CONSTRUCTION & GRADING BMPS

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EROSION AND SEDIMENT CONTROL:

VEGETATIVE FILTER STRIP

DEFINITION

Permanent strips of stiff, dense vegetation established along the general contour of slopes or across concentrated flow areas.

PURPOSE

This practice is used to accomplish one or more of the following purposes:
- Reduce sheet and rill erosion.
- Reduce ephemeral gully erosion.
- Reduce sediment transport to surface waters.

PLANNING CRITERIA & IMPLEMENTATION

This practice applies to all land uses where sheet and rill erosion or ephemeral gully erosion are resource concerns.

Density
Establish plants so that gaps between plants are no greater than 3 inches at the end of the first growing season.

Species selection
Select species adapted to local soil and climate conditions, easily established, long-lived, and manageable. Use species that exhibit characteristics required for adequate functions, such as emergence through several inches of sediment or resuming growth from buried stem nodes, rhizomatous or stoloniferous growth habit, and stems that remain intact and erect year-round.

Establishment
Establish barriers vegetatively or from seed.

Seeding dates, depths, and rates must be appropriate for the species selected and the conditions of the site. Ensure good seed-to-soil contact when planting seeds by rolling or packing the soil after seeding. Plant barriers established vegetatively at a density to ensure a functional barrier as quickly as possible (usually two growing seasons). For most herbaceous species, this will require a spacing in the row of no more than 6 inches for bare-root seedlings, cuttings, sod chunks, plugs, rhizomes, or divisions consisting of no less than 5 viable stems. For suckering shrubs or herbaceous species established from 6-inch (gallon) potted material use a spacing in the row of no more than 12 inches.

Prepare the site sufficiently to ensure seed germination or proper rooting conditions for vegetative material establishment. Ensure good root-to-soil contact by packing the soil after planting. If necessary use appropriate site stabilization measures , during the barrier establishment period. The mature barrier widths must be the larger of 3-feet wide or 0.75 times the design vertical interval. Sow broadcast or drilled seed in a strip at least 3-feet wide. When using a row planter, plant a minimum of 2 rows. Do not use plant materials considered invasive or noxious for the vegetative barrier.

Additional Criteria for Reducing Sheet and Rill Erosion

Gradient

Layout vegetative barriers so the gradient along the barrier is at least 0.2 percent and no greater than 1.0 percent, except where the vegetative barrier crosses concentrated flow areas. For barriers entering a concentrated flow area, gradients may be up to 1.5 percent for 100 feet for better row alignment.

Conduct all tillage and equipment operations in the interval between barriers parallel to the vegetative barrier. Construct and maintain a berm or channel immediately upslope from the barrier to divert water along the vegetative barrier. Use a minimum berm height/channel depth of 3 inches. Water flowing along a vegetative barrier berm/channel must flow into a stable outlet.

Spacing

Determine the horizontal spacing between the vegetative barriers using the lesser of—

- The horizontal distance between barriers when the vertical interval is 6 feet, or
- The water erosion planning length of slope “L” that achieves the allowable soil loss for the field, considering the planned practices in the conservation management system.

Plan crop strip widths in multiples of the widths of planting, tillage, spraying, and harvest equipment. This spacing may be adjusted up to 10 percent between the barriers.

Vegetation

The species composition will provide the designated minimum stem density with the designated stem diameter and have a minimum VSI of 0.05.

Additional Criteria to Reduce Ephemeral Gully Erosion

Alignment

Install vegetative barriers across concentrated flow areas perpendicular to the direction of water flow.

Width and length

Vegetative barriers will consist of a minimum of two rows. Length of the vegetative barrier will vary depending on the topography. Each strip must be long enough to ensure that the ends of the strip are at least 1.5 feet higher than the center of the concentrated flow area. When the concentrated flow area has a preexisting headcut, place one barrier at the bottom of the headcut and the other at the top.

Spacing

Base spacing between the vegetative barriers on the vertical interval of 1.5 feet for conditions where no tillage is performed between the barriers and 3 feet for all other conditions where sediment deposition and bench development is anticipated.

Minimum level bottom section length

Design the minimum level bottom section length (in feet) numerically equal to the peak discharge [in cubic feet per second (cfs) for a 2-year 24-hour design storm from the total watershed upslope of the lowest barrier. This equates to a specific discharge of 1 cfs/ft of vegetative barrier. Level bottom section is defined as the bottom width of a trapezoidal waterway. This will be shaped during construction or formed by sediment deposition. Use methods in chapter 2 of the NRCS National Engineering Handbook (NEH) (Title 210), Part 650, “Engineering Field Handbook” to estimate peak discharge for local soil, climate, and management conditions.

If the channel does not have a level bottom section, design the barriers so that the peak discharge through the barrier for a 2-year, 24-hour storm does not exceed allowable velocities for the soil, vegetation, and slope conditions as determined using chapter 7 of 210-NEH-650.

Vegetation

Establish species that will provide the designated minimum stem density with the designated stem diameter and have a VSI of 0.10.

CONSIDERATIONS

The “benching” process that occurs on slopes where barriers are installed (tillage erosion moves soil from the upper part of the cropped strip, which then accumulates in the lower part of the cropped strip) can expose soil material that is unfavorable for crop growth.

Using management practices such as NRCS Conservation Practice Standards (CPSs) Conservation Crop Rotation (Code 328) and the Residue and Tillage Management (Codes 329 and 345), with Vegetative Barrier (Code 601) increases the effectiveness of the barrier. This practice may improve the efficiency of other practices such as strip-cropping, filter strips, riparian forest buffers, grassed waterways, diversions, and terraces.

Practices such as water and sediment control basins, subsurface drainage, and underground outlets may be needed to adequately handle surface and subsurface water. Established vegetative barriers systems can pond water above the barriers. Subsurface drains may need to be installed across the slope parallel to the barrier, or through the ponded areas above barriers that are installed across concentrated flow areas.

When compatible with the purposes and criteria for this practice, use plant materials that attract undesirable insects away from crops or desirable insects that are beneficial to the adjacent crops.
When compatible with the purposes and criteria for application of this practice, select plant materials that enhance food and cover for targeted wildlife. When compatible with the purpose and the barrier vegetation, avoid conducting activities within the barrier during the nesting season to minimize impacts to birds.

Stagger rows of planted vegetation to increase resistance to overland flow through the vegetated barrier. Mowing in concentrated flow areas is discouraged because it will lower the vegetation stiffness index by reducing average stem diameter.

PLANS AND SPECIFICATIONS

Develop plans and specifications for each field or treatment unit according to the Criteria section requirements above, and Operation and Maintenance section requirements below. Specifications must describe the requirements to apply this practice to achieve the intended purpose. Record the following specification components in an approved NRCS CPS Vegetative Barrier (Code 601) implementation requirements document.

- Field map with location of vegetative barriers
- Purpose of the barrier
- Width of crop strip (when appropriate)
- Vegetative barrier and crop strip orientation (when appropriate)
- Width of each barrier
- Linear feet of barrier
- Vegetative species
- Establishment date, establishment method, seeding rate (when seeded), or spacing of vegetative planting stock
- Site stabilization and/or preparation

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for this practice. As a minimum include —

- Replant or reseed establishment failures immediately; gaps in seeded barriers may be reestablished more effectively and immediately with transplanted plant material.
- Mowing of vegetative barriers may be used as a management practice to encourage the development of a dense stand and prevent shading of crops in adjacent fields. Mow at a 15-inch stem height, or the recommended height for the species, whichever is taller.
- Barriers may be periodically burned (where permitted), if the species used will tolerate fire. Carry out burns just prior to the spring regrowth period, while the vegetation is dormant. All burns will be conducted in accordance with a smoke/burn management plan.
- Control weeds as necessary to ensure a dense stand within the barrier by mowing, spraying, or wick application of labeled herbicides.
- Do not use vegetative barriers as a field road or turn row. Vegetative barriers in concentrated flow areas will not be crossed with machinery.
- Do not cut vegetative barriers with water furrow plows or similar implements to install drainage ditches to allow the passage of surface and subsurface water. If necessary, drain water with underground outlets installed up gradient of the barrier.
- Perform pest control with techniques and pesticides that will not significantly damage the vegetation.
- Fill and replant washouts or rills that develop immediately. Fill gaps in established barriers with transplanted plant material.

BOUNDARY FENCING

DEFINITION

A constructed barrier to animals or people.

PURPOSE

This practice is used to accomplish the following purpose:

- Provide a means to control the movement of animals, people, and vehicles to accomplish specific conservation objectives.

CONDITIONS WHERE PRACTICE APPLIES

Apply this practice on any area where management of animal or human movement is needed.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and construct this practice to comply with all Federal, State, and local regulations. The landowner must obtain all necessary permissions from regulatory agencies or document that no permits are required. The landowner and/or contractor is responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

Ensure all fencing materials installed are durable and of high quality, and the type and design of the fence installed meets the management objectives and site challenges. Use permanent, portable, or temporary fences based on management objectives.

Position fences to facilitate changes in management strategies, access requirements, or otherwise meet conservation objectives. The fence design and installation must include height, size, spacing, type of materials, and location of features such as gates and cattle guards.

The fence design and materials must have a life expectancy appropriate for the management system and resource objectives. Base the durability of materials in the design and location of fences on topography, environment, purpose, and management objectives. Specialized bracing, designs, and materials may be necessary to cross features such as gullies, canyons, and streams.

Design, locate, and install fences to minimize impacts on local wildlife as appropriate.
Provide for proper disposal of materials when fence construction requires the removal of existing fencing materials to prevent harm to animals, people, or equipment.

CONSIDERATIONS

Consider soil properties, soil moisture conditions, and erosion concerns. Consider livestock management and adaptive grazing strategies, trailing, access to water facilities, and wildlife deterrence or passage. Consider animal and human safety concerns by enhancing visibility of fences through design materials, fence markers, signage or fladry systems (line of rope mounted along the top of a fence, from which are suspended strips of fabric or colored flags that will flap in a breeze). Consider using natural barriers where appropriate and design and locate fences to ease access for construction, maintenance, and landscape aesthetics. Establish cleared rights-of-way to facilitate fence construction and maintenance where applicable. Avoid clearing of vegetation during the nesting and brood rearing seasons for migratory and ground nesting birds.

PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for applying the practice according to the requirements of this standard. As a minimum, include:

- Plan view or map showing layout of fence and location of gates.
- Details for fence installation showing post spacing, bracing, and gate installation.
- Material quantities and requirements.

OPERATION AND MAINTENANCE

Regular inspection of permanent, temporary, and portable fences is a part of an ongoing maintenance program that ensures proper function of the fence for the lifespan of the practice. As a minimum, include the following in the operation and maintenance plan:

- Conduct inspections of fences after storms and other disturbance events.
- Repair or replacement of loose or broken material, gates, and other forms of ingress and egress.
- Removal of trees and limbs.
- Repair or replacement of water gaps as necessary.
- Repair of eroded areas as necessary.
- Repair or replacement of markers or other safety and control features as required.
- Maintain fladry or signage as necessary.

MULCHING

DEFINITION

A mulch is a layer of material applied to the surface of soil. Reasons for applying mulch include conservation of soil moisture, improving fertility and health of the soil, reducing weed growth, and enhancing the visual appeal of the area. A mulch is usually, but not exclusively, organic in nature.

PURPOSE

To prevent erosion by protecting bare soil from rainfall and wind, reducing runoff velocity, conserving moisture, and fostering plant growth. Mulches can be composed of straw, wood chips, bark, pine needles, recycled paper, wood fibers, cotton, flax, or gravel, and they act to protect soil and enhance seed germination by reducing evaporation and insulating the soil.

PLANNING CRITERIA & IMPLEMENTATION

Applicable to all bare soil surfaces where construction activities will cease for 14 days or more and will not resume within 21 days. Provides a temporary or permanent cover and aids in stabilization measures. Immediately follow temporary and permanent seeding of an area with mulching.

Additional control measures may be necessary for the establishment of vegetation if the area is susceptible to erosion. Straw and wood chip mulch require removal before soil stabilization or permanent seeding is to take place. Straw and wood mulch are prone to removal by runoff and wind if not correctly anchored. Wood fiber hydraulic mulches may be short-lived. Recycled paper lasts longer. A strong potential for introducing weed-seed and unwanted plant material exists with use of pine needles and un-certified straw.

The type of mulch to be applied depends on soil type, site conditions, landscape requirements, and economics. Roughen embankments and fill areas before applying mulch.

MAINTENANCE

- Inspect for failures and loss of mulch during the wet season.

- Reapply immediately if disturbed.

DRAIN OUTLET PROTECTION

DEFINITION

Outlet protection structures prevent scour and erosion at discharge outlets by dissipating the energy and reducing velocities. Typical applications include an apron lined with rock riprap, concrete, or vegetation.

PURPOSE

To prevent the discharge of degraded water to ground or surface water supplies as a result of property development and natural or human-induced erosion.

PLANNING CRITERIA & IMPLEMENTATION

All outlet protection structures should be designed by a licensed professional civil engineer. Select the most appropriate materials for outlet protection. A rock-lined apron is commonly used because it is stable and durable, requires little maintenance, and blends in with the natural environment. Consider using vegetation for outlet protection in channels subject to low volumes and velocities. For outlets on slopes steeper than 10 percent, provide additional protection using larger rock to accommodate higher flow energies. Base the design of an outlet protection structure on the size of the channel and peak flow volume, and on the peak shear stress of discharging water during the design runoff event.

