the cheapest and best way to prevent erosion. **Grass seeding alone can reduce erosion by more than 90 percent.** Sod, mulch, blankets, and other products can further increase protection (see tables below).

Soil cover requirements

Bare soil in excavated or fill areas must be seeded, mulched, or covered immediately after final grading work is completed. Stockpile topsoil and spread over site prior to seeding. **Bare soil areas must be seeded, mulched, or covered after 14 days** when temporary or final grade is established if no work is planned in that area during the following 7 days (i.e., 21 consecutive days). This requirement can be extended if snow or freezing conditions prevent site work. Seed or cover soil stockpiles if they will not be used for more than 21 consecutive days.

Soil cover vs. erosion reduction

Soil covering	Erosion reduction
Mulch (hay or straw)	
½ ton per acre	75 percent
1 ton per acre	87 percent
2 tons per acre	98 percent
Grass (seed or sod)	
40 percent cover	90 percent
60 percent cover	96 percent
90 percent cover	99 percent
Bushes and shrubs	
25 percent cover	60 percent
75 percent cover	72 percent
Trees	
25 percent cover	58 percent
75 percent cover	64 percent
Erosion control blankets	95–99 percent

Seed types and application

Prepare bare soil for planting by disking across slopes, scarifying, or tilling if soil has been sealed or crusted over by rain. Seedbed must be dry with loose soil to a depth of 3 to 6 inches.

For slopes steeper than 4:1, walk bulldozer or other tracked vehicle up and down slopes before seeding to create tread-track depressions for catching and holding seed. Mulch slopes after seeding if possible. Cover seed with erosion control blankets or turf mats if slopes are 2:1 or greater.

Fertilize poor soils with 400–800 pounds per acre of 10-10-10 fertilizer. Apply lime at 1 to 2 tons per acre if needed. Disk or harrow fertilizer and lime 2 to 4 inches into soil. Follow the contour (level path) with tractors and other equipment on all slopes if possible.

Check seed bag tags to make sure correct seed is used. Mix seed thoroughly prior to loading seeders. Use the following tables to calculate seed application rates, mixture portions, and soil pH requirements, or use seed mixes approved for your site. Apply seed by hand, seeder, drill, or hydroseed. Drilled seed should be ½ inch deep. Mulch right away if possible.

Apply *more* seed to channels, ditches, lawn, and landscaped areas. Apply less seed to areas that are flat or that will not be mowed very often. Water seeded areas during dry conditions to ensure seed germination and early growth. Re-seed areas that do not show growth within 14 days after rain or watering.

Kentucky Transportation Cabinet seed mixes

Mixture Type	Percentage	Seed Type
Mixture No. I	75%	Kentucky 31 Tall Fescue
	10%	Red Top
	5%	White Dutch Clover
	10%	Ryegrass (perennial)
Mixture No. III	30%	Kentucky 31 Tall Fescue
	15%	Red Top
	15%	Partridge Pea
	20%	Sericea Lespedeza
	10%	Sweet Clover – Yellow
	10%	Ryegrass

Protect bare areas during the cold season by sowing winter rye, winter wheat, or mulching. Sow permanent seed when weather permits.

Do not mow newly seeded bluegrass or red fescue until it is at least 4 inches high. Crownvetch should never be mowed. KY 31 tall fescue can be mowed for appearance or only occasionally, according to site conditions and the owner's preferences.

Seed mixes for wildflower and native plant plots are also available. They are more expensive, but are very hardy, require little mowing or watering, and add beauty to landscaped and other areas. Most mixes require mowing only once per year, to control tree and brush growth.

Excellent soil preparation prior to seeding. Seeded development sites erode less, are cleaner, and are easier to market than muddy sites.

Erosion and sediment loss is virtually eliminated on seeded areas (left side). Rills and small gullies form quickly on unseeded slopes (right).

Other suggested seeding rates, soil conditions, and other information for various species and seed mixtures				
Seed species & mixtures	**Seeding rate/acre**	**Per 1000 sq. ft.**	**Soil pH**	**Other information**
Seed and seed mixtures for relatively flat or slightly sloping areas				
Perennial ryegrass + tall fescue Tall fescue + ladino or white clover	25 to 35 lbs. 15 to 30 lbs. 40 to 50 lbs. 1 to 2 lbs.	1 lb. 1 lb. 1½ lb. 2 oz.	5.6 to 7.0 5.5 to 7.5	Apply lime at 2 tons per acre if soil pH is below 5.5; use 400-800 lb. fertilizer (10-10-10) on poor soils. Use wildflower or "no mow" mixes to save on mowing and watering costs.
Steep slopes, banks, cuts, and other low maintenance areas (not mowed)				
Smooth bromegrass + red clover Tall fescue + white or ladino clover Orchardgrass + red clover + ladino clover Crownvetch + tall fescue	25 to 35 lbs. 10 to 20 lbs. 40 to 50 lbs. 1 to 2 lbs. 20 to 30 lbs. 10 to 20 lbs. 1 to 2 lbs. 10 to 12 lbs. 20 to 30 lbs.	1 lb. ½ lb. 1 lb. 2 oz. 1 lb. ½ lb. 2 oz. ¼ lb. 1 lb.	5.5 to 7.5 5.5 to 7.5 5.6 to 7.0 5.6 to 7.0	Track steep slopes with dozer up and down hill before seeding. Mulch slopes after seeding with 2 to 3 tons of straw or 6 tons of wood chips per acre. Use tackifier on mulch, disk it in, or punch in with sheep-foot roller. Disk or sheep-foot on the contour (across slope, on the level). For extremely steep slopes, use erosion control blankets after seeding. Use 24" spacing for blanket staples.

Lawns and other high traffic or high maintenance areas (mowed)				
Bluegrass	105 to 140 lbs.	3 lb.	5.5 to 7.0	Use wildflower mixes to save on mowing and watering costs. Do not establish grassed lawns near streams or wetlands – leave a 15- to 30-foot buffer of natural vegetation.
Perennial ryegrass (turf)	45 to 60 lbs.	2 lb.	5.6 to 7.0	
+ bluegrass	70 to 90 lbs.	2½ lb.		
Tall fescue (turf type)	130 to 170 lbs.	4 lb.	5.6 to 7.5	
+ bluegrass	20 to 30 lbs.	1 lb.		
Ditches and other areas of concentrated water flows				
Perennial ryegrass	100 to 150 lbs.	3 lb.	5.6 to 7.0	Seed ditches and channels thickly. Do not use fertilizer near ditch or channel bottom. Use erosion control blankets or turf reinforcement mats when channel bottom slopes exceed 3 percent. Silt check dams are needed when channel slopes exceed 5 percent or when channels begin downcutting (gullying) on the bottom. Do not use silt fencing or hay bales as silt check dams in channels with slopes greater than 3 percent; use rock, brush, or commercial silt dikes instead.
+ white or ladino clover	1 to 2 lbs.	2 oz.		
Kentucky bluegrass	20 lbs.	½ lb.	5.5 to 7.5	
+ smooth bromegrass	10 lbs.	¼ lb.		
+ switchgrass	3 lbs.	2 oz.		
+ timothy	4 lbs.	¼ lb.		
+ perennial ryegrass	10 lbs.	¼ lb.		
+ white or ladino clover	1 to 2 lbs.	2 oz.		
Tall fescue	100 to 150 lbs.	3 lb.	5.5 to 7.5	
+ ladino or white clover	1 to 2 lbs.	2 oz.		
Tall fescue	100 to 150 lbs.	3 lb.	5.5 to 7.5	
+ perennial ryegrass	15 to 20 lbs.	½ lb.		
+ Kentucky bluegrass	15 to 20 lbs.	½ lb.		

Good mix of sod, seed, and mulch at site of new community center. Note that inlet should be protected by installing a rock or sandbag berm to pond water before it flows into the inlet.

Poor seed establishment on slope. Use erosion control blankets or turf reinforcement mats when slopes are steep (greater than 4:1) and soil quality is poor. Terracing or benching steep slopes also helps.

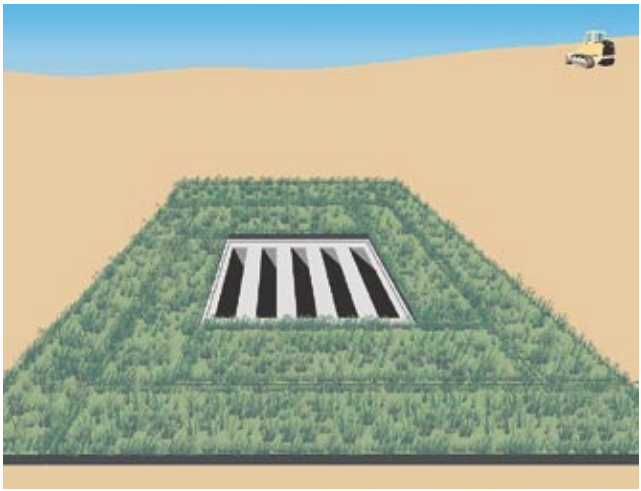
Poor management of bare soil areas on residential construction site. Temporary or permanent seed or mulch must be applied as soon as final grade is achieved.

Sod application

Sod reduces the potential for erosion to near zero. To install, bring soil to final grade and clear of trash, wood, rock, and other debris. Apply topsoil, fertilizer, and lime if needed (approx. 1000 lbs. 10-10-10 fertilizer per acre; 1 to 2 tons of lime per acre).

Use sod within 36 hours of cutting. Lay sod in straight lines. Butt joints tightly, but do not overlap joints or stretch sod. Stagger joints in adjacent rows in a brickwork type pattern. Use torn or uneven pieces on the end of the row. Notch into existing grass.

Anchor sod with pins or stakes if placed on slopes greater than 3:1. Roll or tamp sod after installation and water immediately. Soak to a depth of 4 to 6 inches. Replace sod that grows poorly. Do not cut or lay sod in extremely wet or cold weather. Do not mow regularly until sod is well established.



Sod provides immediate protection around storm drain inlets, on slopes, and other areas.

Mulch types and application

Mulch by itself or applied over seed provides excellent erosion protection (see table). To apply, bring site to final grade and clear rocks, wood, trash, and other debris. Apply seed first. Straw or hay should be hand scattered or blown at a rate of 1½ to 2½ tons per acre (see table). Wood chips, bark, and sawdust should be applied at 5 to 8 tons per acre. Emulsified asphalt or other tackifier should be used on slopes greater than 3:1. In general, apply mulch so that at least 80 to 90 percent of the ground is covered.

Mulch product	Application rate	Benefits	Limitations
Straw or hay	1½ to 2½ tons per acre	Readily available and inexpensive; very effective in controlling erosion; can be applied on large sites via blower	May carry unwanted seeds; may need tackifier or anchoring, especially on steep slopes; crimp mulch in with dozer or straight-set disk harrow to prevent blow-off
Wood chips, bark, sawdust	5 to 8 tons per acre	Very low cost in some locations; can use chips produced from removed vegetation; chips effective on slopes up to 35 percent	High nitrogen demand when decomposing; may float away or blow away during rain storms
Rock	200 to 500 tons or more per acre	May be inexpensive and readily available in some localities; may be suitable for smaller sites	Inhibits plant growth; adds no nutrients to the soil; can be costly to apply on slopes and large sites; adds "hardened" look to slopes
Hydraulic mulches and soil binders	1½ to 2 tons per acre	Easily and rapidly applied with sprayer equipment; can include seed, fertilizer, and soil binders; many new products available	May be too expensive for small or very remote sites; must dry for at least 24 hours before rainfall. See Appendix F for KYTC application limitations.
Compost	2 to 3 tons per acre	Adds nutrients to the soil; readily available and inexpensive in some locations	Limited erosion control effectiveness; not suitable for steep slopes; may be expensive in some areas

Installing sod immediately after grading work is complete can reduce erosion and sediment loss to near zero.

Excellent application of hand-scattered straw mulch in new residential subdivision. Work sites must be seeded and mulched as soon as final grade is established. Crimp mulch into soil with dozer tracking or disk harrows set straight to prevent straw from blowing.

Very good treatment of roadside areas with blown straw after seeding. In areas near lakes, streams, and rivers, straw in roadway must be cleaned up after application.

Excellent soil coverage at stream bank stabilization project using hand scattered straw, jute matting, and erosion blanket.

Good slope protection with permanent rock cover. This slope could have been protected with erosion control blankets or mats and seeded for a "softer" look.

