3.1 Erosion Prevention Fact Sheets (EPP)

Erosion Prevention Practices	EPP-01 Tire Washing

Symbol

TW

Description

As a result of vehicular ingress and egress to the construction site, the facility would remove mud and dirt from vehicle tires and the undercarriage to prevent materials from depositing onto public roads. This application can be used in conjunction with the stabilized construction entrance, EPP-03.

Application

- Temporary construction traffic, phased construction projects and off-site road access.
- Typically used for large construction sites.

Design

- Incorporate with the stabilized construction entrance, EPP-03.
- Construct wash rack on level ground when possible, on a pad of course aggregate.
- Design tire rack to withstand anticipated traffic loads and drain to a detention pond or swale. A typical wash rack has been shown in the standard details. However, wash rack design may consist of other materials or configuration as long as it provides the intended function.
- If a swale is required, then it shall provide sufficient grade, width, and depth to carry runoff.
- The swale shall carry runoff from the wash area to a sediment-trapping device such as a check dam.
- All employees, contractors, subcontractors, and others that leave the site with mud caked tires and/or undercarriages shall use construction entrance.

Maintenance	➢ Remove accumulated sediment to maintain system performance, in the wash rack and/or sediment trap. ➢ Inspect at the end of each shift or workday for damage and repair as needed. ➢ Remove accumulated sediment to maintain system performance, in the wash rack and/or sediment trap.
Inspection	❑ Vehicles are leaving the site through designated construction exit(s). ❑ Mud, dust or dirt is removed prior to exit onto the adjacent road. ❑ The construction exit is sufficiently maintained to prevent mud, dirt, fines and dust from being tracked off-site. ❑ Stones under wash rack have been maintained and free of deleterious materials.

Erosion Prevention Practices	EPP-02 Construction Road Stabilization

CRS CRS

Symbol

CRS

Description

Construction vehicles frequently use access roads, subdivision roads, parking areas and other on-site transportation routes that are not accessible to the public. Construction specifications and drawings should demonstrate methods and practices to stabilize these routes to reduce erosion between the time of initial grading and final stabilization.

Application

- Temporary construction traffic routes, phased construction projects and off-site road access.
- Detour roads for local or temporary construction traffic.
- Construction during wet weather.
- Construction roads utilizing a temporary stream crossing must be indicated and approved.

Design

- Road should follow topographic contours to reduce erosion of the roadway.
- Gravel roads should be of sufficient thickness to support construction traffic.
- Chemical stabilizers or water are usually required on gravel or dirt roads to prevent dust. No additional costs for dust control on construction roads should be required above that needed to meet local air quality requirements.

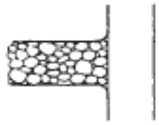
Maintenance

- Periodically apply additional aggregate on gravel roads.
- Active dirt construction roads are commonly watered three or more times per day during the dry season.
- Remove silt and debris from road side ditches and swales to prevent clogging or damming.
- Inspect weekly, and after each rain event and repair any eroded areas immediately.

Inspection

- ❑ Gravel roads are preventing mud and dirt from leaving project area.
- ❑ Dirt and gravel roads do not show signs of erosion, including but not limited to, rill and gully erosion.
- ❑ All stream crossings are maintained as mandated by the appropriate general or individual permit.

Erosion Prevention Practices	EPP-03 Stabilized Construction Exit



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SCE

Description

The construction entrance practice receives all incoming and outgoing traffic of the construction site. By stabilizing the construction entrance there will be a significant reduction in the amount of sediment to and from public right-of-ways, streets, alleys, sidewalks or parking areas. The construction entrance practice is a stabilized pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving. This management practice is likely to create a significant reduction in sediment, nutrients, toxic materials, and oil and grease.

Application

- All points of construction ingress and egress.
- Unpaved areas where sediment tracking occurs from site onto paved or public roads.

Design

- Construction plans must limit traffic exiting the site to properly constructed and stabilized construction exits.
- The entrance must be constructed at a location that minimizes the impact to streams and storm drains and maximizes public safety.
- The aggregate size for construction of the pad must be 2-3 inch stone, at a minimum (KYTC No. 1 or 2, not 57s or DGA).
- The thickness of the pad must not be less than 6 inches. Use geotextile fabric below the rock, if necessary, to improve stability of the foundation in locations subject to seepage or higher water table.
- The width of the pad must not be less than the full width of all points of ingress or egress and, in any case must not be less than 12 feet wide. The length of the pad must be as required but not less than 50 feet.
- Stones should be sized as to remove mud from tires from the construction site.

Design (cont'd)

- Construct on level ground where possible.
- Provide ample turning radii as part of entrance.
- Should be used in conjunction with street sweeping on adjacent public right-of-way.
- Limit egress to the designated construction exit(s) by installing perimeter fencing.
- Wash rack may be included to increase efficiency of removing dirt from tires.
- Construct rock construction exit before clearing, grubbing, and grading the site. Place the gravel to the specific grade and dimensions shown on the plans, and level it out. A geotextile underliner helps to keep rock up out of the mud and functioning properly to remove mud from vehicle and equipment tires.
- Construction entrances will be located as shown on the development plans, or as directed by approving regulatory agency. Any deviation from this location must receive regulatory agency approval.
- Provide drainage to direct muddy runoff from the construction exit toward a sediment trap or other controlled area. In no case should muddy runoff from the construction exit flow onto roads, parking lots, surface waters, or adjacent properties.
- When necessary, wheels must be cleaned with a shovel, scraper, or high pressure water hose to remove sediment before entrance onto roads or other paved areas. When washing is required, it must be done on an area stabilized with KYTC No. 1 or No. 2 rock that drains into an approved sediment trap or sediment basin.