Construct discharge aprons subject to smaller flows by hand as follows:

- Place a 3 inch to 6-inch filter layer of sand or gravel in a trapezoidal-shaped apron. Filter fabric or an erosion control blanket can be substituted for the filter layer of sand or gravel.
- Construct the apron width at the culvert outlet to be 3 times the culvert diameter.
- Flare the apron out at a ratio of 1 foot laterally for each 2 feet of length, until the apron is 3 times the width of the culvert.
- Manually place a base layer of rocks on top of the apron. The size of the rock is a function of the discharge velocity.

MAINTENANCE

Inspection should include identifying erosion problems, documenting sediment accumulation, and identifying blocked or obstructed stormwater flow. The inspection crew may want to install a staff plate or ruler to monitor sediment accumulation if not already installed. Chronic sediment accumulation indicates a significant sediment source upstream in need of stabilization. Maintenance crews should be prepared to replace riprap to provide erosion protection and remove accumulated sediment and debris to ensure unobstructed flow. Removal of trash and debris is another common maintenance practice.

DRAIN INLET PROTECTION

DEFINITION

A sediment filter or an excavated impounding area around a storm drain, drop inlet, or curb inlet. Used to prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area. This practice allows for early use of the drainage system.

PURPOSE

Inlet protection is a temporary measure used where the drainage area to the inlet or inlets of a storm drain system is disturbed and it is not possible to divert sediment-laden water away from the system. Storm sewers which are put into use before their drainage area is stabilized can convey large amounts of sediment to natural drainage ways. This practice should not be used to replace other sediment trapping devices, but it should be used in conjunction with these devices to help prevent sediment from being transported into the system and ultimately downstream or offsite.

- Runoff from disturbed areas larger than one acre should be routed through a temporary sediment trap or basin.
- Filter fabric is used for inlet protection when storm water flows are relatively small with low velocities.
- Block and gravel filters can be used where velocities are higher.
- Gravel and mesh filters can be used where flows are higher and subject to disturbance by site traffic.
- Sod inlet filters may be used if sediment load in the storm water runoff is low.

ADVANTAGES

- Prevents clogging of storm drainage systems and siltation of receiving waters.
- Reduces the amount of sediment leaving the site.

DISADVANTAGES

- May be difficult to remove collected sediment, especially under high flow conditions.
- May cause erosion elsewhere if clogging occurs.
- Practical only for low sediment, low volume flows.

PLANNING CONSIDERATIONS

- Installation of this measure should take place before any soil disturbance in the drainage area. Inlet protection should be used in combination with other measures, such as small impoundments or sediment traps, to provide more effective sediment removal.
- The type of inlet protection device chosen depends on site conditions. Straw or hay bale barriers or sediment fences can be constructed around inlets. A small sediment basin can be excavated around the storm drain inlet. In other cases, gravel filters may be used around or directly over the storm sewer opening.

- The major considerations in deciding the type of protection to be used must be based on the type of inlet, the conditions around the inlet, and the area adjacent to the inlet that may be damaged or inconvenienced because of temporary ponding of water.

DESIGN RECOMMENDATIONS

- Grates and spaces of all inlets should be secured to prevent seepage of sediment laden water.
- All inlet protection measures should include sediment sumps of 1 to 2 feet in depth, with 2:1 side slopes.
- The inlet protection device should be constructed so that any ponding resulting from the installation will not cause damage to adjacent areas or structures.
- The device must be constructed so that clean-out and disposal of trapped sediment and debris can be accomplished with minimal effort.
- The drainage area normally should be no more than one acre.
- Runoff from 10-year storm must enter storm drain without bypass flow.

TYPES OF INLET PROTECTION

Straw or Hay Bale Barriers

If the area adjacent to the inlet is unpaved, straw or hay bale barriers can be constructed around the drain inlet. Permeability through bales is lower than for other types of inlet protection, such as sediment fences. Provide sufficient storage space for runoff or sufficient lineal footage of bales to allow storm flow to pass through the bales.

Excavated Drop Inlet Trap

If the area adjacent to the inlet is paved, an excavated trap can be constructed around the drain inlet.

- This method of inlet protection is applicable where relatively heavy flows are expected and overflow capability is needed. Applicable where the inlet drains a relatively small (less than one acre) flat area, on less than 5 percent slope.
- This practice works well for trapping coarse grained material. Do not place fabric under gate as the collected sediment may fall into the drain when the fabric is retrieved.
- This practice should not be used where the area is paved because of the need for driving stakes to hold the material.
- Excavated traps may be used to improve the effectiveness and reliability of other sediment traps and barriers such as fabric, or block and gravel inlet protection.

Installation

The trap should be excavated around the inlet to provide 67 cubic feet of storage per acre of drainage area to the inlet. The trap should be no less than 1 foot deep or more than 2 feet deep when measured from the top of the inlet. Side slopes should be 3:1 or flatter. Dimensions of the excavation should be based on the site conditions. Normally the traps are square. If there is concentrated flow being directed into the trap, however, then the trap should be rectangular with the long dimension oriented in the direction of the flow. When necessary, spoil may be placed to form a dike on the downslope side of the excavation to prevent bypass flow.

Common Trouble Points

- Sediment fills excavated basin and enters storm drain: Sediment-producing area too large for basin design or inlet not properly maintained.
- Excessive ponding: Gravel over weep holes may be plugged with sediment. Remove debris, clear sediment, and replace gravel.
- Flooding and erosion due to blockage of storm drain: Install trash guard.

Gravel and Wire Mesh Filter

Applicable where flows greater than 0.5 cfs are expected and construction traffic may occur over the inlet.

Installation

A wire mesh should be placed over the drop inlet or curb opening so that the entire opening and a minimum of 12 inches around the opening are covered by the mesh. The mesh may be ordinary hardware cloth or wire mesh with openings up to 1.2 inch. If more than one strip of mesh is necessary, overlap the strips. Place filter fabric over wire mesh. Extend the filter fence/wire mesh beyond the inlet opening at least 18 inches on all sides. Place 3.4 to 3-inch gravel over the filter fabric/wire mesh. The depth of the gravel should be at least 12 inches over the entire inlet opening.

Block and Gravel Inlet Protection

This method is best for paved areas adjacent to inlets. This method uses standard concrete block and gravel to provide a small, sturdy barrier to trap sediment at the entrance to a storm drain. It applies to both drop inlets and curb inlets where heavy flows are expected and an overflow capacity is necessary to prevent excessive ponding around the structure. Concrete blocks are laid without mortar closely around the perimeter of the drain. Gravel is then placed around the outside of the blocks to restrict the flow and form a sediment pool. For slower drainage and therefore more settlement time, the concrete blocks could be eliminated and the device made entirely of gravel. Pool depth should be limited to a maximum of 2 feet. Frequent maintenance is a must for this practice.

Installation

Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with one-half inch openings. If more than one strip is necessary, overlap the strips. Place filter fabric over the wire mesh. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, so that the open ends face outward, not upward. The ends of adjacent blocks should abut. The height of the barrier can be varied, depending on design needs, by stacking combinations of blocks that are 4 inches, 8 inches, and 12 inches wide. The row of blocks should be at least 12 inches but no greater than 24 inches high. Place wire mesh over the outside vertical face (open end) of the concrete blocks. Extend at least 12 inches around the opening to prevent aggregate from being transported through the openings in the block. Use hardware cloth or comparable wire mesh with 1.2 inch openings. Pile gravel, 1-inch diameter or smaller, against the wire mesh to the top of the outside face of the blocks to control drainage rate.

Common Trouble Points

- Top of structure too high: A Bypass storm flow causes severe erosion.
- Blocks not placed firmly against storm drain inlet: Scour holes develop.
- Drainage area too large: Poor trap efficiency and/or sediment overload.
- Approach to drain too steep: Causes high flow velocity and poor trap efficiency. Install excavated basin in the approach.
- Sediment not removed following a storm: Sediment enters storm drain.
- Stone in gravel donut not large enough or inside slope too steep: Stone washes into inlet.

Maintenance

Remove and replace gravel over weep holes when drainage stops.

Fabric Drop Inlet Protection

If the area adjacent to the inlet is unpaved, a fabric drop inlet protection is acceptable. This method consists of a temporary device consisting of porous fabric supported by posts and placed around a drop inlet. When properly braced and sealed at the bottom, the fabric restricts flow rate, forming a sedimentation pool at the approach to the inlet. The fabric allows the pool to drain slowly, protecting the storm drain from sediment. This method of inlet protection is effective where the inlet drains a small, nearly level area with slopes generally less than 5 percent and where shallow sheet flows are expected. The immediate land area around the inlet should be relatively flat (less than 1%) and located so that accumulated sediment can be easily removed. This method cannot easily be used where the area is paved because of the need for driving stakes to hold the material.

Height Of Fabric

1.5 ft maximum, 1 foot minimum; measured from top of inlet.

Stability

Structure must withstand 1.5-foot head of water and sediment without collapsing or undercutting.

Support Posts

Steel fence posts or 2 x 4-inch wood, length 3 foot minimum, spacing 3 foot maximum; top frame support recommended.

Fabric Material

Synthetic, extra-strength fabric. Burlap is acceptable for short-term use only (60 days or less).

Installation

Space support posts evenly against the perimeter of the inlet a maximum distance of 3 ft apart and drive them at least 8 inches into the ground. The stakes must be at least 3 feet long. Overflow must fall directly into the inlet and not on unprotected soil. Build a supporting frame of

2 x 4-inch lumber, maximum height 1.5 ft above the drop inlet crest. The frame adds stability and serves as a weir to control storm overflow into the drop inlet. Alternatively, use wire fence (14 gauge minimum, with a maximum mesh spacing of 6 inches) to support fabric. Stretch fence with top level to provide uniform overflow. Extend wire 6 inches below ground. Excavate a trench approximately 8 inches wide and 12 inches deep around the outside perimeter of the stakes. Cut fabric from a single roll to eliminate joints. Place bottom 12 inches of fabric in trench adjacent to the drop inlet. Fasten fabric securely to the posts and frame or support fence, if used. Overlap joints to the next post. Backfill the trench with 3.4 inch or less washed gravel all the way around. Do not place fabric under grate as the collected sediment may fall into the drain when the fabric is retrieved. Stabilize disturbed areas immediately after construction.

Common Trouble Points

- Posts and fabric not supported at the top: Results in collapse of the structure.
- Fabric not properly buried at bottom: Results in undercutting.
- Top of fabric barrier set too high: Results in flow bypassing the storm inlet or collapsing structure.
- Temporary dike below the drop inlet not maintained: Results in flow bypassing storm inlet
- Sediment not removed from pool: Results in inadequate storage volume for next storm.
- Fence not erected against drop inlet: Results in erosion and undercutting.
- Land slope at storm drain too steep: Results in high flow velocity, poor trapping efficiency, and inadequate storage volume. Excavation of sediment storage area may be necessary.

Sod Drop Inlet Protection

A permanent grass sod filter area around a storm drain drop inlet in a stabilized, well vegetated area.

Where Practice Applies

- Where the drainage area of the drop inlet has been permanently seeded and mulched and the immediate surrounding area is to remain in dense vegetation.
- This practice is well suited for lawns adjacent to large buildings.
- The drainage area should not exceed 2 acres,
- The entrance flow velocity must be low, and
- The general area around the inlet should be planned for vegetation.

Other Inlet Protection Practices

There are several types of manufactured inlet filters and traps which have different applications dependent upon site conditions and type of inlet. One is a catch basin filter that prevents sediments and other contaminants from entering storm drainage systems. The catch basin filter is inserted in the catch basin just below the grating. The catch basin filter is equipped with a sediment trap and up to three layers of a fiberglass filter material.

This is a changing field. New products are being developed and brought to the market. For the most recent information see a trade journal such as Erosion Control or Land and Water. For example, Eco-Blok (www.eco-blok.com) provides an inlet protection product from recycled plastic. Another source for inlet protection is www.thebmpstore.com.

Maintenance

All trapping devices and the structures they protect should be inspected after every rain storm and repairs made as necessary. Sediment should be removed from the trapping devices after the sediment has reached a maximum of one half the depth of the trap. Sediment should be disposed of in a suitable area and protected from erosion by either structural or vegetative means. Temporary traps should be removed and the area repaired as soon as the contributing drainage area to the inlet has been completely stabilized.

Systems Using Filter Fabric

Inspections should be made on a regular basis, especially after large storm events. If the fabric becomes clogged, it should be replaced.

Systems Using Stone Filters

If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.

DUST CONTROL

DEFINITION

Reducing surface and air movement of dust from exposed soil surfaces during land disturbing, demolition, and construction activities.

Where Practice Applies

On construction routes and other disturbed areas subject to surface dust movement and dust blowing where on-site and off-site damage is likely to occur if preventive measures are not taken.

Advantages

A decrease in the amount of dust in the air will decrease the potential for accidents and respiratory problems.

Disadvantages/Problems

Excessive use of water to control dust emissions, particularly in areas where the soil has been compacted, can cause a runoff problem.

Planning Considerations

- Large quantities of dust can be generated during land grading activities for commercial, industrial, or subdivision development, especially during dry, windy weather. Research at construction sites has established an average dust emission rate of 1.2 tons/acre/month for active construction. Earthmoving activities comprise the major source of construction dust emissions, but traffic and general disturbance of the soil also generate significant dust emissions.
- In planning for dust control, it is important to schedule construction activities so that the least area of disturbed soil is exposed at one time.
- For disturbed areas not subject to traffic, vegetation provides the most practical and efficient means of dust control. For other areas control measures include mulching, sprinkling, spraying adhesive or calcium chloride, and wind barriers.
- Maintain dust control measures properly through dry weather periods until all disturbed areas have been permanently stabilized.