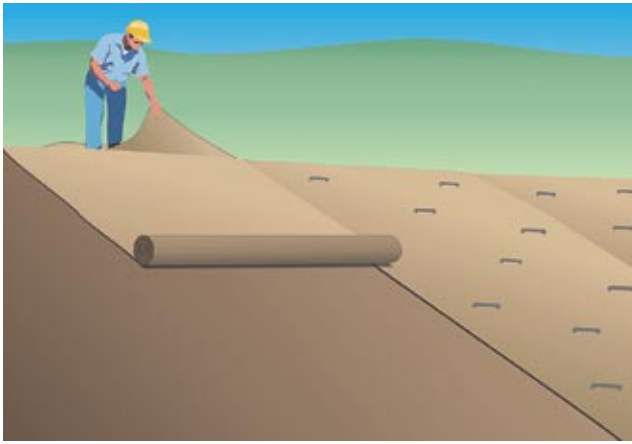
Erosion control blankets

Erosion control blankets are used to protect steep slopes (up to 3:1; check product information sheets), drainage ditches with less than 20:1 slopes, and other areas where erosion potential is high. Most are designed to provide temporary stabilization until vegetation is established. Blankets degrade within 6 to 24 months, depending on their makeup. They usually consist of a layer of straw, coconut fiber, wood fiber, or jute sandwiched between layers of plastic or fiber mesh.

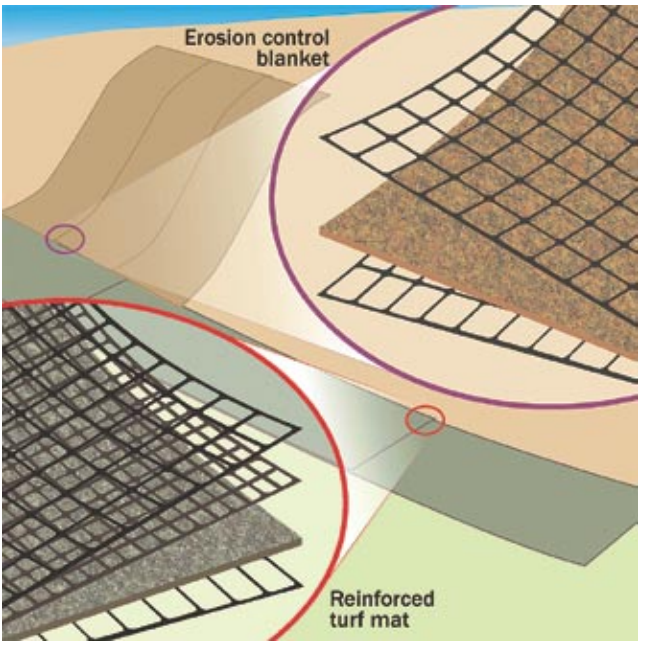
For short slopes (8 feet or less) above channels, install blankets across the slope (horizontal). Install up and down the hill (vertical) for long slopes.

Site conditions	Blanket installation notes
Ditches and channels (from high flow line to ditch bottom—see Section 8)	• Grade, disk, and prepare seedbed. • Seed, lime, and fertilize the area first • Install horizontally (across slope). • Start at ditch bottom. • Staple down blanket center line first. • Staple & bury top in 8" deep trench. • Top staples should be 12" apart. • Uphill layers overlap bottom layers. • Side overlap should be 6"–8". • Side & middle staples = 24" apart. • Staple below the flow level every 12". • Staple thru both blankets at overlaps.
Long slopes, including areas above ditch flow levels	• Grade, disk, and prepare seedbed. • Seed, lime, and fertilize first. • Install vertically (up & down hill). • Unroll from top of hill if possible. • Staple down center line of blanket first. • Staple & bury top in 8" deep trench. • Top staples should be 12" apart. • Side & middle staples = 24" apart. • Uphill layers overlap downhill layers. • Overlaps should be 6"–8". • Staple thru both blankets at overlap.

Walk blankets down to ensure good contact with the soil. Use plenty of staples to keep blankets flat. Overlap blankets at 6 to 8 inches on sides, tops, and bottoms. Do not stretch blankets, and do not exceed manufacturer's directions on maximum slope angle for the product.



Install blankets and mats vertically on long slopes. Unroll from top of hill, staple as you unroll it. Do not stretch blankets.



Erosion control blankets are thinner and usually degrade quicker than turf reinforcement mats. Check manufacturer's product information for degradation rate (life span), slope limitations, and installation. Remember to apply seed, fertilizer, and lime before covering with blankets or mats!

Turf reinforcement mats

Turf reinforcement mats are similar to erosion control blankets, but are thicker and sturdier because they have more layers and sturdier fill material. Mats provide greater protection than blankets because of their heavier construction, and last longer in the field.

Mats are used for steep slopes (3:1 or steeper) and ditches or channels with 15:1 to 10:1 slopes. Mats are installed just like blankets (see previous table). Additional staking or stapling is needed for applications in channels that carry flowing water, and on steep slopes.

Other engineered products are available that are similar to blankets and mats. For example, bonded fiber matrices and other hydraulically applied products contain a mix of soil binders, mulch fibers, and even seed and fertilizer that can provide a stable crust that cements soil particles and prevents erosion. Apply seed prior to hydraulic mats or mulches, if seed is not included in the mix. Consult the manufacturer's installation instructions for product applicability and installation instructions.

Very good installation of erosion control blanket in seeded ditch below well-mulched slope on highway project.

Blankets installed along stream banks or other short slopes can be laid horizontally. Install blankets vertically on longer slopes. Ensure 6 inch minimum overlap.

Excellent slope and bank protection for stream stabilization project. Note that stream bottom is not lined, to preserve rock and gravel habitat.

Good application of erosion control blanket to stabilize shoulder and protect storm drain, but too few staples used along the top edge. Trench in top edge of blanket on steep slopes.

SECTION 5

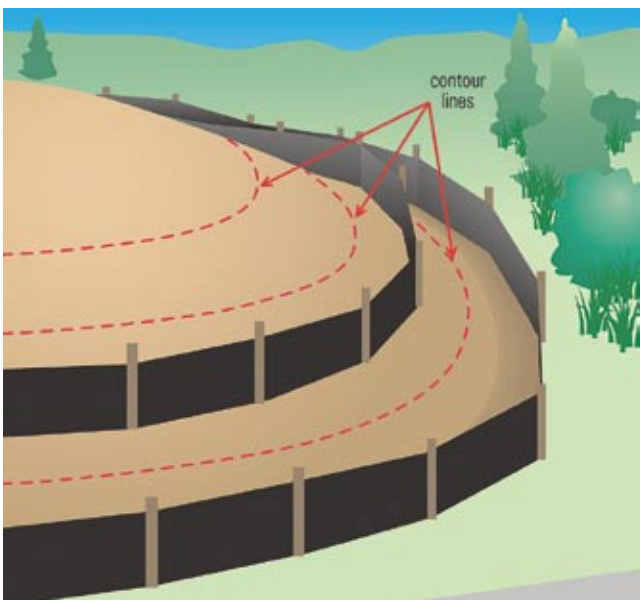
Using Silt Fence and Other Sediment Barriers

The use of silt fences and other sediment barriers involves simple observation and common sense. However, as Will Rogers once noted, “common sense ain’t so common.” The following summary provides details on how to install sediment barriers.

Sediment barrier placement

Sediment barriers—silt fences or rock filters—are required below (downhill from) areas of bare soil. Hay or straw bales must not be used as sediment filters due to their inherent weakness and tendency to fall apart. There are several factors to consider in placing silt fences, rock sediment filters, or other commercial sediment barriers:

- Place filters on downhill edge of bare soil areas.
- Make sure the filter catches all the muddy runoff.
- The goal is to pond runoff, to filter and settle it out.
- Install multiple sediment filters on long slopes.
- Spacing on long slopes is every 60 to 110 feet.
- Put filters across slopes, on the contour (level).



Silt fences should be installed on the contour below bare soil areas. Use multiple fences on long slopes 60 to 80 feet apart. Remove accumulated sediment before it reaches halfway up the fence.

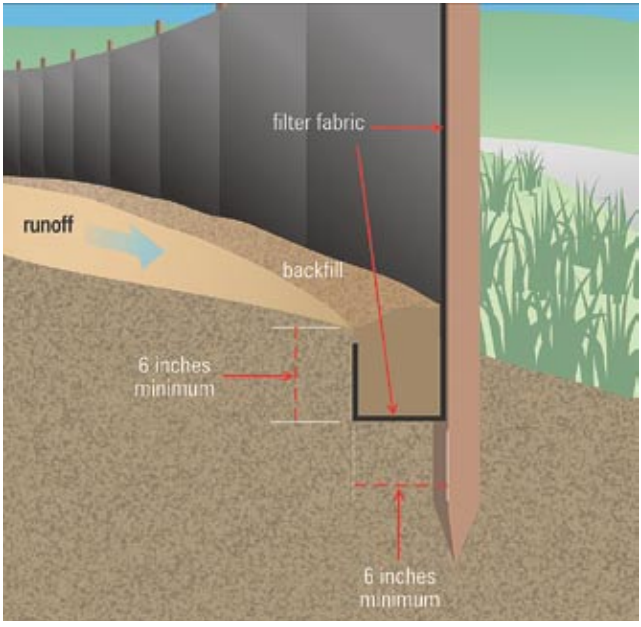
Silt fence installation

Each 100-foot section of silt fence can filter runoff from about ¼ acre (about 110 feet uphill). To install a silt fence correctly, follow these steps:

- Note the location & extent of the bare soil area.
- Mark silt fence location just below bare soil area.
- Make sure fence will catch all flows from area.
- Dig trench 6 inches deep across slope.
- Unroll silt fence along trench.
- Join fencing by rolling the end stakes together.
- Make sure stakes are on downhill side of fence
- Drive stakes in against downhill side of trench.
- Drive stakes until 8 to 10 inches of fabric is in trench.
- Push fabric into trench; spread along bottom.
- Fill trench with soil and tamp down.

Silt fencing should not be installed:

- Up and down hills.
- Above (uphill from) areas of bare soil.
- In ditches, channels, or streams.



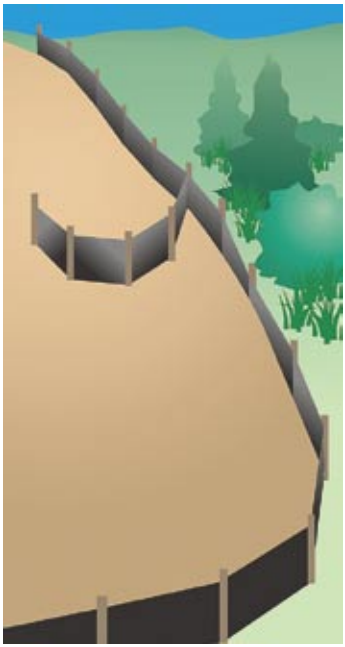
Remember: stakes go on the downhill side. Dig trench first, install fence in downhill side of trench, tuck fabric into trench, then backfill on the uphill side (the side toward the bare soil area).

Silt fence spacing on sloping sites

	Soil Type		
Slope Angle	Silty	Clays	Sandy
Very Steep (1:1)	50 ft.	75 ft.	100 ft.
Steep (2:1)	75 ft.	100 ft.	125 ft.
Moderate (4:1)	100 ft.	125 ft.	150 ft.
Slight (10:1)	125 ft.	150 ft.	200 ft.

For silt fences treating high flows from steep slopes, reinforce the silt fence with woven wire and metal fence posts. Install wire fencing *between* the posts and the silt fence filter fabric, so pressure on the fabric from uphill flows is distributed across the wire fencing, then to the posts.

If muddy runoff flows along the uphill side of a silt fence, install "J-hooks" every 40 to 80 feet. These are curved sections of silt fence that act as small dams to stop, pond up, and filter or settle out flows (see illustration).



Use J-hooks to trap and pond muddy runoff flowing along uphill side of silt fence. Turn ends of silt fence toward the uphill side to prevent bypassing. Use multiple J-hooks every 50 to 150 feet for heavier flows.

Silt fence slicing devices

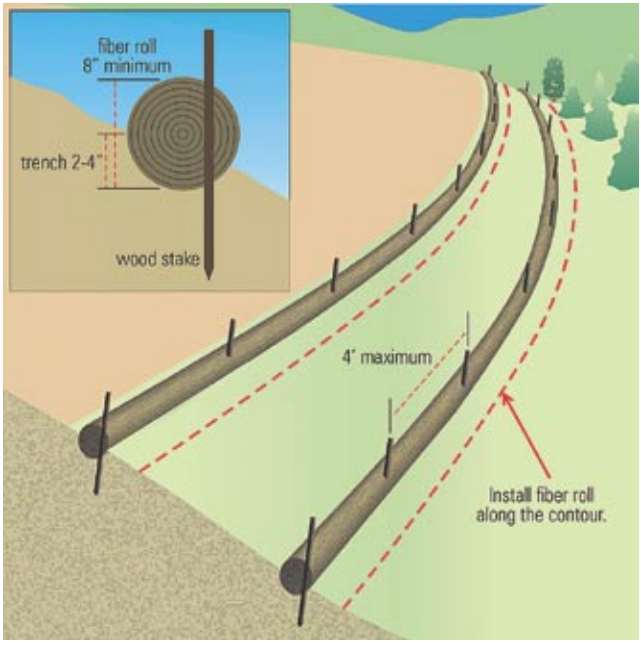
New tractor-mounted equipment that "slices" silt fence into the ground can provide a better installation than the open trench method. The equipment uses a chisel-point or vibratory plow to create a narrow slit in the ground. Rolled silt fencing is pushed into the slit, creating a very tight seal that prevents water from blowing out the bottom of the fence. Posts are driven and attached to the fence after the fencing is installed.

