PDHonline Course C534 (4 PDH)

Construction Stormwater Runoff - Sediment Controls

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SECTION 4: SEDIMENT CONTROLS

Fabric Drop Inlet Protection

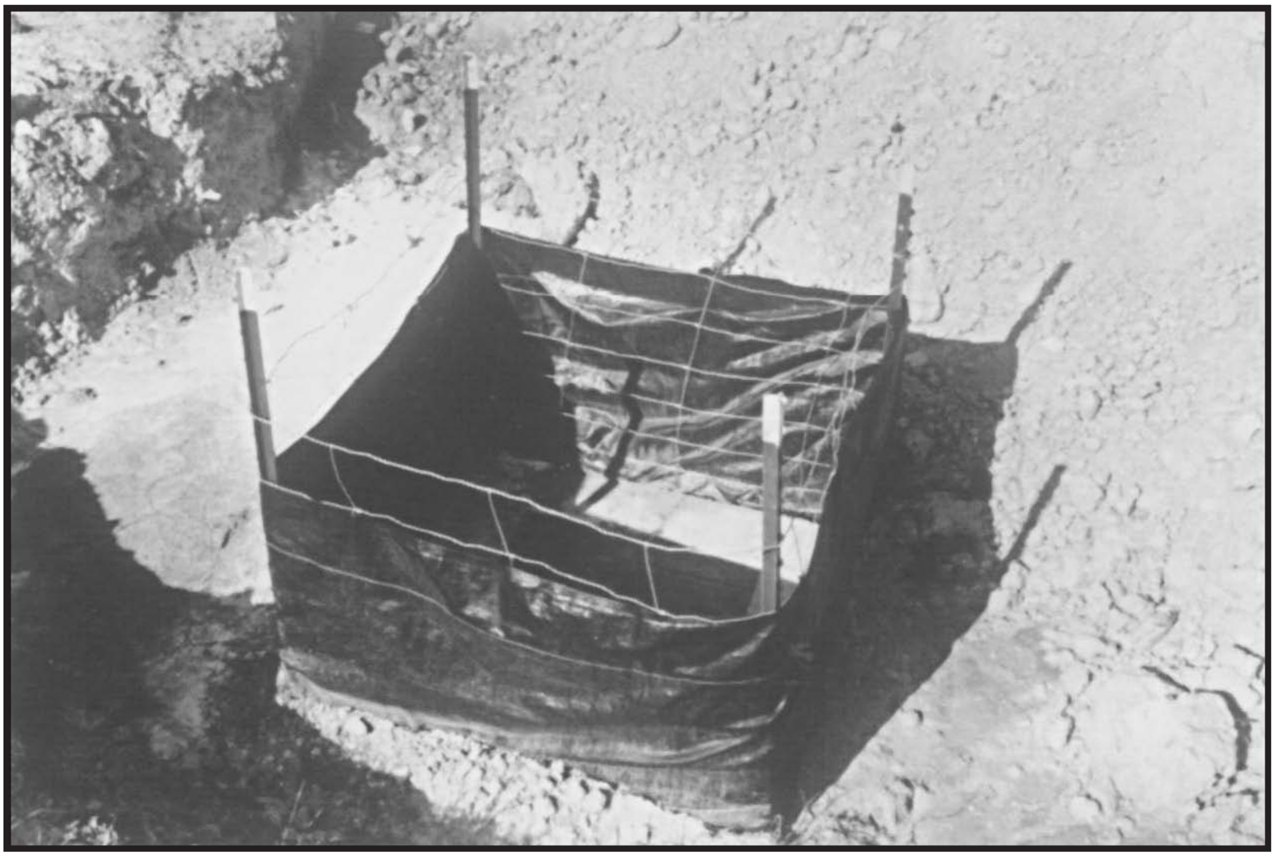

Figure 6.40 Filter fabric is only one way of protecting storm water inlets from siltation early in the grading process.

Practice Description

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

Recommended Minimum Requirements

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

Drainage area

Less than 1 acre per inlet.

Capacity

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

Height of Fabric

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

Approach

Less than 1 percent slope.

Sediment Storage

Generally 35 yard^3/disturbed acre/year for watershed slopes of under 8 percent; 100 yard^3/disturbed acre/year for slopes more than 8 percent.

Support Posts

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

Fabric

Durable, high-strength synthetic woven fabric.

Framing

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

Stakes

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

Approach

Less than 1 percent slope.

Sediment Storage

Generally 35 yard^3/disturbed acre/year for watershed slopes of under 8 percent; 100 yard^3/disturbed acre/year for slopes more than 8 percent.

Support Posts

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

Fabric

Durable, high-strength synthetic woven fabric.

Framing

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

Stakes

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

Safety

Provide protection to prevent children from entering the inlet and outlet.

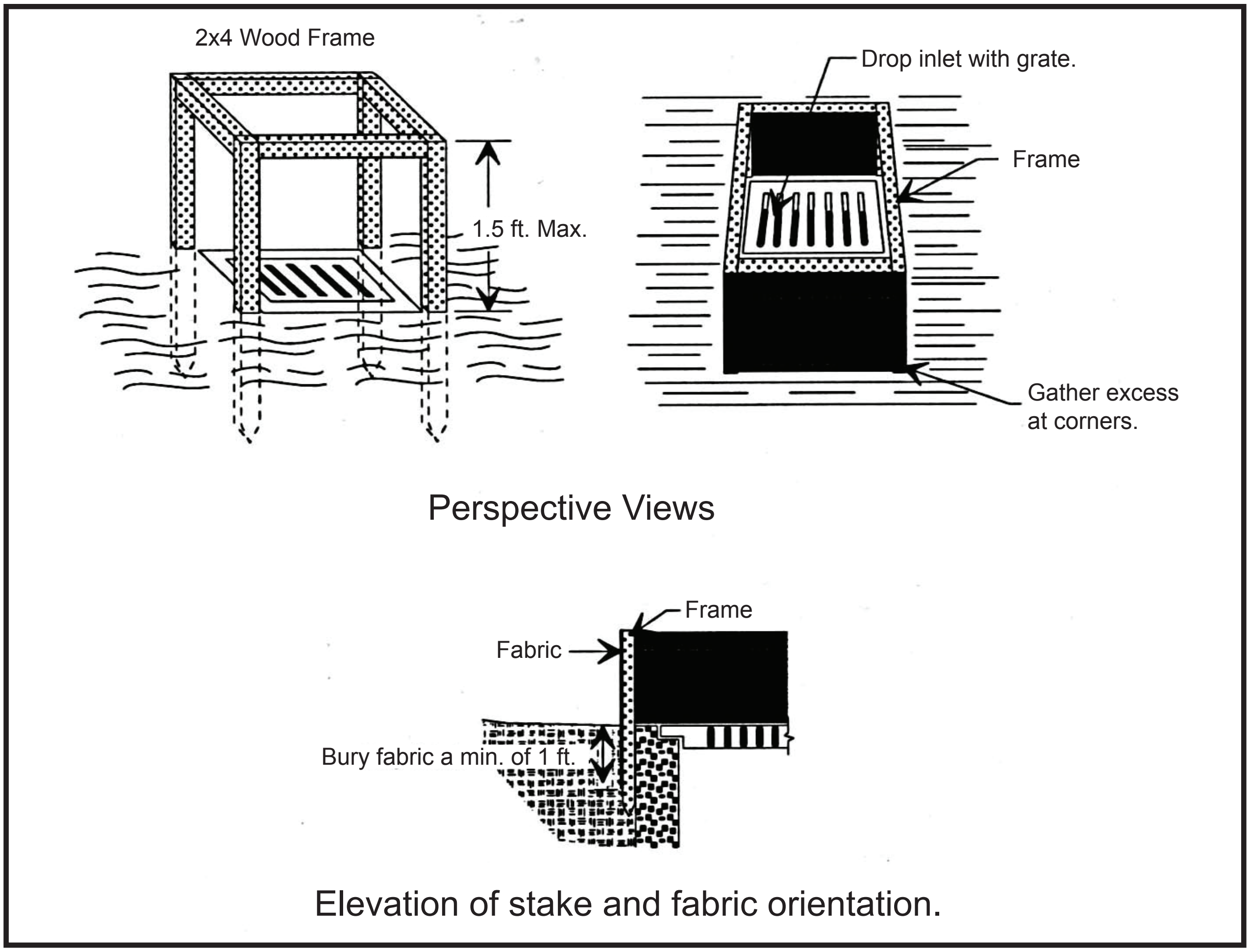

Figure 6.41 Fabric Drop Inlet Protection

Construction

- Space stakes evenly around the perimeter of the inlet a maximum of 3-feet apart and securely drive them into the ground, approximately 18-inches deep.
- To provide needed stability to the installation, frame with 2 x 4 inch wood strips or other suitable materials around the crest of the overflow area at a maximum of 18-inches above the drop inlet crest.
- If possible, cut fabric from one continuous roll to eliminate joints.
- Place the bottom 12-inches of the fabric in a trench and backfill the trench with crushed stone or compacted soil.
- Fasten the fabric securely to the stakes and frame. Joints should be overlapped to the next stake.
- Optional: Wire fence may be used to support the fabric. The wire should be 14-gage minimum with maximum mesh spacing of 6-inches. The top of the fence should be level, and the bottom should be buried at least 6-inches below ground surface.
- The top of the frame and fabric must be well below the ground elevation downslope from the drop inlet to keep runoff from bypassing the inlet. It may be necessary to build a temporary dike on the downslope side of the structure to prevent bypass flow. Material from within the sediment pool may be used for dike construction.

Stabilization
Stabilize all bare areas around the inlet.

Construction Verification
Check finished grades and dimensions of fabric drop inlet protection structures.
Verify sturdiness of frame construction.

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

- Variations in topography on-site indicate fabric drop inlet protection will not function as intended; changes in plan may be needed.
- Design specifications for posts, fabric or fencing cannot be met; substitution may be required. Unapproved substitutions could result in failure of the structure.
- Fabric clogs or creates flooding due to ponding of storm water flows.

Maintenance, Inspection and Removal
- Inspect fabric barrier and frame weekly and after each rainfall event and make needed repairs immediately.
- Remove sediment from the pool area as necessary to restore required storage volume for the next rain. Take care not to damage or undercut the fabric during the sediment removal.
- When the contributing drainage area has been adequately stabilized, remove all materials and unstable sediment and dispose of properly in an upland area to dry and be stabilized. Bring the disturbed area to the grade of the drop inlet; smooth and compact it.
- Remove the temporary fabric drop inlet protection stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	Solution
Overtopping of fence; caused by posts and fabric unsupported at top.	Repair frame as necessary and use frame to support tops of post and fence to support fabric.
Undercutting of fence; caused by fabric not properly buried at bottom.	Use proper installation to bury fabric (see Figure 5.44)
Inadequate storage volume for the next storm; caused by sediment not being removed from pool.	Remove sediment as needed to prevent build-up.
Flow bypassing the inlet; caused by top of fabric set too high.	Lower top of fabric or select other inlet protection device.
Erosion and undercutting of inlet; caused by fence not close enough to inlet.	Relocate fence adjacent to inlet.
High flow velocity and poor trapping efficiency; caused by steep slopes at drain inlet.	Flatten slope at inlet.
Flooding; high water ponding around inlet; caused by improper selection of best management practice.	Reevaluate appropriate best management practice inlet protection device.

Excavated Drop Inlet Protection

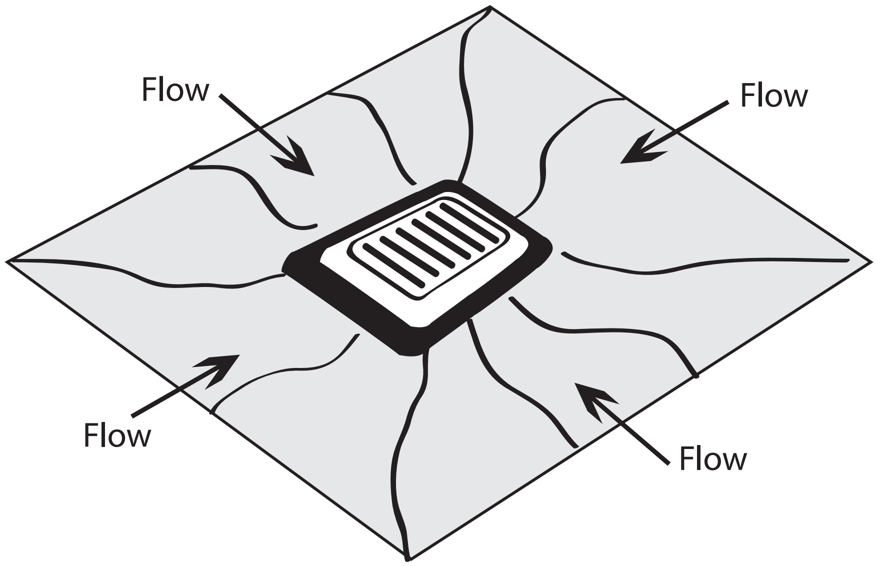

Figure 6.42 Perspective of Excavated Drop Inlet Protection

Practice Description

An excavated area in the approach to a storm drain drop inlet or curb inlet. The purpose is to trap sediment at the approach to the storm drainage system and not permit sediment to flow into the storm drain. This practice applies where early use of the storm drain system is necessary.

Recommended Minimum Requirements

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

Drainage Area

Less than 1 acre per inlet.

Capacity

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

Minimum Depth

One foot, as measured from the top of the drop inlet.

Maximum Depth

Two feet, as measured from the top of the drop inlet.

Side Slopes

Side slopes at 2:1 or flatter around the excavation.

Dewatering

Place drain holes in drop inlet, covered with wire screen and gravel.

Gravel

Use clean gravel, 1/2- to 3/4-inches in diameter.

Sediment Storage
Keep the minimum volume of excavated material around the drop inlet at approximately 35 yd^3/ disturbed acre.

Basin Shape
To fit site conditions, with the longest dimension placed toward the longest inflow area to provide maximum settling efficiency. Try to keep the slopes less than 2:1 and allow access for excavation equipment for sediment removal, if possible.

Drain
Install provision for draining the temporary pool to improve trapping efficiency for small storms and to avoid problems from standing water after heavy rains.

Safety
Provide protection to prevent children from entering the inlet or outlet.

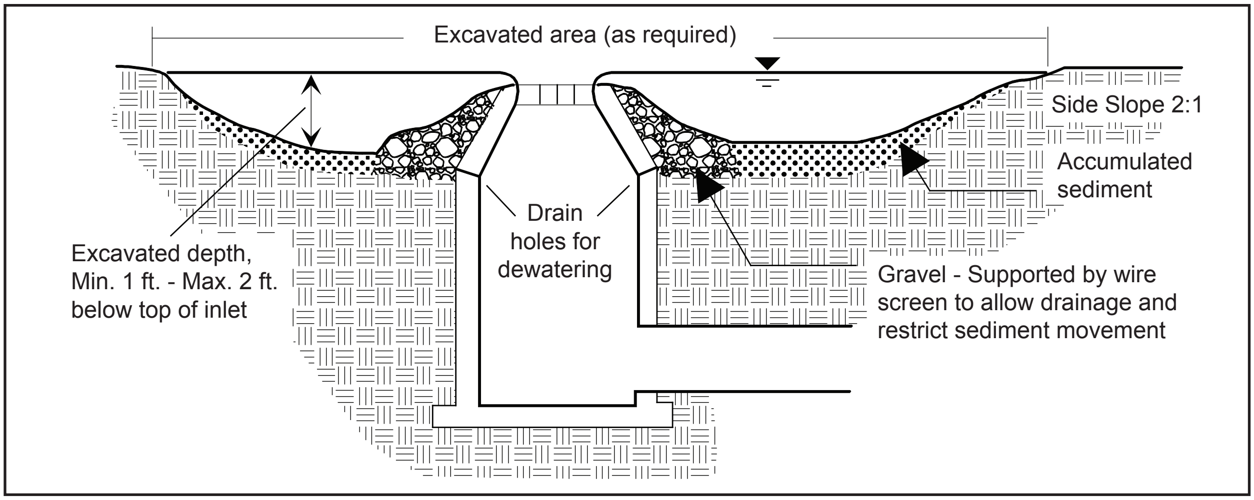

Figure 6.43 Cross section of Excavated Drop Inlet Protection

Construction
Site Preparation
- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Clear the area of all debris that might hinder excavation and disposal of spoil.
- Excavate the basin to the depth, side slopes and dimensions shown on the plans.
- Grade the approach to the inlet uniformly.
- Install drain holes in the drop inlet to drain pool slowly. Cover holes with wire screen and place gravel around sides of inlet.
- When necessary, spoil may be placed to form a dike on the downstream side of the excavation to prevent bypass flow.

Erosion Control
Stabilize disturbed areas, except the excavated pool bottom, in accordance with vegetation plan.

Construction Verification
Check finished grades and dimensions of excavated drop inlet protection structures.

Troubleshooting

Consult with a registered design professional if the following occurs:

- Variations in topography on-site indicate excavated drop inlet protection will not function as intended; changes in plan may be needed.

Maintenance, Inspection and Removal

- Inspect, clean and properly maintain the excavated basin after every storm as needed until the contributing drainage area has been permanently stabilized. While removing sediment from around inlet, do not allow accumulated sediment to discharge into unprotected inlet.
- Remove sediment when the excavated volume is approximately one-half full.
- Spread all excavated material evenly over the surrounding land area or stockpile and stabilize it appropriately.
- When the contributing drainage area has been permanently stabilized, seal drain holes, fill the basin with stable soil to final grading elevations, compact it properly, and establish vegetation or provide other means of protection.
- Remove the temporary excavated drop inlet protection stabilize the site prior to filing *Form H: Request for Termination of a General Permit, Form--MO 780-1409* (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	**Solution**
Sediment entering drain; caused by sediment producing area too large for basin design or inlet not properly maintained.	Enlarge basin and maintain inlet (remove sediment, refresh filter fabric and rock).
Excessive ponding; caused by gravel over drain holes plugged with sediment.	Remove debris, clear sediment and replace gravel.
Flooding and erosion; caused by blockage of the storm drain from debris entering inlet.	Install trash rack around inlet.

Block and Gravel Inlet Protection

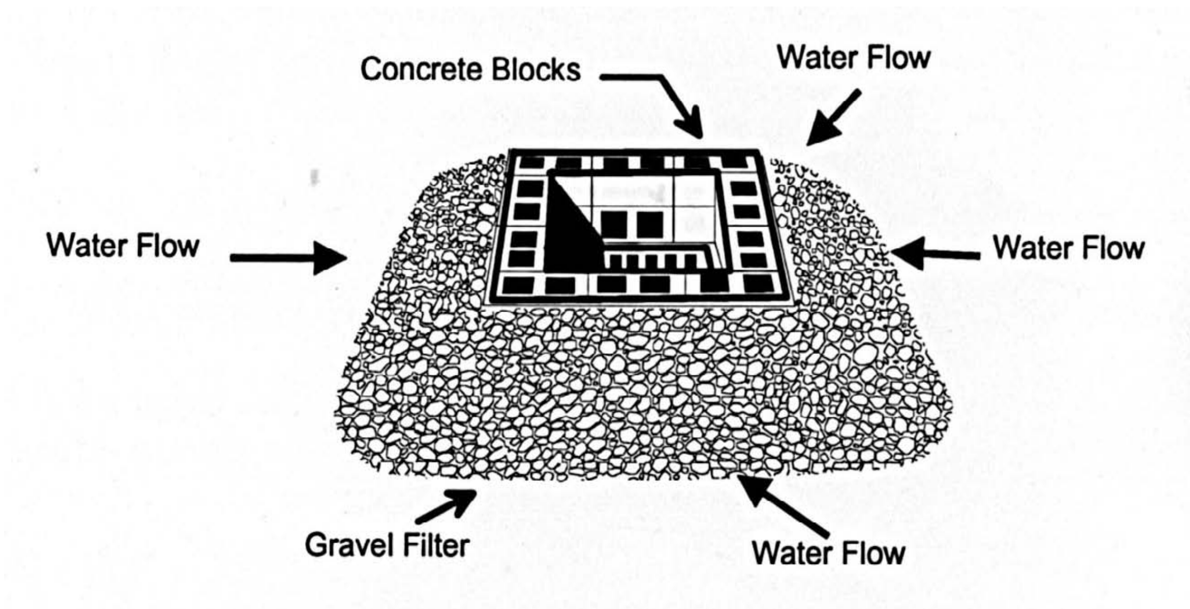

Figure 6.44 Detail of block and gravel drop inlet

Practice Description

Block and gravel inlet protection is a sediment control barrier formed around a storm drain inlet by the use of standard concrete block and gravel. The purpose is to help prevent sediment from entering storm drains before the disturbed construction area is revegetated and stabilized. This practice applies where early use of the storm drain system is necessary.

Recommended Minimum Requirements

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

Drainage Area

Less than 1 acre.

Capacity

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

Height

Height of barrier should be between 1 and 2 feet. Be aware of potential ponding issues and provide emergency overflows to prevent possible excessive flooding.

Side Slopes

Gravel placed around the concrete block structure should have side slopes of 2:1 or flatter.

Dewatering

Some blocks in bottom row should be placed on their side for drainage.

Gravel
Use clean gravel, 1/2- to 3/4-inches in diameter. Place hardware cloth or comparable wire mesh with half inch openings over all block openings to hold gravel in place.

Safety
Provide protection to prevent children from entering the pipe inlet.

The top elevation of the structure must be at least 6-inches lower than the ground elevation downslope from the inlet. It is important that all storm flows pass over the structure and into the storm drain and not past the structure. Temporary dikes below the structure may be necessary to prevent bypass flow. Material may be excavated from inside the sediment pool for this purpose.

Construction
- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Clear area of all debris that might hinder excavation and disposal of spoil.
- Grade the approach to the inlet uniformly.
- Lay one block on its side in the bottom row on each side of the structure to allow pool drainage. The foundation should be excavated at least 2-inches below the crest of the storm drain. Place the bottom row of blocks against the edge of the storm drain for lateral support and to avoid washouts when overflow occurs. If needed, give lateral support to subsequent rows by placing 2 x 4 inch wood studs through block openings.
- Carefully fit hardware cloth or comparable wire mesh with half inch openings over all block openings to hold gravel.
- Place gravel around blocks on a 2:1 slope or flatter, 2-inches below the top of the blocks, and smooth to an even grade.

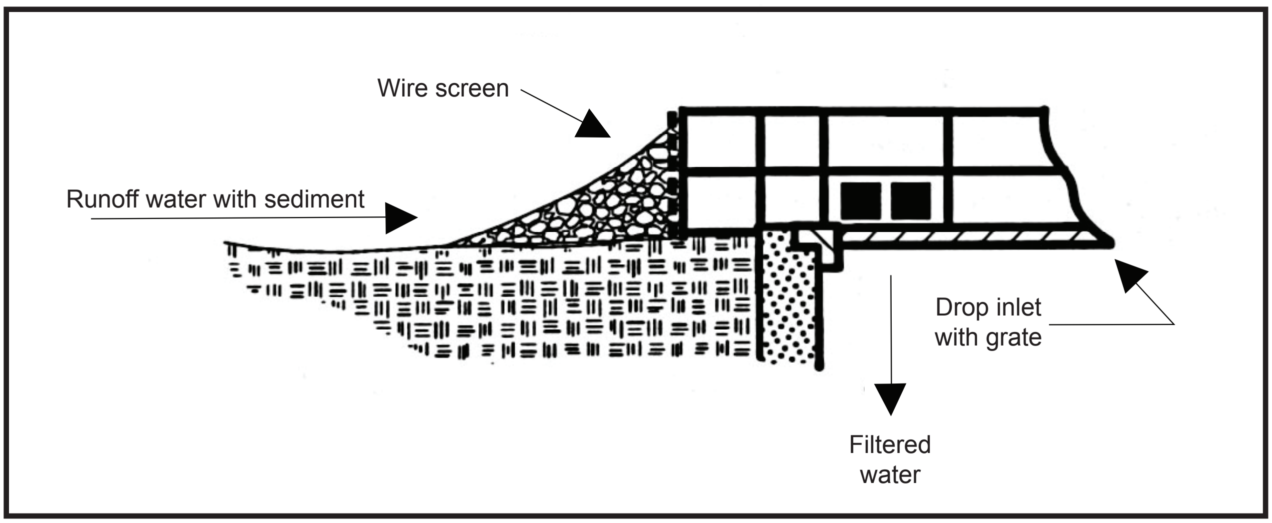

Figure 6.45 Cross section detail of block and gravel drop inlet.

Erosion Control
Stabilize disturbed areas in accordance with the vegetation plan.

Construction Verification
Check finished grades, material sizing and dimensions of block and gravel drop inlet protection structures.

Troubleshooting

Consult with registered design professional if variations in topography on-site indicate block and gravel drop inlet protection will not function as intended; changes in plan may be needed.

Maintenance, Inspection and Removal

- Inspect the barrier after each rain and make repairs as needed.
- Remove sediment as necessary to provide adequate storage volume for subsequent rains and replace gravel surrounding the inlet as it fills with sediment.
- When the contributing drainage area has been adequately stabilized, remove all materials and any unstable soil, and salvage or dispose of it properly. Bring the disturbed area to proper grade, then smooth and compact it. Appropriately stabilize all bare areas around the inlet.
- Remove the temporary block and gravel inlet protection stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	Solution
Bypass flow and erosion; caused by top of structure being too high.	Lower height of structure.
Scour; caused by blocks not placed firmly against the storm drain inlet.	Reset blocks firmly against drain inlet.
Poor trap efficiency or sediment overload; caused by too large of a drainage area.	Increase size of temporary sediment pool.
Poor trap efficiency; caused high flow velocity due to too steep of an approach to the drain.	Use excavated basin (see Excavated Drop Inlet Protection).
Sediment entering the storm drain; caused by sediment not being removed promptly.	Remove sediment promptly following storms.

Domed Inlet Protection

Figure 6.46 These are the two parts to this domed inlet device. Here it is secured to the ground weighted with gravel.
Source: Silt Saver Inc.

Definition and Purpose

This domed inlet protection device has two parts. There is a reusable HDPE (high-density polyethylene) frame and a hat that fits over the frame made primarily of two fabrics, a non-woven geotextile on the lower part and an open weave geotextile on the upper part. The open weave will allow for stormwater discharging quicker and reducing depth of ponded water. The frame has super stress crack resistance combined with high impact strength and rigidity. The base can be either round or square depending on the configuration of your storm sewer inlet openings.

Recommended Minimum Requirements

These inlet protection devices should be installed immediately after the storm sewer is constructed so stub openings can be protected before the next storm event.

Construction

These devices are manufactured and purchased from area distributors. The device should be installed over the opening and small stone or sand bags placed in the pockets at the bottom of the geotextile cover to keep the cover in place over the rigid cap.

Maintenance, Inspection and Removal

- Inspect each inlet protection device weekly and after rain events. Clean any sediment accumulation and dispose of sediment in a proper manner.
- Replace the geotextile cover if it is torn or damaged.
- While inspecting and cleaning inlet, do not allow accumulated sediment to discharge into unprotected inlet.
- Removal of this temporary domed inlet protection must be performed and the site stabilized prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	**Solution**
Any inlet protection device has the potential to create ponding. Protection devices that completely block the inlet or reduce the flow to the inlet can cause flooding or bypass of the storm flow to the next inlet down stream of the protected inlet.	Choose the inlet protection device according to the specific situation on your construction site.
Flooding during storm event; caused by the inlet device being completely blocked.	Choose the appropriate inlet protection device according to the situation on your site and provide routine and adequate maintenance.