Maintenance

- Inspect weekly and after each rainfall.
- Periodically requires addition of stones for top; add gravel material when soil sub grade becomes visible.
- All sediment spilled, dropped, washed or tracked onto public rights-of-way must be removed immediately.
- Stir aggregate with back-hoe on a weekly basis or as required based on construction activity.

Inspection

- ☐ Entrance/exits are exclusively used by all traffic.
- ☐ Construction exit is sufficiently maintained to prevent mud, dirt, and dust from being tracked off-site, and stone has been stirred with back-hoe.
- ☐ Sediment from construction entrances and exits must be prevented from entering any storm drain, ditch, or watercourse through use of sediment traps, sand bags, commercial sediment dikes, inlet filters, or other approved methods. Maintain traps or other sediment trapping structures as needed.

Erosion Prevention Practices	EPP-04 Buffer Zones

BZ Symbol

BZ

Description

Buffer zones allow the utilization of vegetation to protect soils from erosion as well as reduce the velocity of runoff. This BMP allows the removal of sediment through filtering and settling. This management practice is likely to create a significant reduction in sediment by reducing erosion and retaining plant vegetation along waterways.

Application

- There are two types of buffer strips: General Buffers and Vegetated Riparian Buffers.
  - *General Buffers*: A strip of original, undisturbed land adjacent to the disturbed site provides a general buffer.
  - *Vegetated Riparian Buffers*: Buffers that provide protection to adjacent streams by filtering overland flow of sediments and strengthening bank stabilization. These buffers are also useful by cooling streams to promote plant and fish habitation and providing food for the surrounding wildlife.
- Utilization or reinforcement of existing vegetation is preferred. However, where improvements are required; sodding, plugging, use of stockpiled vegetation or seeding is acceptable.
- Sodding is appropriate if it is part of the no construction activity area that contained turf prior to construction, or for any graded or cleared areas that might erode and where a robust plant cover is needed immediately.
- Plantings for buffer reestablishment and enhancement can consist of bare root seedlings, container grown seedlings, container grown plants and balled and burlapped plants. Standard permanent erosion control grasses and legumes may be used in denuded areas for quick stabilization.
- Soil preparation and maintenance are essential for the establishment of planted vegetation.

Design

- Site plans should specify buffer zones along existing site drainage features such as upland swales, ditches, intermittent and ephemeral (i.e. flowing only after rains or during snowmelt) and streams, ponds, wetlands, sinkholes, lakes, and rivers.
  Site development design should attempt to lay in desired structures such as buildings, roads, utilities, and so forth with minimal disturbance to the existing drainage system and its adjacent vegetated buffer zone. Where this is not possible, site plans can specify that newly constructed drainage features be vegetated with native material, with the new buffer zones established around the new drainage system.

Table EPP04-1. Buffer Zone Width Recommendations

Bank slope	Soil Type Along Banks		
	Sandy	Silty	Clays
Very Steep (2:1 or more)	100 ft	80 ft	60 ft
Steep (4:1 or more)	80 ft	60 ft	40 ft
Moderate (6:1 or more)	60 ft	40 ft	30 ft
Mostly Flat (less than 10:1)	40 ft	30 ft	25 ft

General Buffers

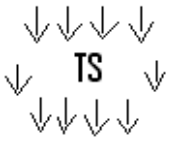
- A sufficient width should be selected to promote plantings' growth and to serve as a filter of overland flow entering the zone.

Vegetated Riparian Buffers

- Prior to structuring the zone, careful consideration should be given to its intent and purpose and how it should be enhanced to meet the requirements of the buffer zone. Stream characteristics such as width, slope, depth and the topography of the surrounding vicinity should be considered.
- Stream buffers must at least include the floodway plus 50 feet perpendicular to the floodway. If a floodway has not been determined, the buffer must be at least 25 feet perpendicular from each side of the stream bank, creek, or unnamed waterway, under "bank-full" conditions.
- Stream buffers are typically 50 feet wide for flat lying areas.
- A buffer should be increased 2 feet in width for every 1% of slope perpendicular to the centerline of the stream.
- If existing vegetation is disturbed or removed, a new multipurpose buffer should be created using the three following zones:
  - Zone 1 – the first 20-feet adjacent to the stream should include trees and shrubs spaced 6-10 feet apart to provide stabilization of the bank deep into the soil.
  - Zone 2 – The next 10-feet should consist of managed forest for chemical absorption and wildlife habitat.
  - Zone 3 – the upper 20-feet should be comprised of grasses for sediment and chemical capture as well as noise reduction.

Maintenance	➢ Inspect sod installations weekly and after significant storm events, until the turf is established, and routinely thereafter. ➢ Maintenance shall consist of mowing, weeding, and ensuring that the irrigation system is operating properly and as designed to sustain growth. ➢ Inspect buffer strips weekly and after significant storm events until vegetation is established, and routinely thereafter. Repair eroded or damaged areas as needed to maintain original purpose and effectiveness of the buffer strip. ➢ Provisions to maintain and protect new plantings from native wildlife should be incorporated with the design documents and drawings.
Inspection	❑ Sod is properly maintained and watered. ❑ Buffer strips are properly maintained. ❑ Plantings are sufficiently protecting from wildlife. ❑ Significant rainstorm events have not deteriorated buffer zone.