Besides better performance, the slicing method is also faster. For slicing and all other applications, posts are spaced 6 feet apart or less.

Other sediment barriers

Brush cleared from the site can make an excellent sediment filter if it is properly placed (see previous illustration) and built up well. Brush barriers are installed on the contour and are 2 to 5 feet high and 4 to 10 feet wide at the base. Walk them down slightly with a loader or dozer to compress the material in the brush barrier. Stuff additional brush on the uphill side where bypasses or undercutting are evident.

Fiber rolls and other commercial products made from coconut fiber, plastic, wood shavings, or other material can also be used as sediment barriers on slopes flatter than 10:1. Follow manufacturers' installation instructions and ensure that sediment filter spacing on slopes is correct. Make sure runoff does not bypass brush barrier, coconut rolls, or other barriers underneath or around the ends.

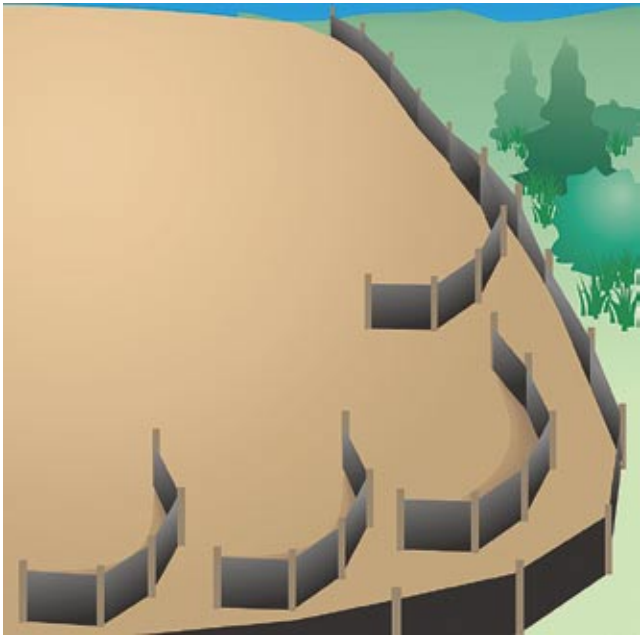


Fiber rolls can be used to break up runoff flows on long slopes. Install on the contour and trench in slightly. Press rolls firmly into trench and stake down securely. Consult manufacturer's instructions for expected lifespan of product, slope limits, etc. As always, seed and mulch long slopes as soon as possible.

Maintenance of sediment barriers

Sediment collecting behind silt fences must be removed before it is halfway up the fence. Move collected sediment to a vegetated area or other place where it will not wash into ditches, channels, or streams. Re-trench and tamp down fencing that is undercut by gullies.

Stop uphill gully formation by grading, seeding, and mulching, or filling with rock, soil, brush, or other material. Use erosion control blankets or turf reinforcement mats to control large areas of uphill erosion. Replace broken or bent-over stakes. Inspect places where fences are joined to make sure joint is solid. Install J-hooks where water flows along silt fence if necessary. Remove all silt fences and grade and seed the area when grass is established, before the project is completed.



Silt fences don't have to be on the property line. Placing them on slopes with the ends turned up to trap sheet flow provides better performance. Stagger fence sections to ensure total coverage. Clean out before sediment reaches halfway up. Repair as needed, and remove when grass is well established.

Very good use of continuous "super" (reinforced) silt fence and shot rock sediment barrier (far side) to filter muddy runoff from commercial development site. Note that wire fencing is installed between the filter fabric and the posts.

Good use of J-hook in silt fence to trap sediment in water running along fence. Sediment must be removed before it reaches halfway to top of fence.

Good installation of silt fence at toe of slope. Do not pile soil or other material on silt fences! Also, if space is available move fence back from toe of slopes to allow room for sediment accumulation and maintenance. Leaving a strip of vegetation between bare soil and fence also improves performance.

Very good installation of multiple silt fences on long slope. Turn ends of fencing uphill to prevent bypass. Leave silt fences up until grass is well established on all areas of the slope. Re-seed bare areas as soon as possible. Remove or spread accumulated sediment and remove silt fence after all grass is up.

Poor installation where silt fences are joined. Roll end stakes together before driving in to create an unbroken sediment barrier or lap curved sections to prevent bypasses. Leaving grass strip between silt fence and bare soil area is a good idea.

Poor installation of silt fencing, fair to good seeding. Silt fence must be trenched in along bottom. Straw bales are not approved as sediment barriers.

Sediment barrier installed backwards. Silt fence fabric should face bare soil area. Stakes go on downhill side. Straw bales can be used to back up fence on downhill side, but not alone.

Very poor attention to silt fence maintenance. Fences and other sediment controls must be inspected and repaired weekly; activities should be logged.

Poor sediment filter installation, no curb inlet protection. Bales alone provide poor protection (note mud on pavement). Very good seed application.

Tractor mounted silt fence slicing devices cut a slit into the ground and push fabric in. Installation is quicker and performance is better than the open trench method, making this approach attractive for large sites.

Excellent example of J-hook installation to intercept muddy runoff flowing along silt fence. Good temporary seeding and mulching (right side).

Good application of silt fence to protect drop inlet (see Section 7). Make sure fencing is trenched in and soil around fabric is compacted.

SECTION 6

Protecting Slopes to Prevent Gullies

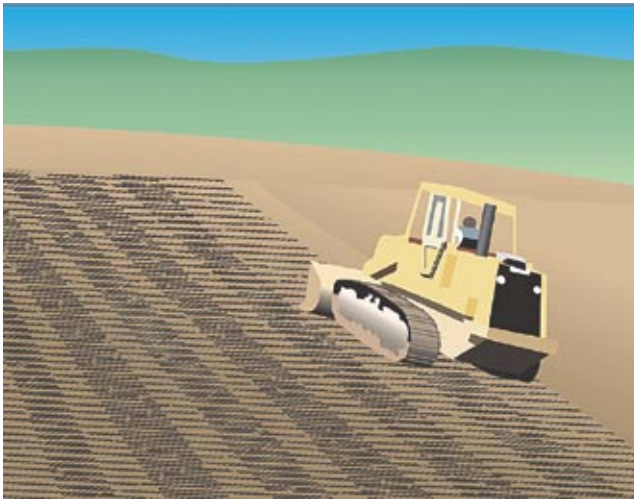
Slopes—especially long ones—must be protected to prevent sheet, rill, and gully erosion. Slopes are stabilized immediately after grading work is completed. Seeding and mulching provide the best and cheapest protection. Erosion control blankets or turf reinforcement mats are needed on most slopes greater than 3:1 (see Section 4).

Approximate slope conversions

Percent	Slope ratio	Degrees
100%	1:1	45°
50%	2:1	27°
33%	3:1	18°
25%	4:1	14°
10%	10:1	6°

Assessing slopes and soils

Steeper slopes (3:1 or steeper) require more protection than flatter slopes. Slopes with highly erodible soils (silty soils) need more protection than those with less erodible soils (sands and gravels). Also, long slopes (greater than 50 feet) are at greater risk for erosion than short slopes.



Tread-track slopes up and down hill to improve stability.

Slope protection basics

Protecting slopes from erosion requires several actions that must be taken together. No single approach will be successful, especially if the slope is long, steep, or has highly erodible soils (see table). Use one or more of the following actions to reduce erosion on slopes:

Divert upland runoff

See Section 3 for information on how to install a berm or channel above the slope to divert upland rain runoff around the bare soil area.

Control slope runoff

If slopes are broken up into benches or steps, runoff can be collected and diverted along berms or in channels to pipe or open channel slope drains with stable outlets.

Till seedbed or condition the soil

Dozer tracks up and down slopes help hold soil in place and lengthen the runoff flow path down the slope. See the table for information on how the condition of the soil surface (compacted, tracked, etc.) can increase or decrease erosion.

Seed and mulch

The best and cheapest protection by far. See Section 4 for details on seed types, application rates, and mulch, blanket, and mat products.

Silt fence or other barrier

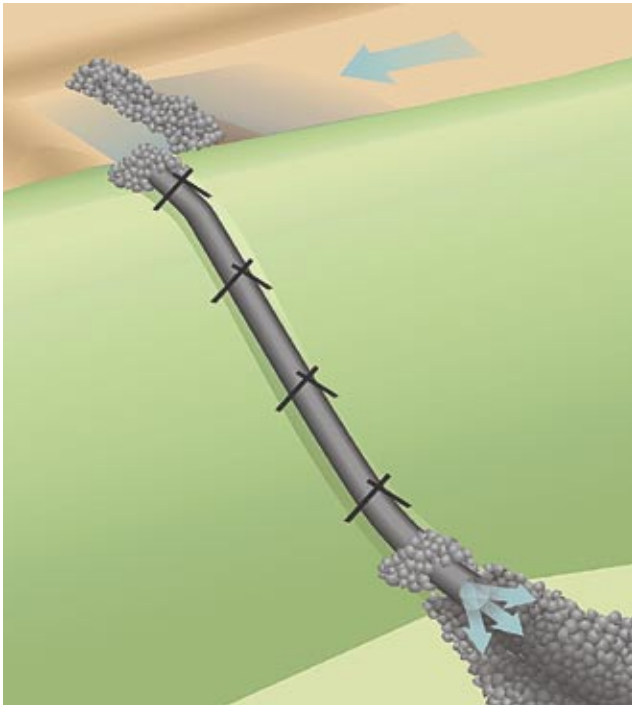
These should be installed at the toe of the slope or slightly away from the toe, and every 75 to 125 feet apart on long slopes. Fiber rolls installed on the contour work very well in breaking up flows on long slopes.

Retaining wall

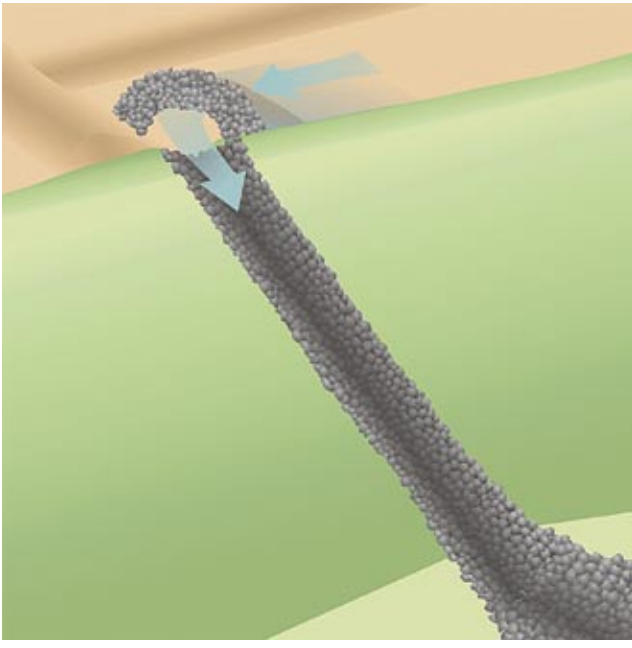
Extremely steep slopes can be leveled out and shortened into two or more steps or benches by installing retaining walls of rock, brick, block, wood, logs, or other material. If rock layers are present along the slope, use these to establish firm benches in a stair-step pattern.

Blankets, mats, or armoring

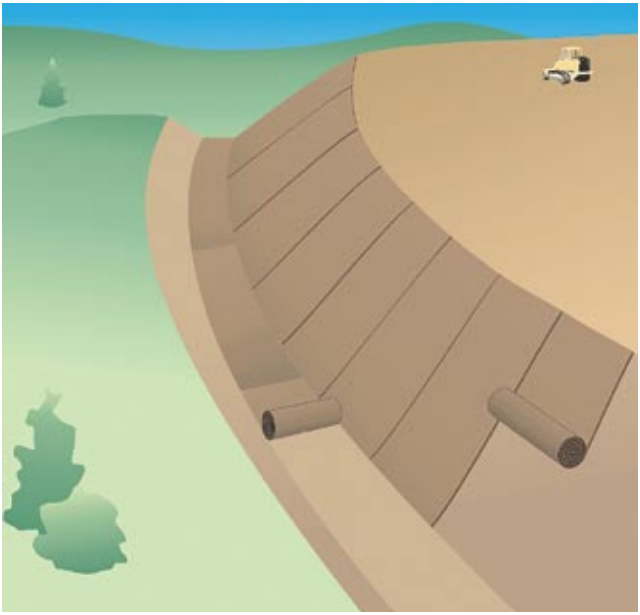
Slopes exceeding 3:1 with highly erodible soils must be protected with erosion control blankets, turf reinforcement mats, or other products such as hydraulic soil binders or bonded fiber matrices. Rock mulch and lined downdrain channels might be needed on steep slopes to control gullying.



Temporary downdrain using plastic pipe. Stake down securely, and install where heavy flows need to be transported down highly erodible slopes. Note silt check dam in front of inlet.