Inlet Bag or Insert

Figure 6.47 Inlet Bag goes around grate.
Source: Dandy Products Inc.

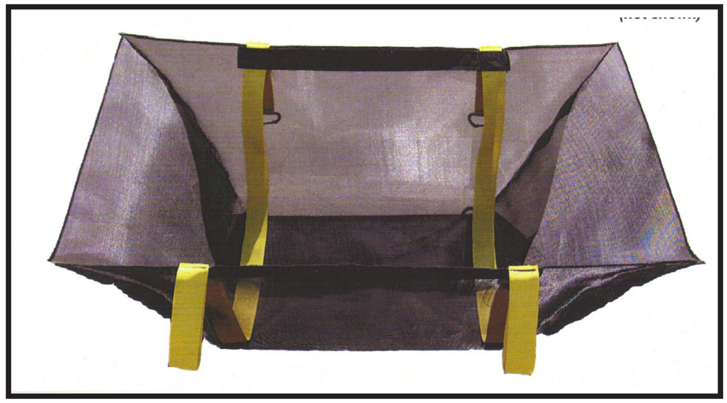

Figure 6.48 Inlet protection insert goes inside the storm drain.
Source: Pollution Solution Inc.

Practice Description

Inlet bags or inserts are inlet protection devices that are manufactured in a bag or sack form and completely cover or surround the inlet grate or fit around the grate and are suspended below the grate to collect the sediment within the storm sewer pipe. Most often the material is a geotextile but can be made of many types of materials. Some of these products are inlet bags that go around the grate or inserts that go inside the storm drain.

To provide some protection against excessive ponding, some manufacturers incorporate overflow tubes in their design that allow storm water to bypass through the bag or insert if the ponding level reaches a certain height.

Recommended Minimum Requirements

All storm sewer inlets that discharge stormwater off-site must be protected to treat the storm water discharge before it exits the construction site. Partially or completely blocking the inlet with a sediment control device will create ponding and possible bypasss or flooding. Keep this in mind when selecting which protection device you choose.

Construction

These products are manufactured and you must follow manufactures requirements for installation and maintenance.

Maintenance, Inspections and Removal

- Inspect each device weekly and after each storm event. Remove accumulated sediment around or in device and then wash device to clear it of sediment and replace it on or into the storm sewer inlet. While cleaning devise, do not allow sediment to discharge into the unprotected inlet.
- Remove the temporary inlet bag or insert and stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Troubleshooting

Bypass and flooding are the two largest issues with inlet protection devices. Select the device that best fits the situation you have on your construction site knowing you may need to change devices during different stages of construction.

Common Problems and Solutions

Problem	Solution
Flooding during storm event; caused by the inlet device being completely blocked.	Choose the appropriate inlet protection device according to the situation you have on your site and provide routine and adequate maintenance.

Figure 6.49 Inlet cover with opening for overflow.

Sediment Fence

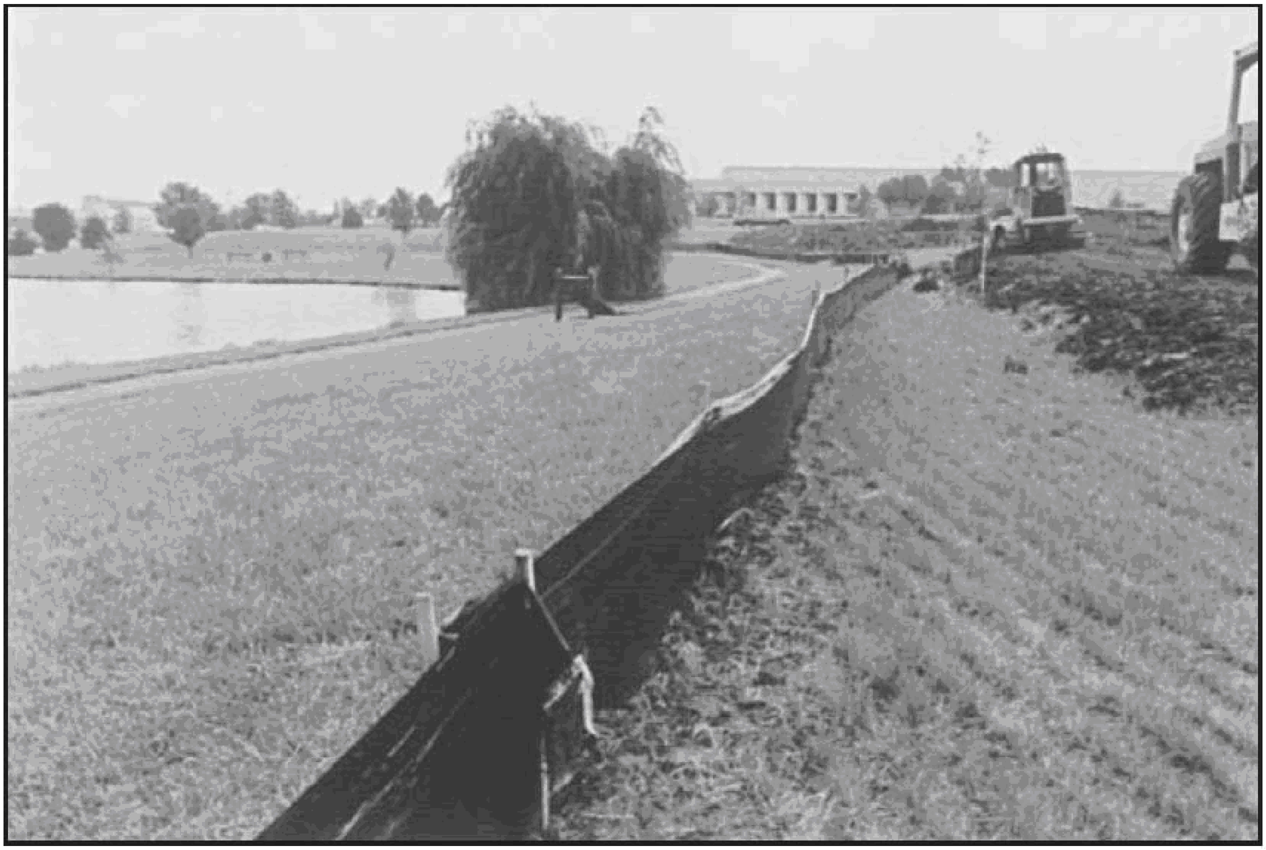

Figure 6.50 A properly installed sediment fence slows water flow long enough for the sediment to settle out. There should be no gaps under fence if heeled in properly. Source: C. Rahm, NRCS. Platte Co.

Practice Description

A sediment fence (often called a silt fence) is a temporary sediment barrier consisting of a geotextile fabric that is attached to supporting posts and trenched into the ground. Sediment-laden runoff ponds uphill from the sediment fence and runoff is temporarily stored to allow sediment to settle out of the water.

This practice applies where sheet erosion occurs on small disturbed areas. Sediment fences are intended to intercept and detain small amounts of sediment from disturbed areas in order to prevent sediment from leaving the site. Sediment fences can also prevent sheet erosion by decreasing the velocity of the runoff. Silt fence is not intended to be used in concentrated flow paths.

Recommended Minimum Requirements

Prior to start of construction, sediment fence placement and installment methods should be designed by a qualified professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Drainage Area

Limit to ¼ acre per 100 feet of fence. Further restrict the area by slope steepness as shown in Table 5.16.

Location

Fence should be built on a nearly level grade and at least 10 feet from the toe of the slope to provide a broad shallow sediment pool. Install on the contour, where fence can intercept runoff as a sheet flow; not located crossing channels, waterways or other concentrated flow paths; not attached to existing trees; and not located vertically up the slope (at a right angle to the slope.)

J-Hook

Silt fence should not be used around the entire perimeter of the site unless it is a small, flat site. It should only be located at areas where stormwater flow discharges with overland or sheet flow. You can use silt fence to create small catchments of stormwater flow by creating a small J-hook shape with the silt fence. The drainage area should be less than ¼ acre with little or no slope (see Figure 3.83).

Length

Maximum of 600 feet; flare ends of fence uphill to temporarily impound water as shown in Figure 5.32.

Geotextile

Commercially available silt fence fabric is almost exclusively woven geotextile fabric. Non-woven material has better flow through but poorer strength. A higher porosity geotextile would be a mono-filament fabric with larger voids between the woven threads.

Table 6.14 Typical Land Slope and Distance for Sediment Fence

Land Slope (percent)	Maximum Slope Distance* above Fence (feet)
Less than 2	100
2 to 5	75
5 to 10 greater than 10	50*

*** Follow manufacturers' recommendations for proper spacing.**

Spacing of Support Posts

A good minimum stand is 6-feet maximum for geotextile fabric supported by wire and 5-feet maximum for geotextile fabric without supportive wire backing. Follow the local design standards in your area and the site SWPPP.

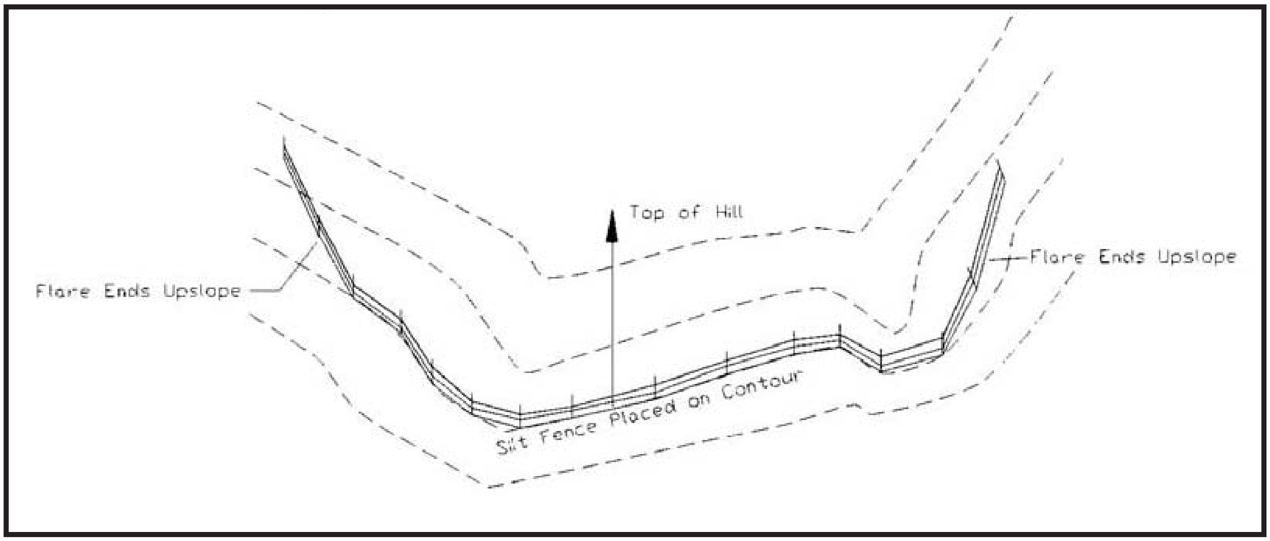

Figure 6.51 Placement of sediment fence

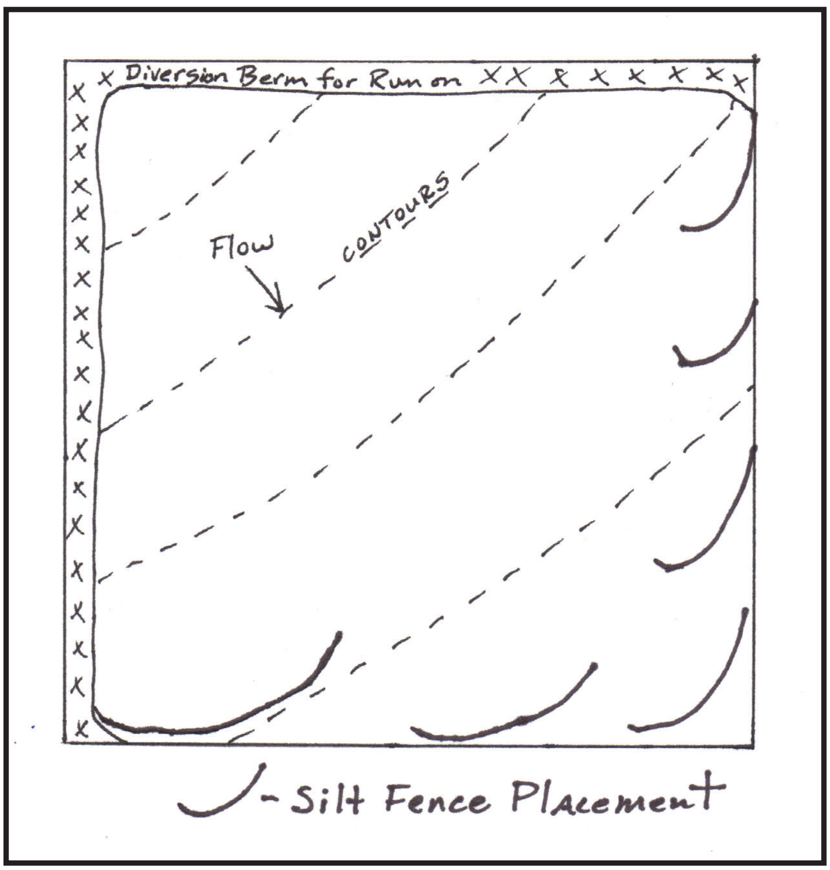

Figure 6.52 Placement of J-hook silt fence along the perimeter of a construction site to slow and pond small areas of stormwater runoff.

Proper Installation of Silt Fence

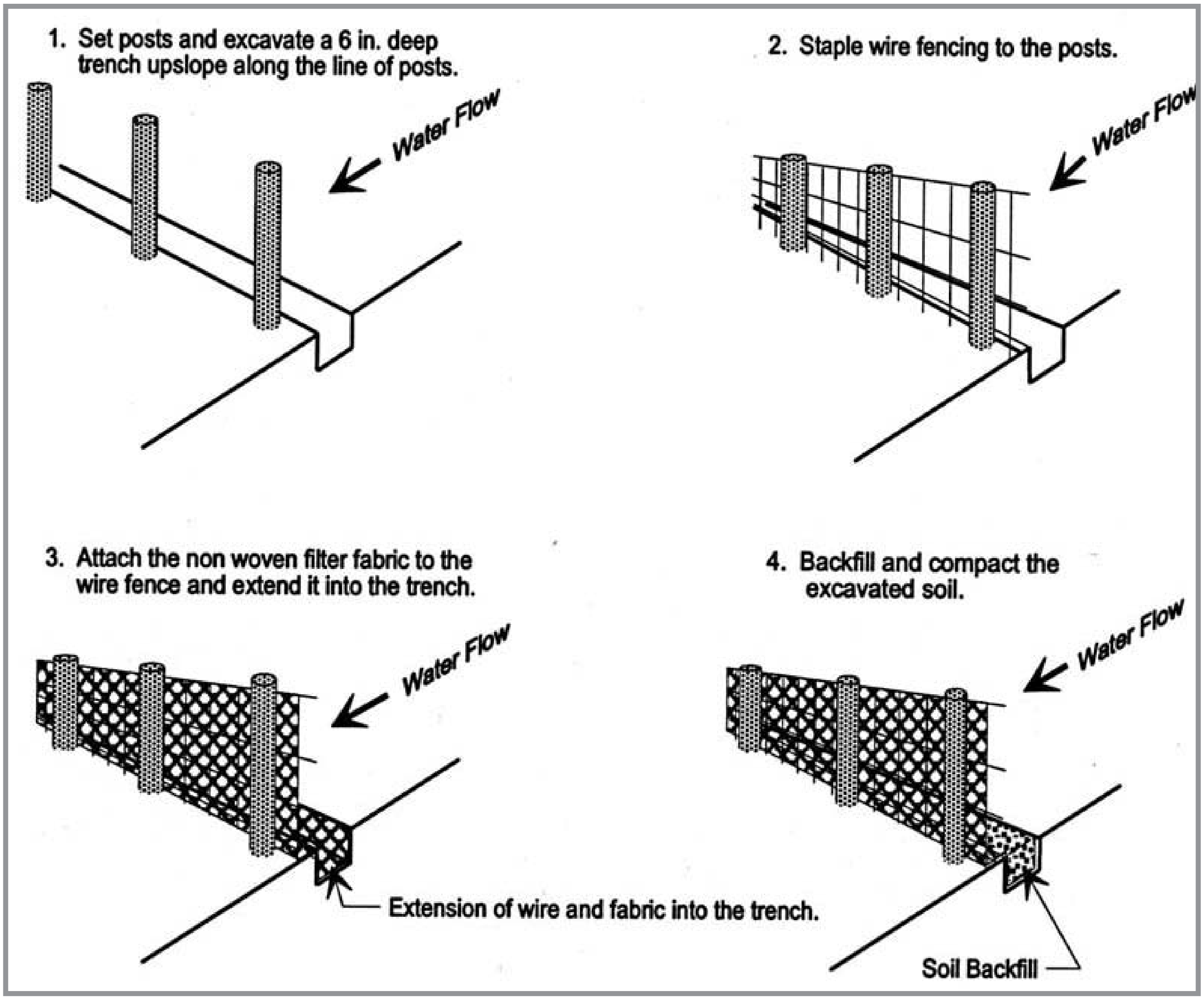

Figure 6.53 Proper Installation of silt fence

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Grade alignment of fence as needed to provide broad, nearly level area upstream of fence.

Fence Installation

- Dig a trench at least 6-inches deep along the fence alignment as shown in Figure 5.84.
- Drive hard wood or steel posts at least 24-nches into the ground on the downslope side of the trench. Space posts a maximum of 6-feet if fence is supported by wire, or 5-feet if no reinforcing wire fence is used.
- Fasten support wire fence to upslope side of posts, extending 6-inches into the trench as shown in Figure 5.84.
- Attach continuous length of fabric to upslope side of fence posts. Try to minimize the number of joints. Avoid joints at low points in the fence line. Where joints are necessary, fasten fabric securely to support posts and overlap to the next post.

- Place the bottom 1-foot of fabric in the 6-inch deep trench (minimum), lapping toward the upslope side. Backfill with compacted earth or gravel as shown in Figure 5.85.
- To reduce maintenance, excavate a shallow sediment storage area in the upslope side of the fence.
- Provide good access in areas of heavy sedimentation for clean out and maintenance.

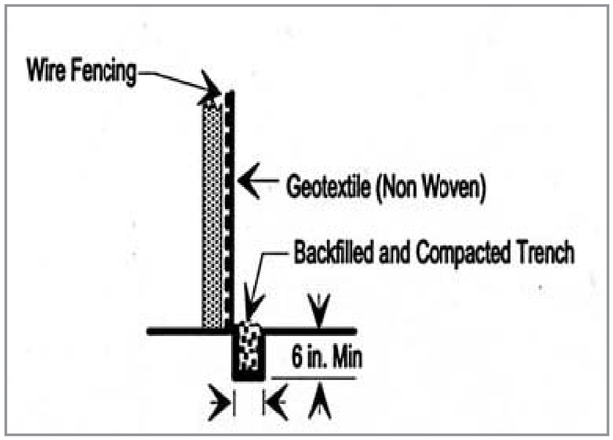

Figure 6.54 Detail of sediment fence installation

Reinforced Stabilized Outlet Installation

- Allow for safe bypass of storm flow to prevent overtopping failure of fence.
- Set outlet elevation so water depth cannot exceed 1.5 feet at the lowest point along the fence.
- Drive posts securely at least 24 inches into the ground, at a spacing of 5- to 6-feet depending on the use of wire fence reinforcement or not. Install a horizontal brace between the support posts to serve as an overflow weir and to support the top of the fabric.
- Immediately downslope of the fabric, excavate foundation for splashpad a minimum of 5-feet wide, 5-feet long and 1-foot deep. Place 1-foot of riprap in the excavated foundation. The surface of the riprap should be flush with the undisturbed ground (no outfall).

Erosion Control

Stabilize disturbed areas in accordance with landscape plan.

Construction Verification

Check finished grades and dimensions of the sediment fence. Check materials for compliance with specifications.

Maintenance, Inspection and Removal

Inspect sediment fences at least once a week and after each rainfall as dictated by your permit. Make any required repairs immediately.

- Immediately replace the fabric of the sediment fence should it collapse, tear, decompose or become ineffective.
- Remove sediment deposits as necessary to provide adequate storage volume for the next rain event and to reduce pressure on the fence. Take care to avoid damaging or undermining the fence during cleanout.
- Remove all fencing materials and unstable sediment deposits and bring the area to grade and stabilize it after the contributing drainage area has been properly stabilized.
- Remove the temporary sediment fence and stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Troubleshooting

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

- Variations in topography on-site indicate sediment fence will not function as intended; changes in the plan may be needed.
- Design specifications for geotextile fabric, support posts, support fence, gravel or riprap cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.
- Fence is not installed on the contour or is installed across channels or other concentrated flow areas.
- Installation of sediment fence as designed appears to create a potential flooding hazard or directs runoff overflows into sensitive ecological areas.

Common Problems and Solutions

Problem	Solution
Overtopping, sagging or collapse of fence occurs; caused by the drainage area too large or too much sediment accumulation allowed before cleanout.	Increase sediment storage capacity upslope of fence or remove accumulation more frequently, then repair fence.
Collapse of fence due to high velocity or undercutting of fence; caused by approach too steep.	Reduce slope of approach area, or consult with a registered design professional.
Sagging or collapse of fence; caused by fence not adequately supported.	Add additional supports.
Undercutting of fence; caused by the bottom of fence not buried properly.	Reinstall fence using proper method of trenching.
Sagging, collapse or undercutting of fence; fence installed across drainage way.	Relocate fence away from drainage way. Silt fence should only be used adjacent to drainageway; other devices should be used across or within drainageway (see Rock Check Dam or Ditch Check).
Water runs on both sides of fence; fence installed vertically or at right angle to contour.	Relocate fence along contours.

Fence should never be used as a check dam or in concentrated flow paths.

Temporary Diversions

Figure 6.55 An unfinished temporary diversion routes sediment-laden storm water to a sediment basin. Temporary diversions should be shaped and protected with a turf reinforcement mat or rock. Establish permanent vegetation if the diversion will be used for one year or more. Source: K. Grimes, Soil and Water Conservation District. St. Charles Co.

Practice Description

A temporary diversion is a temporary ridge or excavated channel or combination ridge and channel. It is designed to either prevent runoff from flowing across the active construction site work areas and discharge it through stable, protected outlets or to divert sediment laden water to sediment traps. Temporary diversions are usually constructed by excavating a channel and using the excavated material to construct a ridge on the down slope side of the channel.

This practice applies wherever storm water runoff must be temporarily diverted to protect disturbed areas and slopes or to retain sediment on-site during construction. When a diversion is needed to direct runoff from undisturbed areas above the construction site around a disturbed area, it must be routed to a stabilized outlet. The diversion must be fully stabilized and non-erodible prior to receivingstorm water flows. Check dams may be installed within the diversion to reduce velocities and control flows better. A diversion of cleanstorm water flow should never be allowed to flow over disturbed areas and create erosion or pick up sediment in the flow. If the untreated flow mixes with sediment ladenstorm water on the construction site, it must be treated through a control device before it discharges off-site.

Recommended Minimum Requirements

Prior to start of construction, temporary diversions should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. Temporary diversions should be constructed to minimize erosion at the design flow.

Drainage Area

Less than 5 acres.

Ridge Design

- Side Slope: 2:1 or flatter; 3:1 or flatter where vehicles must cross.
- Top Width: 2.0 ft.
- Freeboard: 0.3 ft.
- Settlement: 10 percent of fill height.

Channel Design

- Side Slope: 2:1 or flatter; 3:1 or flatter where vehicles must cross.
- Grade: Stable, positive grade towards outlet, but not exceeding 2 percent.

Construction

Site Preparation

- Locate and mark the alignment of the diversion as shown on the plans. The alignment should maintain a stable, positive grade toward the outlet. Minor adjustments to the grade and alignment may be required by site conditions. Realign or elevate the diversion as needed to avoid reverse grade.

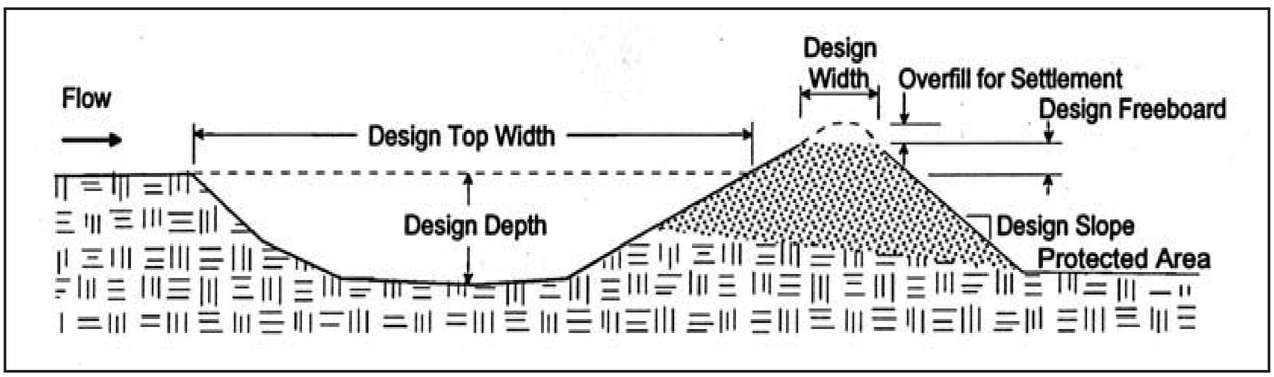

Figure 6.56 Typical temporary combination diversion.

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Remove trees, brush, stumps and other unsuitable material from the site.
- Disk the base of the ridge before placing fill.

Grading

- Construct the diversion to the dimension and grades shown on the design.
- Build the ridge 10 percent higher than designed for settlement and compact with wheels of the construction equipment or sheep foot roller.
- Leave sufficient area along the diversion to permit clean out and regrading.

Erosion Control

- Stabilize the outlets in accordance with design plans during construction of the diversion.
- Vehicles should not be allowed to drive across through diversions.
- Stabilize ridges, side slopes and channels with vegetation or synthetic erosion control measures as specified in the design. Do not allow storm water flows to enter the channel until it is fully stabilized especially if it is being used to direct clean storm water around a disturbed area.
- Outlet should be nonerosive for design flow. Divert flow containing sediment to sediment trap or basin.
- Stabilize ridge with vegetation if in place more than 30 working days.
- Diversions should not be installed on slopes greater than 15 percent or where diversion flows are calculated to be greater than 3-feet per second over vegetation. If the diversion is constructed above a steep slope, install temporary slope drains or other stable outlet to control runoff and prevent erosion of the slope (see Temporary Slope Drains, Grass-lined Channel, Riprap-lined Channel or Turf Reinforcement Mats).

Construction Verification

- The field inspector should verify the dimensions shown on the plans for the following: depth, bottom width, top width, side slopes of channel and ridge, grade of channel bottom, ridge height and channel stabilization techniques.
- Check all of the finished grades and configuration of all channels to eliminate constrictions to flow and to ensure final discharge flows to sediment basins or stabilized outlets. Also check all ridges for low spots and stability.