Methods

- Vegetative Cover: For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control.
- Mulch (including Gravel Mulch): When properly applied, mulch offers a fast, effective means of controlling dust.
- Spray-on Adhesive: Latex emulsions or resin in water can be sprayed onto mineral soil to prevent particles from blowing away.

- Calcium Chloride: Calcium chloride may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage.
- Sprinkling: The site may be sprinkled until the surface is wet. Sprinkling is especially effective for dust control on haul roads and other traffic routes.
- Stone: Used to stabilize construction roads; can also be effective for dust control.
- Barriers: A board fence, wind fence, sediment fence, or similar barrier can control air currents and blowing soil. All of these fences are normally constructed of wood and they prevent erosion by obstructing the wind near the ground and preventing the soil from blowing offsite. A wind barrier generally protects soil downward for a distance of 10 times the height of the barrier. Perennial grass and stands of existing trees may also serve as wind barriers.

Maintenance

Re-spray area as necessary to keep dust to a minimum.

SOIL BINDERS

DEFINITION AND PURPOSE:

Soil binders consist of applying and maintaining a soil stabilizer to exposed soil surfaces. Soil binders are material applied to the soil surface to temporarily prevent water-induced erosion of exposed soils on construction sites. Examples of materials used include: vegetable-based adhesives, copolymers, petroleum oils, and resin-emulsions. Soil binders also provide temporary dust, wind, and soil stabilization (erosion control) benefits. The useful life of most products is 3 to 6 months.

APPROPRIATE APPLICATIONS:

Soil binders are typically applied to disturbed areas requiring short-term temporary protection and in combination with other BMPs such as perimeter controls, seeding, and mulching. Because soil binders can often be incorporated into the work, they may be a good choice for areas where grading activities will soon resume. Application can occur on stockpiles to prevent water and wind erosion.

CONDITIONS FOR EFFECTIVE USE:

Type of Flow: Sheet flow only Consider drying time for the selected soil binder and apply with sufficient time before anticipated rainfall. Soil binders shall not be applied during or immediately before rainfall. May not cure if low temperatures occur within 24 hours of application.

WHEN BMP IS TO BE INSTALLED:

Immediately after completion of a phase of grading.

STANDARDS AND SPECIFICATIONS:

Follow manufacturer's recommendations for application rates, pre-wetting of application area, and cleaning of equipment after use. Use the recommendations to maximize usefulness and avoid formation of pools or impervious areas where stormwater cannot infiltrate.

OPERATION AND MAINTENANCE PROCEDURES:

Inspect at least once per seven calendar days, or within a reasonable time period (not to exceed 48 hours) of a rainfall event which causes stormwater runoff to occur on-site for damage from vehicles, runoff, or freeze-thaw conditions. Reapply product or utilize additional BMP.

FIBER ROLLS/STRAW WATTLES

DEFINITION

Fiber rolls (also called fiber logs or straw wattles) are tube-shaped erosion-control devices filled with straw, flax, rice, coconut fiber material, or composted material. Each roll is wrapped with UV-degradable polypropylene netting for longevity or with 100 percent biodegradable materials like burlap, jute, or coir. Fiber rolls complement permanent best management practices used for source control and revegetation. When installed in combination with straw mulch, erosion control blankets, hydraulic mulches, or bounded fiber matrices for slope stabilization, these devices reduce the effects of long or steep slopes (Earth Saver Erosion Control Products, 2005). Fiber rolls also help to slow, filter, and spread overland flows. This helps to prevent erosion and minimizes rill and gully development. Fiber rolls also help reduce sediment loads to receiving waters by filtering runoff and capturing sediments.

APPLICABILITY

Fiber rolls can be used in areas of low shear stress. Avoid using them in channels that are actively incising or in reaches with large debris loads or potential for significant ice buildup. Fiber rolls have been used to control erosion in a variety of areas--along highways and at construction sites, golf courses, ski areas, vineyards, and reclaimed mines. Fiber rolls can be suitable in the following settings:

- Along the toe, top, face, and at-grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow
- At the end of a downward slope where it transitions to a steeper slope
- Along the perimeter of a project
- As check dams in unlined ditches
- Downslope of exposed soil areas
- Around temporary stockpiles

Siting and Design Considerations

Fiber rolls should be prefabricated rolls or rolled tubes of geotextiles fabric. When rolling the tubes, make sure each tube is at least 8 inches in diameter. Bind the rolls at each end and every 4 feet along the length of the roll with jute-type twine.

Sloped Ground Applications

On slopes, install fiber rolls along the contour with a slight downward angle at the end of each row to prevent ponding at the midsection. Turn the ends of each fiber roll upslope to prevent runoff from flowing around the roll. Install fiber rolls in shallow trenches dug 3 to 5 inches deep for soft, loamy soils and 2 to 3 inches deep for hard, rocky soils. Determine the vertical spacing for slope installations on the basis of the slope gradient and soil type. A good rule of thumb is:

- 1:1 slopes = 10 feet apart
- 2:1 slopes = 20 feet apart
- 3:1 slopes = 30 feet apart
- 4:1 slopes = 40 feet apart

For soft, loamy soils, place the rows closer together. For hard, rocky soils, place the rows farther apart. Stake fiber rolls securely into the ground and orient them perpendicular to the slope.

Biodegradable wood stakes or willow cuttings are recommended. Drive the stakes through the middle of the fiber roll and deep enough into the ground to anchor the roll in place. About 3 to 5 inches of the stake should stick out above the roll, and the stakes should be spaced 3 to 4 feet apart. A 24-inch stake is recommended for use on soft, loamy soils. An 18-inch stake is recommended for use on hard, rocky soils.

Projects Without Slopes

Fiber rolls can also be used at projects with minimal slopes. Typically, the rolls are installed along sidewalks, on the bare lot side, to keep sediment from washing onto sidewalks and streets and into gutters and storm drains. For installations along sidewalks and behind street curbs, it might not be necessary to stake the fiber rolls, but trenches must still be dug. Fiber rolls placed around storm drains and inlets must be staked into the ground. These rolls should direct the flow of runoff toward a designated drainage area. Place them 1 to 1½ feet back from the storm drain or inlet.

Limitations

The installation and overall performance of fiber rolls have several limitations, including the following:

- Fiber rolls are not effective unless trenched.
- Fiber rolls can be difficult to move once saturated.
- To be effective, fiber rolls at the toe of slopes greater than 5:1 must be at least 20 inches in diameter. An equivalent installation, such as stacked smaller-diameter fiber rolls, can be used to achieve a similar level of protection.
- If not properly staked and entrenched, fiber rolls can be transported by high flows.
- Fiber rolls have a very limited sediment capture zone.
- Fiber rolls should not be used on slopes subject to creep, slumping, or landslide.

Effectiveness

Unlike other BMPs that could cause water to back up and flow around the edges, fiber rolls allow water to flow through while capturing runoff sediments. Fiber rolls placed along the shorelines of lakes and ponds provide immediate protection by dissipating the erosive force of small waves. As an alternative to silt fences, fiber rolls have some distinct advantages, including the following (Earth Saver, 2005):

- They install more easily, particularly in shallow soils and rocky material.
- They are more adaptable to slope applications and contour installations than other erosion and sediment control practices.
- They are readily molded to fit the bank line.
- They blend in with the landscape and are less obtrusive than other erosion and sediment controls such as silt fence.
- They do not obstruct hydraulic mulch and seed applications.
- They can be removed or left in place after vegetation is established.

Maintenance Considerations

The maintenance requirements of fiber rolls are minimal, but short-term inspection is recommended to ensure that the rolls remain firmly anchored in place and are not crushed or damaged by equipment traffic. Monitor fiber rolls daily during prolonged rain events. Repair or replace split, torn, unraveled, or slumping fiber rolls. Fiber rolls are typically left in place on slopes.

If they are removed, collect and dispose of the accumulated sediment. Fill and compact holes, trenches, depressions, or any other ground disturbance to blend with the surrounding landscape.

STRAW OR HAY BALE BARRIER

Definition

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales. Used to intercept and detain small amounts of sediment from disturbed areas of limited extent to prevent sediment from leaving the site. Decreases the velocity of sheet flows and low-to-moderate level channel flows.

Where Practice Applies

- Downslope from disturbed areas subject to sheet and rill erosion.
- In minor swales where the maximum contributing drainage area is less than one acre.
- Where effectiveness is required for less than 3 months.

Advantages

When properly used, straw bale barriers are an inexpensive method of sediment control.

Disadvantages/Problems

- Straw bale barriers are easy to misuse. They can become contributors to a sediment problem instead of a solution unless properly located and maintained.
- It is difficult to tell if bales are securely seated and snug against each other.

Planning Considerations

- Straw or hay bale barriers are used similarly to sediment fence barriers; specifically where the area below the barrier is undisturbed and vegetated. Bale barriers require more maintenance than silt fence barriers and permeability through the bales is slower than sediment fence.
- Bales should be located where they will trap sediment; that is, where there will be contributing runoff. Bales located along the top of a ridge serve no useful purpose, except to mark limits of a construction area. Straw or hay bales located at the upper end of a drainage area perform no sediment-collecting function.

Installation

Maximum recommended slope lengths upslope from straw or hay bale barriers are as follows:

Percent Slope	**Maximum slope length (feet)**
1	180
4	100
9	60
14	40
18	30
30	20
(Based on providing storage for 1.0 inch of runoff.)	

- Bales should be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.
- All bales should be either wire-bound or string-tied. Straw bales should be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings.
- The barrier should be entrenched and backfilled. A trench should be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. The trench must be deep enough to remove all grass and other material which might allow underflow. After the bales are staked and chinked (filled by wedging),the excavated soil should be backfilled against the barrier. Backfill soil should conform to the ground level on the downhill side and should be built up to 4 inches against the uphill side of the barrier.
- Each bale should be securely anchored by at least 2 stakes or re-bars driven through the bale. The first stake in each bale should be driven toward the previously laid bale to force the bales together. Stakes or re-bars should be driven deep enough into the ground to securely anchor the bales. For safety reasons, stakes should not extend above the bales but should be driven in flush with the top of the bale.
- The gaps between the bales should be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency. Wedging must be done carefully in order not to separate the bales.
- Straw bale barriers should be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.
- When used in a swale, the barrier should be extended to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale to assure that sediment-laden runoff will flow either through or over the barrier but not around it.

Common Trouble Points

- Improper use: Straw bale barriers have been used in streams and drainageways where high water velocities and volumes have destroyed or impaired their effectiveness.
- Improper placement and installation: Staking the bales directly to the ground with no soil seal or entrenchment allows undercutting and end flow. This has resulted in additions to, rather than removal of, sediment from runoff waters.
- Inadequate maintenance: Trapping efficiencies of carefully installed straw bale barriers on one project dropped from 57 percent to 16 percent in one month due to lack of maintenance.

Maintenance

- Straw bale barriers should be inspected immediately after each runoff-producing rainfall and at least daily during prolonged rainfall.
- Close attention should be paid to the repair of damaged bales, undercutting beneath bales, and flow around the ends of the bales.
- Necessary repairs to barriers or replacement of bales should be accomplished promptly.
- Sediment deposits should be checked after each runoff-producing rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.
- Any sediment deposits remaining in place after the straw bale barrier is no longer required should be dressed to conform to the existing grade, prepared and seeded.

SILT FENCE

DEFINITION

Filter or silt fences are a sediment barrier consisting of a pervious sheet of synthetic polymer filter fabric attached to wire mesh fencing and supported by fence posts.

PURPOSE

Filter or silt fences are constructed to intercept and capture sediment by decreasing the velocity of surface runoff.

APPLICABILITY

All development, mine, construction sites, areas of erosion, reclamation sites, etc. may utilize filter or silt fence to reduce sediment transport. These barriers are temporary in nature and are limited to slowing and filtering sediment associated with surface stormwater runoff, not concentrated, heavy flows.

PLANNING CRITERIA

Filter or silt fences are designed to intercept surface runoff on slopes of varying degrees. Barriers should be constructed in series depending on the size of the contributing drainage area. A rule of thumb is approximately 100 feet of fence for every 0.25 acre of drainage area. Fences require regular maintenance to maintain functionality so access is necessary. Average usable life of filter or silt fences is six months to a year.