Temporary or permanent downdrain using geotextile underliner and riprap. All slope drains must have flow dissipaters at the outlet to absorb high energy discharges, and silt checks at the inlet until grass is established.



Steep, long slopes need blankets or mats. Install blankets and mats up and down long slopes. For channels below slopes, install horizontally. Don't forget to apply seed, lime, and fertilizer (if used) before installing blanket.

Soil conditions vs. erosion

If soil is:	Erosion will be:
Compacted and smooth	30 percent *more*
Tracks across slopes	20 percent *more*
Tracks up & down slopes	10 percent *less*
Rough and irregular	10 percent *less*
Rough & loose to 12" deep	20 percent *less*

Chemical soil stabilizers and hydraulic mulch

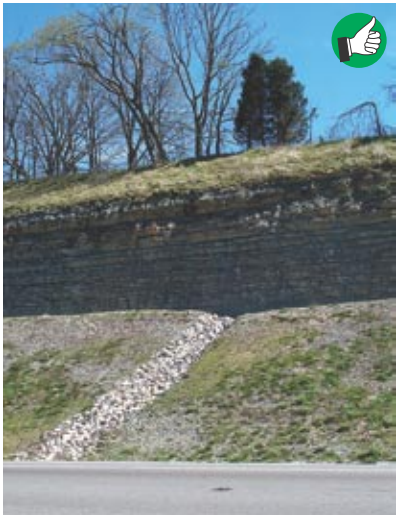
Anionic polyacrylamide (PAM) and other chemical soil binders and stabilizers have been proven effective in controlling erosion on slopes. Do not use these products within 25 feet of natural waterways. Follow manufacturer recommendations regarding mixing and application. Keep equipment off treated areas.

Note that this protection is only temporary—repeat applications or seeding and mulching or other action is still needed for permanent slope protection. Bonded fiber matrices and other hydraulic mulch products applied after seeding or with seed in the mix can provide permanent protection if mixed and applied properly. Apply 1 to 2 tons per acre; follow manufacturer's directions.

Excellent soil conditioning (dozer tracking) prior to seeding and straw-blowing. Seed and mulch provide cheap, excellent protection. Use blankets on slopes if they are steep or soils are poor.

Excellent slope protection with seeding and erosion control blanket. Blankets or mats are required on most projects if slopes are 3:1 or steeper. KYTC requires blankets on all slopes longer than 100 feet if they are 4:1 or steeper.

Excellent use of temporary plastic covering during bridge construction to reduce slope erosion. Filter sediment from pump discharges or discharge to protected infiltration area away from waterways.



Very good application of rock lined downdrain channel to carry water down slope face. Use filter fabric under rock. Install multiple drains at appropriate spacing where flows are heavy. Install flow dissipaters at outlet to absorb energy of the discharge.

Very good use of 20-inch plastic slope drain pipes to convey water from roadway to lower channel. Note staking and rock anchoring at bottom of temporary slope drain pipes.

Good use of rock-filled, stacked gabion baskets to protect steep slope. Soil and bark mulch can be used in or over gabions and planted with live willow or hardwood cuttings to reduce "hardened" look.

Good use of engineered retaining wall to break up slope. Development site and customer preferences will dictate type of materials used.

Poor slope protection. Seed has washed away—blankets or mats should have been used. Channel lining is poor. Silt check dam has washed out; more silt checks are needed.

Very poor slope protection. For best results, prepare soil and apply seed with mulch or blanket immediately after reaching final grade.

SECTION 7

Protecting Culvert and Ditch Inlets and Outlets

Culverts and ditches are designed to carry moderate and large flows of storm water. They can transport a lot of sediment to streams, rivers, wetlands, and lakes if they are not properly protected. In addition, culvert and ditch outlets can become severely eroded if high velocity flows are not controlled.

Culvert and storm drain ponding methods

Muddy runoff that flows toward a culvert, ditch, or storm drain inlet must be slowed down and pooled or filtered to settle out and remove sediment. This can be accomplished by placing rock, reinforced silt fencing, silt dikes, or other barrier in front of the inlet. The goal is to cause ponding of the inflow so sediment can settle out, and allow ponded water to enter the inlet only after sediment has been removed.

Straw bales alone are not approved for inlet protection. The next section describes several inlet protection devices. If the drainage area above the inlet is greater than three acres, a sediment trap or basin is be needed (see Section 9). For all inlet protection approaches, seeding and/or mulching upland areas promptly will greatly reduce incoming runoff volumes and sediment loads

Inlet protection devices

Inlets can be protected with structures made of rock, reinforced silt fence, stone-filled bags, or commercial “inlet dam” products. Accumulated sediment must be removed after each rain to ensure effectiveness. Place materials to form a small dam around the inlet. Build larger dams farther away from inlets with heavy incoming flows. When using rock, mix rock of various sizes so flows can seep through the dam slowly (see photos on following pages). If spaces between rocks are too large, runoff will move through the dam without adequate settling time.

Silt fence dams can be used in low flow areas. Install a wire-reinforced silt fence dam or box around the inlet (see Section 5). Use diagonal bracing on

sides and/or top to protect against incoming flow pressures. Make sure fence is trenched in and securely fastened to posts. Repair bypasses and undercuts promptly.

Place removed sediment in areas where it will not wash into inlets, ditches, channels, or streams. **Do not wash sediment or any other material down curb, channel, or drain inlets.**

Excellent use of concrete blocks and #57 rock for ponding dam to protect inlet. Note 2"x 4" board through blocks for stabilization. Note galvanized fencing and filter fabric between block and rocks.

Very good design and installation of inlet protection ponding dam using concrete blocks and rock. Outlet pipe in background has a rock apron to dissipate flows.

Good application of silt fence frame to protect inlet. Use wire fence backing to reinforce frame, or diagonal bracing across top of stakes. Make sure fence is trenched in to prevent bypasses or undercutting. Inspect and remove sediment as necessary after each rain.

Very good application of mixed rock for culvert inlet ponding dam. Mixing rock promotes better ponding, drainage, and settling of sediment.

Poor protection for drop inlet on concrete pad. Straw bales make good mulch but are not suited for inlet protection or silt check dams.

Poor placement of stone bag inlet dam; poor education of construction site drivers. Bags work well if used properly and maintained. Bags must form a dam around the inlet with no large gaps.

Poor placement and poor maintenance of stone bag inlet ponding dam. Accumulated sediment must be removed and dam should be repaired after each half-inch rain.

Straw bales have rotted and failed, with muddy runoff undercutting bales. Concrete apron and drop inlet grate are nearly covered in sediment. Use straw for mulch only.

Outlet protection methods

Outlets for storm drains, culverts, and paved channels that discharge into natural or constructed channels must be lined with rock or other armoring to prevent downstream bank and channel erosion when flow velocities are high.

The rock-lined "apron" at the outlet must be straight (lined up with the discharging pipe or channel) and laid in flat. Bring the sides up around outlet to prevent erosion, and up the banks a little to prevent scouring. The apron is shaped like a long triangle, with the narrow end located at the outlet and sized about 3 times the diameter of the outlet pipe. The width of the downstream end of the apron will be wider, tied into the channel, and vary according to the shape of the channel it empties into.

The table below provides general information for sizing rock and outlet aprons for various sized pipes. Outlets that discharge high flows must follow the maximum suggested sizing criteria.

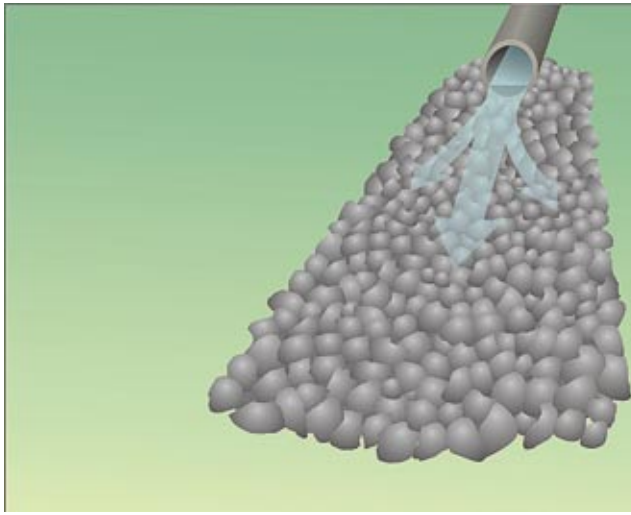
Sizing for flow dissipaters at culvert outlet

Culvert size	Avg. rock diameter	Apron width*	Apron length**	Apron length***
8"	3"	2–3 ft.	3–5 ft.	5–7 ft.
12"	5"	3–4 ft.	4–6 ft.	8–12 ft.
18"	8"	4–6 ft.	6–8 ft.	12–18 ft.
24"	10"	6–8 ft.	8–12 ft.	18–22 ft.
30"	12"	8–10 ft.	12–14 ft.	22–28 ft.
36"	14"	10–12 ft.	14–16 ft.	28–32 ft.
42"	16"	12–14 ft.	16–18 ft.	32–38 ft.
48"	20"	14–16 ft.	18–25 ft.	38–44 ft.

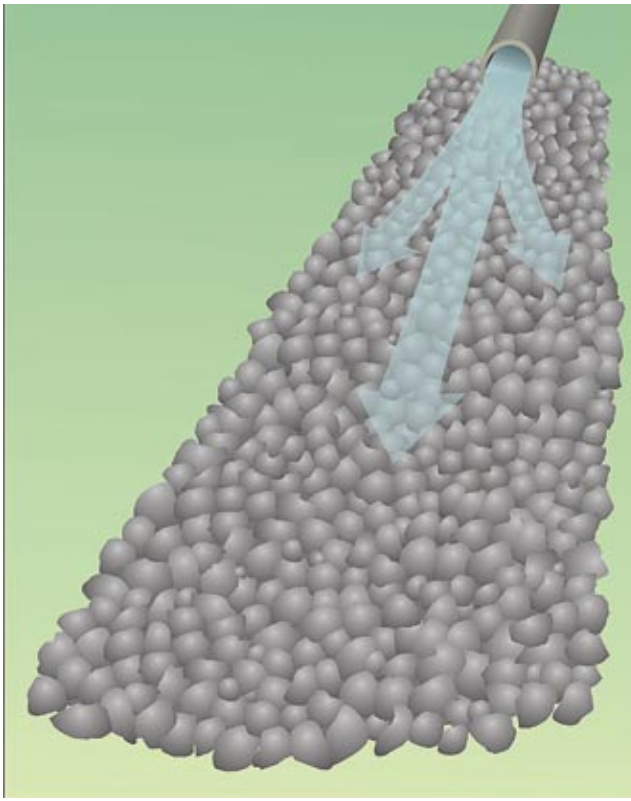
** Apron width at the narrow end (pipe or channel outlet)*
*** Apron length for slow-flow (no pressure head) culverts*
**** Apron length for high flow (pressure head) culverts*

If the culvert outlet and receiving channel do not line up straight, the channel bank receiving the brunt of the outlet flow must be lined or it will erode quickly. If rock will be used, double the average diameter when sizing the rock needed. Gabion baskets—galvanized wire mesh boxes filled with rock—are often used in this

situation, and can be stacked to form a wall if necessary. Mulch and soil can be mixed with the rock in the baskets to promote growth of stabilizing vegetation if desired.



Low-flow energy dissipaters (above) are shorter than those for high-flow outlets (below).



Good placement and construction of rock apron at high-flow culvert outlet. If flow from culvert enters a channel, make sure channel is lined with grass, and blankets or mats, if necessary, to prevent erosion.

Excellent placement and construction of rock apron to dissipate flows from culvert outlet. Area needs seeding and mulching.

Good silt fence installation, fair seeding and mulching on slopes. Poor placement and construction of flow dissipater apron at culvert outlet.

Poor rock apron placement and construction at culvert outlet; poor seeding and slope protection (right side).

Poor slope protection, no rock apron or flow dissipater at culvert outlet. Silt fence must not be used across ditches or channels; do not put sediment traps at culvert outlets.

Poor seed and mulch application, slopes badly eroding. No rock apron or flow dissipater at culvert outlet. Culverts clogged with sediment and rock.

Very poor outlet protection. No slope protection or seeding, no rock apron or flow dissipater at culvert outlet. Misapplication of silt fence across ditch. Flow bypass.

SECTION 8

Stabilizing Drainage Ditches

Man-made drainage ditches with gently sloping bottoms (less than 3%) can be stabilized with thick grass seeding and erosion control blankets (see Section 4). **Natural (i.e., not "man-made") drainage channels and creeks or streams cannot be cleared, re-routed, or otherwise altered without one or more permits from the U.S. Army Corps of Engineers and the KY Division of Water** (see Section 10). Moderately sloping ditches (3%–6% slopes) will likely require turf reinforcement mats and perhaps some riprap if soils are silty. Steeply sloping ditches (greater than 10%) need heavier armoring with concrete, riprap, gabion baskets, geogrid, retaining walls, or other approved products.