Grading

- Construct the diversion to the dimension and grades shown on the design.
- Build the ridge 10 percent higher than designed for settlement and compact with wheels of the construction equipment or sheep foot roller.
- Leave sufficient area along the diversion to permit clean out and regrading.

Erosion Control

- Stabilize the outlets in accordance with design plans during construction of the diversion.
- Vehicles should not be allowed to drive across through diversions.
- Stabilize ridges, side slopes and channels with vegetation or synthetic erosion control measures as specified in the design. Do not allow storm water flows to enter the channel until it is fully stabilized especially if it is being used to direct clean storm water around a disturbed area.
- Outlet should be nonerosive for design flow. Divert flow containing sediment to sediment trap or basin.
- Stabilize ridge with vegetation if in place more than 30 working days.
- Diversions should not be installed on slopes greater than 15 percent or where diversion flows are calculated to be greater than 3-feet per second over vegetation. If the diversion is constructed above a steep slope, install temporary slope drains or other stable outlet to control runoff and prevent erosion of the slope (see Temporary Slope Drains, Grass-lined Channel, Riprap-lined Channel or Turf Reinforcement Mats).

Construction Verification

- The field inspector should verify the dimensions shown on the plans for the following: depth, bottom width, top width, side slopes of channel and ridge, grade of channel bottom, ridge height and channel stabilization techniques.
- Check all of the finished grades and configuration of all channels to eliminate constrictions to flow and to ensure final discharge flows to sediment basins or stabilized outlets. Also check all ridges for low spots and stability.

Maintenance, Inspections and Removal

- Inspect weekly and following each storm event.
- Remove debris and sediment from the channel and rebuild the ridge as needed.
- Check outlets and make necessary repairs immediately.
- Remove sediment from traps or check dams when they are 50 percent full.
- When the work area has been stabilized, remove the ridge and fill in the channel to blend with the natural ground. Remove temporary slope drains and stabilize all disturbed areas with permanent vegetation or other erosion control practices.
- Remove the temporary deversion and stabilize the site stabilized *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).
- Maintain vegetation in channel as shown in the design plan.

Common Problems and Solutions

Problem	Solution
Seepage is encountered during construction.	It may be necessary to install drains.
Variations in topography on-site indicate diversion will not function as intended.	Consult with a registered design professional.
Design specifications for seed variety, seeding dates or erosion control materials cannot be met.	Substitutions may be required. Unapproved substitutions could result in erosion and lead to diversion failure.
Final discharges from diversion channels cause ongoing erosion at the outlets.	Modifications to the diversion system need to be made or energy dissipation devices installed.
Overtopping of channel; caused by sedimentation in channel resulting in grade decreasing or reversing.	Realign or deepen the channel to maintain grade.
Overtopping of ridge due to low point in ridge where diversion crosses a natural depression.	Build up ridge.
Erosion and scour of the channel; caused by high velocity in channel.	Consult a design professional and install velocity dissipators such as check dams.

Breach of ridge caused by uneven channel grade and leading to erosion in channel before vegetation is established.	Repair channel and add more effective erosion control option-erosion control blanket, turf reinforcement mat, transition mat, etc.
Poor vegetation establishment caused by seepage or poor drainage in channel.	Install subsurface drains or stone channel bottom.
Erosion in channel caused by excessive grade in channel.	Consult design professional, repair channel, install an erosion resistant lining and velocity dissipators such as check dams or realign to reduce the grade.
Erosion; caused by excessive velocity at outlet.	Consult a design professional, install an outlet stabilization structure (see Rock Outlets or Energy Dissipators).
Runoff from a storm event causes blow out failure; caused by ridge not being compacted.	Repair and use construction equipment to compact.

Right-of Way/Diversions Bars

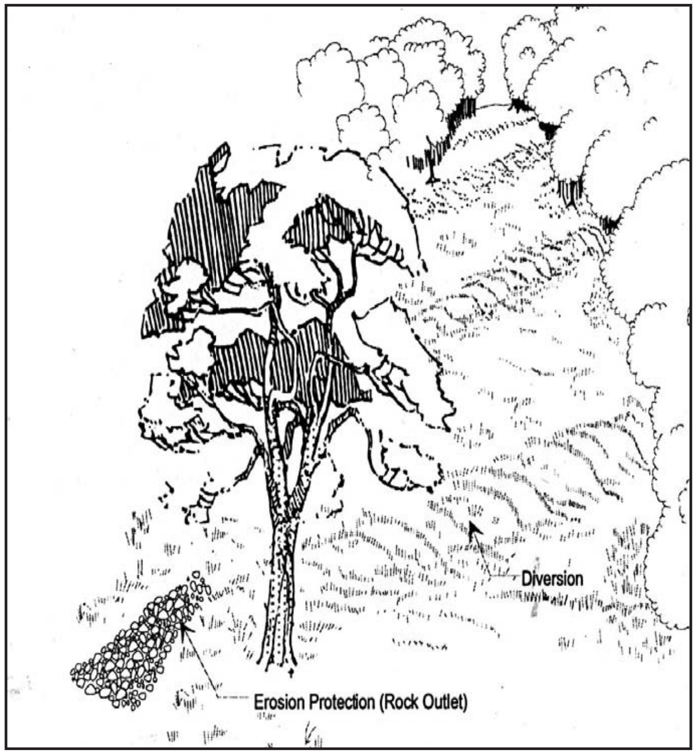

Figure 6.57 Typical Right-of-Way Diversion.

Practice Description

A right-of-way diversion, also known as a water bar, is a temporary ridge or combination of a ridge and excavated channel designed to shorten the flow length within a sloping right-of-way. The diversion thereby reduces the erosion potential by diverting storm runoff to a stabilized outlet. This practice applies to sloping right-of-ways or other long, narrow sloping areas such as utility access clearings.

Recommended Minimum Requirements

Prior to start of construction, right-of-way diversions should be designed by a qualified professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. The diversions should be built according to planned alignment, grade and cross section.

Height

18-inches.

Side Slopes

Side slopes are 2:1 or flatter; 3:1 or flatter where vehicles cross.

Base Width of Ridge

6-feet.

Spacing
Spacing as given in Table 5.14.

Grade
Stable, positive grade towards outlet, but less than 2 percent.

Outlet
Right-of-way diversion must cross full access width and extend to a stable outlet.

Table 6.15 Recommended Spacing of Water Bar Diversions

Slope	Diversion Spacing (ft.)
Less than 5%	125
5 to 10%	100
10 to 20%	75
20 to 35%	50
Greater than 35%	25

Source: *North Carolina Field Manual*, 1991

Construction
Site Preparation
- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Clear the access right-of-way and grade as necessary.
- Construct sediment traps or outlet stabilization structures as needed.
- After utilities have been installed in the corridor, locate the first bar at the required distance from the slope crest depending on steepness of the right-of-way slope (Table 5.14). Set the crossing angle so as to maintain a positive grade of less than 2 percent.
- Set the direction of the right-of-way diversions to use the most stable outlet locations. If necessary, adjust length of or spacing between bars to prevent runoff from upslope bars from merging with downslope water bar outlets.

Grading
- Mark the location and width of the ridge, and scarify the entire length.
- Excavate, fill and shape the diversion to planned alignment, grade and cross section.
- Fill the ridge to above the design height, then compact with rubber-tired equipment down to the design height.

Erosion Control
- Establish vegetation on the ridge and channel immediately following construction.

Construction Verification
- Verify the dimensions shown on the plans for height, base width, channel depth, grade and side slopes.
- Check all of the finished grades and configuration of all channels to eliminate constrictions to flow and to ensure the final discharge flows to sediment basins or stabilized outlets. Also check all ridges for low spots and stability.

Maintenance, Inspections and Removal

- Inspect right-of-way diversions weekly and after storm events for erosion and sediment deposition and periodically for vehicle wear.
- Remove debris and sediment from channels and sediment traps or basins.
- Repair ridges to grade and planned height.
- Add rock at crossing areas and stabilize outlets as needed.
- Repair and establish vegetation on right-of-way diversions immediately after installation of additional utilities in the right-of-way.
- To remove temporary right-of-way diversions, grade the ridge and channel to blend with the natural ground, compact the channel fill and establish vegetation on disturbed areas. (Do not remove right-of-way diversions until all disturbed areas draining to them are stabilized).
- Remove the temporary right-of-way diversion and stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	Solution
Gully erosion occurs between right-of-way diversions caused by diversion spacing being too wide for slope.	Install additional bars.
Ridge is worn down and channel is filled where vehicles cross caused by unstable surface.	Stabilize surface by using gravel or other surface treatment and reduce vehicle traffic.
Erosion at outlets caused by unstable outlet structures.	Install an outlet stabilization structure or extend the upslope bars so runoff will not converge on the lower outlets.
Erosion in channel caused by too steep of a grade.	Realign the right-of-way diversion to reduce grade.

Temporary Slope Drains

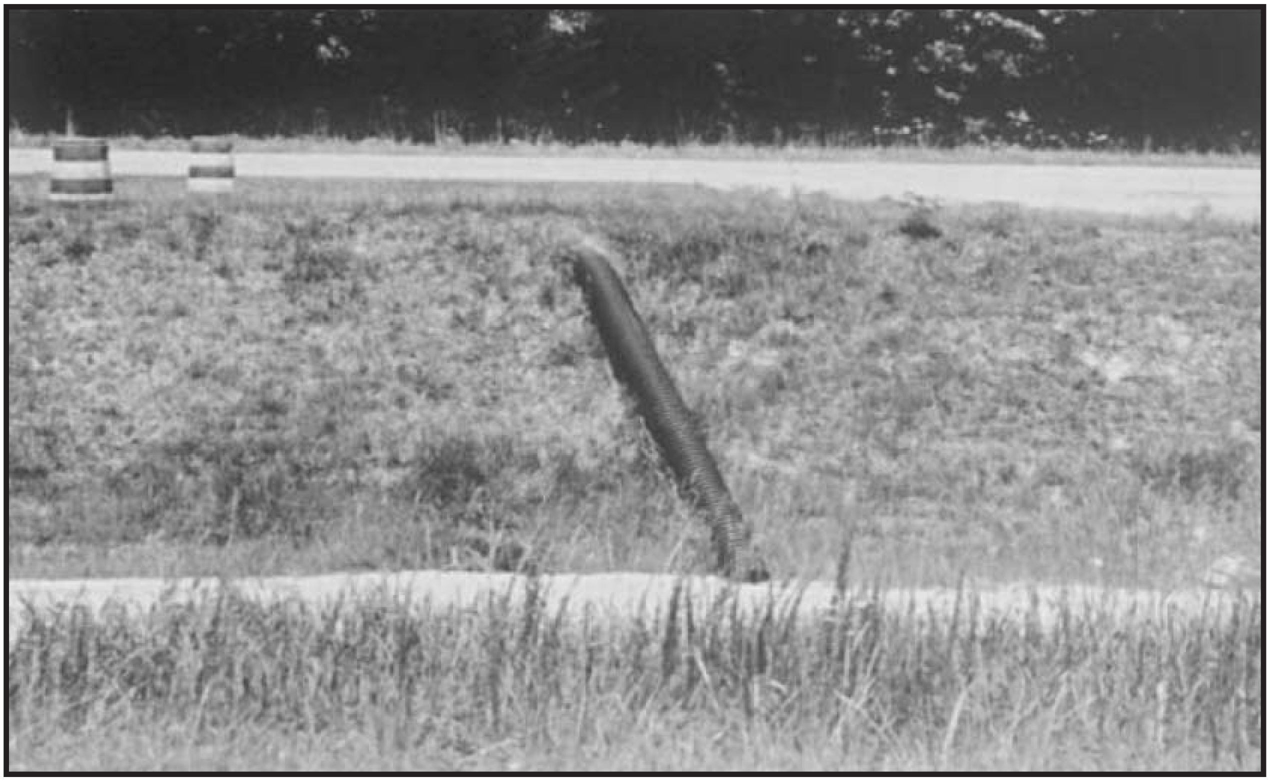

Figure 6.58 Temporary slope drains can be used almost immediately to carry surface runoff down a steep slope, allowing vegetation a chance to become established. Source: North Carolina Department of Environment and Natural Resources

Practice Description

A temporary slope drain is a pipe or other conduit designed to convey concentrated runoff down the face of a cut or fill slope without causing erosion. This practice applies wherever storm water runoff must be conveyed down a steep slope.

Prior to start of construction, temporary slope drains should be designed by a registered design professional. Plans and specifications should be referred to the job foreman and field personnel throughout the construction process.

Recommended Minimum Requirements

Material

Strong, flexible pipe, such as heavy-duty, non-perforated, corrugated plastic.

Design Life

18 months or less.

Inlet Section (optional).

Standard “T” or “L” flared-end section with metal toe plate.

Inlet to Pipe at Top of Slope

Compacted fill over pipe with minimum dimensions of 1.5-foot depth, 4-foot top width and 6-inches higher than ridge.

Outlet

Pipe should extend beyond toe of slope and discharge into a sediment trap or basin unless the contributing drainage area is stable or undisturbed. The pipe could also "T" with a perforated horizontal pipe discharging into a stable, vegetated area acting as a level spreader, turning concentrated flow into sheet flow.

Pipe Size

Refer to the appropriate design manual for your area (see Design Manual Reference).

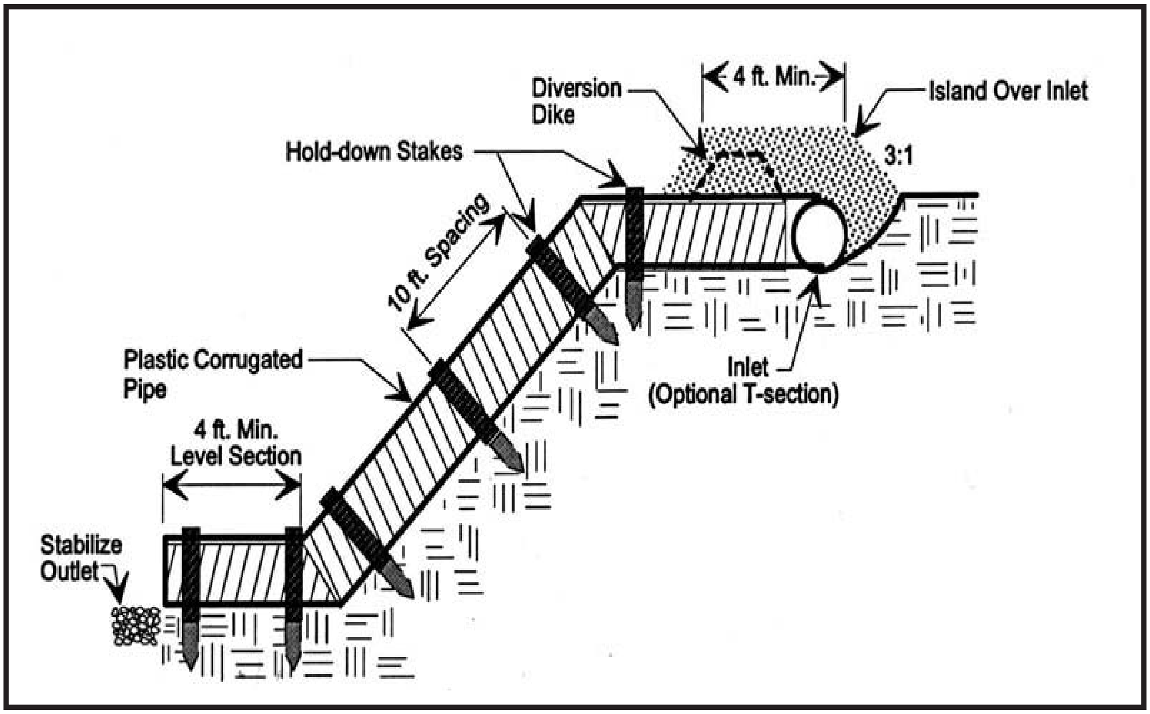

Figure 6.59 Typical Cross Section of Temporary Slope Drain with Optional T-section Inlet

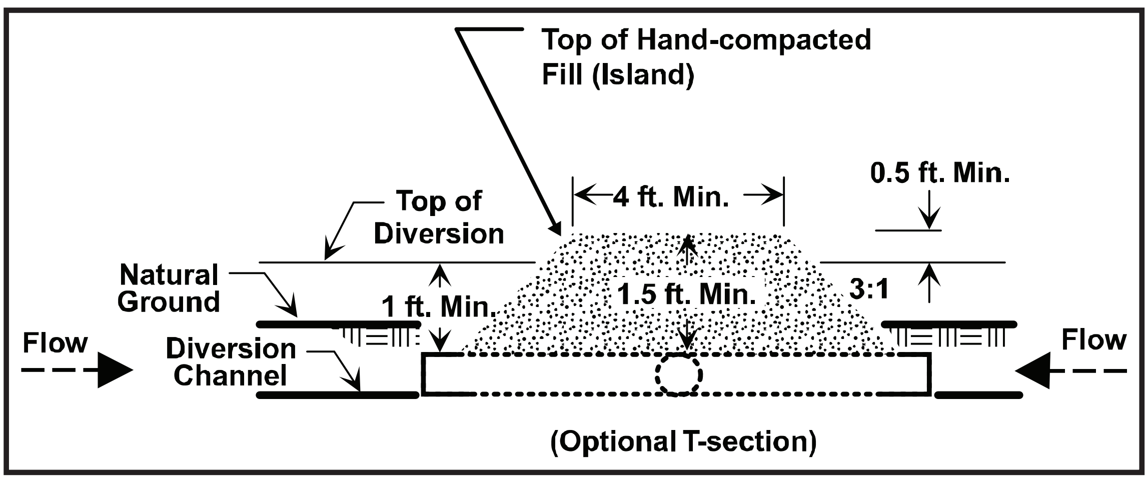

Figure 6.60 Detail of Inlet to a Temporary Slope Drain

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Place temporary slope drains on undisturbed soil or place well-compacted fill at locations and elevations shown on the plans.
- Grade the diversion channel at the top of the slope toward the temporary slope drain. A stable, positive grade not exceeding 2 percent is needed. Slightly slope the section of pipe under the ridge.
- Hand tamp the soil under and around the pipe in lifts not to exceed 6-inches.
- Ensure fill over the drain at the top of the slope has minimum dimensions of 1.5-foot depth (above top of pipe) and 1-foot top width.
- Ensure all slope drain connections are secure and watertight.
- Ensure all fill material is well-compacted. Securely anchor the exposed section of the drain with grommets or stakes spaced no more than 10 feet apart.
- Extend the drain pipe beyond the toe of the slope and adequately protect outlet from erosion.

Erosion Control

- Make the settled, compacted diversion ridge no less than 1 foot above the top of the pipe at every point.
- Immediately stabilize all disturbed areas following construction with vegetation or other appropriate means of protection.
- Provide for energy dissipation at the outlet of the pipe (see Energy Dissipators section.).

Construction Verification

- Verify the dimensions shown on the plans for the following: diameter of pipe, inlet, outlet elevations, orientation relative to how flow will enter the existing drainage pattern and diversion specifications (see Temporary Diversions).
- Joints should be carefully inspected for separations or looseness.

Troubleshooting

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

- Variations in topography on-site indicate temporary slope drains will not function as intended.

Maintenance, Inspection and Removal

- Inspect slope drains and supporting diversions once a week and after every storm event.
- Check the inlet for sediment or trash accumulation; clear and restore to proper condition.
- Check the fill over the pipe for settlement, cracking or piping holes; repair immediately.
- Check for holes where the pipe emerges from the ridge; repair immediately.
- Check the conduit for evidence of leaks or inadequate anchoring; repair immediately.
- Check the outlet for erosion or sedimentation; clean and repair, or extend if necessary.

- After slopes have been stabilized, remove the temporary diversions and slope drains, and stabilize all disturbed areas.
- Remove the temporary slope drains stabilize the site prior to filing *Form H: Request for Termination of a General Permit, Form--MO 780-1409* (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	Solution
Overtopping of the drain caused by undersized or blocked pipe; drainage area may be too large.	Install additional pipes and remove debris frequently.
Overtopping of the drain caused by improper grade of channel and ridge.	Regrade to provide positive drainage.
Overtopping of the drain caused by poor entrance conditions and trash buildup at pipe inlet.	Deepen and widen the channel at the pipe entrance; inspect and clear inlet frequently.
Erosion at outlet caused by focused erosive flow being released at too high an elevation.	Extend pipe to a stable grade or an outlet stabilization structure as needed.
Pipe separates or is displaced caused by lack of securement.	Tie the pipe down and secure the joints.
Animals going into the pipe outlet caused by open-ended pipe.	Install a free swinging animal guard.

Subsurface Drains

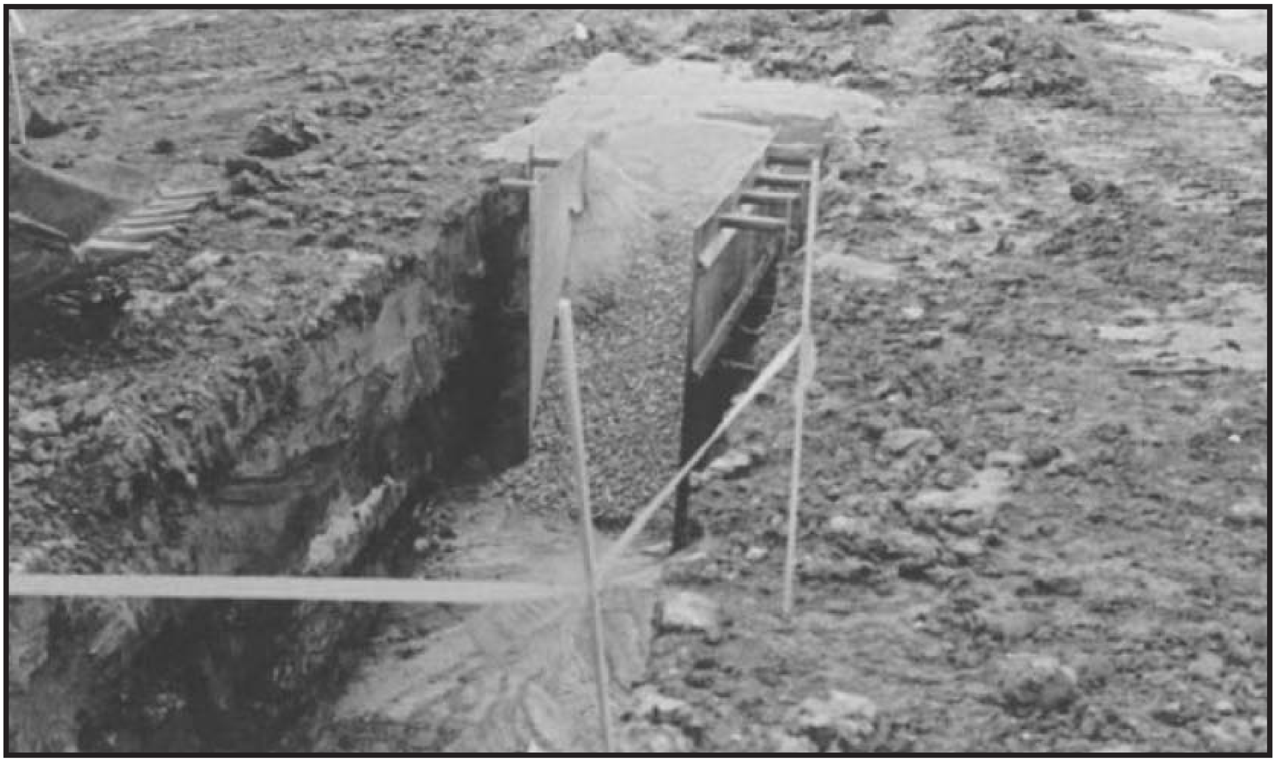

Figure 6.61 A gravel-filled trench is one of several ways to solve subsurface drainage problems. Note safety barrier around the trench.
Source: Bob Clay, Missouri Department of Natural Resources, Nodaway County

Practice Description

A subsurface drain is a perforated pipe or continuous layer of porous material installed below the ground surface that intercepts, collects and carries excessive groundwater to a stable outlet. Subsurface drains by themselves do not provide erosion control.

The purpose of a subsurface drain is to reduce storm water runoff volumes, and improve soil moisture conditions, vegetation growth and ground stability. Subsurface drains also prevent wet, soft ground from interfering with construction activities. Drains may be constructed using a gravel-filled trench, perforated pipe in gravel bedding or manufactured drain panel products. This practice applies where groundwater is at or near the ground surface or where adequate drainage cannot be provided for surface runoff.

Recommended Minimum Requirements

Prior to start of construction, subsurface drains should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Drainage system layout, depth, construction details and specifications should be included in the design plans. Some aspects of the design may depend on-site specific conditions not known or only estimated prior to installation and will need to be verified or modified during construction.

The timing of construction of these devices is critical. They should not be installed prior to final stabilization of the area where they will collect sediment laden runoff. Subsurface drains are not intended to collect sediment. If they do, they may become blocked or clogged and need to be reconstructed.

During the construction process, prior to final stabilization, infiltration trench excavations shall be completely protected from storm water runoff. These protection methods may include diversions, berms and other approved runoff barriers. Final placement of subsurface drain fill material and connection to the storm sewer system shall take place after the drainage area from which it receives water is completely stabilized.

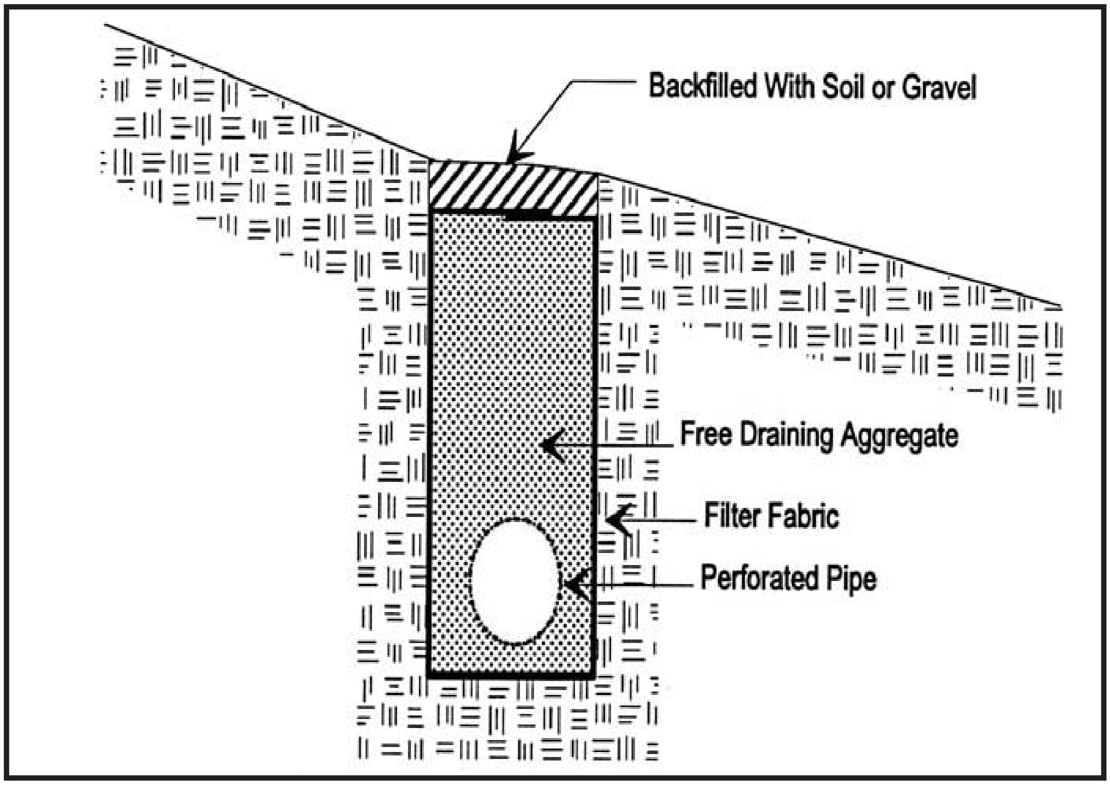

Figure 6.62 Typical Detail for Installation of Subsurface Drain

Layout and Depth
Generally, a depth of 3-feet and a spacing of 50 feet will be adequate.