Erosion Prevention Practices	EPP-05 Temporary Seeding



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TS

Description

Temporary seeding is used as a means of providing stabilization subject to erosion. This management practice is likely to create a significant reduction in sediment loss and a partial reduction in nutrients and toxic materials.

Temporary seeding may also prevent costly maintenance operations on other erosion control systems and improve the visual resources of the construction area.

Application

- Apply to areas that are left in rough grade condition, and will not be disturbed for 21 days or more.

Design

- <u>Conventional Seeding</u>
  Common methods of application include: disc, cultivator, broadcasting, and no-till drilling.
- <u>Hydroseeding</u>
  Hydroseeding uses a mixture of mulch, seed, and tactifier which is sprayed over a disturbed area for coverage.
- The area must be protected from excess run-on from upgradient areas as necessary with diversions or berms.
- Plant species must be selected on the basis of quick germination, growth, and time of year to be seeded. Fertilizer, lime, seedbed preparation, seed coverage, mulch, and irrigation must be used as necessary to promote quick plant growth.
- Mulch should be specified for sites with slopes greater than five percent (20H:1V) and slope lengths greater than 100 feet.

Desgin (cont'd)

- Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, and anchoring.
- Install the needed erosion control practices before seeding such as diversions, ditches, and berms.
- Do not apply fertilizer, lime, or seed before heavy rain storms (e.g., predicted to be one-half inch or more in one hour or less.)
- Mix seed, mulch, and other material for application via hydraulic spray equipment or follow the procedure below.
- Spread lime (in lieu of a soil test recommendation) on acid soil (pH 5.5 or lower) and subsoil at a rate of one ton per acre of agricultural ground limestone. For best results, test soil pH and fertility – this can reduce the expense of unneeded lime and fertilizer and potential excess nutrient loss through runoff and leaching.
- Fertilizer (in lieu of a soil test recommendation) must be applied at a rate of no more than 800 pounds per acre of 10-10-10 analysis or equivalent.
- Work the lime and fertilizer into the soil with a disk harrow, springtooth harrow, or similar tools to a depth of two inches. On sloping areas, the final operation must be on the contour.

Table EPP05-1. Seeding Rates for Temporary Site Protection

March 1 to October 31	Per 1,000 Square Feet	Per Acre
1. Oats		120 lbs.
2. Perennial Ryegrass	1 lb.	40 lbs.
3. Tall Fescue	1 lb.	40 lbs.
4. Wheat	3 lbs.	120 lbs.
5. Annual Rye	3 lbs.	120 lbs.
November 1 to February 28	Per 1,000 Square Feet	Per Acre
1. Annual Rye	3 lbs.	120 lbs.
2. Wheat	3 lbs.	120 lbs.
3. Perennial Ryegrass	1 lb.	40 lbs.
4. Tall Fescue	3 lbs.	120 lbs.

- Apply the seed uniformly with a cyclone seeder, drill, or hydroseeder (slurry can include seed and fertilizer) preferably on a firm, moist seedbed. Seed no deeper that one-fourth inch to on-half inch.
- When feasible, except where a cyclone type seeder is used, the seedbed should be firmed following seeding operations with a cyclone, roller, or a light drag.
- On sloping land, seeding operations should be on the contour wherever possible.
- Triple the seeding rate for all ditches that will carry flowing water; cover seed with erosion control blanket or turf reinforcement mat if needed to prevent ditch erosion.

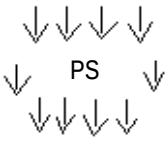
Maintenance

- Inspect frequently during the first six weeks following planting to assure that appropriate moisture levels are maintained and determine if stands are uniform and dense.
- Water until grass is thoroughly established, especially during dry, hot seasons, adverse conditions or when planted late in the planting season.
- Check for damage caused by equipment or heavy rains. Damaged areas should be repaired, fertilized, seeded, and mulched. Tack or tie down mulch as necessary.

Inspection

- ❑ Area is watered daily until stabilization has taken place.
- ❑ After stabilization, water as needed.
- ❑ Heavy equipment has not been used within area.
- ❑ Washout areas have been repaired.
- ❑ Vegetative coverage is (check one): ☐ 20-40% ☐ 40-60% ☐ 60-80% ☐ 80-100%

Erosion Prevention Practices	EPP-06 Permanent Seeding



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PS

Description

Permanent seeding establishes a permanent ground cover over disturbed areas. This practice can greatly reduce erosion from a disturbed area.

Application

- Permanent seeding can be used to reduce sediment runoff from disturbed areas during construction.
- Permanent seeding can reduce air born pollutants arising from construction disturbances.

Design

- The area must be protected from excess runoff as necessary with upgradient diversion berms or ditches. Plant species must be selected on the basis of quick germination, growth, and time of year to be seeded. Fertilizer, lime, seedbed preparation, seed coverage, mulch, and irrigation must be applied as necessary to promote quick plant growth.
- <u>Conventional Seeding</u>
  Common methods of application include: disc, cultivator, broadcasting, and no-till drilling.
- <u>Hydroseeding</u>
  Hydroseeding uses a mixture of mulch, seed, and tactifier which is sprayed over a disturbed area for coverage.
- Permanent seeding shall be applied to disturbed areas within 14 days of final grading unless Temporary Seeding - EPP-05, is to be used in the interim.
- This practice can be used in conjunction with other BMPs to reduce erosion during and after construction.