Drainage ditch slopes and soils

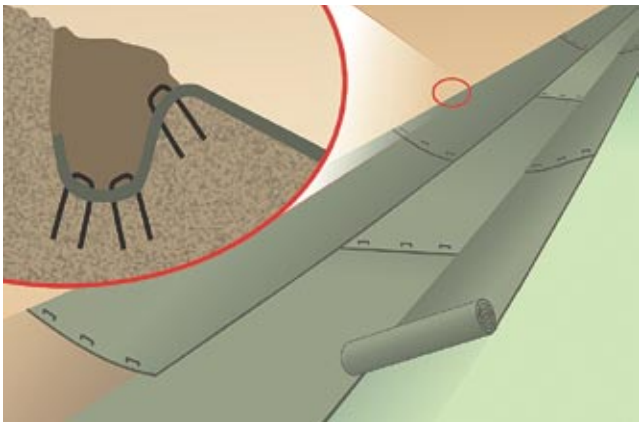
As noted in Section 6, silty soils are the most erodible and clay is the least erodible. Steeper ditches and those with highly erodible soils need more protection. Drainage ditch bank slopes must not exceed 2:1. If tractor mowers or other equipment will cross channels in the future, bank slopes must be 3:1 or flatter. The outlet must be installed, seeded, stabilized, and protected before the ditch receives incoming flows.

Stabilization approaches for drainage ditches

	Soil Type in Ditch		
Ditch Slope	Sandy	Silty	Clays
Steep >10%	Concrete or riprap	Concrete or riprap	Riprap
Moderate 10%	Riprap with filter fabric	Riprap or turf mats & seeding	Riprap or turf mats & seeding
Slight 5%	Riprap or turf mats & seeding	Seeding & turf mats	Seeding & turf mats
Mostly Flat <3%	Seeding & blankets	Seeding & mulching	Seeding & mulching

Erosion control blanket and turf mat linings

All ditches steeper than 10% require rock, concrete, or other armored liners and/or grade control structures. Ditches of 10% or less can be stabilized with turf reinforcement mats or erosion control blankets if they are seeded quickly. See Section 4 for installation and other information on turf reinforcement mats, erosion control blankets, and seeding/mulching applications.



Lay in ditch blankets similar to roof shingles; start at the lowest part of the ditch, then work your way up. Uphill pieces lap over downhill sections. Staple through both layers around edges. Trench, tuck, and tamp down ends at the top of the slope. Do not stretch blankets or mats.

Silt check dams of rock, brush, or other products

Drainage ditches need temporary silt check dams to capture sediment and reduce ditch bottom downcutting. Silt dikes or dams can be made of rock, stone-filled bags, fiber rolls, or brush. They are only effective when the drainage area is 10 acres or less.

Silt fencing and straw bales are not approved for use as silt check dams, and must not be used in drainage ditches that carry flowing water. Also, do not place silt checks in creeks or streams. Sediment must be intercepted before it reaches streams, lakes, rivers, or wetlands.

Seed ditches and install silt checks before excavating, filling, or grading uphill areas. Inspect, repair, and clean out sediment from upstream side of silt checks after each rainfall exceeding ½ inch. Remove temporary silt checks after the site is stabilized and vegetation is established. Placing filter fabric under the ditch check during installation will make removal much easier. Stone bag silt checks are easiest to remove, and can be re-used.

Spacing for silt check dams

Ditch slope	Silt check dam spacing	Additional information
30%	10 ft.	Calculated for 3' high silt check dams. Center of dam should be 6" lower than sides. Use 5"–10" rock, stone bags, or commercial products.
20%	15 ft.	
15%	20 ft.	
10%	35 ft.	
5%	55 ft.	
3%	100 ft.	
2%	150 ft.	
1%	300 ft.	
0.5%	600 ft.	

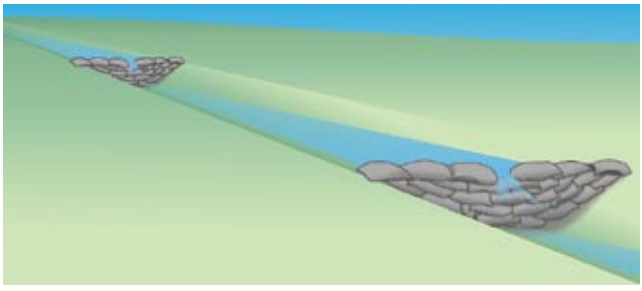
Silt check dams are spaced according to the slope of the ditch bottom (see table). Extend the ends of the silt check to the top of the bank to prevent bypassing and sidecutting. Keep the middle part lower and relatively flat so overflows aren't too concentrated and bypasses are prevented.

Lining steep ditches

Riprap is used to line sides and bottoms of steep ditches. Rock used in liners is mixed so the spaces between large rocks are filled with smaller rock. See table for rock sizing.

Rock sizing for ditch liners

Flow velocity	Average rock diameter
6 ft. per second	5 inches
8 ft. per second	10 inches
10 ft. per second	14 inches
12 ft. per second	20 inches



Silt check dams of rock, stone-filled bags, or commercial products must be installed before uphill excavation or fill activities begin. See table for correct silt check spacing for various channel slopes. Tied end of bag goes on downstream side.

As ditch depth and steepness increase, rock size must also increase. Line the bare ditch bottom and sides with non-woven filter fabric to prevent undercutting and washouts. If flows are 10 feet per second or more, use #2 rock as a bottom liner, below the larger rock. Rock must be placed along ditch bottom first, then up the sides. Rock layer thickness should be 1½ times the average diameter of the largest fourth of the rocks.

Install a protected outlet first by excavating a 1½- to 2-foot trench at the toe of the slope and filling with riprap. See Section 7 for details on outlet apron construction. Replace dislodged rock after storms as needed.

Good construction of rip-rap lined ditches on road project. Good use of erosion blankets on slopes. Seed coverage on slopes is fair to poor.

Good installation of temporary rock silt checks. Remember to tie sides of silt check to upper banks. Middle section should be lower. Clean out sediment as it accumulates. Remove silt checks after site and channel are stabilized with vegetation.

Good placement and spacing of fiber-roll silt checks. Coconut fiber rolls and other commercial products can be used where ditch slopes do not exceed three percent.

Poor application of commercial silt check product. Check dam needs to be longer (tied into banks). More are needed, at correct spacing for channel slope. Area needs to be re-seeded; ditch may need blanket liner.

Poor silt check installation. Straw bales are not approved as silt checks for ditch or channel applications due to rotting, installation difficulties, and high failure potential.

SECTION 9

Installing Sediment Traps and Basins

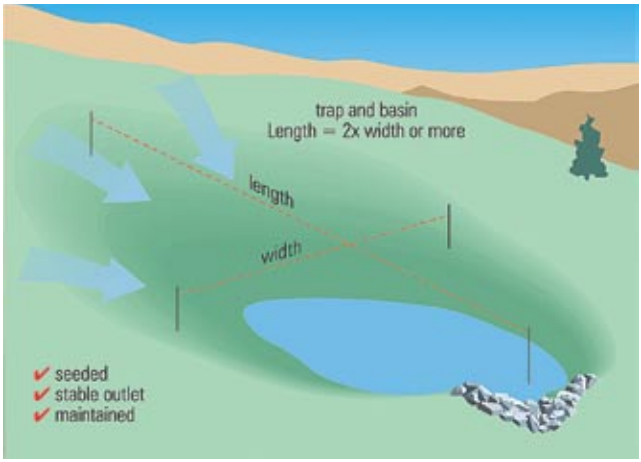
The purpose of a trap or basin is to provide an area where muddy runoff is allowed to pool, so sediment will settle out. Sediment traps and basins are installed in natural drainage areas before excavation or fill work begins. **Do not depend on sediment traps and basins alone to control sediment loss from your construction site.** Other uphill controls on bare areas, slopes, and in ditches and channels are needed to prevent overloading traps and basins.

Containment for the pooling area can be an excavated hole or a dike made of earth or stone. Straw bales and silt fencing are not approved for use as containment structures for concentrated runoff flows.

Locations for traps and basins

Low-lying sites on the downhill side of bare soil areas where flows converge are ideal places to install temporary sediment traps and basins. In general, sediment traps are designed to treat runoff from about 1 to 5 acres. Sediment basins are larger, and serve areas of about 5 to 10 acres. Basins draining areas larger than 10 acres require an engineered design, and often function as permanent storm water treatment ponds after construction is complete.

Do not put sediment traps or basins in or next to flowing streams or other waterways. Make sure pooled water does not flood buildings, roadways, or other structures.



Sediment traps

Any depression, swale, or low-lying place that receives muddy flows from exposed soil areas can serve as a sediment trap. Installing several small traps at strategic locations is often better than building one large basin. The simplest approach is to dig a hole or build a dike (berm) of earth or stone where concentrated flows are present. This will help to detain runoff so sediment can settle out. The outlet can be a rock-lined depression in the containment berm.

Sediment basins

Sediment basins are somewhat larger than traps, but the construction approach is the same (see below). Sediment basins usually have more spillway protection due to their larger flows. Most have risers and outlet pipes rather than rock spillways to handle the larger flows.

Sediment basins are often designed to serve later as storm water treatment ponds. If this is the case, agreements are required for long-term sediment removal and general maintenance. Construction of a permanent, stable outlet is key to long-term performance.

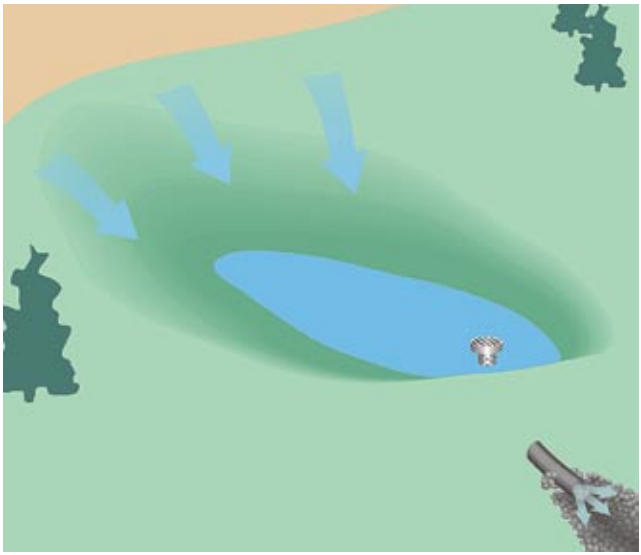
Sizing and design considerations

A minimum storage volume of 134 cubic yards per acre of exposed soil drained is required for basins and traps. Traps and basins are designed so that flow paths through the trap or basin are as long as possible, to promote greater settling of soil particles. Sediment basin length must be twice the width or more if possible—the longer the flow path through the basin, the better.

Side slopes for the excavation or earthen containment berms are 2:1 or flatter. Berms are made of well-compacted clayey soil, with a height of 5 feet or less. Well mixed rock can also be used as a containment berm for traps. Place soil fill for the berm or dam in 6” layers and compact. The entire trap or basin, including the ponding area, berms, outlet, and discharge area, must be seeded and mulched immediately after construction (see Section 5).

An overflow outlet can be made by making a notch in the containment berm and lining it with rock. Rock

in the notch must be large enough to handle overflows, and the downhill outlet should be stabilized with rock or other flow dissipaters similar to a culvert outlet. Overflow should be at an elevation so dam will not overtop. Allow at least one foot of freeboard. Outlets must be designed to promote sheet flow of discharges onto vegetated areas if possible. If the discharge will enter a ditch or channel, make sure it is stabilized with vegetation or lined (see Section 8).



Sediment basins often have pipe risers, but well-constructed rock overflow outlet notches in the dam or retaining berm are acceptable if the overflow area is protected from erosion.

If used, outlet risers and discharge pipes must be 12 inches diameter or larger. Corrugated metal pipe works best for risers. Plastic or other pipe can also be used for temporary applications. Risers should be topped with trash racks and anti-vortex baffles, and have ½-inch holes every 3 to 6 inches apart. Large holes or slots, if used, should not appear in the lower two-thirds of the riser. Risers should be anchored to a concrete base, and should be bedded in a pile of 1- to 5-inch rock to a height of at least 2 to 3 feet to promote sediment filtration during draindown. Riser tops must be at least 2 feet below the top of the containment berm or dike. If risers or outlet pipes that do not comply with these design criteria are used for temporary applications, inflows must pass through a filter made of mixed rock piled around the pipe. Rock should be removed after upland area is well vegetated.

Inspection and maintenance

Inspect inlets, berms, spillway, and outlet area for erosion after each rain exceeding 0.5 inch (0.1 inch for KYTC projects). Repair gullied areas and any upslope areas contributing large volumes of sediment. Clean trash and plugged areas from the riser pipe. Repair and reseed bare areas. Ensure that downstream receiving area is stable. Remove sediment before it fills half the trap or basin volume.

Fair installation of two traps above small pond. Dikes are a little too small; placement is too close to pond. Area needs seed and mulch.

Fair sediment trap construction. Rock dike is undersized and lacks a defined overflow notch. Poor maintenance attention. Silt fence beyond rock dike is not needed—silt fence should not be used across flow channels.