METHODS AND MATERIALS

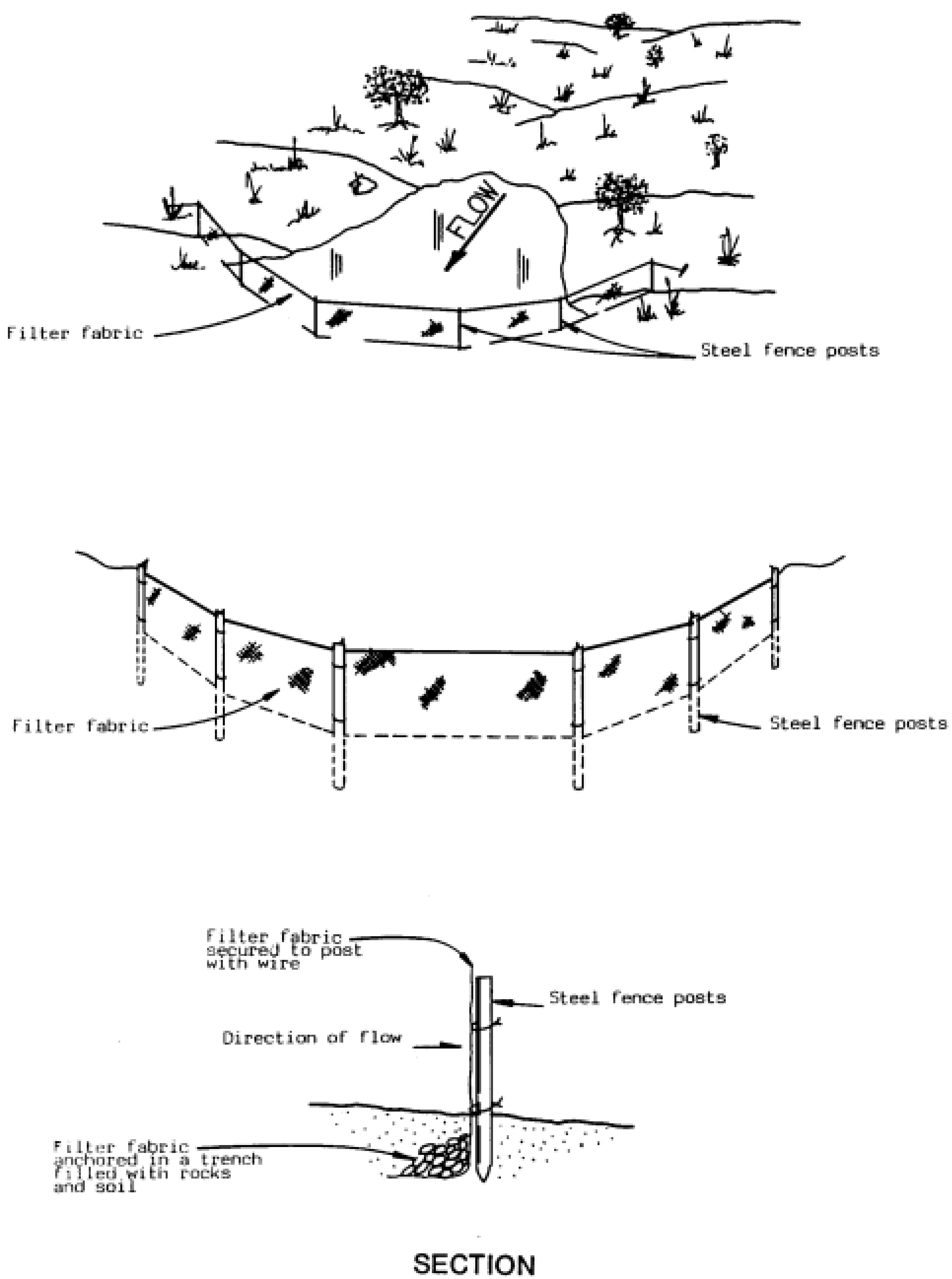
Construction of filter or silt fences involves attaching filter fabric to wire mesh fencing and steel T-Bar fence posts. Depending upon the specifics of the site, fence posts should be placed on three-to-six-foot centers. A trench is constructed along the base of the fence and approximately eight inches of the filter fabric is buried both vertically and horizontally to "toe in" the fabric. The wire mesh and the filter fabric are securely attached on the uphill side of the fence posts. The trench is then backfilled, and soil is compacted against the filter fabric.

MAINTENANCE

The filter or silt fence should be thoroughly inspected after each precipitation or storm event and immediately repaired. Sediment should be removed regularly to keep the barrier functional. Sediment should not be allowed to reach one-half the height of the fence. Excavated material must be disposed of properly, off site and never placed down slope.

EFFECTIVENESS

The effectiveness of filter or silt fences is excellent if they are installed properly and maintained regularly. Fence barriers will last longer than straw bale lines due to their greater strength and durability.



SILT FENCE/FILTER FENCE

STABILIZED ENTRANCE/EXIT

Definition
A temporary stone-stabilized pad located at points of vehicular ingress and egress on a construction site.

Purpose
To provide a stable entrance and exit from a construction site and keep mud and sediment off public roads.

Advantages
- Mud on vehicle tires is significantly reduced which avoids hazards caused by depositing mud on the public roadway.
- Sediment, which is otherwise contained on the construction site does not enter stormwater runoff elsewhere.

Disadvantages
- Effective only if installed at every location where traffic leaves and enters the site.

Planning Considerations
- Avoid locating at curves in public roads or on steep slopes.
- Construction entrances provide an area where mud can be removed from vehicle tires before they enter a public road. If the action of the vehicle traveling over the gravel pad is not sufficient to remove the majority of the mud, then the tires must be washed before the vehicle enters a public road.
- If washing is used, provisions must be made to intercept the wash water and trap the sediment before it is carried off-site. Construction entrances should be used in conjunction with the stabilization of construction roads to reduce the amount of mud picked up by vehicles.
- This practice will only be effective if sediment control is used throughout the rest of the construction site.

Design Recommendations
- Remove all vegetation and other objectionable material from the foundation area. Grade and crown foundation for positive drainage.
- Stone for a stabilized construction entrance shall be 1 to 3-inch stone, reclaimed stone, or recycled concrete equivalent placed on a stable foundation as specified in the plan.
- Pad dimensions: The minimum length of the gravel pad should be 50 feet, except for a single residential lot where a 30 foot minimum length may be used. Longer entrances will provide better cleaning action. The pad should extend the full width of the construction access road or 10 feet whichever is greater. The aggregate should be placed at least six inches thick.
- A geotextile filter fabric shall be placed between the stone fill and the earth surface below the pad to reduce the migration of soil particles from the underlying soil into the stone and vice versa. Filter cloth is not required for a single family residence lot.
- If the slope toward the road exceeds 2%, construct a ridge, 6 to 8 inches high with 3:1 side

slopes, across the foundation approximately 15 ft from the entrance to divert runoff away from the public road. All surface water that is flowing to or diverted toward the construction entrance should be piped beneath the entrance. If piping is impractical, a berm with 5:1 slopes that can be crossed by vehicles may be substituted for the pipe.

- Washing: If the site conditions are such that the majority of mud is not removed from the vehicle tires by the gravel pad, then the tires should be washed before the vehicle enters the road or street. The wash area should be a level area with 3-inch washed stone minimum, or a commercial rack. Wash water should be directed into a sediment trap, a vegetated filter strip, or other approved sediment trapping device. Sediment should be prevented from entering any watercourses.
- A filter fabric fence should be installed down-gradient from the construction entrance in order to contain any sediment-laden runoff from the entrance.

Common Trouble Points

- Inadequate runoff control: Sediment washes onto public road.
- Stone too small, pad too thin, or geotextile fabric absent: Results in muddy condition as stone is pressed into soil.
- Pad too short for heavy construction traffic: Extend pad beyond the minimum 50-ft length as necessary.
- Pad not flared sufficiently at road entrance: Results in mud being tracked onto road and possible damage to road edge.
- Unstable foundation: Use geotextile fabric under pad and/or improve foundation drainage.

Maintenance

- The entrance should be maintained in a condition that will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic topdressing with additional stone.
- Inspect entrance/exit pad and sediment disposal area weekly and after heavy rains or heavy use.
- Remove mud and sediment tracked or washed onto public road immediately.
- Mud and soil particles will eventually clog the voids in the gravel and the effectiveness of the gravel pad will not be satisfactory. When this occurs, the pad should be top-dressed with new stone. Complete replacement of the pad may be necessary when the pad becomes completely clogged.
- If washing facilities are used, the sediment traps should be cleaned out as often as necessary to assure that adequate trapping efficiency and storage volume is available. Vegetative filter strips should be maintained to insure a vigorous stand of vegetation at all times.
- Reshape pad as needed for drainage and runoff control.
- Repair any broken road pavement immediately.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary practices are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

TRACK WALKING (SURFACE ROUGHENING)

Definition

Roughening a bare soil surface with horizontal grooves running across the slope, stair stepping, or tracking with construction equipment; or by leaving slopes in a roughened condition by not fine grading them.

Purpose

To aid the establishment of vegetative cover from seed, to reduce runoff velocity and increase infiltration, and to reduce erosion and provide for sediment trapping.

Where Practice Applies

All construction slopes require surface roughening to facilitate stabilization with vegetation, particularly slopes steeper than 3:1. This practice should also be done prior to forecasted storm events and before leaving a job site for a weekend.

Advantages

Surface roughening provides some instant erosion protection on bare soil while vegetative cover is being established. It is an inexpensive and simple erosion control measure.

Disadvantages/Problems

While this is a cheap and simple method of erosion control, it is of limited effectiveness in anything more than a moderate storm. Surface roughening is a temporary measure. If roughening is washed away in a heavy storm, the surface will have to be re-roughened and new seed laid.

Planning Considerations

- Roughening a sloping bare soil surface with horizontal depressions helps control erosion by aiding the establishment of vegetative cover with seed, reducing runoff velocity, and increasing infiltration. The depressions also trap sediment on the face of the slope.
- Consider surface roughening for all slopes. The amount of roughening required depends on the steepness of the slope and the type of soil. Stable, sloping rocky faces may not require roughening or stabilization, while erodible slopes steeper than 3:1 require special surface roughening.
- Roughening methods include stair-step grading, grooving, and tracking. Equipment such as bulldozers with rippers or tractors with disks may be used. The final face of slopes should not be bladed or scraped to give a smooth hard finish.
- Graded areas with smooth, hard surfaces give a false impression of "finished grading" and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, but they encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity.
- Rough, loose soil surfaces give lime, fertilizer, and seed some natural coverage. Niches in the surface provide microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

Construction Recommendations

- Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.
- Graded areas with slopes greater than 3:1 but less than 2:1 should be roughened before seeding. This can be accomplished in a variety of ways, including "track walking," or driving a crawler tractor up and down the slope, leaving a pattern of cleat imprints parallel to slope contours.
- Graded areas steeper than 2:1 should be stair-stepped with benches. The stairstepping will help vegetation become established and also trap soil eroded from the slopes above.
- Disturbed areas which will not require mowing may be stair-step graded, grooved, or left rough after filling.
- Stair-step grading is appropriate for soils containing large amounts of soft rock. Each "step" catches material that sloughes from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment.
- Areas which will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
- It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all, but is not as effective as other forms of roughening, as the soil surface is severely compacted and runoff is increased.

Maintenance

Areas which are graded in this manner should be seeded as quickly as possible. Regular inspections should be made. If rills appear, they should be regraded and reseeded immediately.

INLET INSERT

DESCRIPTION

Drop inlet inserts can be installed at the inlets to a drainage system to protect downstream water quality from pollutants such as sediment, trash, grease and oil, organic compounds, and metals. Drop inlet inserts function as a flow-through treatment device providing mechanical and media filtration of stormwater runoff. A number of devices are commercially available.

APPLICABILITY

Primary applications include:

- Use at construction sites where space or traffic constraints limit the use of other forms of storm drain inlet protection or where additional storm water quality protection is needed.
- Use as a spill control device to protect stormwater quality from areas at risk of discharging grease and oil or other pollutants to a drainage system.
- Not recommended as a stand-alone permanent BMP. However, drop inlet inserts can be used as pretreatment device within a system of permanent BMPs.
- Most effective when used for small drainage areas; typically less than 0.25 acres.
- Not suitable for drainage areas with significant amounts of sediment, trash, or pine needles because of the potential for frequent clogging on the inlet and damage to the drop inlet insert.

Advantages

- Typically requires no additional footprint for installation, as inserts are placed in existing or proposed facilities.
- Relatively easy installation procedures and maintenance access.
- Many brands of inserts can be cleaned or replaced in a short amount of time.

Disadvantages

- Typically requires frequent maintenance to ensure effective performance. When not maintained, a drop inlet insert may become:
    - Damaged: allowing stormwater to enter a drainage system untreated, or
    - Clogged: blocking stormwater from entering a drainage system and potentially causing localized flooding or other drainage problems.
    - Typically a drop inlet insert provides minimal capacity to retain suspended sediment or debris before maintenance is needed.
- Initial cost savings from use of this relatively inexpensive BMP may be offset by the number of units required for protection of a large drainage system and the costs associated with frequent maintenance or replacement of multiple units.

DESIGN CONSIDERATIONS

The following describes three types of drop inlet inserts that may be applicable for use.

- Tray insert – consists of a series of trays, with the top tray serving as an initial sediment trap. Underlying trays often contain filters composed of a variety of different types of media including polypropylene, porous polymers, treated cellulose, and activated carbon.
- Box insert – typically constructed of plastic or wire mesh with filtering media that fits directly into the box. Hydrocarbons are removed as the stormwater passes through the media. Trash, debris, and sediment remains in the box as the stormwater flows through.

Both tray and box type drop inlet inserts typically provide overflow features.

- Sock insert –filter fabric (usually polypropylene) is either attached to a frame or directly to the drop inlet grate. Each of these options provides very little storage capacity and frequent maintenance may be required depending on the quality of stormwater. Some models allow for sediment removal with a vacuum truck, while others require physically removing the insert for cleaning.

INSTALLATION CONSIDERATIONS

- Refer to manufacturer’s instructions for product specific installation procedures.
- The unit must be installed flush or slightly below grade to prevent stormwater from bypassing the insert.

INSPECTION AND MAINTENANCE

- Refer to manufacturer’s instructions for device specific inspection and maintenance.
- If using inserts as a permanent BMP, inspect several times during the first year after installation to establish a schedule for required cleaning and replacement frequencies. At a minimum, inspect inserts before the winter season and after major storm events.
- When removing the drop inlet insert, be careful not drop suspended sediment back into the drop inlet.
- Properly dispose of accumulated sediment, debris, and spent media or inserts.