Depth
Depth of the drain will determine how much the water table is lowered.

- Maximum: Limited by the impenetrable layer, and if pipe is used, by the allowable load on the pipe.
- Minimum: 2-feet under normal conditions.
- Spacing: Dependent on soil permeability and the depth of the drain.
- Multiple Drains: Determining the required spacing can be difficult. Install the first drain. Install an additional drain if seepage or high water table problems occur.

Location
Over 50 feet from the dripline of any trees.

Grade
Grade trench according to the design plan to prevent siltation within the drain. Steep grades should be avoided.

Gravel Bedding
Three inches or more of gravel placed completely around the drain and graded to prevent the infiltration of fine-grained soils into the drain.

Filter
As specified in design plan; determined by soil permeability. Usually filter fabric, although gravel bedding may be designed as a filter to prevent migration of fines.

Outlet
To a stable watercourse, with outlet above the mean water level in the receiving channel. Protect drains from erosion, undermining, damage from periods of submergence and the entry of small animals.

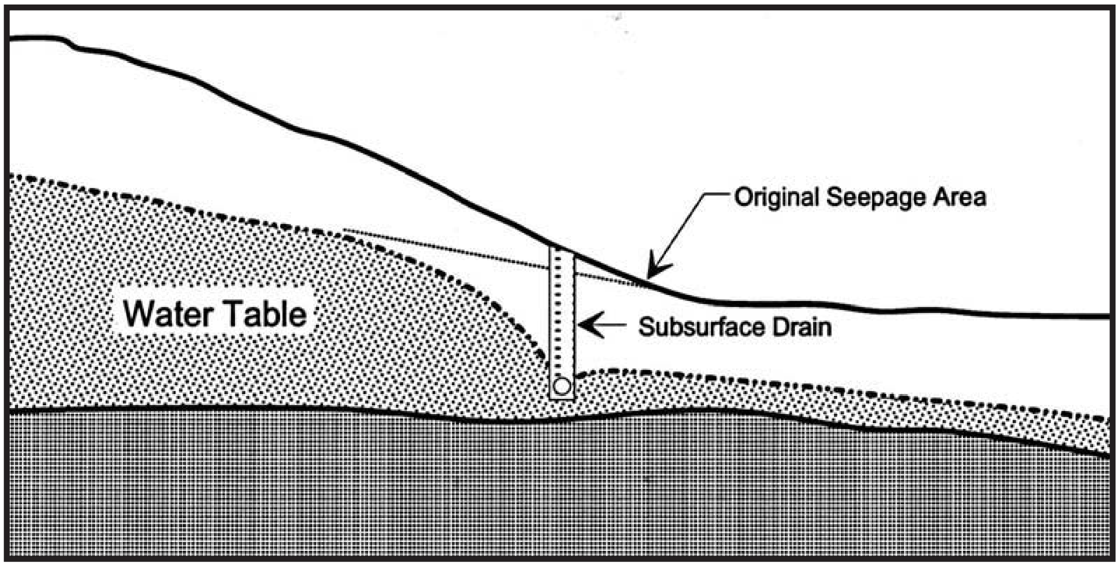

Figure 6.63 Detail of typical subsurface drain construction

Clean-outs
Required for long sections of drain.

Materials
Perforated, continuous closed-joint pipes of corrugated plastic, concrete, corrugated metal or bituminous fiber.

Strength and Durability
Should meet the requirements of the site in accordance with the manufacturer's specifications.

Construction
Installation
- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Dig a trench to specified grade at least 3-inches (or as shown on the design) below the design bottom elevation of the pipe to accommodate the gravel bedding or filter material.
- Line trench with filter cloth, providing enough material to fold it back over the top of the finished gravel bedding. This helps prevent movement of soil into the gravel.
- Lay pipe on the design grade and elevation avoiding reverse grade or low spots. Do not use damaged, deformed, warped or otherwise unsuitable pipe.

- Place bedding material around pipe with at least 3-inches (or as shown on the design) of material on all sides. Place gravel around drains for proper bedding and improved flow of groundwater into the drain.
- Ensure gravel for bedding around flexible pipe does not exceed 3/4 inch in size to prevent damage to the pipe.
- Fold filter cloth over the top of the gravel bedding.
- Backfill immediately after placement of the pipe and bedding. Ensure the material does not contain rocks or other sharp objects and place it in the trench in a manner that will not damage or displace the pipe. Overfill the trench slightly to allow for settlement.
- Install clean-outs for maintenance as shown on the design plan.
- Construct the outlet above the mean water level in the receiving channel as shown in the design plan. For the outlet section of the drain, use at least 10 feet of non-perforated corrugated metal, cast iron, steel or heavy-duty plastic pipe. Cover at least 2/3 of the pipe length with well compacted soil.
- Place a suitable animal guard securely over the pipe outlet to keep out rodents.
- Cap the upper end of each drain with a standard cap made for this purpose, with concrete or with other suitable material to prevent soil from entering the open end.

Erosion Control

- Stabilize any soft, yielding soils under the drain with gravel or other suitable material.
- Keep the settled fill over the pipe outlet slightly higher than the surrounding ground to prevent erosion and wash out from surface runoff. Apply seed and erosion control to the fill as soon as installation is complete.
- Provide for energy dissipation at the outlet of the pipe (see Energy Dissipators section.)

Safety

Narrow trenches are subject to collapse and can be a safety hazard to persons in the trench. No person should enter a trench without shoring protection or properly sloping the sides of the trench. Follow Occupational Safety and Health Administration, or OSHA, guidelines for trench safety.

Construction Verification

- Verify the dimensions shown on the plans for the following: location and length, depth and cross section of trench.
- The dimensions and specifications of the aggregate used in the bedding and manufactured materials such as pipe, tile or panel drain should be verified.

Maintenance, Inspection and Removal

- Inspect subsurface drains periodically to ensure they are free-flowing and not clogged with sediment.
- Keep outlet clean and free of debris.
- Keep surface inlets open and free of sediment and other debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain. Drains should not be located within the dripline of trees.
- Where drains are crossed by heavy vehicles, inspect the pipe to ensure it is not crushed.
- If this practice is temporary for construction only, it must be removed and the site stabilized prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Troubleshooting

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

- Variations in topography on-site indicate subsurface drains will not function as intended.
- Design specifications for aggregate or manufactured products cannot be met; substitutions may be required. Unapproved substitutions could result in failure of the drain to function as intended.
- Sediment discharges into the device clogging it; area draining to the subsurface drain must be stabilized prior to installing the drain.

Common Problems and Solutions

Problem	Solution
Poor drain performance; caused by bedding material that does not allow groundwater to free-drain or does not provide filtration for pipe.	Replace with properly graded material or filter fabric.
Poor drain performance; caused by pipe being crushed by construction traffic.	Replace damaged section of pipe.
Poor drain performance; caused by sediment clogging the pipe or gravel trench.	Stabilize area draining to trench, remove rock, clean out trench, reinstall pipe and clean the bedding material.

Rock Outlets

Figure 6.64 Riprap at the downstream end of a rock outlet should be level with the receiving channel or slightly below it .
It should not restrict the channel or produce an overfall that will result in scouring and erosion.
Source: Becky Holland, NRCS Volunteer. Jackson Co.

Practice Description

A rock outlet is a structure constructed to reduce and dissipate water energy in order to control erosion at the outlet of a channel or conduit. A rock outlet is an apron constructed of adequately sized rock riprap designed to prevent scour where storm water outlets a channel or conduit. It is also intended to minimize the potential for downstream erosion by reducing the velocity and energy of concentrated storm water flows.

This practice applies where the discharge velocity of a pipe, box culvert, diversion or other water conveyance structure exceeds the permissible velocity of the receiving area.

Recommended Minimum Requirements

Prior to start of construction, rock outlets should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. The rock outlet should be built according to planned alignment, grade, cross section and length.

Grading

There should be a smooth transition between the rock outlet and the receiving channel; that is, the elevation of the rock apron at the downstream end should be at the same elevation as the bottom of the receiving channel.

Alignment
If possible, the alignment of the rock outlet should be straight throughout its length. If a curve is required, it should be located as closely as possible to where the flow enters the rock outlet.

Riprap
Riprap should consist of a well-graded mixture of rock (a range of sizes). Minimum and maximum rock size is dependent on volumes and velocities of storm water flows exiting the pipe. Larger rock should predominate, with sufficient smaller sizes to fill the voids between the rocks. The diameter of the largest rock size should not be greater than 1.5 times the d_{50} size (diameter of 50 percent of the rock).

Riprap Thickness and Length
Minimum thickness of riprap should be 1.5 times the maximum rock diameter. Length of riprap must be designed such that erosion at the outlet is minimal for receiving material.

Rock Quality
Select rock for riprap from field stone or quarry stone. The rock should be hard, angular and highly chemical and weather resistant. The specific gravity of the individual stones should be at least 2.5 times heavier than water.

High Tensile Strength Geotextile Fabric
Install between the rock riprap and the subgrade to prevent undermining of the structure due to piping of fine-grained subgrade soil.

Toewalls
According to the design plan; may be needed around full perimeter to prevent maintenance problems.

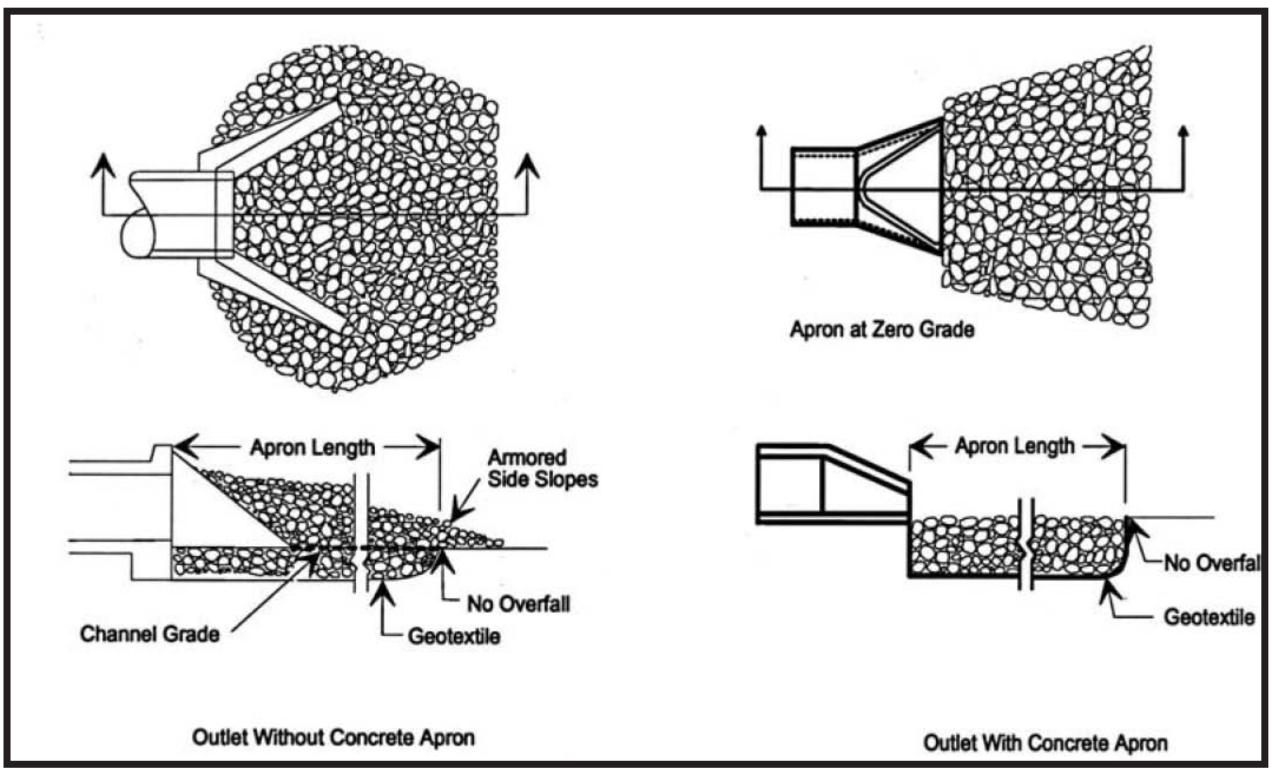

Figure 6.65 Typical rock outlet.

Construction

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Clear trees, stumps, brush, sod and all other unsuitable material that would interfere with construction of the rock outlet.
- Excavate the apron area subgrade below design elevation to allow for thickness of the filter layer and the riprap.
- Compact any fill used in the subgrade to the specified maximum density as determined by testing, and smooth enough to protect fabric (if used) from tearing.

Installation of Geotextile Filter

Place the geotextile fabric on the compacted smooth foundation. If more than one fabric piece is needed, the upstream piece should overlap the downstream piece by at least 1.5 feet in all directions. Staple geotextile fabric at the edges and overlaps to prevent movement during rip rap placement.

If the geotextile fabric tears when placing the riprap, repair immediately by laying and stapling a piece of fabric over the damaged area, overlapping the undamaged areas by at least 1.5 feet in all directions.

Installation of Riprap

- Install the riprap to the lines and elevations shown in the design. If there is no defined channel, the final cross-section should be level or slightly depressed in the middle; if well defined, the filter and riprap should extend to the top of the bank.
- Make sure the top of the rock apron is level with or slightly below the receiving stream. (Riprap should not restrict the channel or produce an overfall.)
- Blend the riprap smoothly to the surrounding grade.

Erosion Control

Stabilize all disturbed areas immediately following installation.

Construction Verification

- Check finished grade and configuration of structure.
- Check conformance of materials to specifications.

Maintenance, Inspection and Removal

- Inspect rock outlets after storm events for stone displacement and for erosion at the sides and ends of the apron.
- Make needed repairs immediately; use appropriate size stone, and do not place them above finished grade.
- If this practice is temporary for construction only, it must be removed prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements). Any land disturbance that occurs as a result of permanent retention or removal must be stabilized.

Troubleshooting

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

- Variations in topography on-site indicate rock outlet will not function as intended; changes in plan may be needed.
- Design specifications for riprap or geotextile cannot be met; substitution may be required. Unapproved substitutions could result in failure of the outlet.
- Rock is displaced downstream after storm event due to too small size of stone for the volume and velocities.

Common Problems and Solutions

Problem	Solution
Erosion around the apron and scour holes at the outlet; caused by foundation not excavated deep enough or wide enough or riprap restricts the flow cross section.	Remove filter and riprap, widen or deepen channel, replace filter and riprap.
Downstream erosion; caused by rock apron not on zero grade.	Modify grade or install grade stabilization measures at downstream edge of apron.
Rock displacement; caused by riprap installed smaller than specified.	Selective grouting over the rock materials may stabilize the situation, or replace riprap with larger size.
Downstream erosion; caused by riprap not extended enough to reach a stable section of channel.	Extend length of outlet.
Rock is displaced downstream after a storm event; rock is too small.	Needs to be redesigned.
Stone displacement and erosion of the foundation; caused by no filter installed under the riprap.	Remove riprap and install filter.

Compost Blankets, Berms and Socks

Compost has been viewed as a valuable soil amendment for centuries. Compost-enriched soil can also be used in practices that reduce erosion, control sediment runoff and alleviate soil compation. See Appendix G *Innovative Uses of Compost: Erosion Control, Turf Remediation and Landscaping*. EPA 350-F-97-043.

Compost Blankets

A compost blanket is a layer of loosely applied compost or composted material placed on the soil in disturbed areas to control erosion and retain sediment resulting from sheet-flow runoff.

Compost blankets can be placed on any soil surface:

- Rocky
- Frozen
- Flat
- Steep.

Figure 6.66 Applying a compost blanket in a new housing development. Source: Iowa Natural Resource Conservation Service, Urban Conservation Photo Gallery www.ia.nrcs.usda.gov/features/

The method of application and the depth of the compost applied will vary depending upon slope and site conditions. It can be used in place of traditional sediment and erosion control tools such as mulch, netting, or chemical stabilization. When properly applied, the erosion control compost forms a blanket that completely covers the ground surface. The compost blanket can be vegetated by incorporating seeds into the compost before it is placed on the disturbed area or the seed can be broadcast onto the surface after installation.

Compost blankets prevent storm water erosion by:

- Presenting a more permeable surface to the oncoming sheet flow, facilitating infiltration.
- Filling in small rills and voids to limit channelized flow.
- Promoting establishment of vegetation on the surface.

Compost blankets are most effective when applied on slopes between 4:1 and 1:1, such as stream banks; road embankments; and construction sites, where storm water runoff occurs as sheet flow. Compost blankets are not applicable for locations with concentrated flow. Because the compost is applied to the ground surface and not incorporated into the soil, a compost blanket provides excellent erosion and sediment control on difficult terrain, Including steep, rocky slopes.

Installation and Maintenance

- The compost should be applied to the soil surface in a uniform thickness, usually between 1- and 3-inches thick.
- The compost can be distributed by hand using a shovel or by mechanical means such as a spreader unit. The compost blanket should extend at least 3 feet over the shoulder of the slope to ensure storm water runoff does not flow under the blanket.
- Although seed can be broadcast on the compost blanket after installation, it is typically incorporated into the compost before it is applied, to ensure even distribution of the seed throughout the compost and to reduce the risk of the seed being washed from the surface of the compost blanket by stormwater runoff.
- In some applications, better sediment and erosion control can be achieved by using the compost blanket in conjunction with another best management practice, (e.g., lock-down netting, compost filter berms, or compost filter socks).

Figure 6.67 Applying a compost blanket on the side of a highway construction site. Source: *University of Georgia, Extension Learning, Bulletin 1200 Compost Utilization for Erosion Control*, May 2009

- Lock-down netting will help hold the compost in place, while compost filter berms or compost filter socks placed across the slope will slow down the flow of water. Compost filter berms or filter socks can also be placed at the top and bottom of the embankment.
- The compost blanket should be checked periodically and after each major rainfall.
- If areas of the compost blanket have washed out, another layer should be applied. In some cases, it may be necessary to add another storm water best management practice, such as a compost filter sock or sediment fence.
- On slopes greater than 2:1, establishing thick, permanent vegetation as soon as possible is the key to successful erosion and sediment control.
- Restricting or eliminating pedestrian traffic on such areas is essential.

Compost Filter Berms

Compost filter berms are contoured runoff and erosion filtration methods usually used for steeper slopes with high erosive potential. The berm allows runoff water to penetrate it and continue to flow while filtering sediment and pollutants from the water. It also slows the flow down, allowing soil particles to settle out. Berms work well in many of the same areas as blankets but are the preferred method if the slope exceeds a 4:1 gradient.

A compost filter berm is a dike of compost or a compost product placed perpendicular to sheet flow runoff to control erosion in disturbed areas and retain sediment. It can be used in place of a traditional sediment and erosion control tool such as a silt fence. The compost filter berm, which is trapezoidal in cross section, provides a three-dimensional filter that retains sediment and other pollutants while allowing the cleaned water to flow through the berm. Composts used in filter berms are made from a variety of feedstocks, (e.g., municipal yard trimmings, food residuals, separated municipal solid waste, biosolids and manure).

Figure 6.68 Source: University of Georgia, Extension Learning, *Bulletin 1200 Compost Utilization for Erosion Control*, May 2009

Compost filter berms are generally placed along the perimeter of a site, or at intervals along a slope, to capture and treat storm water that runs off as sheet flow. A filter berm also can be used as a check dam in small drainage ditches. The berms can be vegetated or unvegetated. Vegetated filter berms are normally left in place and provide long-term filtration of storm water as a post-construction best management practice. Unvegetated berms are often broken down after construction is complete and the compost is spread around the site as a soil amendment or mulch.

Filter berms installed to control erosion and sediment on a slope or near the base of a slope are trapezoidal in cross section, with the base generally twice the height of the berm. The height and width of the berm will vary depending upon the precipitation of the site. Modify the compost filter berm dimensions based on site-specific conditions, such as soil characteristics, existing vegetation, site slope and climate, as well as project-specific requirements.

Installation and Maintenance Activities

- The compost should be uniformly applied to the soil surface, compacted, and shaped to into a trapezoid. Compost filter berms can be installed on frozen or rocky ground.
- The filter berm may be vegetated by hand, by incorporating seed into the compost prior to installation (usually done when the compost is installed using a pneumatic blower or mixing truck with a side discharge), or by hydraulic seeding following berm construction. Proper installation of a compost filter berm is the key to effective sediment control.
- The compost filter berms should be inspected regularly, as well as after each rainfall event, to ensure they are intact and the area behind the berm is not filled with silt.
- Accumulated sediments should be removed from behind the berm when the sediments reach approximately one third the height of the berm.
- Any areas that have been washed away should be replaced. If the berm has experienced significant washout, a filter berm alone may not be the appropriate best management practice for this area.
- Depending on the site-specific conditions, the site operator could remedy the problem by increasing the size of the filter berm or adding another best management practices in this area, such as an additional compost filter berm or compost filter sock, a compost blanket or a silt fence.

Limitations

Compost filter berms can be installed on any type of soil surface. However, remove or cut down heavy vegetation to ensure the compost contacts the ground surface. Filter berms are not suitable for areas where large amounts of concentrated runoff are likely, such as streams, ditches or waterways, unless the drainage is small and the flow rate is relatively low.

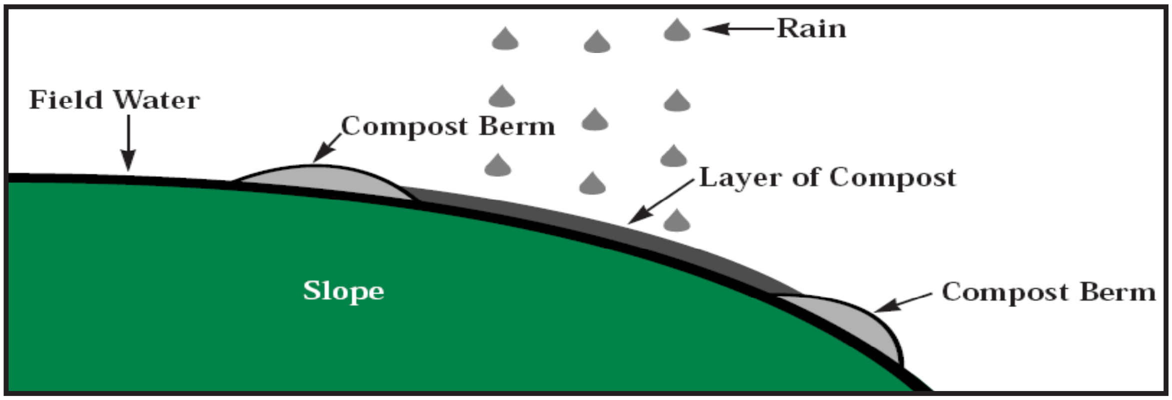

Figure 6.69 Source: *EPA Innovative Uses of Compost Erosion Control, Turf Remediation and Landscaping,* EPA530-F-97-043, Oct. 1997

Compost Filter Socks

Compost filter socks are applicable to construction sites or other disturbed areas where storm water runoff occurs as sheet flow. It is a mesh tube filled with composted material placed perpendicular to sheet-flow runoff to control erosion and retain sediment in disturbed areas. The compost filter sock, which is oval to round in cross section, provides a three-dimensional filter that retains sediment and other pollutants while allowing the cleaned water to flow through. Composts used in filter socks are made from a variety of feedstocks, including municipal yard trimmings, food residuals, separated municipal solid waste, biosolids and manure.

Compost filter socks offer a large degree of flexibility for various applications. To ensure optimum performance, remove or cut down heavy vegetation. Level extremely uneven surfaces to ensure the compost filter sock uniformly contacts the ground surface. Filter socks can be installed perpendicular to flow in areas where a large volume of storm water runoff is likely, but should not be installed perpendicular to flow in perennial waterways and large streams. Compost filter socks are often used in conjunction with compost blankets to form a storm water management system. Together, these two best management practices retain a very high volume of storm water, sediment and other pollutants.

Figure 6.70 Installation of filter socks in a road ditch by Indiana Department of Transportation. The filter socks will be staked through the center.
Source: *EPA NPDES Stormwater Menu of BMPs, Compost Filter Socks.*

Compost filter socks can be vegetated or unvegetated. Vegetated filter socks can be left in place to provide long-term filtration of storm water as a post-construction best management practice. The vegetation grows into the slope, further anchoring the filter sock. Unvegetated filter socks are often cut open when the project is completed and the compost is spread around the site as soil amendment or mulch. The mesh sock is then disposed of unless it is biodegradable.

Compost filter socks are generally placed along the perimeter of a site, or at intervals along a slope, to capture and treat storm water that runs off as sheet flow. Filter socks are flexible and can be filled in place or filled and moved into position, making them especially useful on steep or rocky slopes where installation of other erosion control tools is not feasible. There is greater surface area contact with soil than typical sediment control devices, thereby reducing the potential for runoff to create rills under the device or create channels carrying unfiltered sediment.

Common industry practice for compost filter devices is drainage areas do not exceed 0.25 acre per 100 feet of device length and flow does not exceed one cubic foot per second. Additionally, they can be laid adjacent to each other, perpendicular to storm water flow, to reduce flow velocity and soil erosion. Filter socks can also be used on pavement as inlet protection for storm drains and to slow water flow in small ditches. Filter socks used for erosion control are usually 12 inches in diameter, although 8 -, 18 - and 24-inch diameter socks are used in some applications.

Installation and Maintenance Activities

- No trenching is required; therefore, soil is not disturbed upon installation. After the filter sock is filled and put in place, anchor it to the slope. The preferred anchoring method is to drive stakes through the center of the sock at regular intervals; alternatively, stakes can be placed on the downstream side of the sock.
- Direct the ends of the filter sock upslope to prevent storm water from running around the end of the sock – meaning storm water should flow over the middle area of the filter sock. The sock should not create a dam that causes water to flow around it.
- The filter sock may be vegetated by incorporating seed into the compost prior to placement in the filter sock. The compost retains a large volume of water, which helps prevent or reduce rill erosion and aids in establishing vegetation on the filter sock.
- Inspect compost filter socks regularly, as well as after each rainfall event, to ensure they are intact and the area behind the sock is not filled with sediment.
- If there is excessive ponding behind the filter sock or accumulated sediments reach the top of the sock, add an additional sock on top or in front of the existing filter sock in these areas, without disturbing the soil or accumulated sediment.
- If the filter sock was overtopped during a storm event, the operator should consider installing an additional filter sock on top of the original, placing an additional filter sock further up the slope, or using an additional best management practice, such as a compost blanket in conjunction with the sock(s).