Design (cont'd)

- Soil should be capable of supporting permanent vegetation and have at least 25 percent silt and clay to provide an adequate amount of moisture holding capacity. An excessive amount of porous sand will not consistently provide sufficient moisture for good growth regardless of other soil factors.
- Plan to seed all areas as soon as final grade is reached, to take advantage of soil seedbed conditions and to minimize erosion potential.
- Where compact soils occur, they should be broken up sufficiently to create a favorable rooting depth of 6-8 inches.
- Stockpile topsoil to apply to sites that are otherwise unsuited for establishing vegetation. Approximately 400 cubic yards of topsoil per acre are needed for application depths of 3 inches (~ 9.3 cubic yards per 1,000 square feet.)
- Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application and anchoring, and maintenance. After the grading operation, spread topsoil as needed.
- Install the needed erosion control practices, such as diversion berms and ditches.
- Spread lime (in lieu of a soil test recommendation) on acid soil and subsoil, at a rate of one ton per acre of agricultural ground limestone. For best results, test the soil – this can reduce the expense of unneeded lime and fertilizer and potential excess nutrient loss through runoff and leaching.
- Fertilizer (in lieu of soil test recommendation) should be applied at a rate of no more than 800 pounds per acre of 10-10-10 analysis. For best results, test the soil to determine fertilizer requirements. In limestone areas with streams and rivers impacted by high algae concentrations, use 10-0-10 fertilizer.
- Work the lime and fertilizer into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of 4 inches. On sloping land, the final operation must be on the contour.

Table EPP06-1. Kentucky Transportation Cabinet Seed Mixes

Mixture Type	Seed Mixture
Mixture No.I	75% Kentucky 31 Tall Fescue 10% Red Top 5% White Dutch Clover 10% Ryegrass (perennial)
Mixture No.III	30% Kentucky 31 Tall Fescue 15% Red Top 15% Partridge Pea 20% Sericea Lespedeza 10% Sweet Clover – Yellow 10% Ryegrass
KYTC does not specify the seeding rate but requires that sufficient seed be applied to ensure a "dense, uniform vegetative cover."	

Table EPP06-2. Recommended Seeding Rates and Other Information for Various Species and Seed Mixtures

Seed species & mixtures	Seeding rate/acre	Per 1000 sq. ft	Soil pH	Other Information
Seed and seed mixtures for relatively flat or slightly sloping areas				
Perennial ryegrass	25 to 35 lbs	1 lb	5.6 to 7.0	Apply lime at 2 tons per acre if soil pH is below 5.5; use 400-800 lb fertilizer (10-10-10) on poor soils. Use wildflower mixes to save on mowing and watering costs.
+ tall fescue	15 to 30 lbs	1 lb	5.5 to 7.5	
Tall fescue	40 to 50 lbs	1.5 lbs		
+ ladino or white clover	1 to 2 lbs	2 oz		
Steep slopes, banks, cuts, and other low maintenance areas (not mowed)				
Smooth bromegrass	25 to 35 lbs	1 lb	5.5 to 7.5	Track Steep slopes with dozer up and down hill before seeding. Mulch Slopes after seeding with 2 to 3 tons of straw or 6 tons of wood chips per acre. Use tackifier on mulch, disk it in, or punch in with sheep-foot roller. Disk or sheep-foot on the contour (across the slope, on the level). For extremely steep slopes, use erosion control blankets after seeding. Use 20" spacing on blanket staples.
+red clover	10 to 20 lbs	0.5 lb		
Tall fescue	40 to 50 lbs	1 lb	5.5 to 7.5	
+ white or ladino clover	1 to 2 lbs	2 oz		
Orchardgrass	20 to 30 lbs	1 lb	5.6 to 7.0	
+ red clover	10 to 20 lbs	0.5 lb		
+ ladino clover	1 to 2 lbs	2 oz		
Crownvetch	10 to 12 lbs	0.25 lb	5.6 to 7.0	
+ tall fescue	20 to 30 lbs	1 lb		
Lawns and other high traffic or high maintenance areas (mowed)				
Bluegrass	105 to 140 lbs	3 lbs	5.5 to 7.0	Use wildflower mixes to save on mowing and watering costs. Do not establish grassed lawns near streams or wetlands – leave a 15 to 30 foot buffer or natural vegetation.
Perennial ryegrass (turf)	45 to 60 lbs	2 lbs	5.6 to 7.0	
+ bluegrass	79 to 90 lbs	2.5 lbs		
Tall fescue (turf type)	130 to 170 lbs	4 lbs	5.6 to 7.5	
+ bluegrass	20 to 30 lbs	1 lb		
Channels and other areas of concentrated water flows				
Perennial ryegrass	100 to 150 lbs	3 lbs	5.6 to 7.0	Seed ditches and channels thickly. Do not use fertilizer near ditch or channel bottom. Use erosion control blankets or turf reinforcement mats when channel bottom slopes exceed 3%. Silt check dams are needed when channel slopes exceed 5% or when channels begin downcutting (gullying) on the bottom. Do not use silt fencing or straw bales as silt check dams in channels with slopes greater than 3%; use rock or brush instead.
+ white or ladino clover	1 to 2 lbs	2 oz		
Kentucky bluegrass	20 lbs	0.5 lb	5.5 to 7.5	
+ smooth bromegrass	10 lbs	0.25 lb		
+ switchgrass	3 lbs	2 oz		
+timothy	4 lbs	0.25 lb		
+ perennial ryegrass	10 lbs	0.25 lb		
+ white or ladino clover	1 to 2 lbs	2 oz		
Tall fescue	100 to 150 lbs	3 lbs	5.5 to 7.5	
+ ladino or white clover	1 to 2 lbs	2 oz		
+ perennial ryegrass	15 to 20 lbs	0.5 lb		
+ Kentucky bluegrass	15 to 20 lbs	0.5 lb		