EFFECTIVENESS CONSIDERATIONS

Drop inlet inserts function as a flow through treatment device, with various designs employing mechanical and media filtration of stormwater runoff. Based on the design concepts employed, drop inlet inserts when properly maintained can remove pollutants of concern for lake clarity (fine sediment particles and species of nitrogen and phosphorus). However, the effectiveness of this BMP can markedly decline without adequate maintenance, and stormwater runoff with high sediment loadings will quickly clog or damage the insert requiring maintenance that may be too frequent to be practical. Furthermore, a large number of drop inlet inserts would be necessary to protect the water quality for large drainage systems. The most practical applications of this BMP are for temporary water quality protection at construction sites and as a spill protection device.

FILTER BERMS

Description

A filter berm is a temporary ridge constructed of loose gravel, stone, or crushed rock. It slows and filters flow, diverting it from an exposed traffic area. It is used to retain sediment from traffic areas.

Where Practice Applies

Where a temporary measure is needed to retain sediment from rights-of-way or in traffic areas on construction sites.

Advantages

- This is an efficient method of sediment removal which reduces the speed of runoff flow.

Disadvantages/Problems

- A gravel filter berm is more expensive to install than other practices which use materials found on-site.
- Has a limited life span.
- Can be difficult to maintain because of clogging from mud and soil on vehicle tires.

Design Criteria

Berm material should be 3⁄4 inch to 3 inches in size, washed, well-graded gravel or crushed rock with less than 5 percent fines.

Spacing Of Berms

- Every 300 feet on slopes less than 5 percent.
- Every 200 feet on slopes between 5 and 10 percent.
- Every 100 feet on slopes greater than 10 percent.

Berm Dimensions

- 1-foot high with 3:1 side slopes.
- 8 linear feet per 1 cfs runoff based on the 10-year, 24-hour design storm.

Maintenance

- Filter berms should be inspected regularly after each rainfall, or if damaged by construction traffic. All needed repairs should be performed immediately.
- Accumulated sediment should be removed and properly disposed of and the filter material replaced, as necessary.

STORMWATER MANAGEMENT:

DIVERSION DAM (PERMANENT)

Description

A permanent ridge or channel, or a combination ridge and channel, constructed across sloping land or at the top or bottom of a steep slope. Used to convey runoff water, this practice is used to reduce slope lengths, break up concentration of runoff, and move water to stable outlets at a non-erosive velocity.

Where Practice Applies

This practice applies to sites where runoff can be diverted and used or disposed of safely to prevent flood damage or erosion and sediment damage, including:

- Above steep slopes to limit surface runoff onto the slope.
- Across long slopes to reduce slope length to prevent gully erosion.
- Below steep grades where flooding, seepage, or sediment deposition may occur.
- Around buildings or areas that are subject to damage from runoff.

Diversions must have stable outlets. The site, slopes, and soils must be such that the diversion can be maintained throughout its planned life.

Permanent diversions are not applicable below high sediment producing areas unless land treatment practices, or structural measures designed to prevent damaging accumulations of sediment in the channels are installed with or before the diversions.

Advantages

Diversions are among the most effective and least costly practices for controlling erosion and sedimentation.

Planning Considerations

Permanent diversions should be planned as a part of initial site development. They are principally runoff control measures that subdivide the site into specific drainage areas.

Permanent diversions can be installed as temporary diversions until the site is stabilized, then completed as a permanent measure, or can be installed in final form during the initial construction. The amount of sediment anticipated and the maintenance required as a result of construction operations will determine which approach should be used.

Stabilize permanent diversions with vegetation or materials such as riprap, paving stone, or concrete as soon as possible after installation.

Base the location, type of stabilization, and diversion configuration on final site conditions. Evaluate function, need, velocity control, outlet stability, and site aesthetics. When properly located, land forms such as landscape islands, swales or ridges can be used effectively as permanent diversions.

Base the capacity of a diversion on the runoff characteristics of the site and the potential damage after development. Consider designing an emergency overflow section or bypass area to limit damage from storms that exceed the design storm. The overflow section may be designed as a weir with riprap protection.

Design Recommendations

Capacity

Peak runoff values should be determined by accepted methods. Recommended minimum design frequencies are shown below. In all cases, the design storm frequency should be chosen to provide protection compatible with the hazard or damage that would occur if the diversion should overtop.

- Homes, schools, industrial buildings, etc.: 50-year design frequency
- Playfields, recreation areas, similar land areas: 25-year design frequency

Permissible Flow Velocity

Soil Texture	Bare Channel	Vegetated Channel
Sand, silty sandy loam	1.5 feet/second	2.5 feet/second
Silty clay and sandy clay loam	2.0 feet/second	3.5 feet/second
Clay	2.5 feet/second	4.5 feet/second

Cross Section

The channel may be parabolic or trapezoidal. It should be designed to have stable side slopes.

Side slopes for permanent diversions should not be steeper than 3:1 for maintenance purposes and preferably 4:1. In no case should side slopes be steeper than 2:1.

Back slope of the ridge is not to be steeper than 2:1 and preferably 4:1.

The ridge should include a settlement factor equal to 5 percent of its height.

The minimum top width of the diversion ridge after settlement is to be 4.0 feet at the design elevation.

Freeboard equaling 0.5 foot minimum.

In determining the cross section of temporary diversions, consideration should be given to soil type and frequency and type of equipment that is anticipated to be crossing the diversion.

Grade

Channel grade for diversions may be uniform or variable. The permissible velocity for the soil type and vegetative cover will determine maximum grade. Level diversions with blocked ends may be used, provided pipes of sufficient size and spacing are placed in the embankment to drain the channel after runoff stops.

Outlets
Diversions are to have adequate outlets which will convey runoff without causing erosion.

The following types of outlets are acceptable:

- Natural or constructed vegetated outlets capable of safely carrying the design discharge. The outlet should be established and well vegetated prior to construction of the diversion.
- Properly designed and constructed grade stabilization structures or storm sewers.
- Natural or constructed open channels which are stable and have adequate capacity and depth.
- A stable area having a good sod cover or a woodland area with a deep erosion resistant litter. The outlet end of the diversion channel should be flared in a manner to spread the water over a wide area at a shallow depth.

Level Spreader
A level lip spreader should be considered at diversion outlets discharging onto area already stabilized by vegetation. Spreaders shall be excavated at least 6 inches deep into undisturbed soil. The bottom of the excavation and the downstream lip of edge shall be level. Minimum spreader lengths shall be based on the peak rate of flow from a 10-year frequency storm.

Diversion Dikes
Diversion dikes should be used to divert runoff for temporary or permanent protection of cut or fill slopes. Diverted runoff must be discharged onto a stabilized area or through a slope protection structure.

Recommended Criteria

- Drainage area 5 acres or less.
- Top width 2 feet minimum.
- Height (compacted fill) 18 inches unless otherwise noted on the plans. (Height measured from the upslope toe to top of the dike).
- Side slopes 2:1 or flatter.
- Grade dependent upon topography, but must have positive drainage to the outlet; may require vegetative or mechanical stabilization where grades are excessive.

Protection Against Sediment

- Permanent diversions - As a minimum, a filter strip of close growing grass should be maintained above the channel. The width of the filter, measured from the center of the channel, should be one-half the channel width plus 15 feet. The diversion ridge and channel should be vegetated to prevent erosion. Small eroded areas and sediment-producing channels draining into the diversion should be shaped and seeded prior to or at the time the diversion is constructed.

Construction Recommendations

- All trees, brush, stumps, and other objectionable material should be removed so they will not interfere with construction or proper functioning of the diversion.
- All ditches or gullies which must be crossed should be filled and compacted prior to or as part of the construction.
- Fence rows and other obstructions that will interfere with construction or the successful operation of the diversion should be removed.

- The base for the diversion ridge should be prepared so that a good bond is obtained between the original ground and the placed fill.
- Vegetation should be removed and the base thoroughly disked before placement of the fill.

Vegetation
Diversions should be vegetated as soon after construction as practical. Consider jute matting, excelsior matting, or sodding of channel to provide erosion protection.

Seeding, fertilizing, mulching, and sodding should be in accord with applicable vegetative standards for permanent cover. See Permanent Seeding.

Very moist channels are often best vegetated by working rootstocks of reed canary grass into the seedbed.

When soil conditions are unfavorable for vegetation (such as very coarse-textured subsoil material), topsoil should be spread to a depth of 4 inches or more on at least the center half of parabolic shaped channels or on the entire bottom of trapezoidal shaped channels.

Seeded channels should be mulched. For critical sections of large channels, and for steep channels, the mulch should be anchored by cutting it lightly into the soil surface or by covering with paper twine fabric or equivalent material; or jute netting should be used.

Maintenance
If no sediment protection is provided on temporary diversions, periodic cleanout will probably be required.

DIVERSION DAM (TEMPORARY)

Definition

A ridge or channel, or a combination ridge and channel, constructed across sloping land; or at the top or bottom of a steep slope used to convey runoff water.

Purpose

- To reduce slope lengths, break up concentration of runoff, and move water to stable outlets at a non-erosive velocity.
- To protect work areas from upslope runoff.
- To divert sediment-laden water to an appropriate sediment-trapping facility.

Where Practice Applies

This practice applies to construction areas where runoff can be diverted and disposed of properly to control erosion, sedimentation, or flood damage. Specific locations and conditions include:

- Above disturbed existing slopes, and above cut or fill slopes to prevent runoff over the slope;
- Across unprotected slopes, as slope breaks, to reduce slope length;
- Below slopes to divert excess runoff to stabilized outlets;
- Where needed to divert sediment-laden water to sediment traps;
- At or near the perimeter of the construction area to keep sediment from leaving the site;
- Above disturbed areas before stabilization to prevent erosion and maintain acceptable working conditions.
- Where active construction activities make the use of a permanent diversion unfeasible.

Temporary diversions may also serve as sediment traps when the site has been over excavated on a flat grade. They may also be used in conjunction with a sediment fence.

Advantages

Diversions are among the most effective and least costly practices for controlling erosion and sedimentation.

Planning Considerations

- A temporary diversion is intended to divert overland sheet flow to a stabilized outlet or a sediment trapping facility during establishment of permanent stabilization on a sloping disturbed area. When used at the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.
- If the diversion is going to remain in place for longer than 15 days, it should be stabilized with temporary or permanent vegetation.
- It is important that diversions are properly designed, constructed and maintained since they concentrate water flow and increase erosion potential. Particular care must be taken in planning diversion grades. Too much slope can result in erosion in the diversion channel or at the outlet. A change of slope from steeper grade to flatter may cause deposition to occur. The deposition reduces carrying capacity and may cause overtopping and failure.
- Frequent inspection and timely maintenance are essential to proper functioning.

- Sufficient area must be available to construct and properly maintain diversions. It is usually less costly to excavate a channel and form a ridge or dike on the downhill side with the spoil than to build diversions by other methods. Where space is limited, it may be necessary to build the ridge by hauling in dike fill material or using a sediment fence to divert the flow. Use gravel to form the diversion dike where vehicles must cross frequently.
- Temporary diversions may be planned to function one year or more, or they may be constructed anew at the end of each days grading operation to protect new fill.
- Temporary diversions may serve as in-place sediment traps if over excavated 1 to 2 feet and placed on a nearly flat grade. The dike serves to divert water as the stage increases. A combination silt fence and channel in which fill from the channel is used to stabilize the fence can trap sediment and divert runoff simultaneously.
- Wherever feasible, build and stabilize diversions and outlets before initiating other land-disturbing activities.

Design Criteria
Temporary diversions must be planned to be stable throughout their useful life and meet criteria given below. Otherwise, they should be designed as permanent diversions.

Drainage Area
Not more than three acres.

Capacity
Peak runoff from 10-year storm.

Minimum Cross Section

Top Width	Height Side	Slopes
0 ft.	1.5 ft.	4:1
4 ft.	1.5 ft.	2:1

Grade
The grade may be variable depending upon the topography and must have a positive grade to the outlet. The maximum channel grade should be limited to 1.0 percent.
Spacing
The maximum spacing of diversions on side slopes or graded rights-of-way should be no greater than the following:

Land Slope (%)	Spacing (ft.)
1 or less	300
2	200
3-5	150
5 or greater	100

- Diverted runoff should outlet onto a stabilized area, into a properly designed waterway, grade stabilization structure or sediment trapping facility.
- Diversions that are to serve longer than 30 working days should be seeded and mulched as soon as they are constructed to preserve dike height and reduce maintenance.

Maintenance

- Inspect temporary diversions once a week and after every rainfall.
- Damage caused by construction traffic or other activity should be repaired before the end of each working day.
- Immediately remove sediment from the flow area and repair the diversion ridge.
- Check outlets carefully and make timely repairs as needed.
- When the area protected has been permanently stabilized, remove the ridge and the channel to blend with the natural ground level, and appropriately stabilize it.