Good sediment trap installation, but poor maintenance has caused trap to fill and bypass to occur. Remove sediment before trap is half full. Make sure containment dike has an overflow notch to control the discharge location.

Good trap location; needs cleaning out. Trap might be too small for area drained. Very good channel protection, seeding, and mulching.

Fair to poor trap installation. Dike overflow notch is too deep; basin is too small. No seed or mulch covering bare soil areas.

Poor sediment trap construction. Dike is poorly built, without an overflow notch. Placement is too close to pond. No seeding or mulching evident in drainage area.

SECTION 10

Protecting Stream Channels, Wetlands, and Lakes

Streams must not have sediment control devices or stabilization structures placed into them without one or more permits. The Kentucky Division of Water uses solid or dashed blue lines on a USGS topo map to identify a stream. The U.S. Army Corps of Engineers defines any waterway with a defined bed and bank to be a stream and regulated by the U.S. Clean Water Act, *even if it only has water flowing in it during or immediately following rain* (see Section 12 and Appendix C).

Setback requirements

Avoid activities near waterways if possible. Maintain vegetation along buffers by establishing setbacks (see table for recommendations). Flag off vegetated buffer areas to keep equipment away. Some jurisdictions have mandatory setback requirements. Check with the local planning and zoning office before working near waterways.

Need information on permits required for working in or near streams and wetlands in Kentucky?

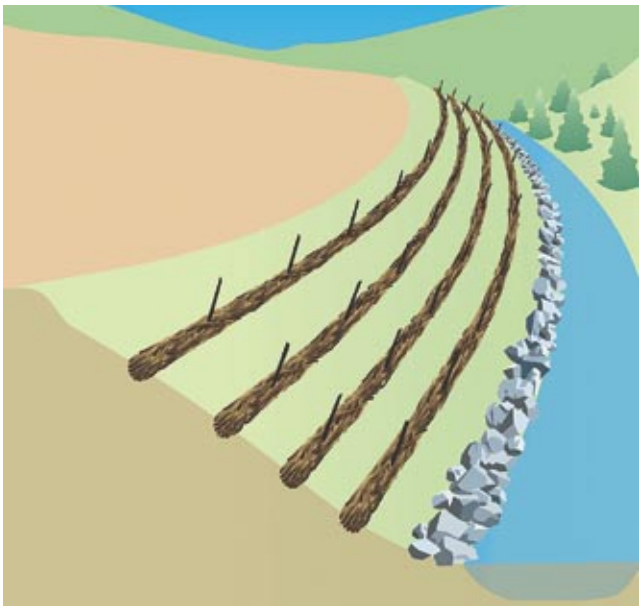
Call 502-564-3410 and ask for the Water Quality Certification Section

Recommended setbacks from waterways

	Soil Type Along Banks		
Bank Slope	Sandy	Silty	Clays
Very Steep (2:1 or more)	100 ft.	80 ft.	60 ft.
Steep (4:1 or more)	80 ft.	60 ft.	40 ft.
Moderate (6:1 or more)	60 ft.	40 ft.	30 ft.
Mostly Flat (less than 10:1)	40 ft.	30 ft.	20 ft.

Vegetated buffers

Preserve existing vegetation near waterways wherever possible. This vegetation is the last chance barrier to capture sediment runoff before it enters the lake, river, stream, or wetland. Where vegetation has been removed or where it is absent, plant native species of trees, shrubs, and grasses. Use live stakes or cuttings to save on planting costs (see next page).



Live willow or hardwood stakes driven through live wattles or rolls, trenched into slope, provide excellent stream bank protection. Protect toe of slope with rock or additional rolls or wattles.

Stream bank stabilization

Stream banks are likely to erode if:

- Vegetation has been removed
- Bank slopes are steeper than 3:1
- Outside curves are not protected
- Runoff increases in the drainage area

Removal of vegetation should be avoided if at all possible. Bank slopes can be cut back and replanted if severe erosion is occurring. Outside channel curves might need protection with large rock, imbedded root wads, logs, gabions or other material if banks are collapsing. Note that work in and around a stream will likely require one or more permits. Environmental impacts are regulated by the U.S. Clean Water Act Sections 401 and 404. In addition, KRS 151 regulates the flooding impacts of building in the floodplain and stream (see Appendices for details).

Increased runoff in the drainage area, caused by new roads, parking lots, roofs, etc. can be addressed by promoting infiltration at every available opportunity. Direct roof gutters, parking lot discharges, and other runoff onto grassy swales and vegetated or landscaped areas, rather than into ditches or creeks.

Unstable or bare stream banks can be stabilized with willow or hardwood cuttings harvested from vegetated areas near the site. Live stakes are 1- to 3-foot long cuttings from live hardwood trees or shrubs. Stakes are harvested during the dormant season (November–February) and driven into the stream bank, right-side up. They will develop roots and grow if sufficient moisture is available and they are not heavily damaged during installation. Willow, maple, poplar, cottonwood, dogwood, sycamore, oak and other hardwoods can be used. Plant half of the stake or cutting below the ground surface. Push into the ground where soils are soft; make a pilot hole with wooden or metal stake if soil is very hard. **Make sure the bottom end—nearest to the roots—is put into the ground!** Stakes or cuttings can be harvested and rooted in cool damp sand mixed with moist compost prior to planting if desired. Cover roots with at least 1 to 2 inches of soil when planting. Keep soil moist during dry season, until plants are well established.

Wattles are also effective in stabilizing stream banks. Wattles are bundles of live cuttings approximately 4 to 6 inches in diameter and 6 feet long. They are placed across the slope at 3- to 5-foot intervals, in long rows. Wattles are laid in shallow trenches, staked down, and covered with 2 to 3 inches of soil. Shoots and roots will sprout along the entire length of the wattle, creating a continuous erosion barrier and stabilizing the bank.

Stream crossings

Note that work in and around a stream will likely require one or more permits. Environmental impacts are regulated by the U.S. Clean Water Act Sections 401 and 404. In addition, Kentucky KRS 151 regulates the flooding impacts of building in the floodplain and stream (see Appendices for details). Keep equipment away from and out of streams. If a temporary crossing is needed, put it where the least stream or bank damage will occur. Look for:

- Hard stream bottom areas
- Low or gently sloping banks
- Heavy, stable vegetation on both sides

Use one or more culverts (18 inches minimum) as needed, sized to carry the two-year 24-hour rain

storm. Cover culverts with at least 12 inches of soil and at least 6 inches of mixed #2 and #57 rock. A 25-foot long, 6" thick pad of rock should extend down the haul road on each side of the crossing, similar to a construction entrance (see Section 2). Remove culverts and cover material when crossing is no longer needed. Grade, seed, or otherwise re-plant vegetation removed. See Section 12 and Appendices C and D for permit information if culverts are placed in streams.

Good use of silt fence, straw, rock, and other practices for temporary stream crossing. Any work in stream channels—such as installation of culverts—requires a Section 404 permit from the U.S. Army Corps of Engineers and a Section 401 Water Quality Certification from the KY Division of Water.

Excellent soil coverage at stream bank stabilization project using hand scattered straw, jute matting, and erosion blanket.

SECTION 11

Maintaining and Closing Out Your Construction Project

Erosion and sediment controls need to be inspected and maintained. Temporary controls must be removed and permanently stabilized when the project is completed. Failing to fill, grade, and seed temporary sediment traps or basins or failing to remove silt fences, silt check dams, and other controls can result in legal liabilities and KPDES storm water permit violations. See details of the storm water KPDES construction permit and the Appendices for more information on post-construction closeout requirements.

Inspecting storm water flow structures

Erosion and sediment controls must be inspected weekly and after each rain exceeding 0.5 inch (0.1 inch for KYTC projects). Keep records of inspection observations and actions taken, and file with other erosion and sediment control plan paperwork.

Keep erosion and sediment controls in good working order until the project is completed. Brush and other debris should be removed from culvert and channel inlets. Rock or sediment accumulating behind silt fences or other sediment filters should be removed regularly. All structures that have become dislodged or damaged (such as silt fences, rock aprons, etc.) should be repaired as soon as possible.

Managing trash, supplies, and materials

Keep rock entry/exit pads clean by raking/grubbing or adding new rock as needed when sediment begins to fill spaces between the rock. Make sure that waste materials, building materials, and supplies are properly tied down or contained so that wind and storm water runoff cannot carry the materials away. **Keep your site clean!** Chemicals, paints, and hazardous waste products should be stored in a trailer or other structure to avoid spills and runoff. Provide for proper sewage disposal.

Have a plan to handle fuel, oil, or other spills. Have spill kits and containment material on-site, especially near fueling or equipment service areas. Try to

maintain vehicles and equipment away from the site if possible. If maintenance must occur on-site, ensure that spills are cleaned up quickly.

Vegetated cover considerations for close-out

No site is closed out properly until vegetation is established on all bare soil areas and ditches are stable. Check seeded areas, and reseed areas where vegetation is thin or absent. This is especially important for slopes, ditches, and channels.

Removing temporary sediment controls

When project is completed:

- Remove all silt fencing and stakes. Grade out and seed or remove accumulated sediment or broadcast over grassed areas or dispose of off-site.
- Culvert inlets should be stabilized, vegetated, and showing no visible gullies. Rock or soil that has been washed away by runoff or upstream flows should be replaced. Brush or other debris that could clog inlets should be removed.
- Check ditches and channels to make sure banks and ditch bottoms are well vegetated. Reseed bare areas and replace rock that has become dislodged.
- Check areas where erosion control blankets or matting was installed. Cut away and remove all loose, exposed material, especially in areas where walking or mowing will occur. Reseed all bare soil areas.
- Replace rock washouts near culvert and channel outlets. Fill, grade, and seed or riprap eroded areas around inlets and outlets. Make sure downstream ditches and channels are fully vegetated. Fill and seed any gullies along the banks or other slopes.
- Fill in, grade, and seed all temporary sediment traps and basins that have been removed. Double the seeding rate where runoff flows might converge or high velocity flows are expected.
- Remove temporary stream crossings and grade, seed, or re-plant vegetation removed during crossing installation.

Final site stabilization

Make sure all subcontractors have repaired their work areas prior to final closeout. Conduct a final inspection of all work areas, vegetation, storm water flow structures, and downstream receiving waters to make sure no visible gullies or sediment movement is evident. Notify site owner or manager after all temporary erosion and sediment controls have been removed and final stabilization has been completed. If the site is one acre or larger and covered under a KPDES Storm Water Permit, submit a Notice of Termination to the Kentucky Division of Water (see http://www.water.ky.gov/permitting/wastewaterpermitting/KPDES/storm/).

Excellent installation of rock flow dissipater at culvert outlet. Make sure inlets, outlets, and slopes are well stabilized before leaving the site and filing your "Notice of Termination" for ending permit coverage.

Poor job of seeding and protecting curb inlet with stone bags. Project should not be closed out until all bare soil areas are vegetated and all temporary controls (inlet dams, silt checks, silt fencing) have been removed. File "Notice of Termination" with the KY Division of Water when project is completed.

SECTION 12

Regulatory Information

Storm water permits

Need information on Storm Water Permits?

Call 502-564-3410; Ask for the KPDES Division

Or visit this Internet site:
http://www.water.ky.gov/permitting/wastewaterpermitting/KPDES/

Construction projects one acre or larger **must** be covered by a federal Clean Water Act *Storm Water KPDES permit*. The permits are issued by the Kentucky Division of Water. If a project smaller than one acre is part of a larger development that exceeds one acre, it also must be covered by a KPDES permit as of March 10, 2003. Following the erosion and sediment control recommendations in this guidebook will help you meet most of the permit requirements. **The main goal of the entire permit program is to keep sediment and other pollutants out of lakes, rivers, streams, and wetlands.** For more details on permit requirements, see Appendix A of this guide.

Erosion protection and sediment control plans

If you're working in Jefferson County, Fayette County, Northern Kentucky, or other designated urban areas, you need to file an erosion and sediment control plan with the local government before you begin work. The plans require you to note which of the erosion and sediment control measures you will use during construction. Plans are also required for Kentucky Transportation Cabinet construction projects. See Appendices of this guide for specific plan requirements and inspection checklists.

If you are working elsewhere in the state and your project is one acre or larger, you have to develop a written erosion and sediment control plan as part of your overall "Storm Water Pollution Prevention (BMP) Plan." These plans do not have to be filed, but must be available at the construction site for review by contractors, subcontractors, and regulatory staff.

Utility construction regulations

In general, utility construction crews and other subcontractors are responsible for their own erosion

and sediment controls. General contractors should make sure that all utilities and subcontractors use rock pad construction entrances. Tracking mud out onto paved roads can lead to legal liabilities. If crews disturb areas that have already been stabilized, they should replace any mulch, sod, seed, blanket, matting, rock, or other material disturbed. Failure to properly grade, seed, and stabilize work sites may violate permit requirements.

If your project is larger than one acre and covered under a KPDES Storm Water Permit, it is recommended that subcontractors and others conducting excavation or fill activities sign an agreement that they will follow the Storm Water Pollution Prevention (BMP) Plan. If utility projects are conducted in or near streams, Clean Water Act Section 404 permit coverage may be required (see next subsection).