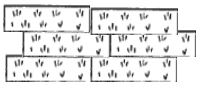
Maintenance

- Water soil until the grass is firmly established, especially if seedlings are made late in the planting season.
- Inspect all seeded areas for failures and make necessary repairs.
- If stand is inadequate (less than 80% coverage) overseed, fertilize, using half of the original rates
- If stand is more than 60% damaged, reestablish following original seedbed preparation methods, seeding and mulching recommendation and apply lime and fertilizer as needed according to a new soil test.

Inspection

- ❑ Area is watered daily until stabilization has taken place.
- ❑ Area has been maintained (watered, repaired) since stabilization.
- ❑ Heavy equipment has not been used within area.
- ❑ Eroded areas have been regarded and re-established.

Erosion Prevention Practices	EPP-07 Sodding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SO

Description

Sodding is a method used to quickly establish permanent grass stands. This practice can prove very effective in quickly stabilizing critical, erosion-prone areas.

Application

- Ditches or channels carrying intermittent flow.
- Areas around drop inlets in grass swales.
- Residential or commercial lawns that would be aesthetically enhanced sodding.
- Other critical areas not previously described.

Design

- Establish permanent grass stands quickly.
- Prevent erosion by stabilizing formerly denuded areas.
- Reduce the amount of air borne sediment, dust and mud leaving the project site.
- Stabilize channels where concentrated overland flow occurs.
- Sod should be machine cut and contain one-half inch to 1 inch of soil, not including roots or shoots or thatch.
- Specify that sod will be installed within 36 hours of digging and removal from the field.
- Avoid planting when subject to frost heave or hot weather if irrigation is not available.
- Sod should not be used on slopes steeper than 2H:1V. If it is to be mowed, installation should be on slopes no greater than 3H:1V.

Design (cont'd)

- The sod should consist of strips of live, vigorously growing grasses. The sod should be free of noxious and secondary noxious weeds and should be obtained from good, solid, thick-growing strands. The sod should be cut and transferred to the job in the largest continuous pieces that will hold together and that are practical to handle.
- The sod should be cut with smooth, clean edges and square ends to facilitate laying and fitting. The sod must be cut to a uniform thickness of not less than three-fourths of an inch measured from the crown of the plants to the bottom of the sod strips for all grasses except bluegrass. Bluegrass sod must be cut to a uniform thickness of not less than 1.5 inches.
- The sod must be mowed to a height of not less than 2 inches and no more than 4 inches before cutting.
- The sod must be kept moist and covered during hauling and preparation for placement on the sod bed.
- Soils in areas to be sodded must be capable of supporting permanent vegetation and must consist of at least 25 percent silt and clay to provide an adequate amount of moisture-holding capacity. An excessive amount of porous sand will not consistently provide sufficient moisture for the sod regardless of other soil factors.
- Compacted soils must be boken up sufficiently to create a favorable rooting depth of 6-8 inches.
- Stockpile topsoil to apply to sites that are otherwise unsuited for establishing vegetation.
- Grade as needed and feasible to permit the use of conventional equipment for the sod bed preparation. After grading operation, spread topsoil where needed.
- Apply lime (in lieu of a soil test) on acid soil and subsoil at a rate of one ton per acre. The lime should be agricultural ground limestone or equivalent. For best results, conduct a soil test. This can reduce expense of unneeded lime and fertilizer an potential excess nutrient loss through runoff and leaching.
- Apply fertilizer (in lieu of a soil test) at 1,000 pounds per acre 10-10-10 analysis. For best results, conduct a soil test.
- Work lime and fertilizer into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of 4 inches.

Design (cont'd)

- No sod should be placed when the temperature is below 32° F. No frozen sod must be placed nor should any sod be placed on frozen soil.
- Sod should be carefully placed and pressed together so it will be continuous without any voids between the pieces. Stagger the joints between the ends of strips in a brick-like pattern. Ensure that the edge of the sod at the outer edge of the sod at the outer edges of all gutters is sufficiently deep so that the surface water will flow over onto the top of the sod.
- For channel sodding, carefully place the sod on rows or strips at right angles to the centerline of the channel (i.e. at right angles to the direction of flow). On steep, graded channels, stake each strip of sod with at least two stakes not more than 18 inches apart. The stakes should be wooden and approximately ½" x ¾" x 12". Drive the stakes flush with the top of the sod and with the flat side against the slope.
- On slopes 3:1, or steeper, and where drainage into a sod gutter or channel is one-half acre or larger, roll or tamp the sod and then peg chicken wire, jute, or other netting over the sod for protection in the critical areas. Stake the netting and sod with at least two stakes not more than 18 inches apart. The stakes should be wooden and approximately ½" x ¾" x 12". Drive the stakes with the flat side against the slope and on an angle toward the slope. Staple the netting on the side of each side of each stake within 2 inches of the top of the stake, then drive the stake flush with the top of the sod.
- The sod should be tamped or rolled after placing and then watered. Watering must consist of a thorough soaking of the sod and of the sod bed to a depth of at least 4 inches. Maintain the sod in a moist condition by watering for a period of 30 days.