Transition Mats

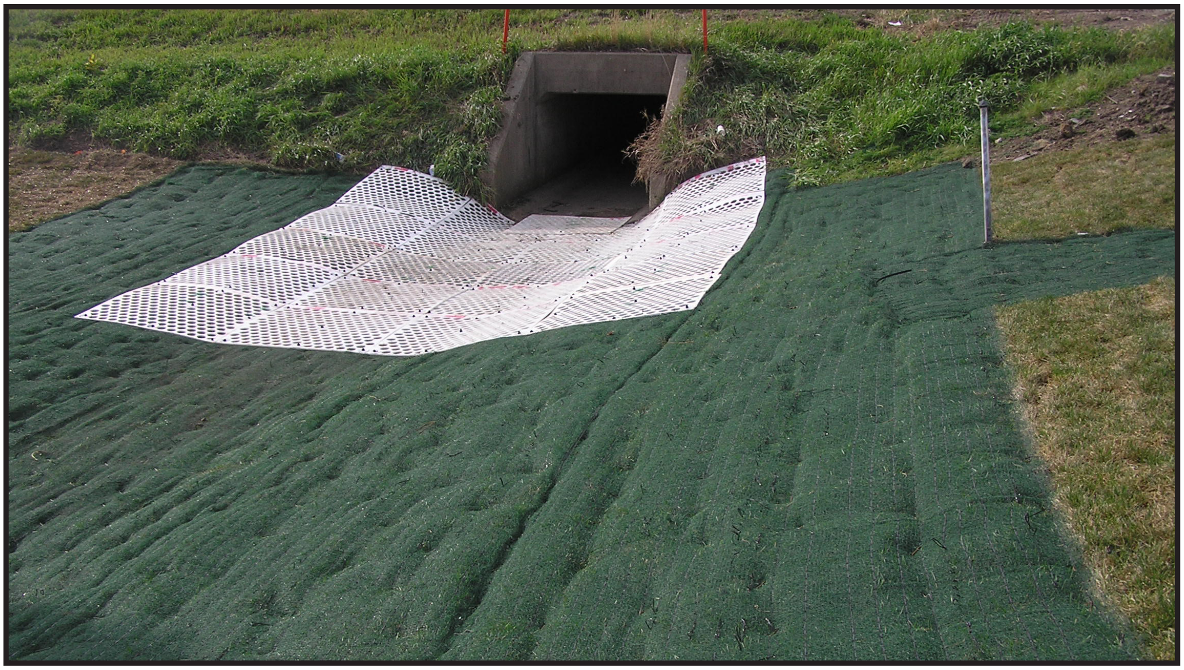

Figure 6.71 Transition mat as an alternative to rip rap. Source: Erosion Tech LLC

Practice Description

A transition mat is a biotechnical alternative for rip rap. It is a mechanically-anchored 4 x 4 feet x .5 inch semi-rigid, polymer mat designed with voids throughout the structure that enables vegetative growth. Transition mats provide mechanical protection over highly-erosive areas, like storm water pipe outfalls, curb outfalls, over-flow structures and shorelines. Transition mats do not dissipate energy by impact, but mechanically protect the critical area until the high energy forces have dissipated as the storm flow exits further from the pipe discharge point. The resulting downstream forces are managed by appropriate soil covers calculated and specified as part of the transition mat engineered system. Transition mats provide resistance against much greater shear stress and velocities than vegetation alone or rock rip rap, and they are comparable in performance to Articulated Concrete Blocks. Vegetation provides many aesthetic, functional and synergistic benefits, but is not required for transition mat performance.

Recommended Minimum Requirements

Prior to start of construction, a vegetated occasional-overflow structure should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

- Transition mats must be used in combination over other soil covers:
  - Sod.
  - Sod and turf reinforcement mats.
  - Hybrid mats (e.g., geo-textile mat combinations where vegetation is unlikely).
- Design for the use of sod when feasible, to achieve the benefits of vegetation immediately. Design parameters prefer sod, or a combination of sod and transition mat in regions with adequate rainfall to ensure the best installation and performance possible.

- Specified anchors are essential to performance. Staples are not allowed. Anchor transition mats for consistent contact over the entire surface.
- Follow installation guidelines. Certified installers are preferred. Include an installation worksheet for each storm water outlet.
- See specifications for either cohesive or non-cohesive soils.
- Grade a level and smooth the soil surface at the scour area to avoid water concentration to create an appropriate base for the scour prevention measures. Install materials at or below the surface of the outlet. (The transition mat may be permanently attached over the surface of the discharge outlet.)
- Design for as much channel expansion as possible to help reduce velocities and increase infiltration potential.

Construction

Soil Cover Options

The transition mat has several installation types:

Type A - Over Sod

Most storm water pipe outlets and parking lot outlets are good applications for transition mats over sod. Sod provides immediate soil protection and eliminates any risk of poor seed germination. Additional uses include occasional overflow structures and streambank protection preserving the natural landscape aesthetics.

Type B - Over Sod and Transition Mat

Transition mats over a sod and an open-weave transition mat combination for a higher level of protection, especially on slopes greater than 10 percent. Sod eliminates the germination issue of a plain transition mat installation. Appropriate locations would be 24- to 72+-inch storm water pipes, high flow parking lot outlets and streambank restoration.

Type C - Over a Transition Mat

Transition and transition reinforcement mats over bare soil (including composite mats). The flows should be less than 3-feet per second and the area fairly level to minimize concentrated erosive forces. A rural culvert outlet might be an appropriate application, or erosion protection at a temporary construction outlet. Maximum pipe size would generally be 24-inches for an open-weave mat, and up to 48-inches for a high-performance composite mat.

Type D - Over a Geotextile/Transition Mat

In a stream bed or shoreline application where vegetation is unlikely, or where vegetation may be delayed for whatever reason; use a 3 to 4 oz. geotextile for soil retention and soil protection under the transition mats. Above the normal-water line, use Type A or B to protect the slope bank from boat or wind wave erosion.

See manufacturer specifications for detailed installation guidelines.

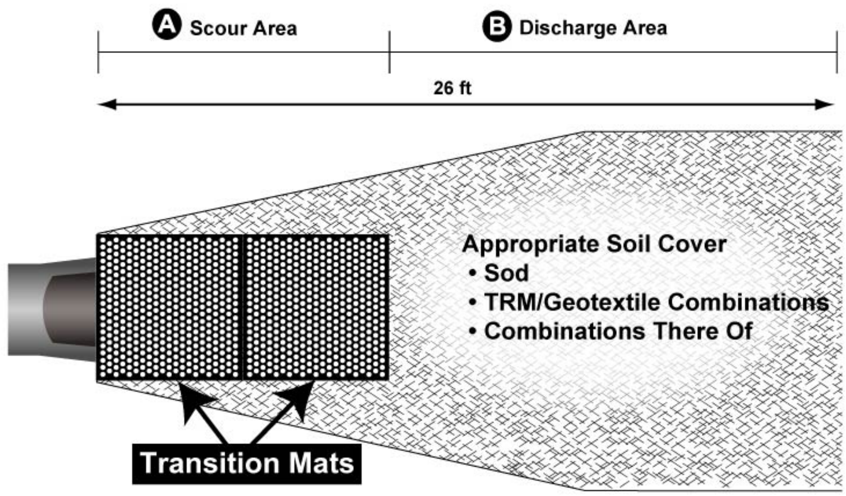

Figure 6.72 Transition Mat Detail Source: Erosion Tech LLC

Maintenance Inspection and Removal

- Transition mats are generally permanent installations, and maintenance should not be necessary.
- Until vegetation is established, inspect during construction on a weekly basis and after storm events. Remove accumulated sediment from the mat.

Troubleshooting

Consider sub-surface drainage for trickle flows, such as irrigation overcharge. Installations with continuous low flows, such as irrigation over charge, should use a sub-surface drainage system directly downstream of the outlet to drain that low flow from the surface, thus allowing vegetation to properly establish. Of course, an adequate slope is required for a sub-drain system.

- Calculate the downstream velocity and protect the channel using appropriate mats or sod. Mechanical flow dissipators or check dams may be appropriate during the germination period when seeding transition mats.
- Channel slopes restricting expansion require protection.
- Do not install at slope changes greater than 25 percent between the discharge area and the downstream channel that create impact or waterfall erosion.

Common Problems and Solutions

Problem	Solution
Erosion at the end or along sides of the mat; caused by insufficient mat size.	Consult a design professional and have new, larger mat installed.
Insufficient vegetation growth through mat; caused by inadequate or contaminated topsoil or trickle flows over saturating the soils.	Check soil below the transition mat for good topsoil, reseed and reinstall the turf reinforcement mat and transition mat.
Insufficient vegetation growth through mat; caused by poorly drained soil.	Consider installation or underdrain, reseed and reinstall the turf reinforcement mat and transition mat.

Temporary Sediment Trap

Figure 6.73 Sediment traps are used to collect sediment laden runoff from disturbed areas on construction sites. Source: EPA

Recommended Minimum Requirements

Prior to start of construction, sediment traps should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. The sediment traps should be built according to planned grades and dimensions.

Location

- Where access can be maintained for sediment removal and proper disposal.
- Where runoff can be directed into basin at low velocity.

Drainage Area

- Below areas less than 5 acres in size. If the drainage area is larger, construct a sediment basin (see Sediment Basin).
- In the approach to a storm water inlet located below a disturbed area as part of an inlet protection system.
- Where failure of the structure will not result in loss of life, damage to homes, commercial or industrial buildings, main highways or railroads; or in the use or service of public utilities.

Structure Life

Limited to 18 months.

Sediment Storage
A minimum of 3,600 cubic square per acre of drainage area or sufficient to safely pass run-off greater than the two year frequency, 24-hour duration or design storm event.

Embankment
Dam Height
Less than five feet.

Top Width
At least five feet.

Fill Slopes
2.5:1 or flatter.

Settlement
10 percent or less.

Fill Material
Locally available soil; machine compacted in 8-inch lifts; moist when compacted; free of organic material, tree roots and waste material.

Spillway
A rock-lined open channel spillway should be constructed in the embankment to safely pass stormwater runoff. As an option, a perforated outlet riser can be used as the principal spillway.

Capacity
Sufficient to safely pass runoff from the two year frequency, 24-hour duration or design storm event.

Bottom Width
At least five feet.

Crest
A minimum of 18-inches lower than the top of the embankment.

Outlet
Include an apron at least five feet long to dissipate energy.

Filter
Geotextile should be placed between the embankment soil and the rock in the spillway section.

Construction
Site Preparation
- Locate the temporary sediment trap in an upland area as close to the sediment source as possible, considering soil type, pool area, dam length and spillway conditions.
- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Follow all federal, state and local requirements on impoundment sites.
- Clear, strip and grub the foundation of the dam to minimum depth of 4-inches, removing all woody vegetation, rocks and other objectionable material. Dispose of trees, limbs, logs and other debris in designated disposal areas.
- Divert off-site run-on from all undisturbed areas away from the sediment trap.
- Excavate the sediment trap (if necessary), stockpiling and stabilizing any surface soil having high amounts of organic matter for later use.

Embankment

- Scarify the base of the embankment before placing fill.
- Use fill from predetermined borrow areas. Fill should be clean, stable mineral soil free of organics, roots, woody vegetation, rocks and other debris, and must be wet enough to form a ball without crumbling, yet not so wet that water can be squeezed out.
- Compact the fill material in 8-inch continuous layers (maximum) over the length of the dam. (One way is by routing construction equipment over the dam so each layer is traversed by at least one wheel of the equipment.)

Open Channel Spillway

- Excavate a trapezoidal outlet section in the compacted embankment.
- Install geotextile fabric on the base of the channel, extending it up the sides to the top of the embankment.
- Place specified stone to the lines and grades, working smaller stones into voids to achieve a dense mass. The spillway crest should be level with a minimum width of five feet.
- Construct a stone outlet apron below the toe of the dam on level grade until a stable condition is reached (5-feet minimum).
- The base of the stone outlet should be at least two feet thick.
- Make the edges and end of the stone apron section flush with the surrounding ground.
- Cover the inside face of the stone outlet section with a 1-foot layer of well graded stone (2-inch minus).

Set a clean-out measurement stake in the basin at a height equal to one-half the distance from the bottom to the spillway crest.

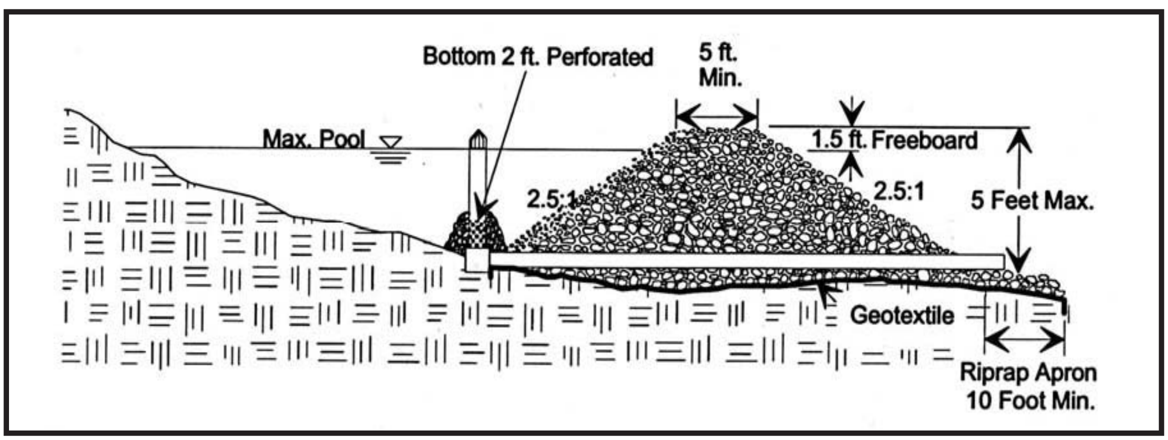

Figure 6.74 Temporary Sediment Trap with Spillway Riser

Optional Spillway Riser Construction

- Clear all vegetation and roots from the pipe foundation; prepare the bedding.
- Situate the spillway pipe and riser (minimum 18-inch diameter) on a firm, even foundation.
- Align the pipe and construct with the bell end of the pipe facing upstream. Around the barrel, place a 4-inch layer of moist, clayey, workable soil (not pervious material, such as sand, gravel, or silt), and compact with hand tampers to at least the density of the foundation soil. Don’t raise the pipe from the foundation when compacting under the pipe haunches. Connect the pipe to the riser.

- Perforate the bottom 2 feet of spillway riser with 1/2 inch diameter holes spaced 3-inches apart (or use a manufactured perforated riser) for draining the sediment trap. Wrap the riser with geotextile fabric.
- Embed the riser at least 12-inches into concrete. The weight of the concrete should balance the buoyant force acting on the riser. Buoyant Force = Volume of Riser x 62.4 lbs./ft.^{3}
- Surround the entire riser with two feet of clean uniformly graded stone.
- At the pipe outlet, install a riprap apron at least five feet wide and 10 feet long. The riprap should be a minimum of 6-inches in diameter (see Rock Outlets).
- Dewatering can also be accomplished with a skimmer (see Skimmers).

Erosion Control

- The size of disturbed areas should be minimized. Stabilize all disturbed areas immediately after construction. Establish vegetation and erosion controls within 14 days after construction is complete.
- Divert sediment-laden water to the upper end of the temporary sediment trap to improve trap effectiveness.
- Direct all runoff into the basin at low velocity.

Safety

Because temporary sediment traps will likely impound water, the following precautions should be taken:

- Avoid steep slopes; the slopes around the temporary sediment trap should be 2.5:1 or flatter; 3:1 if maintained by tractors or other machinery.
- Fence area and post warning signs if trespassing is likely.

Construction Verification

- Check finished grades and dimensions of the temporary sediment trap.
- Check materials for compliance with specifications.

Maintenance, Inspection and Removal

- Inspect the temporary sediment trap weekly and after each storm event.
- Remove and properly dispose of sediment on an upland area to dry and be stabilized when it accumulates to one-half the design volume, as indicated by the clean-out stake.
- Periodically check the embankment, spillway and outlet apron for erosion damage, settling, seepage or slumping along the toe, and repair immediately.
- Replace the spillway gravel facing if it becomes clogged.
- Inspect vegetation and reseed if necessary.
- Replace any displaced riprap, being careful no replacement rock is above the design grade.
- Remove the temporary sediment trap after the drainage area has been permanently stabilized, inspected and approved. Do so by draining any water, removing the sediment to a designated disposal area, grading the site to blend with the surrounding area; then stabilize.
- Remove the temporary sediment trap and stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Troubleshooting

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

- Variations in topography on-site indicate sediment trap will not function as intended.
- Design specifications for fill, pipe, seed variety or seeding dates cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.

Common Problems and Solutions

Problem	Solution
Embankment overtopping and possible failure of the structure; caused by inadequate spillway size.	Increase size of spillway.
Overtopping and possible failure; caused by extensive embankment settling.	Add additional fill to bring embankment back to design grade.
Erosion and displacement of rock; caused by rock outlet apron not extending to stable grade.	Extend apron.
Erosion of spillway or embankment slopes; caused by inadequate vegetation or rock size in spillway too small.	Improve vegetation, incorporate rolled erosion control product, or replace rock with larger size.
Settling of embankment; caused by inadequate compaction or use of unsuitable soil.	Add fill in settled areas to restore embankment to original grade.
Structural failure; caused by inadequate compaction due to construction with dry soil.	Replace failed material and compact to original grade.
Slumping failure; caused by overly steep slopes.	Repair damage and flatten slope without reducing the storage volume.
Piping failure; caused by too steep of a slope between stone spillway and earth embankment.	Flatten slope, then repair piping damage.
Inadequate storage capacity; caused by sediment not being properly removed.	Remove sediment on a regular schedule.
Inadequate storage capacity; caused by having a greater are a contributing sediment than originally designed.	Stabilize the disturbed area contributing to the trap or regrade the construction site and add additional traps to better distribute sediment laden storm water among the traps to handle the sediment discharging to the drainage area.
Safety or health hazard; caused by ponded water due to sediment clogging the gravel on the upstream slope of the riprap.	Remove sediment and install security fence if necessary.

Energy Dissipators

Figure 6.74 Energy dissipators reduce flow velocities so water can exit at nonerosive rates. Source: C. Rahm, NRCS St. Charles Co.

Practice Description

An energy dissipater is a physical structure intended to reduce the erosive energy typically encountered down grade from a pipe or culvert. Erosive energy from intense flows may also be encountered in median ditches or road ditches. Energy dissipation may be accomplished by the installation of large boulders, wood pilings, engineered concrete structures or other means approved by the engineer. Unlike ditch checks and rock dams, energy dissipaters are not intended to impound water and sediment. Energy dissipaters must be constructed in a fashion such that the water that flows through, over or around the structure is equally distributed in the discharge channel and does not exacerbate or cause a resultant erosion problem.
(Source MoDOT 806.8)

Recommended Minimum Requirements

Prior to the start of construction, energy dissipators should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Capacity

Ten year peak runoff or the design discharge of the water conveyance structure, whichever is greater.

Size:

The energy dissipators should be specifically designed for the velocities and application. It must be long enough to dissipate runoff energy. The width should be designed to match the configuration of the receiving channel.

Riprap Structures

Apron

Should have zero grade with no overfall at the end of the apron.

Alignment

Should be straight throughout its entire length, but if a curve is necessary to align the structure with the receiving stream, locate the curve in the upstream section of the structure.

Riprap

Riprap should consist of a well-graded mixture of stone. Larger stone should predominate, with sufficient smaller sizes to fill the voids between the stones. The diameter of the largest stone size should be not greater than 1.5 times the d_{50} size.

Riprap Thickness

Minimum thickness of riprap should be 1.5 times the maximum stone diameter.

Stone Quality

Select stone for riprap from field stone or quarry stone. The stone should be hard, angular and highly chemical and weather resistant. The specific gravity of the individual stones should be at least 2.5 times heavier than water.

Filter

Install a filter to prevent soil movement through the openings in the riprap.

The filter should consist of a graded gravel layer or a synthetic filter cloth.

Concrete Structures

Requirements for concrete structures will vary according to the specific design configuration. The structure should conform to the dimensions, grades and alignments shown on the plans and specifications.

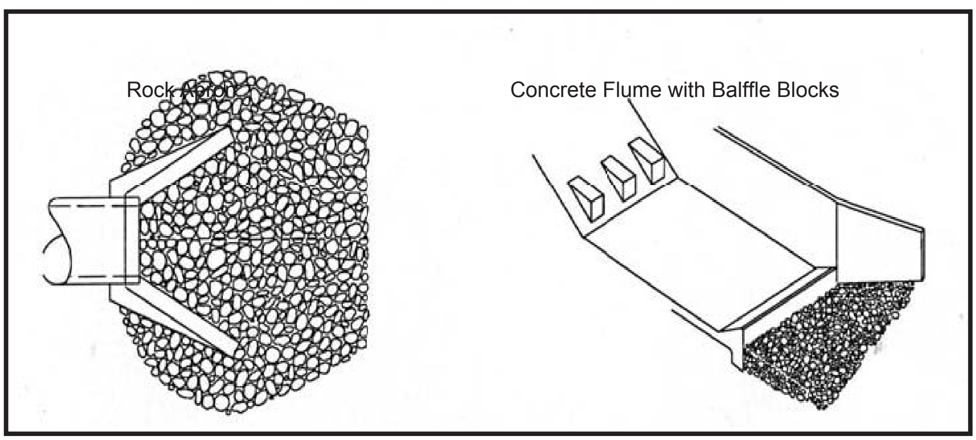

Figure 6.75 Common energy dissipators.

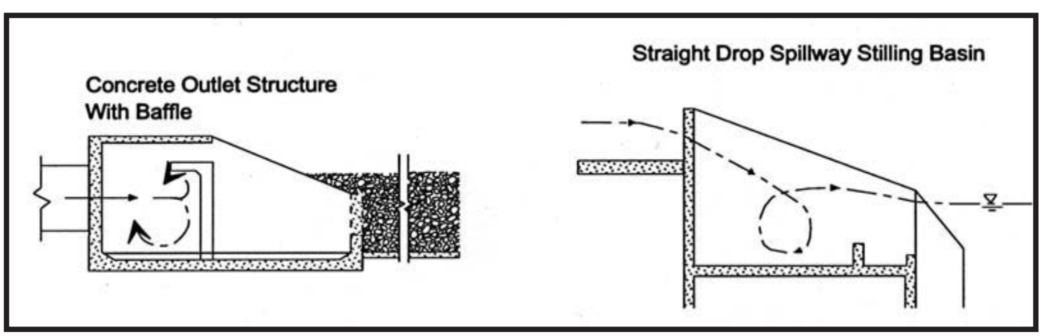

Figure 6.78 More Common Energy Dissipators

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Completely remove stumps, roots and other debris from the construction area. Fill depressions caused by clearing and grubbing operations with clean, non-organic soil.
- Grade the site to the lines and grades shown on the plans. Compact any fill required in the subgrade to the density of the surrounding undisturbed material.

Riprap Structures

- Ensure the subgrade for the geotextile and riprap follows the required lines and grades shown in the plan. Low areas in the subgrade on undisturbed soil may also be filled by increasing the riprap thickness.
- Filter cloth must meet design requirements and be properly protected from penetration or tearing during installation. Repair any damage by removing the riprap and placing another piece of filter cloth over the damaged area. All connecting joints should overlap a minimum of 1.5 feet. If the damage is extensive, replace the entire filter cloth.
- Riprap may be placed by equipment. Care should be taken to avoid damaging the filter.
- Construct the apron on zero grade with no overfall at the end. Make the top of the riprap at the downstream end level with the receiving area or slightly below it.

Concrete Structures

- Reinforcing steel should be placed in strict accordance with the design plans and maintained in the proper position during the pouring of concrete. Concrete should be placed in horizontal layers not exceeding 24-inches in thickness or as specified in the design, and consolidated by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping.
- Concrete should be placed in sturdy wood or metal forms, adequately supported to prevent deformation. Forms should be oiled prior to placement to prevent bonding between concrete and forms.
- If possible, concrete should not be placed during inclement weather or periods of temperature extremes. If temperature extremes cannot be avoided, American Concrete Institute guidelines for placement of concrete during such extremes should be consulted.
- Concrete should be allowed to cure as called for in the plans and specifications. Typically, the surface should be kept wet during curing by covering it with wet burlap sacks or other means. Design strengths should be confirmed by laboratory tests on representative cylinders made during concrete placement. Form work should be left in place until the concrete attains design strength.

Erosion Control

Immediately after construction, stabilize all disturbed areas with vegetation.

Construction Verification

Check finished structures for conformance with design specifications.

Troubleshooting

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

- Variations in topography on-site indicate energy dissipator will not function as intended.
- Design specifications for riprap, filter fabric, concrete, reinforcing steel or backfill cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.

Maintenance, Inspection and Removal

- Inspect riprap outlet structures weekly and after rain events to see if any erosion around or below the riprap has taken place or if stones have been dislodged. Check concrete structures for cracks and movement. Immediately make all needed repairs to prevent further damage.
- These are permanent structures which are not removed when construction is complete unless the structure is temporary and also removed.
- If the energy dissipator is temporary for construction only, it must be removed prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	Solution
Riprap Structures	
Erosion around the apron and scour holes at the outlet due to riprap restricting the flow cross section.	Remove filter and riprap, widen or deepen channel, replace filter and riprap.
Erosion at downstream end.	Modify grade or install grade stabilization measures at downstream edge of apron.
Rock displacement	Replace riprap with larger size.
Stone displacement and erosion of the foundation.	Remove riprap and install filter; replace riprap.
Concrete Structures	
Movement of base, cracking or complete failure of the concrete structures due to poor foundation preparation.	Inspect foundation thoroughly before concrete placement.
Excessive spalling, cracking or erosion of concrete surface due to concrete poured during inclement weather conditions.	Prohibit placement during inclement weather or follow accepted guidelines for such conditions.
Low strength, cracking, spalling or other undesirable conditions due to concrete not meeting specification.	Remove existing materials and reinstall after performing sufficient testing to verify concrete specifications.