STREAM CROSSINGS (FOREST OPERATIONS)

Description

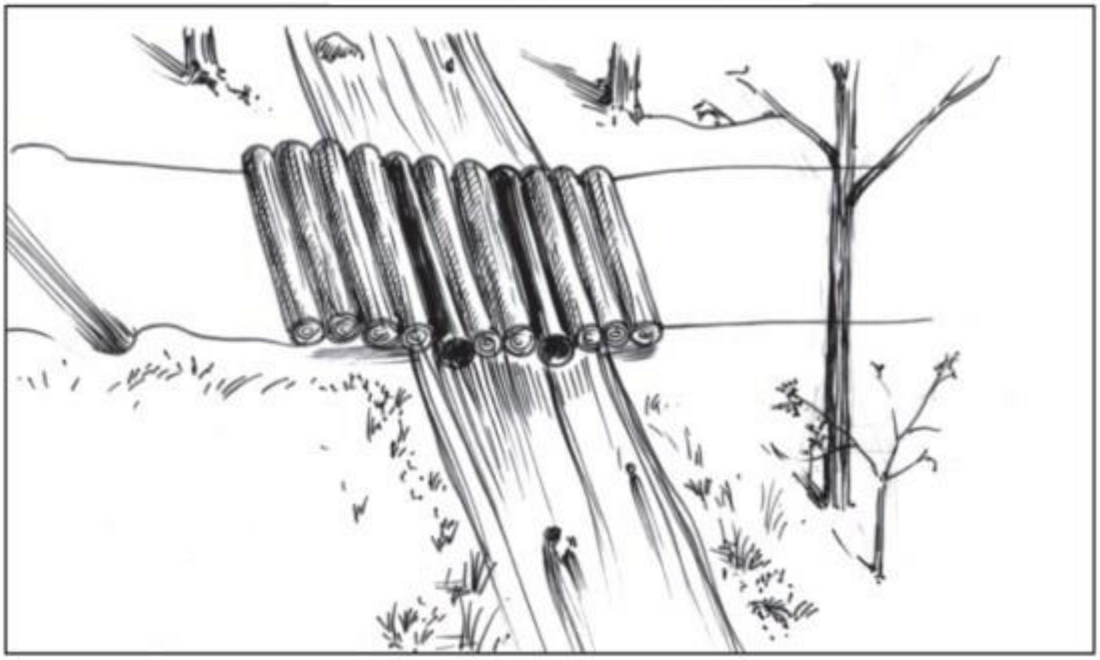
Stream crossings during forestry operations represent one of the principal ways that sediment can enter a waterbody. Stream crossings are usually necessary on the majority of forest operations. The objective of this BMP is to provide a stable means of transporting forest vehicles and timber across streams under both temporary and permanent conditions. Reducing erosion, sedimentation, and turbidity are the water quality goals of this BMP.

Typical requirements for both temporary and permanent stream crossings during forestry operations may include.

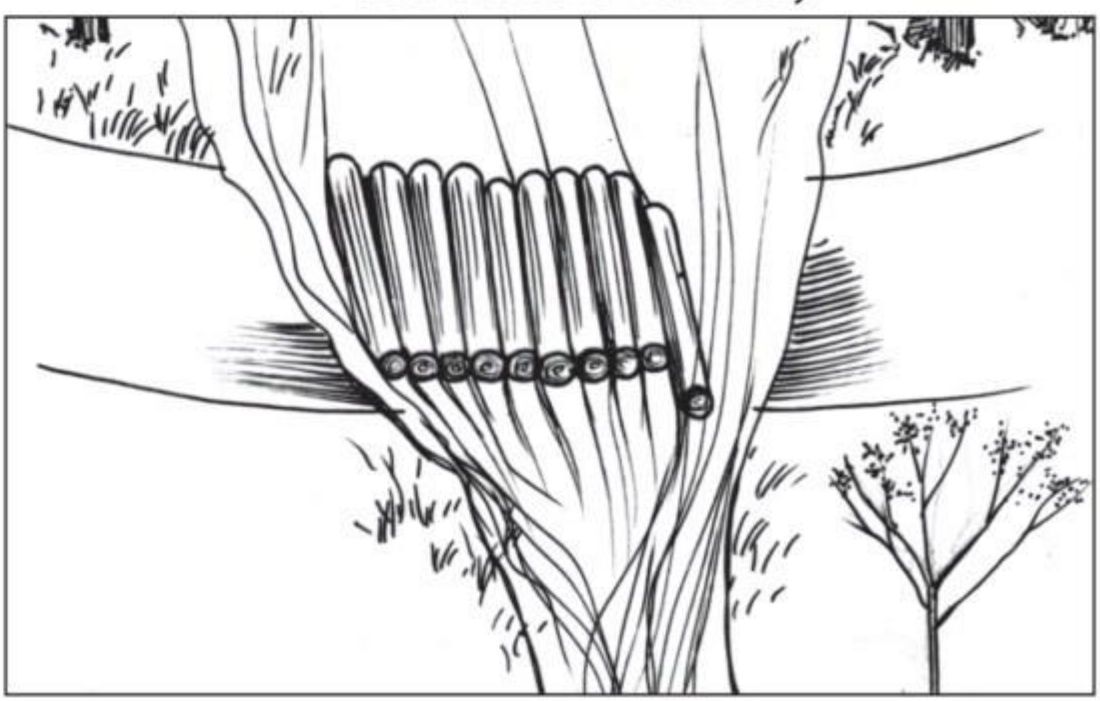
- When a stream crossing is required, existing old crossings must be rehabilitated and used, provided that it can be shown that this will cause less disturbance than constructing a new crossing.
- Temporary crossing structures must be removed at the end of the operation, and the site must be stabilized.
- The rehabilitation, new construction, and stabilization of stream crossings are to be designed to similar specifications.

Other Stream Crossing Requirements Include

Poled ford done correctly



Poled ford done incorrectly



- All crossing will be made at right angles to the channel.
- When crossing involves fill or other closed or semi-closed structures that will obstruct flow, the structures must be designed to accommodate at least the 25-year storm.
- If a culvert is to be used, the work plan must state the diameter of the culvert.

- All banks and approaches to stream crossings require stabilization during and at the end of the operation.
- All stream crossings should be accurately mapped and labeled on the map. Markings on the ground with paint or flagging at the time the work plan is filed is also required.
- If a stream crossing must be changed during the operation, a forester must be notified and approve the change before it is made.
- Within 1000 feet upstream of a public water supply reservoir, measured along the course of the stream from the high water mark of the reservoir, all stream crossings must use a temporary bridge.

Stream Crossing Options
Three types of crossings are allowed: corduroy or poled ford; bridges; and culverts.

Corduroy, or Poled Ford
Corduroy, or Poled Ford Logs are placed in a stream parallel to the direction of flow. Logs should be large enough to keep the skidder out of the water, and should be level with the stream banks. Culverts are then placed in and amongst the logs, to permit streamflow though the ford, and prevent damming. Ductile iron culverts or pieces of gas pipeline can be used since they can support heavy logging equipment without collapsing.

Bridges
Bridges function the best to keep forest machinery out of the water and to prevent sediment from being dragged into the stream from tires and the logs themselves. Bridges also help to keep stream banks intact.

There are two ways to bridge a stream: build a skid- der bridge onsite using logs and wooded planking, or construct a re-usable temporary skidder bridge of lumber bolted together. This joined lumber can be lifted into place to cross a stream and then removed when the timber harvesting is completed.

Culverts
Culverts can be used to cross a stream for forestry operations but they must be sized according to the amount of drainage area upgradient from the crossing. Hay bales are also required to stabilize the stream banks where crossing will occur. Silt fences can also be used however they should never be placed directly in the stream. New erosion control products such as turf-reinforced mats (TRMs) can also be placed prior to and after stream crossings to help stabilize the soil and prevent erosion and sedimentation. Seeding following the harvesting operations and removal of temporary bridges is also required.

STREAM CROSSING (TEMPORARY)

Definition
A bridge, ford or temporary structure installed across a stream or watercourse for short-term use by construction vehicles or heavy equipment. To provide a means for construction vehicles to cross streams or watercourses without moving sediment into streams, damaging the streambed or channel, or causing flooding.

Where Practice Applies
Where heavy equipment must be moved from one side of a stream channel to another, or where light-duty construction vehicles must cross the stream channel frequently for a short period of time.

Planning Considerations

- Contact the local Conservation District regarding any stream crossing or other work conducted in a wetland resource area. The Wetlands Protection Act requires that for any stream crossing or other work conducted in a wetland resource area, or within 100 feet of a wetland resource area, the proponent file a "Request for Determination of Applicability " or a "Notice of Intent " with the Conservation District.
- Careful planning can minimize the need for stream crossings. Try to avoid crossing streams, whenever possible, complete the development separately on each side and leave a natural buffer zone along the stream.
- Temporary stream crossings are necessary to prevent damage to stream banks and stream channels by construction vehicles crossing the stream. This reduces the sediment and other pollutants continually being tracked into the stream by vehicles. These are temporary crossings that represent channel constrictions which may cause obstruction to flow or erosion during periods of high flow. They should be in service for the shortest practical period of time and should be removed as soon as their function is complete.
- Select locations for stream crossings where erosion potential is low. Evaluate stream channel conditions, overflow areas, and surface runoff control at the site before choosing the type of crossing. When practical, locate and design temporary stream crossings to serve as permanent crossings to keep stream disturbance to a minimum.
- Plan stream crossings in advance of need, and when possible, construct them during dry periods to minimize stream disturbance and reduce cost. Ensure that all necessary materials and equipment are onsite before any work is begun. Complete construction in an expedient manner and stabilize the area immediately.
- When construction requires dewatering of the site, construct a bypass channel before undertaking other work. If stream velocity exceeds that allowed for the in place soil material, stabilize the bypass channel with riprap or other suitable material. After the bypass is completed and stable, the stream may be diverted.
- Unlike permanent stream crossings, temporary stream crossings may be allowed to overtop during peak storm periods. The structure and approaches should, however, remain stable. Keep any fill needed in floodplains to a minimum to prevent upstream flooding and reduce erosion potential. Use riprap to protect locations subject to erosion from overflow.
- Stream crossings are of three types: bridges, culverts, and fords. In selecting a stream crossing practice consider: frequency and kind of use, stream channel conditions; overflow areas; potential flood damage; and surface runoff control.

Culverts

Culverts are the most common stream crossings. In many cases, they are the least costly to install, can safely support heavy loads, and are adaptable to most site conditions. Construction materials are readily available and can be salvaged. The installation and removal of culverts, however, causes considerable disturbance to the stream and surrounding area. Culverts also offer the greatest obstruction to flood flows and, therefore, are subject to blockage and washout.

Bridges

- Where available materials and designs are adequate to bear the expected loadings, bridges are preferred for temporary stream crossings.
- Bridges usually cause the least disturbance to the stream bed, banks, and surrounding area. They provide the least obstruction to flow and fish migration. They generally require little or no maintenance, can be designed to fit most site conditions, and can be easily removed and materials salvaged. Bridges, however, are generally the most expensive to design and construct. Also, they present a safety hazard if not adequately designed, installed, and maintained. If washed out, they cause a longer construction delay and are more costly to repair.
- In steep watersheds it is recommended to tie a cable or chain to one corner of the bridge frame with the other end secured to a large tree or other substantial object. This will prevent flood flows from carrying the bridge downstream where it may cause damage to property.

Fords

- Fords should only be used where crossings are infrequent.
- Fords made of stabilizing material such as rock are sometimes used in steep areas subject to flash flooding, where normal flow is shallow (less than 3 inches deep) or intermittent. Fords are especially adapted for crossing wide, shallow watercourses.
- When properly installed, fords offer little or no obstruction to flow, can safely handle heavy loadings, are relatively easy to install and maintain, and, in most cases, may be left in place at the end of construction.

Potential Problems Include

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

Design and Construction Recommendations

- A stream crossing must be non-erosive and structurally stable, and must not introduce any flooding or safety hazard. Bridge design in particular should be undertaken only by a qualified engineer. The following standards apply only to erosion and sediment control aspects of bridges, culverts, and fords.

- The anticipated life of a temporary stream crossing structure is usually considered to be 1 year or less. Remove the structure immediately after it is no longer needed.
- As a minimum, design the structure to pass bank-full flow or peak flow, whichever is less, from a 2-year frequency, 24-hour duration storm without over topping. Ensure that no erosion will result from the 10-year peak storm.
- Ensure that design flow velocity at the outlet of the crossing structure is nonerosive for the stream channel.
- Consider overflow for storms larger than the design storm and provide a protected overflow area.
- Construct crossing when stream flow is low. Have all necessary materials and equipment on site before work begins.
- Minimize clearing and excavation of streambanks, bed, and approach sections. Plan work to minimize crossing the stream with equipment. If possible, complete all work on one side of the stream before crossing to work on other side.

Location
The temporary crossing should be located where there will be the least disturbance to the stream channel, the stream banks, and the flood plain adjacent to the channel, and adjacent wetlands.

Width
The minimum road width of a temporary crossing should be 12 feet.

Alignment
The temporary crossing should be at right angles to the stream whenever possible. If the approach conditions to the crossing are such that a perpendicular crossing is not possible, then a variation of up to 15 degrees is allowable.

Approaches
The centerline of the roadway approaches to the crossing should coincide with the crossing alignment for a distance of 30 feet in either direction. The maximum height of fill associated with the approaches should not exceed 2 feet. Limit surface runoff by installing diversions.

Surface Water and High Flow Diversion
A water diversion structure such as a swale should be constructed across the roadway at the end of both approaches to the crossing to allow stream flow exceeding the design storm to pass safely around the structure. These swales will also prevent surface water from flowing along the roadway and directly into the stream. Locate swales not more than 50 feet from the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

Temporary Stream Diversion
Avoid diverting a stream out of its natural channel by working on one-half of the installation at a time. If stream must be diverted, select most appropriate location considering extent of clearing, channel grade, amount of cut, and spoil disposal. Excavate diversion channel starting at the lower end. If stream velocity exceeds that allowable for the temporary channel, stabilize with riprap. Temporary bypass channel must be stable for flows up to and including the 10-year storm. The crossing site should be built in the dry streambed and stabilized before the stream is redirected to its normal course.