Maintenance

- Sod should be kept moist for at least the first three weeks, until properly rooted.
- Inspect sod twice a week after installation to check on moisture conditions and grass viability. Irrigate sod immediately after installation and every few days afterwards if no significant rainfall occurs during the first 2 weeks. Soak the area thoroughly to a depth of 3 inches during irrigation.
- Sod areas where original placement does not establish or take root.
- Do not mow for the first three weeks.
- Once mowing begins, cutting height should be 3" or greater.
- Fertilize and mow grasses once established.

Inspection

- ❑ Sodded areas are properly watered and maintained.
- ❑ Heavy construction equipment has been prohibited from crossing sodded areas.
- ❑ Sodded areas are mowed once established.

Erosion Prevention Practices	EPP-08 Surface Roughening

Symbol

SR

Description

This BMP corrects the affects of runoff velocities, sediment trapping and sheet flow length by constructing small furrows across a slope, and utilizing construction equipment to track soil surface. The primary function of surface roughening is to temporarily stabilize a slope until it can receive permanent vegetation.

Application

- All exposed construction slopes, particularly slopes that are steeper than 3H:1V.
- Exposed soils where seeding, planting, and mulching will benefit from surface roughening.
- Areas that have the potential for erosion of clay (smooth, hard surfaces), silt or sand sized particles.

Design

Roughening methods include:

- Terracing, (see EPP-13)
- Fill Slope Roughening
- Grooving
- Roughening with tracked machinery

Factors to be considered in choosing a method are

- Slope steepness
- Mowing requirements
- Soil type

Design (cont'd)

- Specify that surface roughing is perpendicular to the direction of flow

Soil Conditions vs. Erosion

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

- Stair-step grade or groove all cut all slopes that are steeper than 3H:1V.
- Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance , and slightly slope the horizontal position of the step in toward the vertical wall
- Do not make individual vertical cuts more than 2 feet high in soft materials or more that 3 feet high in rocky materials.
- Groove the slope using machinery to create a series of ridges and depressions that run across the slope, on the contour.
- Place fill slopes with a gradient steeper than 3H:1V in lifts not to exceed 8 inches, and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill 4-6 inches deep.
- Use grooving or tracking to roughen the face of the slopes, if necessary. Grooves and track indentions must be perpendicular to the direction of downslope flow.
- Apply seed, fertilizer, and straw mulch then track or punch in the mulch with the bulldozer.
- Do not blade or scrape the final slope face.
- Make mowed slopes no steeper 3H:1V.
- Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use a culipacker-seeder. Make the final pass of any such tillage on the contour (i.e. across the slope rather than up and down).
- Make grooves formed by such implements close together (less than 10 inches, and not less than 1 inch deep).
- Excessive roughness is undesirable where mowing is planned.

Design (cont'd)

- Limit roughening with tracked machinery to soils with a sandy component to avoid undue compaction of the soil surface. Tracking soils with heavy clay content can cause compaction and seal the slope soils, increasing runoff and making seed germination difficult.
- Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back-blade during the final grading operation.
- Immediately seed and mulch roughened areas to obtain optimum seed germination and growth. Use erosion control blankets or turf reinforcement mats on long (> 50 feet) steep (> 2H:1V) slopes as necessary, or hydroseed.

Maintenance

- Periodically check the seeded or planted slopes for rills and washes, particularly after significant storm events, greater than 0.5 in.
- Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

Inspection

- ❑ Surface roughened areas inspected after recent wet weather events.
- ❑ Rills and washed areas have been re-roughened and re-seeded.
- ❑ Practice is maintained and properly functioning; other practices are not required.