Rock Check Dam

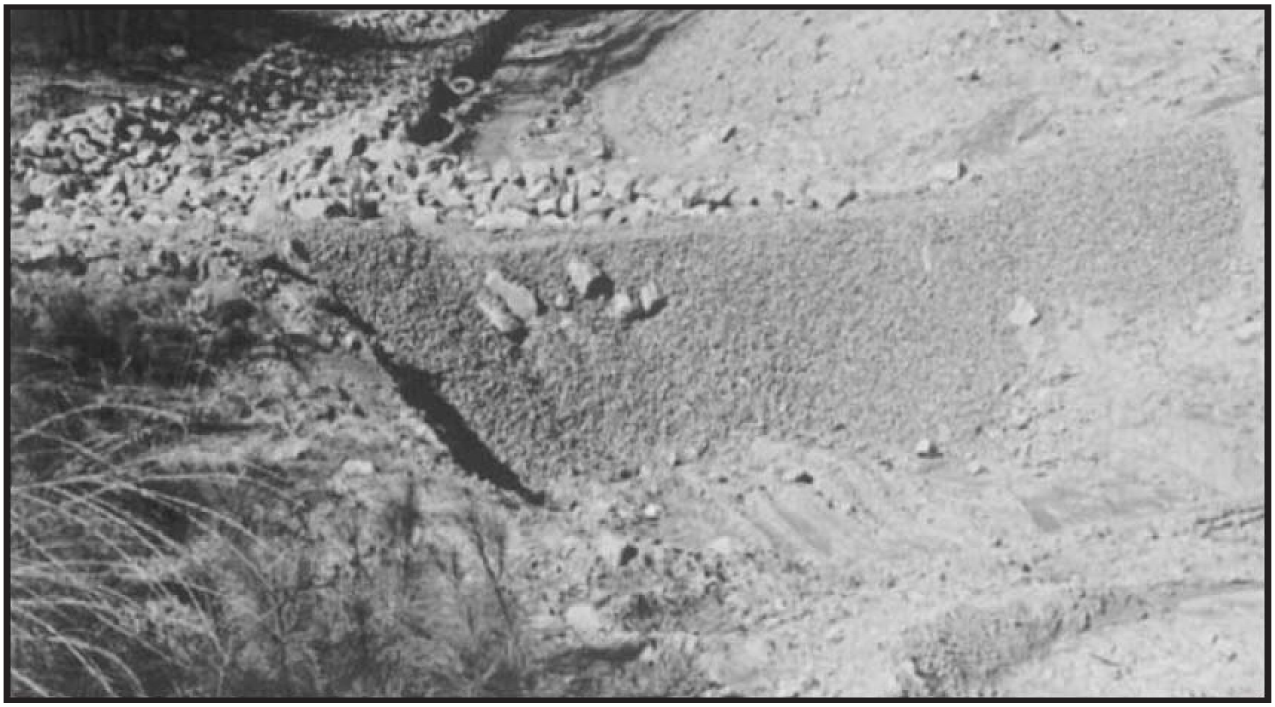

Figure 6.79 Rock check dams can provide sediment control in channels and swales. Source ABC of BMPs, LLC

Practice Description

A rock check dam is a stone dam designed to capture sediment within drainage swales and diversions on the construction site. This practice can be used as an alternative to a standard sediment basin for locations with a drainage area of 20 acres or less. It may be preferred over standard sediment basins for sites where an earthen embankment would be difficult to construct.

Recommended Minimum Requirements

Prior to start of construction, rock check dams should be designed by a registered design professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. The rock check dam should be built according to planned grades and dimensions.

The major design elements include:

- Middle of the check dam is the lowest point where stormwater flow will go over the check dam. Make sure the ends are at a higher elevation than the middle.
- The downhill side slope of the check dam has a longer angle of repose to dissipate the energy of the stormwater flow over the dam to prevent scour on the downstream side of the check dam.
- The spacing between check dams is such that the bottom of the upper check dam is at the same elevation as the top of the check dam below it. This will not allow the stormwater flow to increase velocity as it goes down the slope but make the feature more like a stair step journey.

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Divert runoff from undisturbed areas away from the rock check dam and basin area.
- Do not divert toward existing buildings or houses.
- Stabilize the diversion, swale or channel with vegetation or a turf reinforcement mat to prevent or minimize erosion of the channel.

Construct the check dams as shown in the Figure 5.89 and remember the following three design principals:

- The middle of the check dam is the lowest point so the storm water flow is directed to the middle of the channel.
- The down gradient side of each check dam is at a lower angle to allow for energy dissipation of the storm water flow over the check dam to reduce the potential for scour.
- Space the check dams so the elevation of the bottom of the upper check dam at the same elevation as the top of the lower check dam. This allows water to pond back to the check dam above it to reduce velocity and create a stair step cascade of the storm water flow.

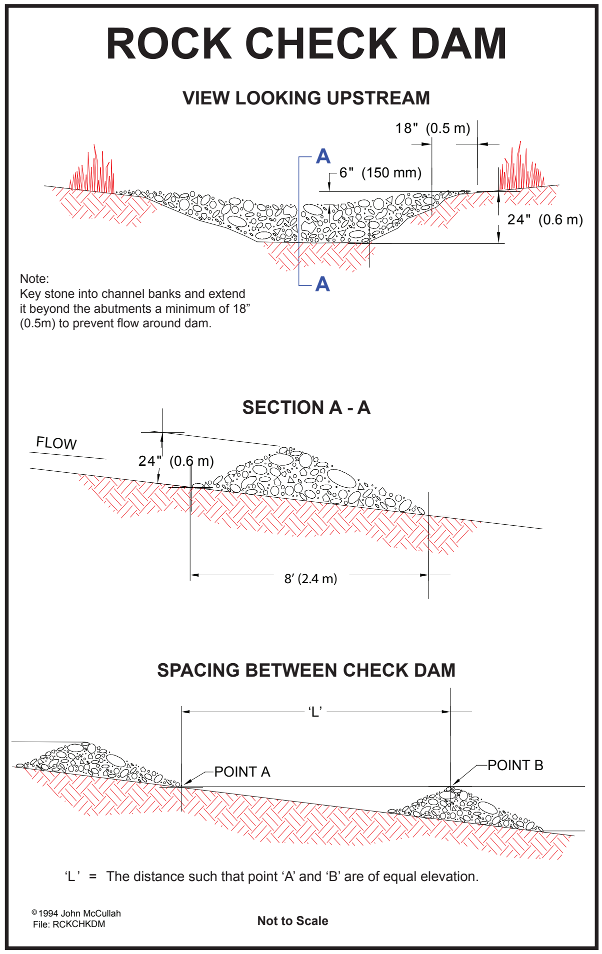

Figure 6.80 Detail of Rock Check Dam

Safety

Because rock check dam sediment basins impound water, they should be considered potentially hazardous. Take the following precautions:

- Avoid steep slopes; both cut and fill slopes should be 2.5:1 or flatter; 3:1 where maintained with tractor or other equipment.
- Fence area and post warning signs if trespassing is likely.
- Do not construct directly above structures that could be damaged in the event of failure.

Construction Verification

Check finished grades and dimensions of the rock check dam. Check materials for compliance with specifications.

Maintenance, Inspection and Removal

- Inspect the rock check dams weekly and after each storm event as required by your permit.
- Remove sediment when it accumulates to half the design volume.
- Check the dam and abutments for erosion, piping or rock displacement and repair immediately.
- If the channel does not drain between storms, replace the stone on the upstream face of the dam.

- After the construction site has become permanently stabilized:
  - Remove all temporary check dams and any unstable sediment.
  - Smooth the site to blend with the surrounding area and stabilize.
  - Remove all water and sediment from the basin prior to dam removal.
  - Place the sediment in designated disposal areas and is not allowed to flow into streams or drainage ways during structure removal.
  - Leave check dams in place if they are designed as permanent structures.
- Remove of this temporary rock check dam and stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	Solution
Variations in topography on-site indicate the rock check dam will not function as intended.	Changes in plan may be needed, consult with a registered design professional.
Erosion increased during storm events; caused by the channel not being properly stabilized.	Stabilize the channel immediately with vegetation or turf reinforcement mat.
Storm flow goes around the sides of check dam eroding the bank; caused by the elevation of dam being too high in the middle.	Lower the middle of the check dam so storm water flow goes over the middle, repair damage and stabilize eroded side slopes.
Rock is displaced; caused by the stone size being too small or embankment slope is too steep.	Replace larger size stone or reduce slope.
Rock is displaced; caused by the high velocities because spacing between dams is too long and therefore does not rsufficiently reduce velocity.	Consult the design professional to recalculate the drainage slope and dam heights to determine correct check dam spacing.
Erosion occurs in downstream area; caused by the apron not extended to stable grade.	Repair erosion and extend apron.
Erosion of abutments occurs during spillway flow; caused by the rock not being high enough on the abutment.	Extend rock higher on the abutment.
Sediment is being carried through the spillway or accumulates in excess between clean outs; caused by the drainage area being too large.	Divert runoff from undisturbed areas way from the basin, enlarge basin and clean out basin more frequently or consult the professional designer for other alternatives.
Sediment is lost through the check dam; caused by the layer of gravel aggregate on the upstream face not being thick enough or is too coarse to restrict flow through the dam.	Replace gravel aggregate with material having proper gradation to provide filtration.

Ditch Checks

Figure 6.81 This check dam device appears to be working correctly but there should also be erosion control protection covering the channel to reduce scour and erosion of the channel bottom. Source ABC of BMPs, LLC

Practice Description

As with rock check dams, premanufactured ditch checks are used in water ways and swales to reduce water velocities in concentrated flows, dissipate energy to drop out larger sediment loads in fast moving water and reduce erosion in ditches until permanent, vegetation can be established. With routine maintenance, life expectancy is usually six and nine months.

Sediment fence and straw bales are generally not recommended for ditch checks. Suitable products include silt dikes, permeable plastic triangular berms and permeable M panels. In lighter flows use straw and excelsior wattles and compost socks. A critical component of any ditch check is that it does not cause more erosion on the downstream side than what it is protecting upstream. All channels should have erosion control practices in place such as blankets or turf reinforcement mats to further reduce scour and erosion of the channel.

Recommended Minimum Requirements

Drainage Area

The drainage area requirements are in direct relation to how wide the ditch or swale is and the strength of the ditch check. Hydraulic design is recommended to ensure proper material selection and placement.

BMP Lifespan

Six and nine months. Some will last longer.

Anchors
Vary by product type. Silt dikes require stapling with 6-inch staples(in fill conditions, 12- to 18-inches geotextile fabric pins are required) Permeable plastic berms require 10-inch landscape spikes. Permeable M panels require separate M-pins. Wattles and logs typically require 18- to 24-inch wood stakes on 2-foot centers.

Other Materials
A geotextile fabric is strongly recommended for any rock ditch check to separate the rock from the finished grade.

Location
A generally accepted standard for ditch check location is to locate ditch checks where elevation change from one check to the next is equivalent to the height of the particular ditch check used.

Construction
Site Preparation
Finish swale grading to plans. If swale is not in its final configuration, immediately install designed ditch check according to the manufacturer's requirements for effective sediment control. If swale is completed and ready for final stabilization, use the appropriate erosion control practice as designed by the engineer, then install ditch checks that will allow for vegetation establishment. A critical component of any ditch check is the elevation at the center of the check be lower than any other point. including the termination of the check into the side slope. At no time should water have the ability to flow around the ditch check.

Erosion Control
Erosion control measures should be used in conjunction with a ditch check. In many cases, effective erosion control can reduce the need for as many ditch checks on a project.

Figure 6.82 Wattle Ditch Check Source: American Excelsior

Construction Verification

The field inspector should:

- Verify the dimensions shown on the plans for the ditch location.
- Verify the top elevation as it relates to the termination at the sides.
- Verify the ditch check is properly secured to the ground surface.
- Evaluate stabilization techniques required for effective erosion control.
- Check all finished grades and final ditch check locations.

Maintenance, Inspection and Removal

- Maintenance includes periodic sediment removal after rain events to allow for maximum capacity of sediment. Each rain event will drop a significant amount of sediment. For rock ditch checks, complete removal of sediment laden rock and replacement with clean rock is required after the ditch check is plugged and ponds water. Geotextile may need to be replaced as well. If ditch checks become damaged from bed load and floating debris, replace as necessary.
- Remove temporary ditch check and stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	Solution
Erosion occurs into the side slope - water goes around ditch check.	Increase length of ditch check so lowest point is in center of channel or swale.
Significant erosion occurs between ditch checks - too much distance between ditch checks.	Install additional ditch check in between - follow recommended guideline for spacing.
There is poor erosion control on grade between ditch checks.	Re-grade, seed and apply appropriate erosion control practice.
There is scour on downstream side of ditch check-may be caused by too much water flowing in ditch or poor ditch check design for hydraulic condition.	Use alternative ditch check and install appropriate erosion control measure to reduce erosion on downstream side of ditch check.
Stormwater flow cuts around the ends of the ditch check.	Ditch check is lower at the ends than the middle and needs to be redesigned and installed properly.

Wattles

Figure 6.83 Wattles are used here as slope breaks to reduce the velocity of overland flow. Source: Missouri Department on Natural Resources Southwest Regional Office

Definition and Purpose

Wattles are degradable or nondegradable materials rolled or bound into a tight tubular roll and placed on the toe and face of slopes to intercept runoff, reduce flow velocity, release the runoff as sheet flow and provide removal of sediment from the runoff. Wattles may also be used for inlet protection and as check dams under certain situations. A degradable wattle consists of wood excelsior, rice or wheat straw, or coconut fibers. Nondegradable wattles consist of recycled tire products, foam peanut material or other material bound in a heavy mesh tube.

Recommended Minimum Requirements

This Best Management Practice may be implemented on a project-by-project basis with other best management practices when determined necessary and feasible. Wattles may be used:

- Along the toe, top, face and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
- Below the toe of exposed and erodible slopes.
- As check dams in drainage swales.
- For drain inlet protection.
- Down-slope of exposed soil areas.
- Along the perimeter of a small area (less than 1/3 acre) such as home lot.

Construction

- Runoff and erosion may occur if the wattle is not adequately trenched in.
- Wattles must be overlapped along the edges of at least 12-inches.
- Wattles at the toe of slopes greater than 1:5 may require the use of 500 mm (20" diameter) or installations achieving the same protection (e.g., stacked smaller diameter fiber rolls, etc.).
- Wattles may be used for drainage inlet protection if they can be properly anchored.
- Degradable wattles are somewhat difficult to move once saturated.
- Wattles could be transported by high flows if not properly staked and trenched in place.
- Wattles have limited sediment capture zone.
- Do not use wattles on slopes subject to creep, slumping or landslide.

Maintenance, Inspection and Removal

- Inspect wattles each week and after rain events as required by your permit.
- Clean accumulated sediment from behind wattles prior to the next rain event.
- Maintain wattles to provide an adequate sediment holding capacity. Sediment shall be removed when the sediment accumulation reaches one-half of the barrier height. Removed sediment shall be incorporated in the project or disposed in accordance with Missouri State solid waste regulations.
- Remove wattles as soon as possible after the project site has been stabilized. Dispose of in accordance with solid waste regulations and permit requirements.
- Remove the temporary wattles and stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Common Problems and Solutions

Problem	Solution
Erosion and rills form under the wattle; caused by the wattle not being properly trenched into the ground.	Repair erosion, fill rills and trench wattle properly.
Erosion around edges of the wattle; caused by the wattle not placed on the contour with a slight up gradient at the edges.	Reinstall wattles on the contour with a slight turn up gradient at the edges.
Erosion at the joints of two wattles; caused by the wattles not being properly overlapped.	Reinstall wattles with overlap of the edges at least 12-inches.

Straw Bale Barrier

Practice Description

This barrier is a temporary row of entrenched and anchored straw bales. This practice applies downstream of very small disturbed areas of one acre or less subject to sheet erosion. The purpose is to intercept and detain small amounts of sediment in order to prevent sediment from leaving the construction site. EPA does not recognize straw bale barriers as an effective best management practice and many areas of Missouri are phasing out their use.

Recommended Minimum Requirements

Prior to start of construction, straw bale barriers should be designed by a qualified professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. The straw bale barrier should be built according to planned grades and dimensions.

Drainage Area

Areas subject to sheet erosion: from one acre or less.

Bale Size

14-inch x 18-inch x 36-inch (no seed).

Anchors

Two 36-inch long (minimum) 2 x 2 inch hardwood stakes driven through each bale.

Slopes

4:1 above the barrier; with maximum drainage area of one acre or less.

Effective Life

Less than three months.

Location

On nearly level ground. The barrier should follow the land contour as closely as possible. Not in live streams or in swales where there is the possibility of a washout. Not in areas where rock or another hard surface prevents the full and uniform anchoring of the barrier.

Restricted Use

When used as a best management practice, straw bales shall be replaced after 60 days or sooner if failure is imminent. Straw bales shall be used as a solution only as a last alternative. The date the straw bales were installed shall be recorded on the weekly Storm Water Pollution Protection Plan inspection report.

Construction

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Grade alignment of barrier as needed to provide broad, nearly level area upstream of barrier.

Grading

- Excavate a trench at least 4-inches deep, a bale's width, and long enough the end bales are somewhat upslope of the sediment pool (Fig. 5.87).
- Place each bale end to end in the trench so the bindings are oriented around the sides rather than top and bottom (Fig. 5.87).
- Anchor the bales by driving two 36-inch long 2 x 2 inch hardwood stakes through each bale until nearly flush with the top. Drive the first stake toward the previously laid bale to force the bales together. Ensure there are no gaps between bales.
- Wedge loose straw into any gaps between the bales to prevent sediment-laden water from running through.
- Backfill and compact the excavated soil against the bales to ground level on the down slope side and to 4-inches above ground level on the upslope side.

Erosion Control

Stabilize disturbed areas in accordance with the vegetation plan.

Construction Verification

Check finished grades and dimensions of the straw bale barrier. Check materials for compliance with specifications.

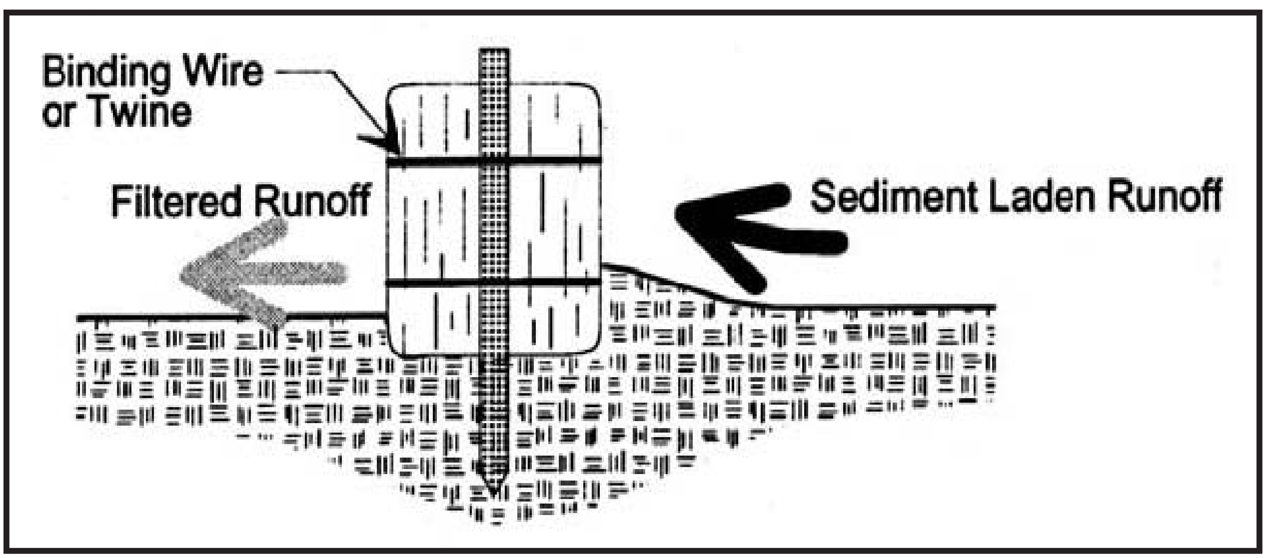

Figure 6.84 Installation of straw bales.

Maintenance, Inspection and Removal

- Inspect straw bale barriers weekly and after each storm event as required by your permit.
- Remove sediment deposits promptly, taking care not to undermine the entrenched bales.
- Inspect periodically for deterioration or damage from construction activities. Repair a damaged barrier immediately.
- After the contributing drainage area has been stabilized, remove all straw bales and sediment. Bring the disturbed area to grade and stabilize.
- Removal of this temporary device must be performed and the site stabilized prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

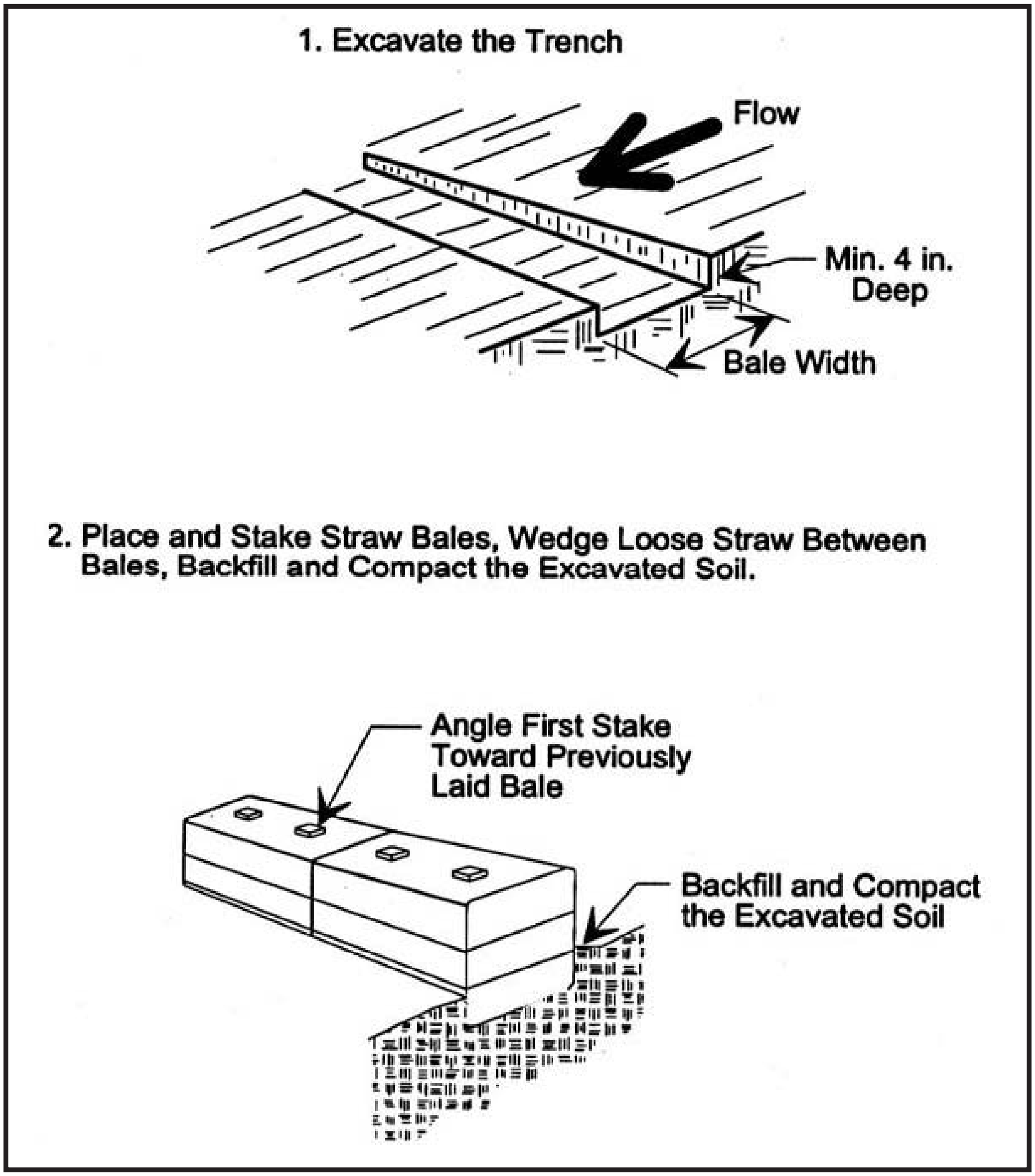

Figure 6.85 Straw bale alignment.

Common Problems and Solutions

Problem	Solution
Variations in topography on-site indicate sediment fence will not function as intended.	Changes in plan may be needed.
Erosion under or around end of bales; caused by the barrier terminating at an elevation below the top of the temporary pool or at an unstabilized area, is located on too steep a slope or was placed in an area of concentrated flow.	Correct problem by re-grading or stabilization; if straw bale barrier is in area of concentrated flow, use different method of sedimentation control (see Rock Check Dam or Ditch Check).
Overtopping of barrier; caused by inadequate storage capacity, no provision was made for safe bypass of storm flow, or the drainage area is too large.	Reduce the area draining to the straw bales or use device other than straw bales.
Unsightly after project stabilization; caused by bales not removed after area has been stabilized.	Remove in a timely manner and stabilize the disturbed area.
Undercutting of barrier; caused by bales not entrenched at least 4-inches or backfilled with firmly compacted soil.	Reinstall barrier using proper installation methods.
Collapse or dislodge of barrier; caused by bales not adequately staked.	Reinstall barrier using proper installation methods.
Collapse or dislodge of barrier; caused by too much sediment allowed to accumulate between clean outs.	Remove accumulated sediment more frequently.

Vegetative Buffer Strip

Figure 6.86 Vegetative buffer strips slow surface runoff, reduce sedimentation and help capture pollutants. Depending on the choice of plant materials, they can be low maintenance areas (mow once or twice a year) or provide habitat for wildlife.

Practice Description

A vegetative buffer strip is a wide belt of vegetation designed to provide infiltration, intercept sediment and other pollutants and reduce stormwater flow and velocity. Vegetative buffer strips are similar to grassed swales except they are designed to accept only overland sheet flow. They cannot treat high velocity flows. Surface runoff must be evenly distributed across the vegetative buffer strip. After a channel forms in the vegetative buffer strip, it is no longer effective.

Vegetative buffer strips can consist of grass, woody vegetation or other erosion resistant plants. They can be used adjacent to impervious surfaces and next to stream corridors or wetlands to slow the flow and help remove sediment from runoff. They can also be used in conjunction with infiltration basins, infiltration trenches or alongside streams to provide water quality treatment for post-construction.

Recommended Minimum Requirements

Prior to start of construction, vegetative buffer strips should be designed by a qualified professional. The site superintendant and field personnel should refer to plans and specifications throughout the construction process. The vegetative buffer strip should be built according to planned alignment, grade and cross section. Should any field adjustment to the design and installation be needed, a qualified professional should be consulted in the modification to the original design or specification.

Drainage Area

Less than 5 acres.

Location

Adjacent to low or medium density residential areas on gently sloping ground (less than 5 percent), with length of strip running along the contour, along the perimeter of a site, or any available vegetated area or area capable of being vegetated.

Vegetation

A mix of erosion resistant plants that form a dense mat and effectively bind the soil (see Permanent Seeding).

Slope

Uniform, even and relatively flat (5 percent or less) with a level spreading device (level lip, weir, etc.) across the top edge of the vegetative buffer strip.

Minimum Width

Should conform to those in Table 6.16.

Minimum Length

At least as long as the contributing runoff area, but no less than 50 feet plus 4 feet for each one percent increase in slope.

Table 6.16 Minimum Width of Vegetative Buffer Strip

Slope of Land	Width of Vegetative Buffer Strip	Width of Vegetative Buffer Strip
(Percent)	For Grassed Areas (ft.)	For Forested Areas (ft.)
0	10	25
2	12	29
4	14	33
6	16	37
8	18	41
10	20	45
15	25	55

Construction

Site Preparation

- Natural wooded strips in addition to grass strips should be considered. At the start of development, designate, identify and fence off any areas to be preserved. Avoid storing debris from clearing and grubbing activities and other construction waste material in these areas during construction.
- If a vegetative buffer strip is constructed, clear and grub the vegetative buffer strip area before the impervious area is completed.

Grading

- If the adjacent area does not meet the buffer on a uniform contour, grade a swale along the contour directly adjacent to the top edge of the vegetative buffer strip. The swale will serve as a "level spreader" to collect overland flow and distribute the runoff evenly to the vegetative buffer strip. By discharging to the vegetative buffer strip uniformly along the top of the strip, rill and gully formation due to concentration of flow is minimized.
- Line the swale with rock or other erosion resistance material.
- Sod or seed, fertilize and protect the vegetative buffer strip area with an appropriate rolled erosion control product per the specifications.