Transportation project regulations

The Kentucky Transportation Cabinet (KYTC) inspection performance standard for erosion and sediment control is that no sediment should leave the site. KYTC requires that slopes 4:1 or steeper with upland runoff areas exceeding 100 feet and all channels be lined with erosion control blankets. **All KYTC projects are subject to KPDES Storm Water Permit requirements.** The Cabinet requires that inspection of erosion and sediment controls be conducted at least weekly and after each rain of 0.1 inch or more. If transportation projects are conducted in or near streams, Clean Water Act Section 404 permit coverage may be required (see below).

KYTC standards also limit the amount of disturbed area to 750,000 square feet (about 17.2 acres). Written approval from the district engineer is required for exceeding this limit.

Bridge construction/repair and other work near streams require substantial erosion and sediment control efforts. Establish final grade quickly on as much of the site as possible, then stabilize with seed, mulch, blankets, or matting. Bare soil areas at temporary grade should also be seeded and mulched if they will not be worked over 21 consecutive days. See Appendix F for more information on transportation project requirements.

Section 404 permits for wetlands and streams

Activities conducted in or through streams or wetlands require a separate permit under Section 404 of the Clean Water Act, which regulates the placement of dredged or fill material into public waters. If equipment will be operating in or through a creek, wetland, or river, permit coverage is required. See the box below for a list of the permits issued by the U.S. Army Corps of Engineers under the Section 404 permits:

- Structures in Canals
- Maintenance Activities
- Survey Activities
- Outfall Structure O&M
- Temporary Rec. Structures
- Utility Line Activities
- Bank Stabilization
- Linear Transportation Projects
- Hydropower Projects
- Minor Discharges
- Minor Dredging
- Surface Coal Mining Activities
- Structural Discharges
- Stream/Wetland Restoration
- Marina Modifications
- Single-family Housing
- Flood Control Facilities O&M
- Construction & Access
- Dredging of Existing Basins
- Boat Ramps
- Waste Cleanup Operations
- Development on Waterways
- Agricultural Activities
- Reshaping Drainage Ditches
- Recreational Facilities
- Storm Water Management Facilities
- Mining Activities

See Appendix C for contact information regarding Section 404 permits.

Kentucky Division of Water Regional Offices and Supervisors:

Bowling Green: Bill Baker (270) 746-7475
Columbia: Sara Sproles (270) 384-4734
Florence: Todd Giles (859) 525-4923
Frankfort: Massoud Shoa (502) 564-3358
Hazard: Ferris Sexton (606) 435-6022
London: Keith Blair (606) 878-0157
Louisville: Mike Mudd (502) 425-4671
Madisonville: Ed Carroll (270) 824-7529
Morehead: Bob Wells (606) 784-6635
Paducah: Vince Priddle (270) 898-8468

For More Information Contact:

Tom Gabbard
14 Reilly Road
Frankfort, KY 40601
Phone: (502) 564-3410
Fax: (502) 564-2741
E-mail: tom.gabbard@ky.gov

APPENDIX A

Federal and State KPDES Storm Water Permit Requirements

EPA regulations at 40 CFR 122.26(b)(14)(x) and 122.26(b)(15) require NPDES storm water discharge permit coverage for discharges from construction activities that disturb one or more acres. These nationwide regulations are implemented by general NPDES permits, which are issued by EPA and authorized State agencies such as the Kentucky Division of Water, which issues KPDES permits.

The KDOW KPDES Construction General Permit was developed to satisfy federal storm water permitting requirements. KPDES Construction General Permit meets all federal permit requirements and most of the requirements of local governments in Kentucky, though some local governments have additional requirements that must also be addressed by the applicant. See below for a summary of the KPDES Construction General Permit requirements, and Appendix B for a summary of some local government requirements.

The KPDES Construction General Permit covers all storm water discharges associated with construction activity that disturbs one acre or more. A copy of this permit can be downloaded from http://www.water.ky.gov/permitting/wastewaterpermitting/KPDES/storm/. The permit requires all construction activity in Kentucky disturbing one acre or more to:

- Submit a signed Notice of Intent (NOI) form to Kentucky Division of Water at least 48 hours before construction activity begins.
- Submit a copy of the NOI to the municipal operator of any municipal separate storm sewer system (MS4) the site discharges into.
- Develop and implement a “Storm Water Pollution Prevention (BMP) Plan.”
- Continue to implement the plan during construction activity, including inspections every 7 days and after each rain of one-half inch or more.
- Submit a signed Notice of Termination (NOT) form to Kentucky Division of Water after the site has been finally stabilized.

The Storm Water Pollution Prevention or "Best Management Practices" (BMP) Plan must be developed in accordance with good engineering practices. The BMP Plan must identify expected sources of pollution and describe how they will be controlled. The BMP Plan must be completed prior to construction, signed, and kept onsite. BMP Plans required by this permit are considered reports that shall be made available to the public, upon written request, in accordance with Section 308(b) of the Clean Water Act (CWA). Deficient plans may require modification upon notification by the KY Division of Water or local regulatory authority.

Construction site BMP Plan requirements

The BMP Plan must include, as a minimum, the following:

Site Description: The BMP Plan shall include a clear description of the nature of the construction activity, the order of major soil disturbing activities, a site map, and other information. The site map shall indicate drainage patterns and show approximate slopes after grading, areas of disturbance, the location of control measures, surface waters or wetlands, and storm water discharge locations.

Sediment and Erosion Control Measures: The BMP plan must include a clear description of what sediment and erosion control measures will be used and when they will be implemented. The following control measures shall be used as a minimum:

- Soil Stabilization Practices—Existing vegetation shall be preserved where possible. All disturbed areas of the site shall be stabilized. Stabilization shall begin within 14 days on areas of the site where construction activities have permanently or temporarily (for 21 days or more) ceased. When snow cover causes delays, stabilization shall begin as soon as possible. Stabilization practices include seeding, mulching, placing sod, planting trees or shrubs, and using geotextile fabrics and other appropriate measures.
- Perimeter Structural Practices—Silt fences or other equivalent structural practices shall be used on all side and down slope borders of the

site. For common drainage locations that serve more than ten (10) disturbed acres at one time, a sediment basin must be used if possible. Structural practices include protecting drain inlets and outlets and using silt fences, earthen dikes, drainage swales, sediment traps, check dams, subsurface drains, pipe slope drains, reinforced soil retaining systems, gabions, sediment basins and other appropriate measures.

- Storm Water Management Devices—Management devices shall be installed during construction to control the pollutants in storm water discharges that will occur after construction has been completed. Velocity dissipation devices shall be placed at discharge locations and along outfall channels as necessary to provide a non-erosive flow. The goal should be 80% removal of Total Suspended Solids that exceed predevelopment levels. If this goal is not met, the permittee shall provide justification for refusing each device based on site conditions.

Other Control Measures: No solid materials, including building materials, shall be discharged to waters of the Commonwealth, except as authorized by a Section 404 permit. Off-site vehicle sediment tracking and dust generation shall be minimized. Waste disposal methods and sanitary sewer or septic systems shall comply with applicable state or local regulations.

Other State or Local Plans: The BMP Plan shall include any requirements specified in sediment and erosion control plans, storm water management plans or permits that have been approved by other state or local officials.

Maintenance: The BMP Plan shall include a clear description of the maintenance procedures necessary to keep the control measures in good and effective operating condition.

Inspections: Qualified personnel shall inspect all storm water control measures and drainage features at least once every seven days and within 24 hours of the end of a storm that is 0.5 inch or greater (0.1 inch for KYTC projects). Discharge locations shall be inspected to ensure that velocity dissipaters prevent significant impacts to receiving waters. Vehicle exits

shall be inspected for evidence of offsite sediment tracking. Disturbed areas and material storage areas that are exposed to precipitation shall be inspected for evidence of pollutants entering the drainage system. A signed report summarizing the scope of the inspection, major observations, and any corrective actions taken shall be made and kept as part of the BMP Plan.

Non-Storm Water Discharges: The BMP Plan shall identify and ensure the implementation of appropriate pollution prevention measures for any non-storm water component of a discharge as listed in PART III C, except for flows from fire fighting activities.

Contractors and Subcontractors: The BMP plan shall clearly state the contractor or subcontractors that will implement each control measure identified in the BMP Plan. All contractors and subcontractors identified in the BMP Plan must sign a copy of the certification statement below before conducting any professional service at the site: "I certify under penalty of law that I understand the terms and conditions of the general National Pollutant Discharge Elimination System (NPDES) permit that authorizes the storm water discharges associated with industrial activity from the construction site identified as part of this certification." The certification must include the name and title of the person providing the signature, the name, address, and telephone number of the contracted firm, the address, or other identifying description of the site and the date the certification is made. All certification statements must be included in the BMP Plan.

APPENDIX B

ESC Plan Requirements for Local Governments in Kentucky

Some urban areas in Kentucky have specific requirements for filing earth disturbance plans prior to construction. Check with each local government prior to construction in urban areas to make sure your understanding of the permit requirements is up-to-date. Below is a summary of the requirements of the Metropolitan Sewer District of Louisville and Jefferson County, the Lexington-Fayette Urban County Government, and Sanitation District #1 in Northern Kentucky.

Louisville – Jefferson County Metropolitan Sewer District

On November 21, 2000 the Jefferson County Fiscal Court adopted an Erosion Prevention and Sediment Control (EPSC) Ordinance applies to all land disturbing activities in Jefferson County, including single family, commercial, residential and utility construction. Activities disturbing 5,000 square feet or less and not requiring a building permit, limited private development site investigations, and surveying prior to plan application are exempt.

The EPSC Ordinance requires that all EPSC measures be designed and installed to accomplish an 80% design removal efficiency goal for total suspended solids. The MSD Design Manual, Standard Drawings and Standard Specifications contain approved structural and non-structural Best Management Practices (BMPs) for use in achieving this standard. Structural BMPs include sediment trapping devices, inlet protection measures, perimeter controls and construction entrances. Non-structural methods include phasing a project into manageable pieces, scheduling activities within each phase to minimize amount of disturbed area and provisions for temporary and final stabilization. The Permittee, or his or her designee, is required to conduct inspections of all EPSC measures and perform any modifications, maintenance or repairs as necessary, every 7 calendar days and within 24 hours of each storm event that produces 0.5 inches or more of precipitation. Records of these inspections must be kept on site at all times for review by the appropriate compliance enforcement

agency. For more information, visit the MSD web site at http://www.msdlouky.org/insidemsd/epsc.htm

Lexington-Fayette Urban County Government

An erosion and sediment control plan must be approved by the LFUCG before construction commences for any disturbed area other than the construction of a single family, two family, or townhouse residence. The plan shall be developed and signed by a professional engineer or landscape architect licensed in Kentucky. All hydrologic, hydraulic, structural, and geotechnical design work included in the plan must be done and signed by a professional engineer licensed in Kentucky. Plans must integrate nonstructural and structural practices and procedures to control erosion and sediment loss. Once the erosion and sediment control practices have been constructed, a grading permit can be obtained. The erosion control permit remains in effect throughout the construction project, including the homebuilding phase of construction for residential subdivisions. Land disturbances for the construction of a structure on a single residential lot are permitted through the building permit process and must comply with LFUCG requirements.

An operation and maintenance plan must be developed which provides a schedule for inspection, maintenance and repair of BMPs during construction activities. A maintenance schedule shall also be provided to ensure that permanent measures such as vegetation are properly established after construction is complete. All erosion and sediment controls which are identified in the ESCP shall be inspected and maintained. Any erosion and sediment control devices which are damaged shall be repaired or replaced immediately. For more information, see http://www.lfucg.com/Engineering/ and the storm water manual at http://www.lfucg.com/engineering/engmansw.asp.

Sanitation District # 1 in Northern Kentucky

Sanitation District # 1 (SD1) serves 33 communities in Boone, Campbell, and Kenton Counties of Northern Kentucky. SD1 has established a “Land Disturbance Permit” to control storm water runoff from construction sites and post-construction storm water management for new developments and re-developments in Boone, Campbell, and Kenton Counties

and the municipalities in those counties in the area covered by the KPDES SMS4 Storm Water Permit with the exception of the city of Florence. The regulations require the implementation of proper erosion and sediment control practices; controls for other wastes; and the implementation of post-construction runoff controls in areas undergoing development or re-development. These regulations require review of improvement plans for new developments and re-developments; site inspections and enforcement activities of control measures; long-term operation and maintenance of post-construction controls; and sanctions to ensure compliance.

The requirements apply to all land disturbing activities and all development or re-development activities that disturb an area greater than or equal to one acre. Sites that are smaller than one (1) acre may also be covered by these regulations if they are a part of a larger common plan of development or sale. Persons responsible for a land disturbing activity, development activity, or redevelopment activity shall make application to the District. The land disturbing activity, development activity, or re-development activity cannot commence until the District has issued a Land Disturbance Permit. Drawings of the site with information on drainage, erosion and sediment controls to be used, and other details are also required. For more information, see http://www.sd1.org/StormWater/SWRules&Regs.html.