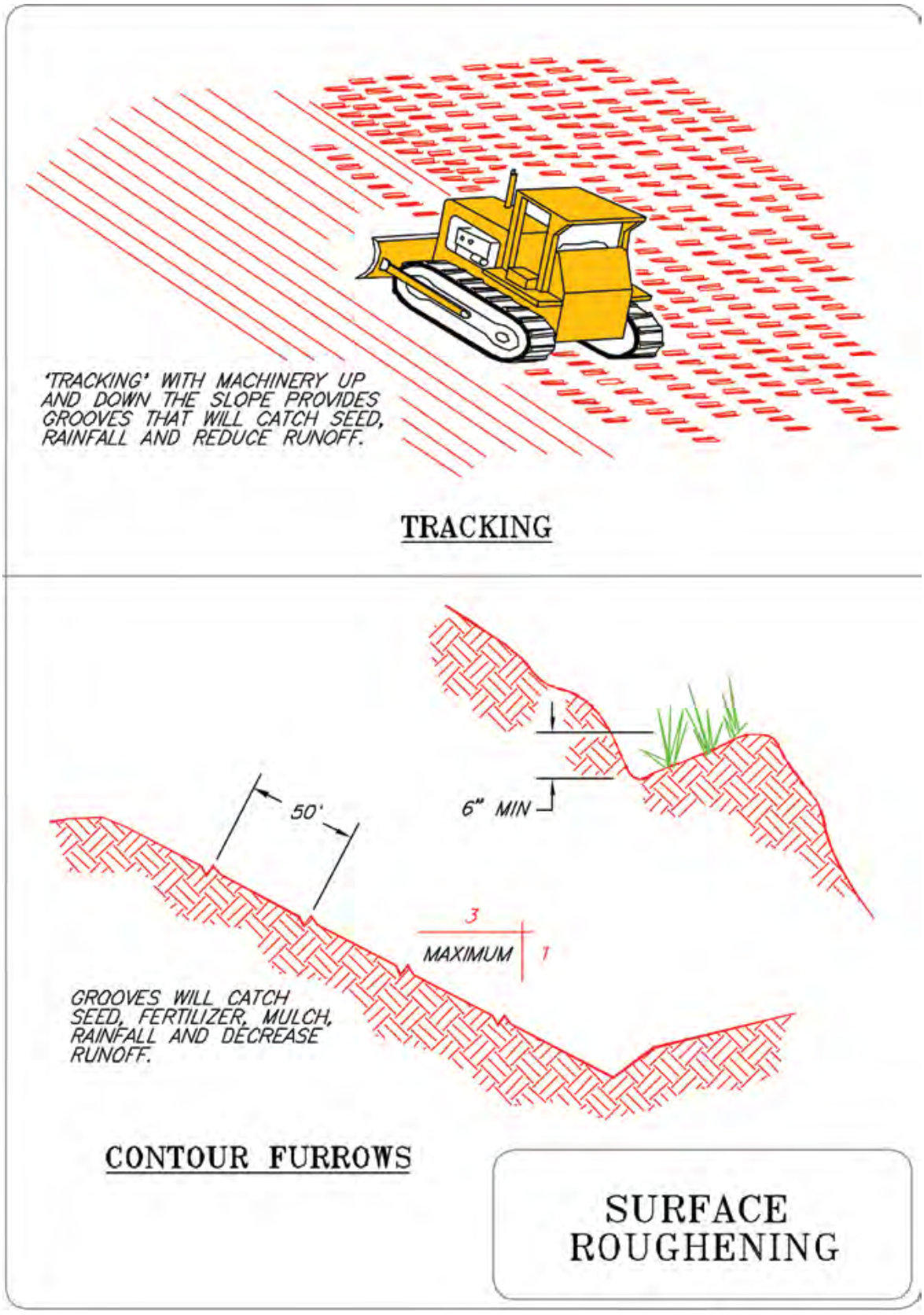
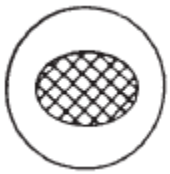


Figure EPP08-1. Kentucky Construction Site BMP Planning and Technical Specifications Manual

Erosion Prevention Practices	EPP-09 Topsoil Stockpiling



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Description

Topsoil is used to enhance the final product of a construction site area. This act is done to support temporary and permanent seeding, as well as aiding in erosion control methods. By implementing this BMP, a reduction in construction waste and some reduction in sediment will occur.

Application

- Where construction activities expose subsoil layers that may not be able to support vegetative growth.
- The structure, pH, or nutrient balance of the available soil cannot be amended by reasonable means to provide an adequate growth medium for the desired vegetation.
- The soil is too shallow to provide adequate rooting depth or will not supply necessary moisture and nutrients for growth of desired vegetation.
- Stockpiling should also be used where high-quality turf or ornamental plants are desired and where slopes are 2H:1V or flatter.
- Areas where reusing and preserving topsoil increases the success rate of new vegetation.

Design

- Consider quality and amount of topsoil available and needed.
- Select location to avoid slopes, flood plains, natural channels, and traffic routes.
- Compost used on site as a recycled aspect of construction clearing.
- Verify proper placement of down slope sediment control practices prior to removing topsoil.

Design (cont'd)

- Strip topsoil only from those areas that will be disturbed by excavation, filling, road building, or compaction by equipment. Normally, 4 to 6 inches are stripped for topsoil use.
- To promote bonding, scarify or rip subsoil to a depth of 8-12 inches; do not compact during topsoil placement operations.
- Avoid stripping topsoil to the extent that stormwater infiltration is significantly reduced.
- Determine depth of stripping by taking soil cores at several locations within each area to be stripped.
- Put sediment basins, diversions, and other controls into place before stripping.
- Position topsoil stockpiles where they will not erode, block drainage, or interfere with site work. Topsoil stockpiles should be on flat ground if possible, and protected by a silt fence or other sediment barrier on the downgradient sides. Top soil that will not be used for more than 14 days must be mulched or seeded.
- If stock piles will not be used within 2 months, they must be stabilized with permanent vegetation to control erosion and weed growth.
- To promote topsoil bonding, before topsoil is applied to the site, disk the subsoil to a depth of at least 4 inches to ensure bonding of the topsoil and subsoil. If no amendments have been incorporated, loosen the soil to a depth of at least 6 inches before spreading topsoil.
- Uniformly distribute topsoil to a minimum compact depth of 2 inches on 3:1 slopes and 4 inches on flatter slopes. Do not spread the soil while it is frozen or muddy or other operations prevent the formation of depressions or water pockets.If site is excavated down to rock, such as sandstone or shale, 8 to 12 inches of topsoil is recommended for good plant growth.
- Do not apply topsoil to slopes steeper than 2:1 to avoid slippage, or to a subsoil of highly contrasting texture. Sandy topsoil over clay subsoil is a particularly poor combination, especially on steep slopes. Water can creep along the junction between the soil layers and cause the topsoil layer to slip or slough.