  Note: Some fertilizing activities may be prohibited near wetlands and other eco-sensitive areas. Consult a qualified professional if needed.
- Vegetated buffer strips should be protected from excessive sediment laden storm water runoff during construction operations because excess sediment will kill the vegetation. This protection can be in the form of silt fence or other sediment control best management practices placed at the top of the slope to pretreat runoff headed for the buffer strip. If excessive sediment is deposited in the buffer strip, appropriate measures should be taken to reestablish the vegetative strip, including complete regrading and reseeding or sodding of the area.

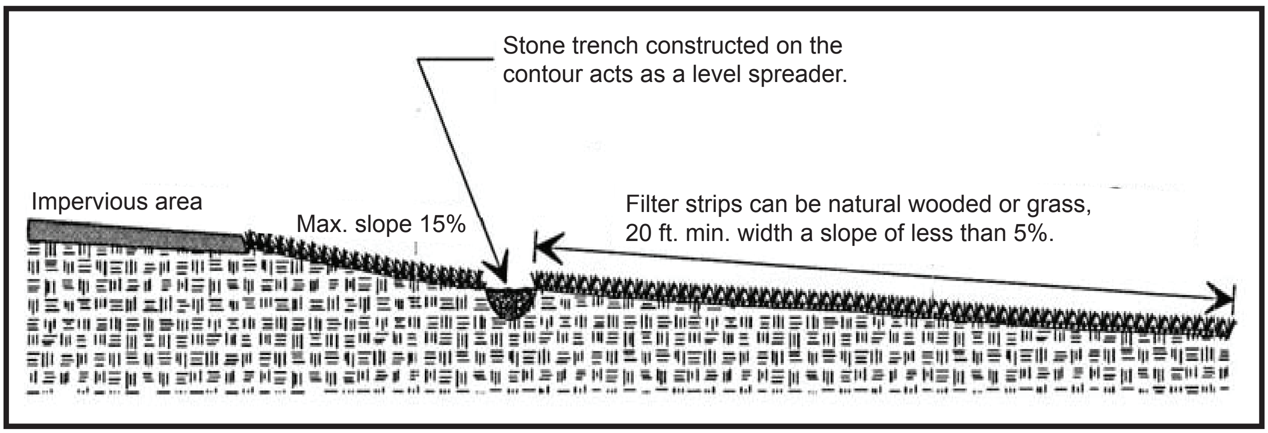

Figure 6.87 Vegetative Buffer Strip

Erosion Control

- Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete.
- Direct all overland flow to the vegetative buffer strip or the level spreading swale at low velocities.

Safety

- Store all construction materials and waste material well away from the vegetative buffer strip.
- Follow all local, state and federal guidelines in constructing utility trenches. If utility lines are buried beneath the vegetative buffer strip, do not perform final grading until all trench settlement has taken place. Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Provide temporary fencing and warning signs until vegetation is established.

Construction Verification

Check the finished grades and configuration of all earthwork, level spreaders and diversions.

Maintenance, Inspection and Removal

- Check for eroded channels in the vegetative buffer strip after every storm event. Fix eroded areas and reseed, mulch and fertilize the affected area. Modify the Storm Water Pollution Prevention Plan to prevent further issues.
- Apply fertilizer in accordance with soil test recommendations and always consider application timing and rates that will protect water quality – i.e. do not apply more than is necessary and do not apply when rain will likely carry fertilizer off to the stream system. Excessive fertilizer can cause a change in pH that allows heavy metals and other toxic compounds to become mobile and available for uptake by aquatic plants and animals. The change in pH can also prohibit nutrient uptake by the targeted vegetation.
- Remove sediment deposits accumulating in the vegetative buffer. This should be done very carefully to avoid damage to the vegetation.
- Protect new plantings from livestock or wildlife.
- Mow grass strips to a height of 6- to 12-inches two to three times a year to suppress weeds and woody vegetation unless natural, woody vegetation is indicated on the plan.
- Repair foot paths and traffic ruts.
- Remove the temporary vegetative bufferstrip and stabilize the site prior to filing *Form H: Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter One - Missouri Permit Requirements).

Troubleshooting

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

- Variations in topography on-site indicate vegetative buffer strip will not function as intended.
- Design specifications for fill, rock, sod, seed, mulch or fertilizer cannot be met; substitution may be required. Unapproved substitutions could lead to the vegetative buffer strip not operating as designed after construction activities have been completed.
- Naturally vegetated areas intended for use as buffer strips have been damaged or inadvertently reduced in width.

Common Problems and Solutions

Problem	Solution
Inadequate vegetation causing erosion of vegetative buffer strip due to too great a length of overland flow, too great a slope or high flow rates due to a drainage area greater than 5 acres.	Repair erosion damage and reevaluate erosion protection measures.
Inadequate vegetation causing erosion of vegetative buffer strip due to malfunctioning irrigation or lack of proper watering to establish the vegetation.	Repair erosion damage and possible irrigation issues, provide sufficient water for plant establishment and reevaluate erosion protection measures.
Settlement of soil in utility trenches or settlement of fill creates ponding within the vegetative buffer strip.	Fill low areas and regrade to provide proper drainage.
Uneven slope or debris clogging the trench at top of vegetative buffer strip creates a diversion of flow around vegetative buffer strip.	Remove debris and regrade as needed to provide proper drainage.
Sediment and debris clogging upper end of vegetative buffer strip creates a reduction in flow across vegetative buffer strip.	Replace clogged portion of vegetative buffer strip.

Dewatering

Figure 6.88 Use of a dewatering bag where storm water is pumped into a geotextile bag. The sediment stays in the bag while the storm water is allowed to flow out through the small voids in the material. Source: ACF Environmental Inc.

Practice Description

Dewatering is a commonly required practice occurrence after a storm event on a construction site. Dewatering is performed in excavated work areas such as utility trenches and footings to clear the area of storm water so work can be performed. It may also be required on sediment traps or basins that are designed to pond water to make storage room for additional storm water during the next rain event. It is also performed in excavated work areas such as utility trenches and footings to clear the area of storm water so work can be performed.

Dewatering can be performed with a suction pump or other device such as a skimmer. Dewatering of storm water from sediment traps or basins must be limited to removing only the top or surface water containing the least amount of sediment. When dewatering with a pump, the water should be pumped into a device such as a geotextile bag or temporary sediment trap to remove or settle the sediment and allow the treated or clearer storm water to be discharged.

Recommended Minimum Requirements

It is best if the stored storm water in the trap or basin has been allowed to sit a minimum of 24 hours after the storm event. Depending on the types of soils and high clay content, additional settling time may be necessary before dewatering the trap or basin. If the intake must be close to the bottom of the excavated area it should be protected with a cloth or geotextile sock to reduce the amount of sediment particles exiting through the hose.

Water must be withdrawn from the top of the basin or treated through a geotextile bag or other treatment system before the storm water is allowed to leave the site.

Maintenance, Inspection and Removal

- Maintain the pump in proper operating condition and make sure the pump does not cause pollution to the surrounding area from fuels, oils, greases or other operating fluids. Monitor the dewatering and discontinue when the discharge begins to contain heavier sediment loads.
- Remove the temporary device and stabilize the site prior to filing *Form H - Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter 1 -Missouri Permit Requirements) for termination of permit coverage.

Troubleshooting

- Make sure the sediment has a proper settling time and sediment laden water is not discharging from the construction site.
- Make sure the geotextile bag (if used) is the proper size for the amount and velocity of flow going into the bag.
- Make sure the geotextile bag is located where it can be accessed for removal. The bag can be heavy, particularly when sediment is wet.
- It is also a good idea to have the dewatering bag placed so the discharged storm water can flow over a vegetated buffer strip or other area of vegetation, if possible.

Common Problems and Solutions

Problem	Solution
Pump loses suction – pump has lost its prime.	Reprime pump and begin dewatering activities.
Pump hose becomes clogged - the protective sock at the end of the hose has become saturated with sediment.	Clean or replace sock and keep the end off the bottom of the trap or basin and out of sediment laden water.
Erosion around the dewatering bag caused by locating the bag on an unstable surface.	Stop dewatering and move the bag to a stable (non-erodible) surface and continue the dewatering process.

Sediment Basin

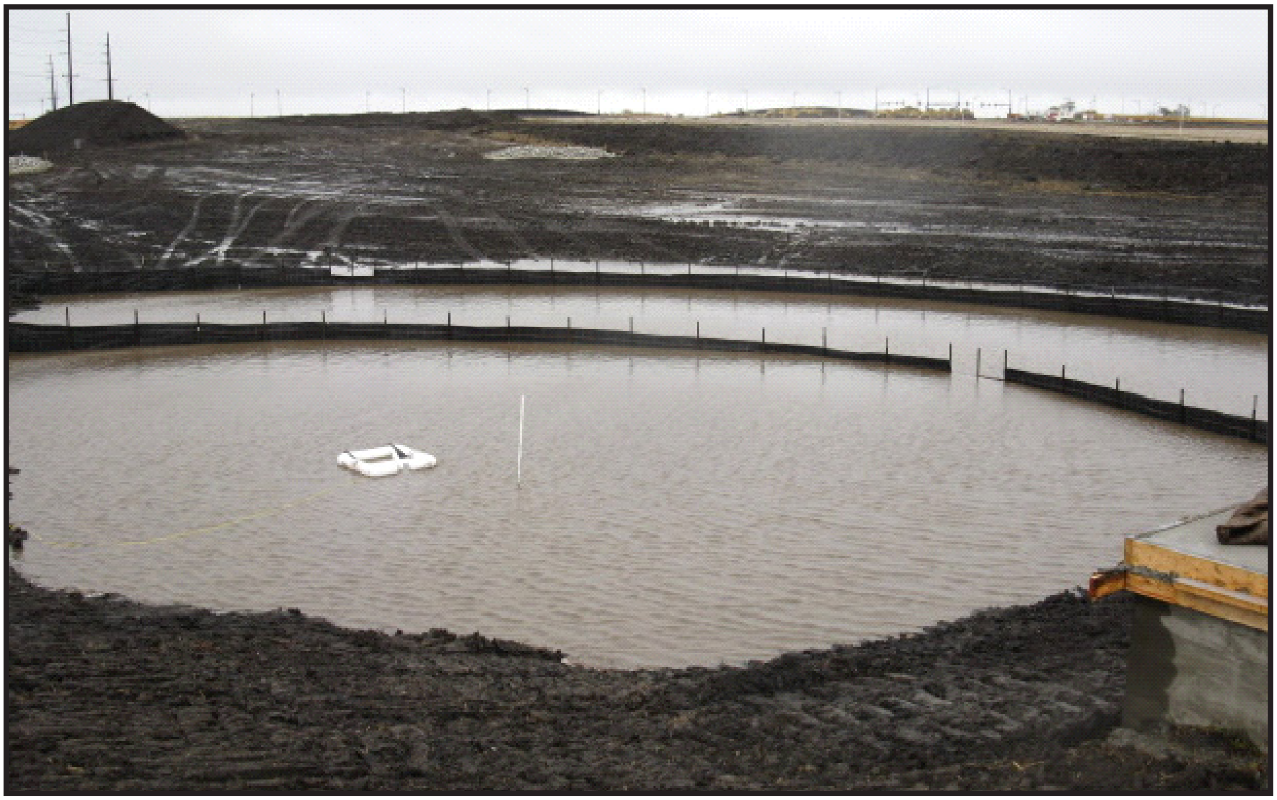

Figure 8.89 A sediment basin can be used to pretreat sediment-laden water before it discharges from the construction site.
Source: BFA Inc.

Practice Description

A sediment basin is a temporary pond constructed to contain sediment-laden storm water for an extended period of time prior to the storm water discharging from the basin. A sediment basin is temporary and should be removed or retrofitted prior to any final construction activities that would make these features a permanent detention or retention pond, after the entire contributing drainage area is stabilized.

This practice applies where other erosion control measures are insufficient to prevent off-site sedimentation. The purpose of a sediment basin is to detain sediment-laden runoff from disturbed areas in wet storage long enough for most of the sediment to settle out.

Recommended Minimum Requirements

Prior to the start of construction, sediment basins should be designed by a registered design professional. Plans and specifications should be referred to by the site superintendent and field personnel throughout the construction process and anytime maintenance practices are required.

Build the sediment basin according to planned grades and dimensions.

Dam Height

10 feet or less.

Contributing Drainage Area

On project sites greater than 10 acres, contributing area is limited to 20 acres or less.

Structure Life

Limited to 10 years.

Detention

At least 24 hours or per local requirements.

Storage Volume

Minimum of 3,600 cubic feet per acre of contributing drainage area (pervious or impervious).

Trap Efficiency

The length to width ratio of the basin should be 2:1 or greater; 5:1 is optimal to capture fine sediments. Locate the inlet as far as possible upstream from the outlet.

Short Circuiting

Design the inflow to the pond as far away from the discharge point as possible. If not possible, design a baffle, weir or wall between the inflow and outflow to increase distance and travel time so there is maximum settling time prior to storm water discharge.

Embankment

- Top Width: At least 6 feet.
- Side Slopes: 2.5:1 or flatter; 3:1 where maintained by tractor or other equipment.
- Settlement: Allow for at least 10 percent.
- Fill material: Stable moist soil compacted in lifts less than 8 inches.

Anti-seep Devices

Either of the following is recommended:

- Use at least two watertight anti-seep collars around the outlet conduit; collars should project 1- to 3-feet from the pipe.
- A sand diaphragm (see Glossary).

Risers

- Hold risers in place with an anchor or large foundation to keep them from becoming buoyant.
- Install appropriate inlet protection on the riser.
- Pipe size for the primary conduit should restrict discharge into the natural drainage area at a rate and volume of storm water that meets the local regulatory requirements and the design plan.

Emergency Spillway

- Constructthe spillway in undisturbed soil in a location that will not erode the dam.
- Cross Section: Trapezoidal-shaped with side slopes of 3:1 or flatter
- Control Section: Level, straight and at least 20 feet long. The spillway should have a minimum width of 10 feet.
- Stabilization: Stabilize with vegetation, erosion control blankets or other erosion control stabilization practices. Install rip-rap, turf reinforcement mats, transition mat or other appropriate material to finished grade if the spillway is not to be vegetated.

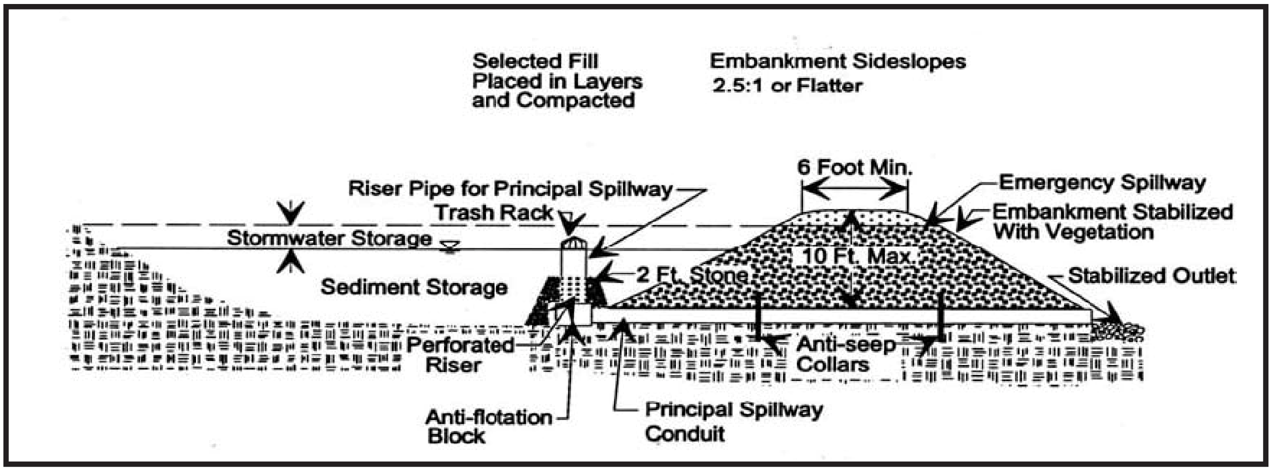

Figure 6.90 Typical Sediment Basin

Construction

Locate the sediment basin as close to the sediment source as possible, considering soil type, pool area, dam length, spillway conditions and proximity of sensitive habitats.

Site Preparation

- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Follow all federal, state and local requirements for impoundments. Clear, grub and strip the dam foundation, removing all woody vegetation, rocks and other objectionable material.
- Dispose of trees, limbs, logs and other debris in designated disposal areas.
- Excavate the foundation (outlet apron first), stockpiling any surface soil having high amounts of organic matter for later use.

Principal Spillway

- Construct a level sediment pool bottom to aid in sediment clean out. Situate the spillway barrel (pipe) and riser on a firm, even foundation. Prepare the pipe bedding.
- Place a 4-inch layer of moist, clayey, workable soil (not pervious material such as sand, gravel or silt) around the barrel, and compact with hand tampers to at least the density of the foundation soil. Don’t raise the pipe from the foundation when compacting under the pipe haunches.

  Perforate the lower half of the riser with 1/2-inch diameter holes spaced 3 inches apart or use a manufactured perforated riser.
- Embed the riser at least 12 inches into concrete, which serves as an anti-flotation block. The weight of the concrete should balance the buoyant force acting on the riser.

  $$\text{Buoyant Force} = \text{Volume of Riser} \times 62.4\ \text{lbs/ft}^3$$
- Surround the riser with 2- to 3-inch diameter clean stone to the height of the perforations on the riser. The stone footprint diameter should be 2 feet for every 1 foot of height.
- Place a domed inlet protector or steel trash rack around the riser inlet. The inlet protection should include overflow design. Trash rack openings should be no more than 4- to 6-inches square.
- At the pipe outlet, install a riprap apron at least 5 feet wide and 10 feet long to a stable grade.

Embankment

- Scarify the foundation of the dam before placing fill.
- Use fill from predetermined borrow areas. It should be clean, stable soil free of roots, woody vegetation, rocks and other debris; and must be wet enough to form a ball without crumbling, yet not so wet that water can be squeezed out.
- Place the most permeable soil in the downstream toe and the least permeable in the center portion of the dam.
- Compact the fill material in 6- to 8-inch continuous lifts over the length of the dam.
- Protect the spillway barrel with 2 feet of fill compacted with hand tampers before traversing over the pipe with equipment.

Emergency Spillway

- Construct and compact the dam to an elevation 10 percent above the design height to allow for settling.
- Place a reference stake indicating the sediment clean out elevation (50 percent of design elevation).
- Construct the spillway in undisturbed soil around one end of the embankment and locate it so that any flow will return to the receiving channel without damaging the embankment.

Stabilize the spillway as soon as grading is complete with vegetation, erosion control blankets or other erosion control stabilization practice; install riprap, TRM, transition mat or other appropriate material to finished grade if the spillway is not to be vegetated.

Erosion Control

- Minimize the size of all disturbed areas. Vegetate and stabilize all disturbed areas as soon as construction is complete.
- Divert runoff from undisturbed areas away from the basin.
- Use temporary diversions to prevent surface water from running onto disturbed areas.
- Divert sediment-laden storm water runoff to the upper end of the sediment basin (as far from the outlet or spillway as possible) to improve trap effectiveness. A forebay may also be incorporated at the basin inlet to dissipate energy.
- Direct all runoff into the basin at a low velocity (channel slope less than one percent).
- Vegetate and stabilize all disturbed areas immediately after construction.

Safety

Because sediment basins that impound water are hazardous:

- Avoid steep slopes; slopes around the sediment basin should be 2.5:1 or flatter; 3:1 where maintained by tractor or other equipment.
- Fence the area and post warning signs if trespassing is likely.
- Drain the basin between storm events.

Construction Verification

Check the finished grades and configuration for all earthwork. Check elevations and dimensions of all pipes and structures.

Maintenance, Inspection and Removal

- Inspect the sediment basin weekly and after each storm event.
- Remove and properly dispose of sediment when it accumulates to one-half the design volume. Proper disposal of sediment may entail placement at a stock pile or other area up gradient of the pond. Spread it out to allow drying and then stabilize it.
- Check the embankment, emergency spillway and outlet for erosion damage, piping, settling, seepage or slumping along the toe or around the barrel and repair immediately.
- Remove trash and other debris from the riser, emergency spillway and pool area.
- Clean or replace the gravel around the riser if the sediment pool does not drain properly.
- Remove the basin after the drainage area has been permanently stabilized, inspected and approved. Do so by draining any water (see Dewatering), removing the sediment to a designated disposal area, smoothing the material to blend with the surrounding area; and then stabilize. If this temporary sediment basin is to be converted to a permanent storm water control measure, or SCM, such as a detention, retention or infiltration basin, refer to your plans and specifications. Make sure the site is entirely stabilized before the permanent device becomes operational (no sediment-laden water should be entering the SCM.)
- Remove the temporary device and stabilize the site prior to filing *Form H - Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter 1 -Missouri Permit Requirements) for termination of permit coverage.

Common Problems and Solutions

Problem	Solution
Seepage is encountered during construction.	It may be necessary to install drains.
Variations in topography on-site indicate sediment basin will not function as intended.	Consult with registered design professional.
Design specifications for fill, pipe, seed variety or seeding dates cannot be met.	Substitutions may be required. Unapproved substitutions could lead to failure.
Piping failure along conduit caused by improper compaction, omission of anti-seep collar, leaking pipe joints or use of unsuitable soil.	Repair embankment using proper construction methods and materials.
Erosion of spillway or embankment slopes caused by inadequate vegetation or improper grading and sloping.	Repair using proper grades and slopes. Stabilize with vegetation, erosion control blankets or other erosion control stabilization practices. install rip-rap, turf reinforcement mats, transition mat or other appropriate material to finished grade if the spillway is not to be vegetated.
Riser and barrel blocked with debris	Remove debris and install trash guard.

Problem	Solution
Overtopping of the principal and emergency spillway caused by undersized principal or spillway design.	Repair erosion damage and reevaluate spillway design.
Frequent operation of emergency spillway and increased erosion potential caused by lack of maintenance.	Clean the sediment out of the basin on a regular basis.
Frequent operation of emergency spillway and increased erosion potential caused by undersized principal spillway.	The sediment basin was designed with insufficient volume. Enlarge the basin or install additional sediment traps upstream in the watershed.
Slumping or settling of embankment caused by inadequate compaction or use of unsuitable soil.	Repair damage with suitable, well compacted material.
Slumping failure caused by steep slopes.	Flatten slopes.
Severe erosion below principal spillway caused by inadequate outlet protection.	Install adequate outlet protection.
Turbid water coming out of outfall pipe; small clay particles do not have sufficient time to settle out. The primary problem is that too much sediment is coming from above. Take needed steps to reduce the overloading of sediment to the basin.	Consult with the registered design professional to pursue additional features such as installation of a pre-sediment basin, addition of baffles or addition of particle curtains.

Do not apply water clarifying chemicals such as polymers to the final sediment basin. If the choice is made to use water clarifying chemicals earlier in the treatment process, see Chemical Application for Turbidity Reduction. Note any restrictions or controls required in federal, state or local regulations.

Chemical Application for Turbidity Reduction

Practice Description

Chemicals such as anionic polymers (polyacrylamide, or PAM) and formulated chitosan products can be mixed with on-site storm water to increase the settling rate of sediment particles. These water clarifying compounds, or water clarifying compounds, cause very small clay soil particles to bind together to form floccules (often referred to as flocs) that clump together and settle out. Small particles can otherwise take many days (if ever) to settle out of the collected storm water.

It is important to protect the receiving waters from aquatic toxicity. If a decision is made to use water clarifying compounds, it is vital they be formulated, selected and mixed properly into the collected storm water. Any material can be toxic if used incorrectly, whether it is naturally occurring or synthetic. Manufacturer's specifications should be followed, and responsible parties should be trained to administer the products properly.

Consideration should be given first to erosion control and then appropriate sediment catchments as the main treatment for turbidity and suspended solid particles. It is also recommended land disturbance be phased in a way to keep disturbance areas as small as possible, as a way to protect water quality and to meet storm water regulations (see Chapter 1.) This proposed staging and dispersement of smaller sediment catchments is compatible with today's placement of permanent storm water control measures.

Note: Large detention basins are no longer the sole preference for permanently managing storm water, because management has evolved to include dispersed practices as a way to meet storm water quality regulations. (see Post-Construction Section).

If that approach is not feasible or fails to produce successful results, the permittee may utilize water clarifying compounds specified by the design engineer with appropriate instruction and application training. If the decision is made to use water clarifying compounds:

- Use water clarifying compounds in conjunction with a best management practice that allows the flocs to settle out and maintain storm water control regularly to ensure the settled flocs are collected and removed from the system to prevent them from unintentionally entering nearby waterbodies.
- Determine if water clarifying compounds are best applied in conjunction with particle curtains, dispersion fields, baffles, a sand filtration system or other practice, and such system should be designed by a licensed engineer, with appropriate consideration of:
  - The nature of the receiving water.
  - System sizing.
  - Pond sizing.
  - Flow requirements.
  - Method of dosing.
  - Proper pH range and pH protection.
  - The system must be designed to capture sediment on-site.

- The operator must be properly trained to use the system and should have direct access to written specifications and operation procedures.
- Site-specific soil bench testing (e.g., jar testing) should be done in advance to determine proper application rates and methods per manufacturer's specifications. This will help to meet state and federal water quality standards for nephelometric turbidity units and to assure the chemical is performing to the best of its ability.
- The water clarifying compounds must be mixed into the water at a specified flow rate to ensure proper dispersion and ion exchange.
- Effluent should be monitored for residual chemical products or aquatic toxicity.
- Keep records for chemical use, effluent testing and corrective measures taken.
- Chemicals must be handled and stored according to applicable material safety data sheets.
- All construction land disturbance (state and local) permit requirements must be met.
- Local regulations may also govern the use of water clarifying compounds.
- Your local or state permitting authority may require prior review and approval of any use of chemicals to control erosion or turbidity, and if approved, include details in the storm water pollution prevention plan.
- Any product, including anionic water clarifying compounds, can be toxic to aquatic life if applied inappropriately.
- Use only products that have undergone whole product testing in an EPA approved laboratory using EPA protocol for acute and chronic toxicity.
- Do not use cationic "PAM", unformulated chitosan, alum or ferric iron compounds as they can be toxic to fish at very low levels. Such material binds to fish gills or depletes available oxygen, hindering oxygen uptake.
- Do not apply directly to or in close proximity to waterbodies.
- Do not use in areas with a shallow groundwater table or highly permeable soils.

Note: The terms flocculant and polymer are commonly used in the storm water industry. Technically, coagulants are often positively charged chemicals used to bind with negatively-charged particles to form flocs. Flocculants are settling aids that increase the rate of this binding process by bridging flocs into larger clumps. The important thing to remember is chemical additives bind to pollutants through negative and positive ion attractions, and in order to protect water quality, strict attention should be paid to proper selection and application.

Particle Curtains

Figure 6.91 Particle Curtains. Source: Florida Erosion and Sediment Control Designer and Reviewer Manual, June 2007

Practice Description

Particle curtains are a series of curtains made of jute and coconut fabrics attached to floats to be used in a sediment pond or similar treatment device. Its purpose is to collect fine particles, when used with a site-specific water clarifying compound such as a floc log. The floc log needs to be upstream of the particle curtain. This storm water control measure is intended to slow down the water flow through the basin so particles can fall out. It is not intended to be a stand-alone measure as it is not adequate sediment control by itself. Use this measure with sediment basins or traps.