Other Phase II Storm Water Cities

Cities in Kentucky with more than 10,000 population (e.g., Bowling Green, Henderson, Madisonville, Elizabethtown, Winchester, Richmond, Georgetown, Somerset, etc.) are subject to KPDES permits under the Kentucky Phase II Storm Water Program. Regulations are similar to those of larger cities—all construction sites of one acre or more must have written erosion and sediment control plans, controls must be inspected every seven days or after rains of one-half inch or more, controls must be removed after the site is stabilized, etc. For more information on the permit process, see http://www.water.ky.gov/permitting/wastewaterpermitting/KPDES/storm/. For regulatory information, see http://www.lrc.state.ky.us/kar/401/005/002.htm.

APPENDIX C

Section 404 Permits for Work in Regulated Waters

Section 404 of the Clean Water Act regulates the placement of dredged or fill material into the waters of the U.S., including small streams and wetlands adjacent or connected to regulated waters (see Section 12). The U.S. Army Corps of Engineers (USACE) administers the permit program dealing with these activities, in cooperation with the U.S. Environmental Protection Agency (USEPA). Individual permits are issued for activities with significant impacts, and nationwide or regional general permits are issued for activities with impacts not deemed to be significant.

For minor activities covered under Section 404 general permits (e.g., road culvert installation, utility line activities, bank stabilization, etc.), permit requirements are typically deemed to be met if activities result in only short-term, limited effects and if all appropriate and reasonable measures related to erosion and sediment control, project seeding and stabilization, and prevention of water quality degradation (e.g., working during low-flow conditions) are applied and maintained. Applicants will be responsible for ensuring that erosion and sediment control measures are selected, installed, and maintained properly. For more information, see http://www.water.ky.gov/permitting/wqcert/.

Contact information for USACE District Offices serving Kentucky:

Huntington District
502 8th Street, Huntington, WV 25701-2070
Tel: 304-529-5487 Fax: 304-529-5085
Website: www.lrh.usace.army.mil

Louisville District
PO Box 59, Louisville, KY 40401-0059
Tel: 502-315-6675 Fax: 502-315-6677
Website: www.lrl.usace.army.mil

Memphis District
Clifford Davis Federal Building, Room B-202,
Memphis, TN 38103-1894
Tel: 901-544-3471 Fax: 901-544-0211
Website: www.mvm.usace.army.mil

Nashville District
3701 Bell Road, Nashville, TN 37214
Tel: 615-369-7515 Fax: 615-369-7501
Website: www.orn.usace.army.mil

APPENDIX D

Kentucky CWA Section 401 Water Quality Certification

Anyone proposing to conduct activities that result in physical disturbances to wetlands or streams will need a Water Quality Certification (WQC) under Section 401 of the Clean Water Act to ensure that Kentucky Water Quality Standards will not be violated (see Section 12). Projects which involve the discharge of dredged or fill materials into waters of the United States, including wetlands, are regulated by the U.S. Army Corps of Engineers under Clean Water Act Section 404 and require Section 401 WQC.

Examples of activities which may require a Section 404 permit and Section 401 water quality certification include: stream relocations, road crossings, stream bank protection, construction of boat ramps, placing fill, grading, dredging, ditching, mechanically clearing a wetland, building in a wetland, constructing a dam or dike and stream diversions.

In Kentucky, the Water Quality Certification Section in the Water Quality Branch is responsible for implementing the Section 401 program. For wetland-related impacts involving greater than one acre of wetland loss, the applicant should follow the Wetland Mitigation Requirements when applying for a WQC. Wetland losses involving less than one acre may be regulated by the U.S. Army Corps of Engineers. The U.S. Army Corps of Engineers is responsible for making official, jurisdictional wetland determinations.

For stream-related impacts that involve more than 200 linear feet of stream disturbance, the applicant should submit detailed plan and profile drawings along with the application (see draft Stream Mitigation Guidelines on web site below. Impacts in streams or lakes designated as Special Use Waters require an individual WQC and special attention should be paid to the sediment and erosion control plan. For more information, see http://water.nr.state.ky.us/wq/wqcertification/index.htm.

APPENDIX E

Floodplain Construction Permits

The Kentucky Division of Water Floodplain Management Section has the primary responsibility for the approval or denial of proposed construction and other activities in the 100-year floodplain of all streams in the Commonwealth. Typical activities permitted are dams, bridges, culverts, residential and commercial buildings, placement of fill, stream alterations or relocations, small impoundments, and water and wastewater treatment plants.

Applicants must submit a completed application with a location map, plans of the proposed construction, and the addressing of public notice. If the proposed construction lies in an area where there is no existing floodplain information, hydrologic and hydraulic analysis must be performed.

KDOW engineers will perform the required analysis provided the Applicant supplies them with the floodplain geometry in the form of cross sections, preferably tabulated on an Excel Spreadsheet. This analysis determines the effects the proposed construction has on existing flood conditions and determine the expected 100-year flood heights and the delineation of the floodway (a portion of the natural floodplain that is restricted to little or no construction).

From this analysis, construction limits for fills and buildings and required elevations for finished floors or floodproofing can be provided. For all construction, especially bridges and culverts, a check is made to ensure that the project has only minimal impacts on existing flood levels. Regulations limit the effect to a maximum of one foot. For more information, see http://water.ky.gov/permitting/floodconstr/.

APPENDIX F

Additional Details for Transportation Projects

The Kentucky Transportation Cabinet (KYTC) requires inspection and documentation of all controls weekly or after each rain of 0.1 inch or more. Approved curled wood fiber or straw/coconut fiber erosion control blankets or mats must be used in all ditches (except sodded, paved, and channel-lined ditches) and on all slopes of 4:1 or steeper, if upland drainage area exceeds 100 feet. KYTC will allow the use of hydromulch in lieu of straw during March 1 to May 15 and September 1 to November 1 only. Use sufficient quantities of mulch and tackifier to promote germination and control erosion until vegetation is established.

Projects conducted within the jurisdiction of a "Storm Water Phase II City" (see Appendix B) should coordinate activities with local storm water programs.

KYTC requires an erosion control plan prior to excavation or grading. Erosion control plans require site drawings that show natural and constructed drainage features and the actions that will be taken to control both erosion on bare soil areas and sediment in sheet runoff or concentrated flows. Erosion and sediment control actions must be indicated on the site drawing. Natural streams and other surface waters should also be noted.

Plans must indicate temporary and permanent erosion control features. At a minimum, this includes silt checks, silt traps, sediment traps/basins, silt fences, and other methods. Streams, wetlands, and other surface waters should be disturbed only when necessary, and as little as possible. Temporary stream crossings should be designated. Erosion and sediment controls must be properly maintained during construction and closed out after construction to ensure continuing compliance with the permit and KYTC requirements. See Section 11 for maintenance information, and Section 12 for information on closeout.

Specific design and other requirements can be found in the project contract documents.

Kentucky Erosion Prevention and Sediment Control • Construction Site Inspection Checklist

EPSC Practices	Field Indicators for Compliance
Project Operations	Grading and clearing conducted in phases and according to plan to minimize exposed soil areas No vegetation removal or other operations in stream or sinkhole buffer zone (25-50 ft. min.) Rock construction entrance/exit in place where vehicles enter paved roads No sediment, mud, or rock on paved public roads in project area Dust control if needed when working in residential areas during dry conditions Inspection of all controls weekly and after each rain exceeding ½ inch during construction
Drainage Management	Upland runoff diverted around or through bare soil areas below with lined ditches or grassed berms Drainage channels exiting the site are seeded & stable, with no muddy flow after rains Discharges from dewatering operations cleaned in silt fence enclosure or filtered No unmanaged muddy runoff leaving site after rains up to 1½ inches
Erosion Protection for Bare Soil Areas	Exposed soil areas seeded after two weeks if no work is planned for next 7 days Soils on flat ground or moderate slopes seeded at approved rate Soils on steep slopes stabilized with seed and mulch and/or other erosion control products

EPSC Practices	Field Indicators for Compliance
Sediment Filters	Silt fence, rock filter, or other sediment control below all bare soil areas Sediment filter installed across slope on the contour, trenched in, posts on downhill side Silt fence posts are 6 feet apart or closer; ends of fence turned uphill Multiple sediment filters 110 feet or less apart on unseeded slopes steeper than 4:1 J-hook interceptors along silt fence where muddy runoff flows along fencing No visible undercutting or bypassing of sediment filter, failures found and repaired promptly
Slope Protection	Slopes tracked, disked, or conditioned after final grade is established Slopes seeded, mulched, or covered with blankets within 21 days, no unmanaged gullying Heavy downslope flows controlled by lined downdrain channels or slope drain pipes No gullies, no muddy runoff from slopes entering streams, rivers, lakes, or wetlands
Inlet Ponding Dams	Ponding structure located at storm drain, culvert, and channel inlets receiving muddy flows No visible undercutting, overtopping, or bypassing of inlet ponding structure Accumulated sediment is less than halfway to the top of the ponding structure
Outlet Protection	High flow discharges have rock or other flow dissipaters of adequate sizing at outlet Channel and culvert outlet areas show no visible signs of erosion, bank failure, or collapse Outlet discharging to lined, stable ditch or vegetated area

Kentucky Erosion Prevention and Sediment Control • Construction Site Inspection Checklist (continued)

EPSC Practices	Field Indicators for Compliance
Ditch Stabilization	No unmanaged ditch bank erosion or bottom scouring visible within or below site Ditches with slopes greater than 3% have silt checks, spaced closer as slope increases Ditches with slopes up to 3% are thickly seeded with grass Ditches 3% to 10% are lined with thick grass and erosion control blankets Ditches 10% to 20% are lined with thick grass and turf mats or other approved product Ditches exceeding 20% are lined with rock, concrete, or other approved erosion control products
Sediment Traps and Basins	Storage volume is at least 134 cubic yards for each acre of bare soil area drained Outlet structure is stable and consists of rock lined overflow or outlet riser pipe Rock overflow has 6” depression to control discharges; discharge area is stable Outlet riser pipe has concrete & rock base, ½ inch holes every 3” to 6”, and trash rack
Maintenance of EPSC Management Practices	Sediment behind silt fence and other filters does not reach halfway to top Sediment traps and basins are less than half full of sediment Gullies noted and repaired, silt fences and other controls inspected and repaired/replaced Written documentation of controls installed, inspection results, and repairs performed All controls removed and control areas graded, seeded, and stabilized before leaving site Regulatory requirements for storm water permitting, etc. addressed as needed

APPENDIX H

Kentucky Construction Site Inspection Report

Kentucky Erosion and Sediment Control Permit Compliance Inspection Report

General Site Information:

COMPANY:	**COUNTY:**
SITE:	**DATE:**

Permit Compliance Information:

Copy of permit kept on site	Yes	No
Copy of Best Management Practices (BMP) Plan kept on site		
Site specific description of project timing/ phasing and implementation		
Adequate site map showing:		
• Drainage patterns indicated on plan		
• Receiving waters (stream, river, lake, wetland, etc.) named		
• Approximate slopes after major grading		
• Area of soil disturbance		
• Undisturbed areas and vegetative buffer zones		
• Location of structural and non-structural controls (BMPs)		
• Areas where stabilization practices are to be employed		
• Storm water discharge locations		

Specific Site Information:

Name of receiving stream:	
Total area of site:	
Area disturbed:	

Inspection Results:

Inspection Criteria: Satisfactory, Marginal, Unsatisfactory	**S**	**M**	**U**
Condition of receiving stream			
Is BMP Plan adequately implemented?			
Timely seeding and mulching			
• Revegetation on cut/fill/cleared areas			
• Condition of slope areas			

Structural Controls			
• Drainage ditch protection/liners installed			
• Inlet protection for curb drains, etc.			
• Outlet protection—no erosion or scour			
• Silt fences below bare soil areas			
• Rock check dams in ditches			
• Sediment traps/ponds maintained			
• Other controls			
Other Controls			
• Secondary containment for fuel; maintenance area designated			
• Proper disposal of concrete wastes; wash in designated area			
• Other (non-storm water discharge, etc.)			
• Off-site tracking of sediment prevented			
Compliance with State and Local Regulations			
• Waste, fertilizer, paint, pesticide/herbicide storage and disposal			
• Proper sewage management			
Operation and Maintenance of BMPs			
• Maintenance plan incorporated into written BMP Plan			
• Maintenance plan followed			
• Maintenance documented			
• Inspections done as required and documented			
• Inspection reports completed and maintained on site, in file			
Contractor Certification on File			
Plan Certification on File			

Comments:

Inspector's Signature

This publication was produced by Tetra Tech with support from the Kentucky Environmental and Public Protection Cabinet. Illustrations were developed by Emily Faalasli of Tetra Tech; photographs were provided by the Kentucky Transportation Cabinet, the Upper Chattahoochee Riverkeeper, and Tetra Tech. Barry Tonning of Tetra Tech was the principal author and project manager, with technical support from Richard Walker, John Kosco, and William Marshall of Tetra Tech.