Sediment Trap

- Where appropriate, install instream sediment traps immediately below stream crossings to reduce downstream sedimentation. Install before excavating or grading the approaches to a ford.
- Excavate trap at least 2 feet below stream bottom and approximately twice the channel width for a minimum distance equal to one-half the length of crossing. Remove all spoil to an area outside the flood plain. Stabilize spoil appropriately.
- Ensure that the flow velocity through the basin does not exceed the allowable flow velocity for the in place soil material; otherwise it should not be excavated. In locations where trees or other vegetation must be removed, the sediment trap may be more damaging to the stream than if it were not installed.

Bridges and Culverts

- Elevate bridge abutments or culvert fill 1 foot minimum above the adjoining streambank to allow storm overflow to bypass structure without damage. Culvert pipe should extend well beyond fill side slopes.
- Protect disturbed streambanks, fill slopes and overflow areas with riprap or other suitable methods. Stabilize other disturbed areas as specified in the vegetation plan. Good surface stabilization is especially important at stream crossings as all eroded material directly enters the stream.
- Earth fill for approaches should be free of roots, woody vegetation, oversized stones, organic material or other objectionable materials. The fill should be compacted by routing construction equipment over the fill so that the entire area of the fill is transversed by at least one wheel track or tread track of the equipment.

Bridges
A temporary bridge should be constructed at or above the stream bank elevation. Excavation of the stream bank should not be allowed for construction of this practice.

- **Span**: Bridges should be constructed to span the entire width of the channel. If the width of the channel as measured from top of bank to top of bank exceeds 8 feet, then a footing, pier, or bridge support may be constructed in the stream bed. An additional footing or support will be allowed for each additional 8 feet of channel width. No footing, pier, or bridge support should be used in the stream bed for channel widths less than 8 feet.
- **Materials**: Materials should be of sufficient strength to support the anticipated design loads. Stringers may be logs, sawn timber, pre-stressed concrete beams, or other appropriate materials. Decking materials must be butted tightly and securely fastened to the stringers to prevent soil, and other construction materials from falling into the stream

channel below.

- **Bridge Anchors**: The bridge should be anchored at only one end with either a steel cable or chain to prevent the bridge from floating away during flood events. The anchoring should be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction in the stream channel below. Acceptable anchors are large trees, large boulders, or driven steel anchors.

Culverts

The minimum size for a culvert should be 18 inches. The maximum size for a culvert should be the largest pipe diameter that will fit into the existing channel without a significant amount of excavation required for its placement. Culverts may be circular or elliptical depending on the site requirements. Culverts should extend a minimum of one foot beyond the upstream and downstream toe of backfill placed around the culvert. Length should not exceed 40 feet.

- **Filter Cloth**: Place filter cloth on the stream bed and the stream banks before installing the culvert and backfill. The filter cloth should extend a minimum of six inches and a maximum of one foot past the toe of the backfill.
- **Culvert Placement**: The culvert should be installed on the natural stream bed grade. No overfall should be permitted at the downstream invert.
- **Backfill**: No earth or fine-grained soil backfill should be used for temporary culvert crossings. Backfill should be clean, coarse aggregate. The backfill should be placed in maximum 6 inch lifts and compacted using a vibrating plate compactor. Material should be hand compacted around the haunches of the pipe, using particular care to assure that the line and grade of the pipe is maintained. The minimum allowable backfill over the pipe should be 12 inches or one-half pipe diameter which ever is greater. If multiple culverts are used they should be separated by a minimum of 12 inches of compacted aggregate backfill. Appropriate headwalls or large rock should be placed on the upstream and downstream ends of the temporary fill crossing to protect against erosion during large flood flows.

Fords

Install geotextile fabric in channel to stabilize foundation, and then apply well-graded, weather-resistant stone (3 to 6 inch) over fabric. Use only stabilization fabric, not filter fabric.

Stabilization

All areas disturbed by the installation of the temporary crossing should be stabilized using rock, gravel, or vegetation as appropriate.

Removal

Remove temporary stream crossings as soon as they are no longer needed. Restore stream channel to original cross section and stabilize all disturbed areas. Appropriate measures should be taken to minimize effects on water quality when removing the crossing. Fords may be left in place if site conditions allow.

Temporary bypass channels should be permanently stabilized or removed. If removed, overfill by at least 10%, compact, and stabilize appropriately. Leave in-stream sediment traps in place.

Common Trouble Points

- **Inadequate flow capacity and/or lack of overflow area around structure**: Results in washout of culverts or bridge abutments.
- **Inadequate stabilization of overflow area**: Results in severe erosion around bridges and culverts.
- **Exit velocity from culvert or bridges too high**: Causes stream channel erosion and may eventually cause erosion of bridge or culvert fill.
- **Debris not removed after a storm**: Clogging may cause washout of culverts or bridges.
- **Inadequate compaction under or around culvert pipes**: Culverts wash out due to seepage and piping.
- **Stone size too small**: Ford washes out.
- **Culvert pipes too short**: Results in a crossing supported by steep, unstable fill slopes.

Maintenance

- Inspect temporary crossing after each rainfall event for accumulation of debris, blockage, erosion of abutments and overflow areas, channel scour, riprap displacement, or piping along culverts.
- Remove debris; repair and reinforce damaged areas immediately to prevent further damage to the installation.
- Remove temporary stream crossings immediately when they are no longer needed. Restore the stream channel to its original cross-section, and smooth and stabilize all disturbed areas.
- Leave in-stream sediment traps in place to continue capturing sediment.

OUTLET PROTECTION

Definition

A structure designed to control erosion at the outlet of a channel or conduit by reducing the velocity of flow and dissipating the energy.

Where Practice Applies

- Outlet protection should be installed at all pipe, culverts, swales, diversions, or other water conveyances where the velocity of flow may cause erosion at the pipe outlet and in the receiving channel.
- Outlet protection should be installed early during construction activities, but may be added at any time, as necessary.

Advantages

- A planned (designed) plunge pool can be an effective energy dissipation device.
- Plunge pools, which can develop unless outlet protection is provided, may severely weaken the embankment and thus threaten its stability.
- Protection can prevent scouring at a culvert mouth and thus prevent gully erosion which may gradually extend upstream.

Disadvantages/Problems

- Some types of structures may be unsightly.
- Sediment removal may be difficult.

Planning Considerations

- Erosion at the outlet of channels, culverts, and other structures is common and can cause structural failure with serious downstream problems.
- A riprap-lined apron is the most commonly used structure for this purpose, because it has relatively low cost and can be installed easily on most sites.
- Other types of outlet stabilization structures include riprap stilling basins, concrete impact basins, and paved outlets.

Design Criteria

- Capacity - Peak runoff from 10-year storm.
- Apron - As shown in plans, set on zero grade, aligned straight, with suffcient length to dissipate energy.
- Foundation - Extra-strength filter fabric or well-graded gravel filter layer, 6 inches thick, minimum.

Installation

- Excavate subgrade below design elevation to allow for thickness of filter and riprap. Install riprap to minimum thickness of 1.5 times maximum stone diameter. Final structure should be to lines and elevations shown in plans.
- Construct apron on zero grade. If there is no well-defined channel, cross section may be level or slightly depressed in the middle. In a well-defined channel, extend riprap and filter to the top of the bank or as shown on plans. Blend riprap smoothly to the surrounding land.

- Apron should be straight and properly aligned with the receiving stream. If a curve is necessary to fit site conditions, curve the apron near the upstream end.
- Compact any fill used in the subgrade to the density of the surrounding undisturbed material.
- Subgrade should be smooth enough to protect fabric from tearing.
- Install a continuous section of extra-strength filter fabric on smooth, compacted foundation.
- Protect filter fabric from tearing while placing riprap with machinery. Repair any damage immediately by removing riprap and installing another section of filter fabric. Upstream section of fabric should overlap downstream section a minimum of one foot.
- Make sure top of riprap apron is level with receiving stream or slightly below it. Riprap should not restrict the channel or produce an overfall.
- Immediately following installation, stabilize all disturbed areas with vegetation as shown in plans.

Common Trouble Points

- Foundation not excavated deep enough or wide enough: Riprap restricts flow cross section, resulting in erosion around apron and scour holes at outlet.
- Riprap apron not on zero grade: Causes erosion downstream.
- Stones too small or not properly graded: Results in movement of stone and down- stream erosion.
- Riprap not extended far enough to reach a stable section of channel: Results in downstream erosion.
- Appropriate filter not installed under riprap: Results in stone displacement and erosion of foundation.

Maintenance

- Inspect riprap outlet structures after heavy rains for erosion at sides and ends of apron and for stone displacement.
- Rock may need to be added if sediment builds up in the pore spaces of the outlet pad.
- Make repairs immediately using appropriate stone sizes. Do not place stones above finished grade.

WASTE AND MATERIALS MANAGEMENT:

STAGING AREA

DESCRIPTION

A construction staging area is a physical location used for the storage of construction related equipment and materials such as vehicles and stockpiles. On sites less than 1 acre the staging area may be the exact same area as the construction boundary area, but for construction sites greater than 1 acre a smaller area within the construction boundary, or in close proximity, should be delineated as the staging area.

APPLICABILITY

- Applicable to all construction sites.
- Locate staging areas on flat areas in high land capability districts.
- Paved areas or land that is already disturbed are both ideal locations for construction staging.
- Make sure that the use, identified in the TRPA Code of Ordinances as Storage Yards, is an approved or special use within the Plan Area Statement or Community Plan where the staging area is located.

Advantages

- Limits the amount of soil disturbed and sediment transmission within the construction site.
- Clearly identifies an area within the construction site to store equipment and materials.

Disadvantages

- None

DESIGN CONSIDERATIONS

- Identify all construction staging areas on the plans and make sure the areas are approved by the permitting authority.
- Delineate the staging area with construction boundary fencing and posting a sign identifying the area as the construction staging area.

INSTALLATION CONSIDERATIONS

- Install all applicable temporary BMPs within the staging area such as vehicle tracking, sediment control, vegetation protection, and stockpile management.
- The staging area shall be restored to its original state or an improved state at the end of construction or when it ceases to be a staging area for the construction site.

INSPECTION AND MAINTENANCE

- Inspect the staging area to ensure that all temporary BMPs are installed and functioning.
- If the area is paved, it should be swept on a regular basis to keep dust down.
- The staging area is subject to a pre-grade inspection to make sure all temporary BMPs are installed and functioning, a winterization inspection to make sure the site is stable through the winter months, and a final inspection to ensure that the site is restored to the pre-project condition or better and any intermediate inspections as needed by the permitting authority.

If the staging area is going to be utilized over two or more grading seasons, the area should be winterized by the end of each grading season (Tahoe: October 15). This includes stabilizing the site and removing all equipment and materials unless the permitting authority has granted permission to store construction related equipment and materials on-site through the winter months.

STOCKPILE MANAGEMENT

DEFINITION

Waste stockpiling is the temporary storage of waste prior to disposal, or as part of recycling, reprocessing, recovery, or reuse activities.

PURPOSE

Stockpile management is implemented to prevent air and stormwater pollution from stockpiles of soil and sand, paving materials, and other loose materials used during the construction process.

Management practices are based on the type of material being stored.

APPLICABILITY

Stockpile management is applicable on all construction sites where materials are stockpiled. Materials include, but are not limited to, the following:

- Soil
- Sand
- Construction debris
- Mulch
- Topsoil
- Asphalt
- Aggregate base and subbase
- Pressure treated wood

Controls typically used to manage stockpiles include:

- Stockpile duration restriction
- Plastic sheeting cover
- Sediment control fence
- Diversion of runoff
- Biodegradable erosion control logs
- Soil stabilization

PLANNING CRITERIA

1. If stockpiles are permitted onsite, a designated stockpile area should be identified in project planning phase.
2. Stockpile locations should be located away from concentrated flows of stormwater, drainages, and inlets, water bodies, and other sensitive environmental areas.
3. All stockpiles, inactive or active, should have the proper BMPs implemented until stockpiling activities cease.
4. Stockpiles of contaminated soils should be managed in accordance with the Soil and Groundwater Management Plan.
5. Include construction plan note indicating the duration that inactive stockpiles are permitted.

This is dependent on-site conditions and stockpile needs.

6. Identify permitted stockpile material and prohibit stockpiling of any material not previously permitted.

CONCRETE WASHOUT

Objectives
Concrete Washout Containment prevents the discharge of concrete waste pollutants to stormwater by providing on-site washout containment in a designated and contained area.

Description
Concrete Washout Containment contains concrete and fluids from the chutes of concrete mixers and hoppers of concrete pumps when they are rinsed out after delivery. Containment areas allow for easier disposal of consolidated solids and prevent pollution from run-off or infiltration to groundwater. A washout facility can consist of a pre-fabricated container or self-installed (fabricated on-site) lined containment area, which can be above- or below grade. Containment areas require sufficient volume to completely contain all liquid and waste concrete materials.

Applicability
Concrete Washout Containment is required on projects where concrete, stucco, mortar, grout, and/or cement are used as construction materials.

Selection Considerations
The number and size of containment areas provided should be based on the expected demand for storage capacity.

- ***Pre-fabricated Washout Containers***: Prefabricated washout containments can be any watertight unit that can contain all liquids and solid waste generated by washout operations. When available, pre-fabricated containers are delivered to the site and minimize installation efforts. They are also resistant to damage and protect against spills and leaks. Some companies will also offer complete service with their product, such as providing maintenance and regular disposal of waste materials. Such full service options could relieve the superintendent of these responsibilities. However, when a contractor selects a company that provides such an option, they must also ensure that the company is properly disposing of materials and it would be prudent to give preference to companies that recycle collected materials.