- Secure the site-specific water clarifying compound far enough upstream to allow for appropriate mixing with the turbid water. Make sure the water can flow over and around the floc logs, adding mixing structures if needed to increase turbulence around the floc logs to facilitate proper mixing.
- Install the particle curtains in lines perpendicular to the flow across the sediment pond or waterway.
- The particle curtains will float.
- Inspect and repair or replace the particle curtains as require.

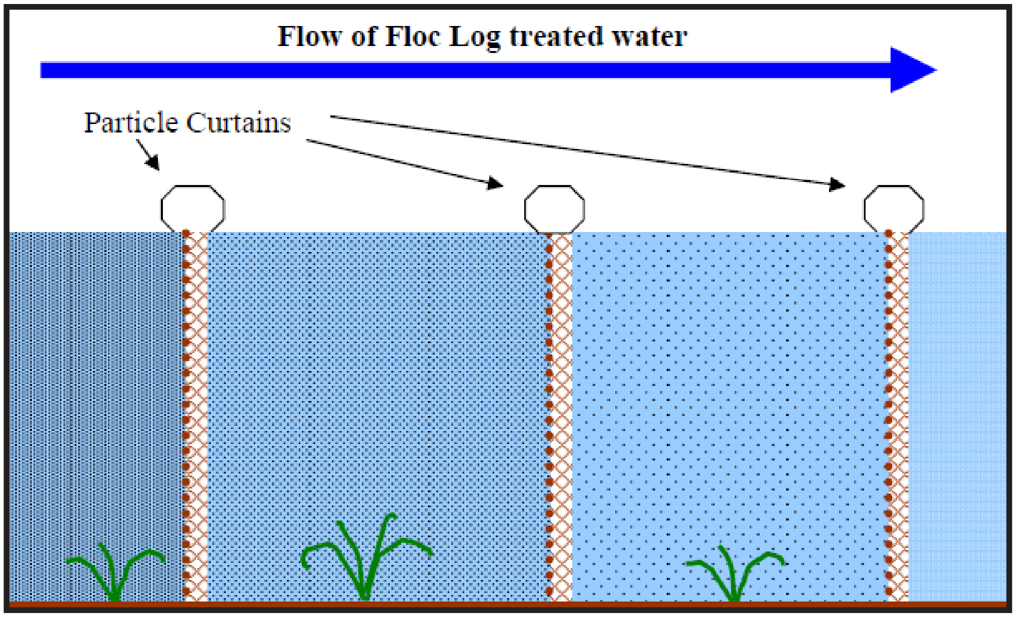

Figure 6.92 Source: *Polymer Enhanced Best Management Practice Application Guide*, March 2010

Maintenance, Inspection and Removal

- Inspect the device prior to use and make sure it is in proper working order. Repair, if necessary.
- Inspect the device periodically while it is in operation so it does not discharge sediment laden water from the construction site.
- Remove the device prior to the end of construction either when the sediment basin is removed or transformed into a permanent storm water control device.
- Remove the temporary particle curtains and stabilize the site prior to filing *Form H - Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter 1 - Missouri Permit Requirements) for termination of permit coverage.

Troubleshooting

- Anchoring devices (e.g, chains attached to weights) can be too short or too tight and therefore not allow curtain to rise and fall with water motions.
- Severe weather may dislodge the floating device and allow a turbid water release.
- Sediments allowed to drain from areas above the high water mark can overload the curtains.

Common Problems and Solutions

Problem	Solution
The curtain loses its shape.	It must be re-anchored. If it continues to break away from the anchors, more anchor points may be necessary.
If the curtain becomes submerged.	The anchor points must be readjusted to allow movement with water level.

Floc Logs

Practice Description

Floc logs are for use in concentrated flow areas for treating turbid storm water. Floc logs are chemically enhanced fabric “logs” used to introduce site-specific water clarifying compounds to turbid waters in such a manner to facilitate mixing and reaction between the compound and the suspended particles. The log will slowly dissolve over time and release the chemical into the flowing water. The compounds will react with suspended sediment causing the particles to bind together.

This storm water control measure is intended for particle collection only. It is not intended to be a stand-alone measure, as it is not adequate sediment control by itself. Use this measure with a sediment pond or similar treatment system.

Do not place floc logs directly into streams, tributaries or in direct paths to streams or other waters of the state. Do not allow runoff from floc logs to flow directly into streams or waters of the state.

Place the floc logs where the sediment-laden storm water will flow over them:

- In ditches that feed a sediment pond or similar treatment system.
- At the intake or outlet of a recirculation system.
- Near the aeration system.

Place logs in a series, one after another. The number of logs is determined by the flow rate of the water and the length of the mixing ditch is determined by the reaction time required for the polymer.

Checks can be placed along the ditch, forcing the water to flow over and around them, to increase turbulence and mixing with the floc logs. Cover the exposed soil in the ditch with jute matting and apply polymer powder to prevent erosion. With highly erosive soils, protection with geotextile or plastic sheeting may be necessary.

Inspect logs following each precipitation event and replace as needed. Use collected sediment higher up in the watershed as fill.

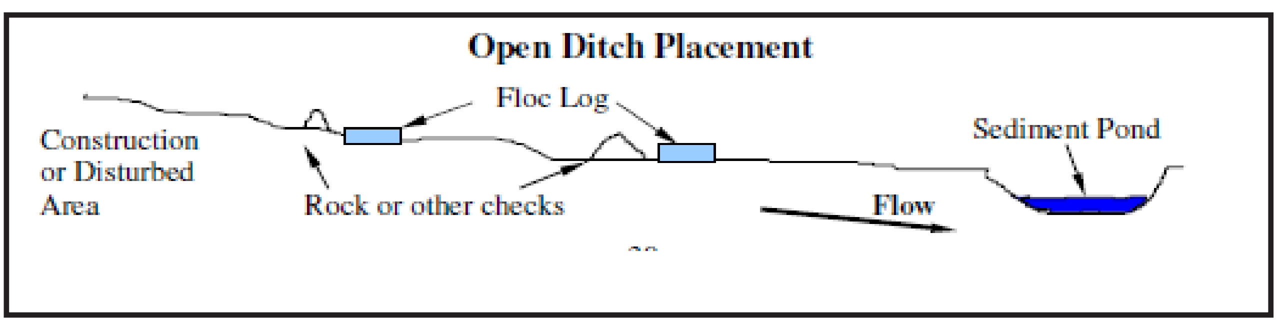

Figure 6.93 Open ditch placement.

Skimmers

Figure 6.94 A skimmer that provides dewatering from the top of the sediment basin. Source: *North Carolina Erosion and Sediment Control Planning and Design Manual.*

Practic Description

A skimmer is a dewatering device designed to remove water from sediment traps or basins. Dewatering the sediment storage structure, is a routine practice between storm events to accommodate additional storm water from the next event. A skimmer is a device that dewaters from the surface. Water at the surface should contain the least amount of sediment as particles settle to the bottom of the sediment storage structure.

Recommended Minimum Requirements

This device must be designed and engineered according to the size of the basin or trap they are dewatering. Therefore, stop dewatering activity when the device begins discharging sediment laden water.

Do not discharge sediment laden water from the construction site. Allow the storm water to sit in the trap or basin for an acceptable time prior to any dewatering activities. The acceptable time allowed for settlement will vary according to the size and type of sediment particles found within the sediment laden water.

Do not attempt to use a skimmer without the use of a baffle design (see Baffles). Part of the skimmer design includes not only the sizing of the skimmer itself, but an evaluation of the exact orifice size. These sizing decisions should be completed by the design engineer and incorporated into the storm water pollution prevention plan.

Do not apply water clarifying chemicals such as polymers to the final sediment basin. If the choice is made to use water clarifying chemicals earlier in the treatment process, refer to Chemical Application for Turbidity Reduction. Note any restrictions or controls required in federal, state or local regulations.

Construction

Follow manufacturers' recommendations for design and sizing of the device.

Troubleshooting

Device discharges sediment laden storm water; caused by lack of baffles or improperly notched baffles that cause sediment-laden strom water to enter the final section of the basin:

- Stop discharging and allow the pond to be still for at least 24-hours to settle sediments before dewatering.
- Stop the flow of dewatering when the device lowers into heavier sediment laden water in the trap or basin.
- Allow the storm water to sit for a longer period so the sediment settles to the bottom of the trap or basin before dewatering.
- Device clogs. Keep the device clean of dirt, sediment and leaves, twigs or other debris so it remains in good working order.
- Maintain the device in proper operating order per manufacturer's recommendations and do not allow the device to clog or fill with sediment.

Maintenance, Inspection and Removal

- Inspect the device prior to use and make sure it is in proper working order. Clean if necessary.
- Inspect the device periodically while it is in operation so it does not discharge sediment laden water from the construction site.
- Remove the device prior to the end of construction either when the sediment basin is removed or transformed into a permanent storm water control device.
- Remove the skimmers and stabilize the site prior to filing *Form H - Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter 1 - Missouri Permit Requirements) for termination of permit coverage.

Baffles

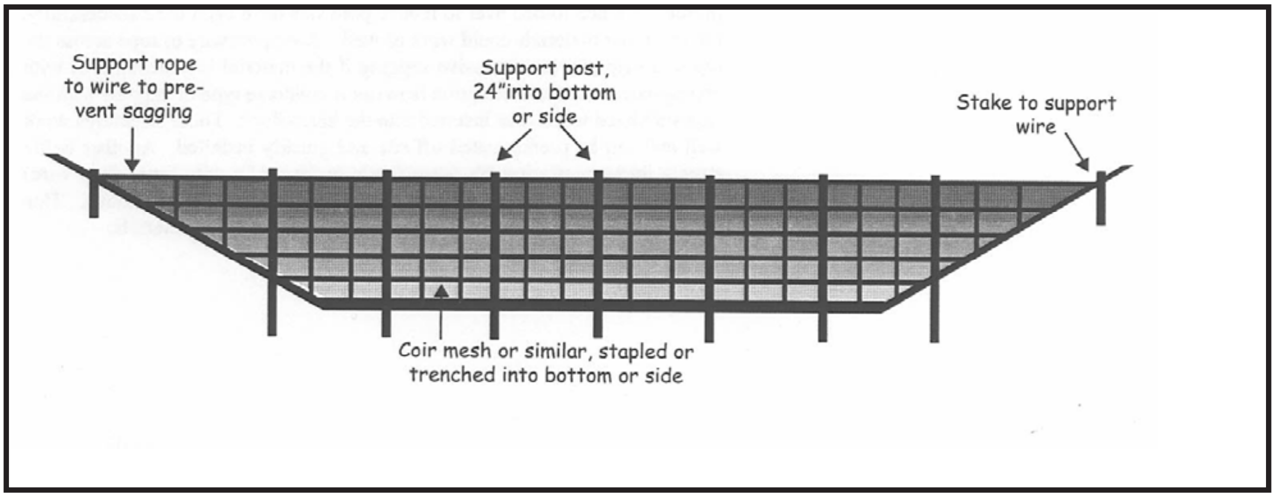

Figure 6.95 Cross-section of a porous baffle in a sediment basin. Note there is no weir because the water flows through the baffle material. Source: *North Carolina Erosion and Sediment Control Planning and Design Manual*

Practice Description

- Baffles are porous barriers installed inside a temporary skimmer or sediment basin to reduce the velocity and turbulence of the water flowing through the measure, and facilitate the settling of sediment from the water before discharge.
- Baffles improve the rate of sediment retention by distributing the flow and reducing turbulence. This process can improve sediment retention and allow the capture of soil particles 50 percent smaller than those that can be captured without baffles.
- Use this practice in any temporary sediment basin.
- Porous baffles effectively spread the flow over the entire width of a sediment basin or trap. Water flows through the baffle material, but is slowed sufficiently to back up the flow, causing it to spread across the entire width of the baffle (Figure 5.77). Spreading the flow in this manner uses the full cross section of the basin, which in turns reduces flow rates or velocity as much as possible. In addition, the turbulence is also greatly reduced. The combination practice increases sediment deposition and retention and also decreases the particle size of sediment captured. The storm water flows into the first section where the larger contaminants settle out before spilling over to additional sections. As a result, the first section should be easily accessible for maintenance.
- The installation can be similar to a sediment fence. Materials such as jute backed by coir erosion blanket, coir mesh, or tree protection fence folded over to reduce pore size have been used successfully. Other similar materials could work as well. A support wire or rope across the top will help prevent excessive sagging if the material is attached to it with zip ties. Another option is to use a sawhorse type of support with the legs stabilized with rebar inserted into the basin floor. These structures work well and can be prefabricated off-site and quickly installed. Success has also been demonstrated by placing silt fence fabric in front of the wire fence backing which has alternating squares.

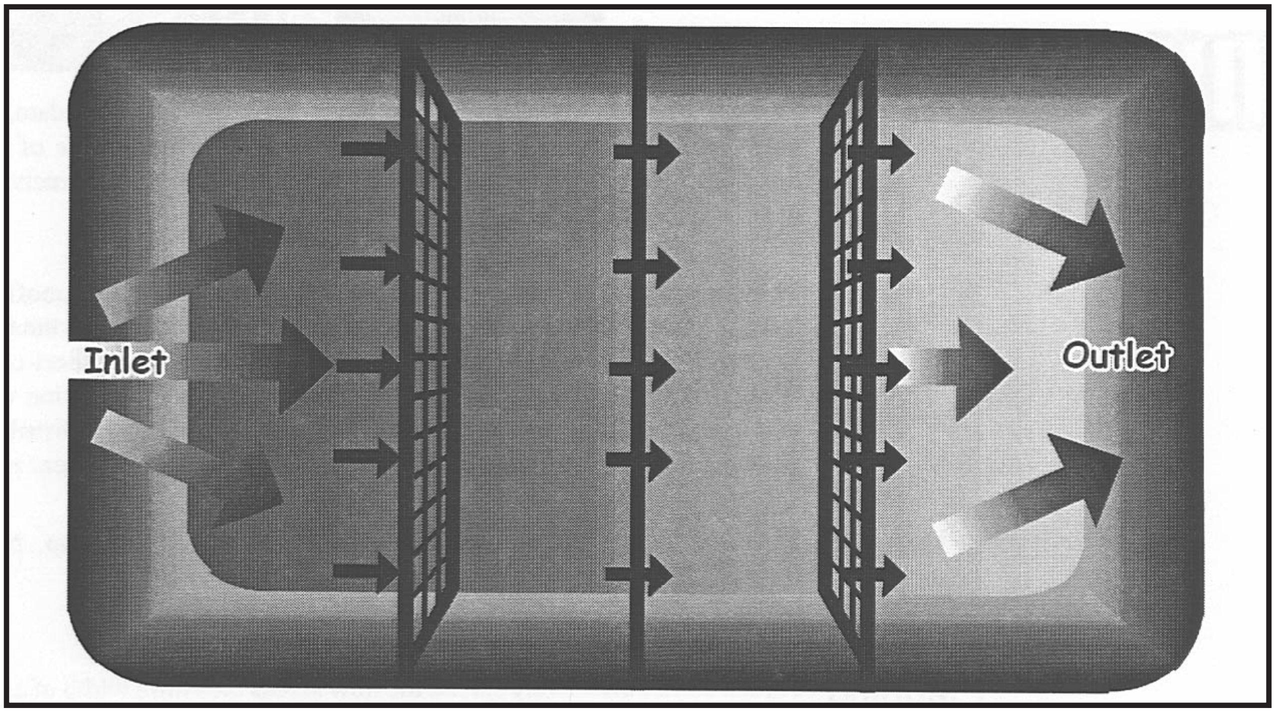

Figure 6.96 Porous baffle in a sediment basin. Source: *North Carolina Erosion and Sediment Control Planning and Design Manual*

- Newer baffle technology includes filtration baskets to catch the floating vegetation and litter at the top of the box, while the sediment is captured in the bottom of the box. This separation of organic matter from the water and sediment, provides a reduction in the nutrients and sediments present in the storm water.
- Remove the baffles and stabilize the site prior to filing *Form H - Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter 1 - Missouri Permit Requirements) for termination of permit coverage.

Dispersion Fields

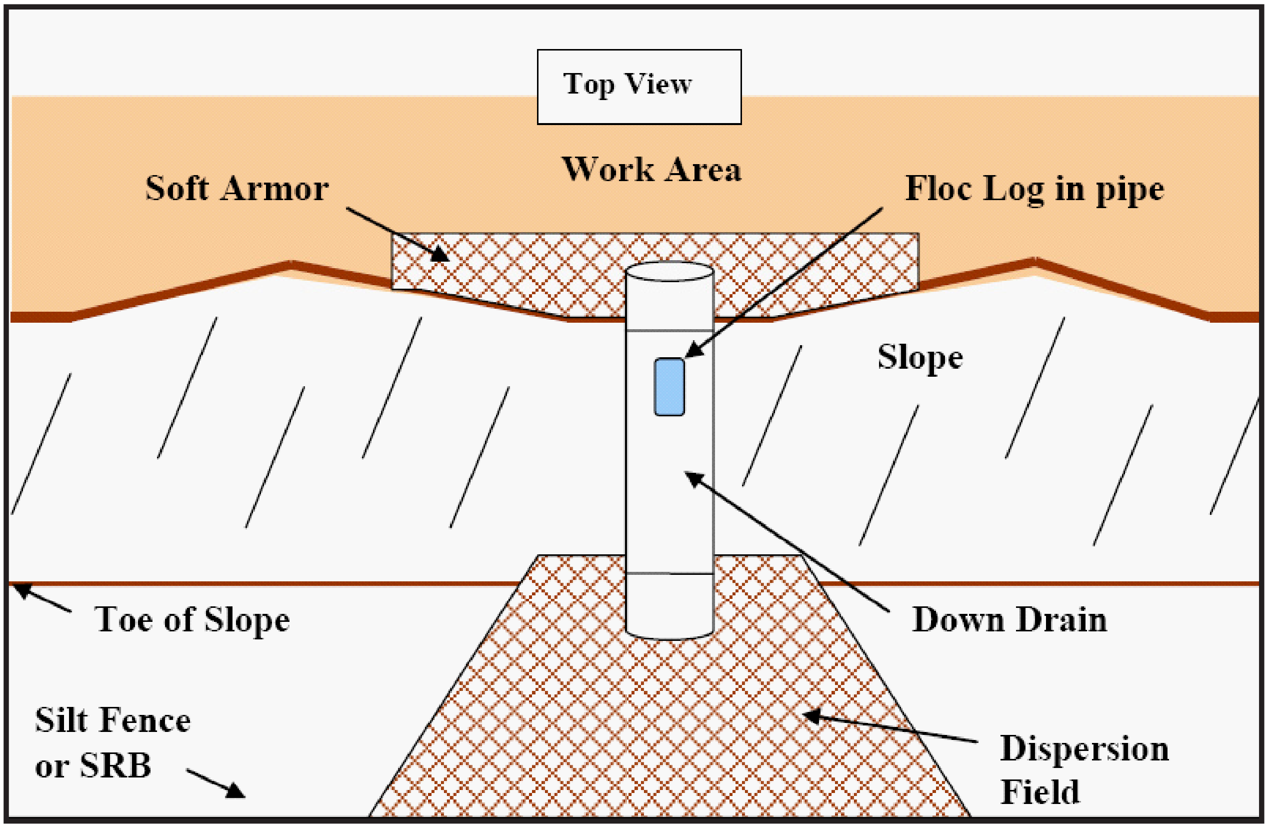

Figure 6.97 Source: *Florida Erosion and Sediment Control Designer and Reviewer Manua*l, June 2007.

Practice Description

Dispersion fields are to be used in conjunction with other best management practices, as it does not provide adequate sediment control by itself. The dispersion field should be covered in jute matting and applied with the site-specific water clarifying compound powder, to provide a surface for the particles to adhere to and help in final clarification of the storm water. A dispersion field is created to allow treated storm water to spread out and slow its velocity. Other best management practices must be used in conjunction, (e.g., floc logs, silt fences, down drains, soft armor matting) to further reduce velocity. The size of the field is dependant on the amount and velocity of storm water expected to enter. With highly erosive soils, protection with geotextile or plastic sheeting may be necessary.

Limitations

High flow velocities will occur at the discharge end of the slope drain. Unless there is a great distance between the slope drain discharge end and the silt fence, and a sediment basin or pond is created, the silt fence barrier may be destroyed if the inflow values are greater than outflow.

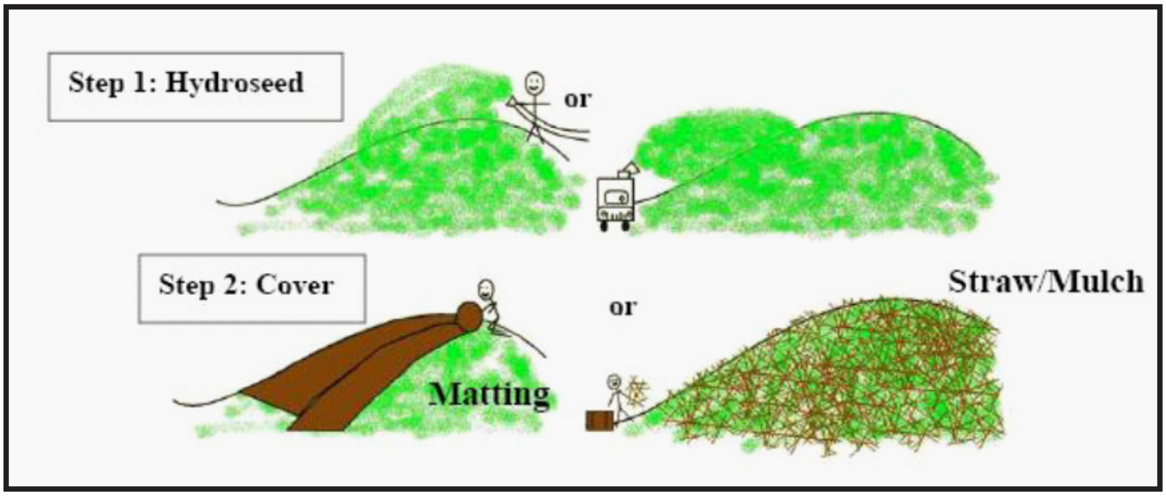

Figure 6.98 Source: *Florida Erosion and Sediment Control Designer and Reviewer Manual*, June 2007.

Inspection And Maintenance

Inspect routinely. Repair coverage and re-apply media as needed to maintain maximum protection against erosion. If failure of media occurs routinely, consider another type or size of protective media.

Dispersion Fields

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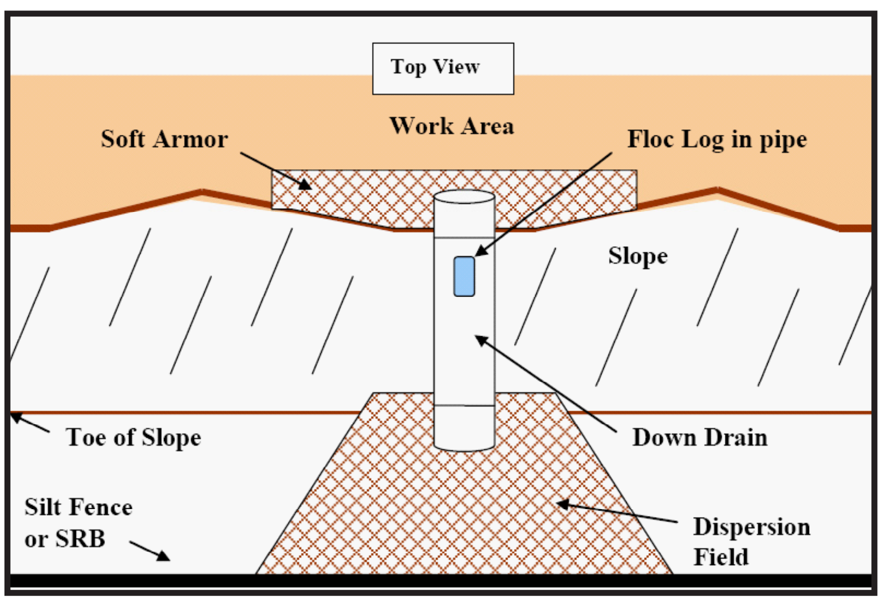

Figure 6.99 Source: *Florida Erosion and Sediment Control Designer and Reviewer Manual*, June 2007.

Sand Media Particulate Filter

Practice Description

In a sand media particulate filter, water is treated by passing it through canisters filled with sand media. Sometimes, water clarifying compounds are added to flowing storm water before it enters the filter. Generally, sand filters are used to provide a final level of treatment. They are often used as a secondary or higher level of treatment after a significant amount of sediment and other pollutants have been removed.

Figure 6.100 Sand Media Particulate Filtration System Source: *Florida Erosion and Sediment Control Designer and Reviewer Manual*, June 2007.

Recommended Minimum Requirements

Water clarifying compounds can be used to aid in settling the smaller soil particles when there is a high concentration of smaller clay particles. This can shorten the time necessary for settling out sediment particles from when the storm water flow enters the sediment storage structure and when it discharges. Water clarifying compounds can be toxic if used incorrectly or allowed to leave the construction site at all, but especially if caused to do so prior to binding with soil particles. Plans and manufacturer specifications and recommendations should be referred to by the site superintendent and field personnel throughout the construction process.

Do not over apply or misuse water clarifying compounds. Follow land disturbance permit requirements, check local ordinances for any restrictions that may apply and do not allow any form of the chemicals to discharge from the site or cause a violation of federal or state water quality standards.

Construction

- Follow manufacturers recommendations for the use of water clarifying compoundss and sand filtration systems. Significant site assessment (including soil testing) is required to determine the exact location of polymer application, the amount of material to use and other key elements for success.
- Construction of the treatment system using water clarifying compounds can be "active" or "passive". An active treatment system is a designed system that incorporates pumps and sand filters while a passive treatment system is designed to rely on settling ponds, check dams, filter dikes, inlet floc socks, etc.

Maintenance, Inspections and Removal

- Inspect coagulant applicator and sand filtration treatment systems on a weekly basis and after rain events. Maintain the systems as required.
- Remove the system when construction is complete and the stabilize the site prior to filing *Form H - Request for Termination of a General Permit*, Form--MO 780-1409 (see Chapter 1 -Missouri Permit Requirements) for termination of permit coverage.

Troubleshooting

- Flocculating water clarifying compounds are soil specific and soil tests must be done to determine the most effective application. Other coagulants are more general and will work on a wide range of soils. Most coagulants are pH and temperature sensitive. Follow all manufacturer's specifications and recommendations.
- Do not over apply or misuse water clarifying compounds.

Common Problems and Solutions

Problem	Solution
Despite use of water clarifying compounds, fine clays and colloids remain in suspension, caused by the wrong type of water clarifying compounds. used for the soils on-site.	Take additional soil samples and re-evaluate the appropriate type of product to use.
Despite use of water clarifying compounds, fine clays and colloids remain in suspension, because there was inadequate mixing time to dissolve the water clarifying compounds into the storm water.	Identify location further upstream from basin to introduce the water clarifying compound or identify areas with greater turbulence that would improve mixing.
Over application and premature purging of the compounds, caused by allowing the water clarifying compounds applicator for a passive treatment system to sit in standing water.	Locate applicator in ditch checks or in pipe outfalls in such a way to keep the applicator out of ponding water.