- ***Below-grade Containment***: Use of below-grade containment areas helps prevent breaches and reduces the likelihood of run-off. This option is recommended for projects expecting extensive concrete work or for airport projects. However, this option is not recommended for areas with high water tables or shallow groundwater; such as near natural drainages, springs, or wetlands.

- ***Above-grade Containment:*** Above-grade containment areas must be sized and installed correctly, and diligently maintained in order to be effective. However, particularly if a prefabricated container is unavailable, this option is better suited in areas with potentially high water tables to prevent leaching of wash water into groundwater, or in areas where excavation is not practical.

Design

Location: Concrete Washout Containment should be placed in a location that provides convenient access for concrete trucks, preferably near the area where the concrete is being poured. Place Concrete Washout Containment a minimum of 50 feet from storm drains, open ditches, or waterbodies, or provide secondary containment for the Concrete Washout Containment.

Number of Containments: Larger sites with extensive concrete work should have Concrete Washout Containment at multiple locations for ease of use. Multiple Washout Containments are also required if a single containment unit is not adequate for the volume of waste material generated before the containment structure is cleaned.

Capacity: Concrete Washout Containment should provide sufficient capacity to handle the expected volume of solids, wash water, and rainfall to prevent overflow and allow 12 inches of freeboard. To estimate capacity, assume 7 gallons of wash water and solids are generated from washing one truck chute, and 50 gallons are generated in washing out the hopper of a concrete ready-mix or pump truck. Estimate the number of trucks based on the total volume of concrete in the project, the hopper capacity of each concrete pump truck, the expected number of loads, and the planned maintenance interval.

Containment Area: For larger sites, it is recommended that self-installed containment (both above- and below-grade) areas be at least 10 feet wide with sufficient length and depth to provide the required capacity. Above-grade self-installed containment areas shall be limited to a size and capacity for which the selected outside barrier is designed to remain structurally sound when filled with waste materials.

Cover: A temporary cover should be provided to prevent rain or other precipitation from filling the containment area and causing wash water overflow. The cover should be a secure, non-collapsing, non-water collecting cover.

Signage: Each on-site facility must have highly visible signage to indicate washout containment locations. Signs should be at least 48 by 24 inches and have 6-inch high contrasting letters, placed at a height of at least 3 feet above ground level and within 30 feet of the facility.

Relationship to Other Erosion and Sediment Control Measures

Operator Education: Use of Concrete Washout Containment as a best management practice (BMP) is only successful if concrete truck operators utilize them. Operators need to be made aware of the presence of these containments. All concrete truck operators, including those of subcontractors, should be trained on the importance of managing concrete waste, washout procedures, and washout locations.

Common Failures or Misuses

- Overflow and discharge of waste when the containment area is not covered prior to anticipated rainfall and/or when accumulated liquid wastes have not been removed.
- Leaking resulting from torn or damaged liners going unnoticed or not being replaced, with consequent discharge of washout liquid or slurry to waterways, storm drains, or directly onto the ground.
- Lack of communication to truck drivers of the necessity of using the containment area for washout.
- Compromised structural integrity due to miscalculated capacity and installation, particularly for self-installed, above-grade containment.
- Insufficient quantity and/or size to contain all liquid and concrete waste generated by washout operations.

DEBRIS AND LITTER MANAGEMENT

AFFECTED FACILITIES

These BMPs apply at all facilities and operations in the field where any waste, scrap, trash or debris is generated.

BACKGROUND

Improper storage and handling of solid or liquid wastes can allow toxic compounds, oils and greases, heavy metals, nutrients, suspended solids and other pollutants to enter storm water runoff and snow melt. The discharge of pollutants to storm water from waste handling and disposal can be prevented and reduced by proper storage, handling and management of waste. Reducing waste generation, source reduction, re-use and recycling can also reduce the potential for storm water pollution.

BEST MANAGEMENT PRACTICES

- Keep all trash container lids closed at all times unless adding or removing material.
- All waste receptacles (dumpsters or cans) should be leak-tight with tight-fitting lids or covers. Plastic liners can be used to ensure leak tightness. Return leaking dumpsters to the owner for replacement.
- Never place liquids or liquid-containing wastes in a dumpster or trash receptacle.
- Do not place outdoor waste receptacles near storm drains or ditches unless at a lower elevation.
- Place waste receptacles indoors or under a roof or roof overhang whenever possible.
- Sweep up around outdoor waste containers regularly and immediately before any expected storm event.
- Arrange for wastes to be picked up regularly and disposed at approved disposal facilities. If waste generation exceeds the capacity of waste containers, either obtain more containers or increase the frequency of pick-ups.
- Do not wash out waste containers or dumpsters outdoors. Return dumpsters to the owners for cleaning at the owner's facility. If municipally owned containers must be washed, do so at a sink or floor drain so that wastewater goes to the sanitary sewer.
- When working in the field, place all wastes in appropriate containers in the vicinity of the work site. If no public containers are available, containerize or bag the wastes and bring them back to base for proper placement into containers.
- If wastewater, liquid or liquid, non-hazardous waste is generated at a fixed facility or in the field, it must be disposed into the sanitary sewer (if approved) or collected for transportation to a disposal site that can receive that type of wastewater.

REQUIRED STRUCTURES AND EQUIPMENT

- All dumpsters and outdoor waste containers should be leak-tight and equipped with covers. This includes roll-off dumpsters that contain trash or liquid materials that may leak.
- Mark any storm drain inlets at fixed municipal facilities with the "Keep It Clean Storm Drain" marker to notify employees not to dispose of any materials or wastes there.

INSTALLATIONS REQUIRED DURING NEW CONSTRUCTION OR RENOVATION

- Design new or renovated facilities with waste or trash accumulation areas indoors or under

cover and bermed to contain run-off.
- Locate dumpsters on a flat, paved surface and install berms or curbs around the storage area to prevent run-on and run-off.

REQUIRED EMPLOYEE AND CONTRACTOR TRAINING
- Train all current employees and contractors whose work outdoors generates any waste, scrap, debris or trash on this BMP.
- Train all new hires and job transferees whose work outdoors will generate any waste, scrap, debris or trash on this BMP.
- Conduct refresher training on this BMP for all employees and contractors as needed.
- All contracts must stipulate that contracted employees are trained in stormwater pollution prevention BMPs.
- Train all employees and contractors who might be required to clean up a spill or leak on proper spill clean-up procedures.
- Train all employees and contractors who work outdoors on good housekeeping and proper storage.

REQUIRED MAINTENANCE
- Repair, replace or return any leaking or damaged dumpsters to the waste management company promptly.
- Repair or replace missing or poorly fitted lids or covers on waste receptacles promptly.

RECORDS
- Keep records of all employees trained.
- Keep records on all wastes disposed: hazardous waste manifests, trash removal statements (bills), receipts or invoices from recyclers.

<u>OTHER</u>:

VEGETATION PROTECTION

DESCRIPTION

Trees, including their root systems and other vegetation not specifically designated and approved for removal from a construction site, shall be protected by installing vegetation protection fencing. This practice provides a visible barrier between the active construction area and the vegetation to be protected. This practice protects vegetation foliage, wood, and roots from compaction and other physical damage from construction equipment, reduces erosion and sediment loss from construction sites, reduces revegetation costs, and minimizes land disturbance.

APPLICABILITY

- Applicable to all construction sites.
- Protection of existing vegetation is especially important within and around SEZs, wetlands and surrounding buffer zones, floodplains, steep slopes (> 30 percent), and areas where vegetation would be difficult to establish and maintain.

Advantages

- Minimizes the amount of land disturbed by construction activities.
- Protection of trees and other vegetation reduces the expense of replacing vegetation and associated soil restoration.
- Retaining existing vegetation on portions of development sites provides water quality benefits by shielding the soil surface from the impact of falling rain, slowing the velocity of runoff allowing greater infiltration, maintaining the soil’s capacity to absorb water within the root zone, and allowing the roots to physically hold the soil in place.
- Areas of undisturbed vegetation downslope from a construction site provide a buffer to capture and retain sediment that may be transported off-site by runoff.
- Protecting established vegetation gives the site a more mature look upon completion.

Disadvantages

- Requires a commitment to project planning, implementation, and maintenance focused upon vegetation protection.
- Vegetation on a small site may be a physical obstruction to construction equipment.

DESIGN CONSIDERATIONS

- During the planning and permitting process, identify trees and other vegetation on the proposed project plan and plan for their retention whenever possible.
- Not all vegetation can be retained on a construction site because of installation of improvements and associated excavation and grading. Plan to protect healthy and less common vegetation.
- Consider the following criteria when identifying vegetation for retention:
    - Location:
        - Consider placing structures away from desirable vegetation and legacy (i.e. unique) trees when designing a site plan for development.
        - To be approved for removal, trees must be located within 6 feet of a planned foundation, or will be adversely affected by construction activities

involving soil compaction or excavation/paving.

  - Avoid disturbing vegetation on steep slopes or other sensitive areas. Construction on steep slope requires expanded excavation for foundations and driveways; consequently, steep slopes are more susceptible to erosion and create a greater challenge for retention and preservation of vegetation.
  - Integrate fire-defensible space measures into plans for vegetation retention.
- Species: Conserve the representation of native trees and shrubs inherent to the site. Preserve species that provide aesthetic value to the property.
- Size: Preserve individual trees that provide aesthetic value to the property.
- Age: Retain healthy mature trees because they have become relatively scarce in the developed environment.
- Vigor: Preserve healthy trees that will be relatively less susceptible to damage, disease, and insects. (Indicators of poor vigor include dead growing tip and tips of branches, stunted leaf growth, sparse foliage, pale foliage color, and signs of disease or insect damage. Hollow, rotten, split, cracked, or leaning trees also have a decreased chance of survival.)
- Structural Competence: Retain healthy trees that are structurally competent to withstand strong winds and snow loading.
- Shade: Preserve trees that will provide shade to structures, especially on southern exposures.
- Screening: Retain vegetation that will provide screening from designated scenic corridors.
- Wildlife Benefits: Retain trees that provide wildlife benefits such as food, thermal or visual cover, and nesting.
- Growing Space: Provide spacing of individuals necessary to maintain healthy vegetation growth.
- Include in development plans maintenance provisions, including fertilization and irrigation requirements, if any, to ensure that existing vegetation will survive after development.

INSTALLATION CONSIDERATIONS

- For individual trees, place protective fencing at the perimeter of the dripline at minimum.
- Install fencing to protect large areas and other vegetation as a group rather than individual trees where feasible.
- When trenching and excavating requires the removal of tree roots, employ a certified arborist for surgical pruning using sanitized equipment. Where possible, do not prune tree roots 4 inches and larger. (A majority of tree roots are within 3 feet of the surface. Severing one major root may cause a loss of up to 20 percent of the total root system. Root systems for a healthy tree can extend laterally a distance equal to one to three times the height of the tree.)
- Install protective fencing that is brightly colored (clearly visible) and at least 48 inches high; anchor it to metal posts.
- On construction sites where there is not adequate space to install protective fencing under the dripline of the tree, wrap the tree trunks with protective wooden staves positioned vertically and extending 10 to 12 feet above the ground surface to protect the tree from equipment damage.
- Do not nail, staple, wrap, or wire signs, equipment, or fencing to trees or other vegetation.
- Do not allow vehicles, personnel, material, or equipment beyond protective fencing.

- Maintain vegetative protective measures until all construction activity including site cleanup and stabilization is complete.
- Consider implementing the following recommendations to ensure that trees and other preserved vegetation will not be damaged during construction:
    - Solicit advice from tree care specialists, such as professional foresters or arborists.
    - To encourage tree retention, water and lightly fertilize trees prior to construction. Prune dead, diseased, and hazardous limbs and apply wood chips and other organic mulch in the no-disturbance zone to help keep the soil from becoming desiccated and compacted.
    - Generally avoid root pruning, unless it cannot be avoided.
    - If tree roots are encountered during excavation, do not leave the roots exposed to the air. Hygienically prune them with the guidance of a professional arborist. While pruning, keep roots protected with moist burlap or peat moss. Loosely backfill with soil as soon as possible. After backfilling, drip-irrigate to gently hydrate the tree.
    - No tree should be confined to a volume of soil less than 8 feet by 8 feet by 8 feet deep. When feasible, plan and design driveways, sidewalks, and other pavement areas to be located as far from retained trees and other vegetation as possible. Consider using alternatives to paving that can benefit vegetation: pavers, pervious concrete, elevated iron grates, and wooden walkways.
    - Ensure that project designs accommodate vegetation growth over time, recognizing that root growth can cause damage to pavement, structures, or subsurface utilities where roots are too confined.
    - Do not backfill soil over the buttress collar of any tree. (This practice asphyxiates fine roots in the upper six to 12 inches of soil.).

- In selecting trees to retain, recognize that removal of neighboring trees during construction can cause sunscald of retained trees, because of the higher levels of sunlight reaching the tree. Recognize also that neighboring trees also support each other and when neighboring trees are removed, retained trees may be prone to breaking from wind and snow and ice loading.
- Periodically monitor and evaluate health and hazard of trees damaged during construction for several years. (Damaged, stressed trees are more prone to disease and insect infestations.)

INSPECTION AND MAINTENANCE

- Check vegetation fencing daily and maintain it as required, especially during clearing and grading operations.
- If installed protective fencing consistently fails to perform adequately, replace it with a more resilient fencing system (e.g. high gauge metal fencing).