Table EPP09-1. Cubic Yards of Topsoil Required to Attain Various Soil Depths

Depth (Inches)	Per 1,000 Square Feet	Per Acre
1	3.1	134
2	6.2	268
3	9.3	403
4	12.4	537
5	15.5	672
6	18.6	806

- If site is excavated down to rock, such as sandstone or shale, 8 to 12 inches of topsoil is recommended for good plant growth.

Design (cont'd)

- The best texture is loam, sandy loam, and silt loam. Sandy clay loam, silty clay loam, clay loam, and loamy sand are fair. Do not use heavy clay and highly organic soils such as peat or much as topsoil.
- Organic matter content should be greater than 1 percent by weight.
- The depth of material meeting the above qualifications should be at least 2 inches. Soil factors such as rock fragments, slope, depth to water table, and layer thickness affect the ease of excavation and spreading of topsoil.
- Organic soils such as mucks and peats do not make good topsoil. They can be identified by their extremely light weight when dry.
- Generally, the upper part of the soil that is richest in organic matter is most desirable; however, material excavated from deeper layers could be worth storing if it meets the other criteria listed above.
- Maintain grades on the areas to be topsoiled according to the approved plan. Adjust grades and elevations for receipt of topsoil.
- Liming is required if pH is less than 6.0 or if the soil is composed of heavy clays. Incorporate agricultural limestone in amounts recommended by soil tests or specified for the seeding mixture to be used. Incorporate lime to a depth of at least 2 inches by disking.
- Compact the topsoil enough to ensure good contact with the underlying soil, but avoid excessive compaction as it increases runoff and inhibits seed germination. Light packing with a roller is recommended where high-maintenance turf is to be established.
- On slopes and areas that will not be mowed, the surface may be left rough after spreading topsoil. A disk may be used to promote bonding at the interface between the topsoil and subsoil.
- After topsoil application, follow procedures for temporary or permanent seeding, taking care to avoid excessive mixing of topsoil into the subsoil,

Maintenance

- Maintain areas where vegetation has been re-established to remedy erosion and damage or vegetation failure by frequently checking the newly applied topsoil.

Inspection

- ☐ Effective management practices such as netting, temporary seeding, mulch and other traditional methods are used to ensure correct storage of the soil. If these practices are not available, other equivalent practices are to be enforced.
- ☐ Appropriate layer of topsoil has been established.
- ☐ Storage piles do not interfere with site drainage.

Erosion Prevention Practices	EPP-10 Mulching

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Description

To secure temporary or permanently seeded areas, mulching is used as a stabilizer. There are several types of mulches to be utilized, some of which include organic materials, straw, wood chips, and bark or other wood fibers. This management practice has the possibility to significantly reduce sediment and partial reduction of nutrients.

Application

- Temporary stabilization of freshly seeded and planted areas, sometimes during periods of unsuitable vegetative growth.
- Temporary stabilization of areas that cannot be seeded or planted (e.g., insufficient rain, steep slope, non-growth season).
- Areas which have been permanently seeded to assist in retaining moisture, and to hold seeding.
- On areas to increase the survival of temporary and/or permanent vegetative cover.
- As short term, non-vegetative ground cover on steepened slopes to reduce rainfall impact, decrease the velocity of sheet flow, and settle out sediment.
- As ground cover around established plants, such as trees or shrubs, and on unprotected flat to minor slopes.
- Apply to planting areas where slopes are 2.5:1 (H:V) or less steep. For steeper slopes the mulch material should be applied hydraulically.
- Areas where climatic conditions require soil moisture retention aid to avoid cracking.

Design

The term “mulch” is commonly used to describe a variety of materials, such as:

- Shredded tree bark and other woody materials, to protect trees and shrubs.
- Straw or hay, scattered across a slope or disturbed area.
- Peat mulch, used in planting trees and shrubs.

- Table EPP-10.01 has a recommended application rate for various types of mulches.

Design (cont'd)

Vegetative Fibers (Straw)

Loose hay or straw are the most common mulch materials used in conjunction with direct seeding of soil. Straw mulch is preferable over hay mulch, which may contain weeds and other objectionable material. Straw mulch is the short-term protection most commonly used with seeding. Wheat or oat straw is recommended from the current season's crop (less than 12 months old). Average fiber length should exceed 6 in.

Straw mulch is applied immediately after seeding, whether by machine or by hand distribution. Anchor the mulch in place using a tacking agent, plastic netting, or punching into the soil mechanically. Plastic netting requires wire staples, wooden stakes, or plastic stakes. If the slopes are too steep for netting, then tacking agents should be selected on the basis of longevity and the ability to hold the fibers in place.

- Mulch should not be applied more than 2 inches deep on seeded sites, unless it is incorporated into the soil by tracking, disking (crimping), or other punching in techniques. If the straw is applied at rates higher than 3 tons per acre, the mulch could be too dense for the sunlight and seedlings to penetrate.
- Before mulching, install any needed erosion and sediment control practices such as diversions, grade stabilization structures, berms, dikes, grass-lined channels and sediment basins
- Obtain clean wheat, barley, oat, or rice straw to prevent the spread of noxious weeds. Avoid moldy, compacted straw because it tends to clump and is not distributed evenly
- The straw must be evenly distributed by hand or machine to the desired depth (about 2 inches) and should cover the exposed area to a uniform depth. One bale (approximately 80 lbs) of straw covers 1000 square feet adequately. The soil surface should be barely visible through the straw mulch. On steep or high-wind sites, straw must be anchored to keep it from blowing away.
- For seeded sites, apply 1.5-2 tons per acre, 1-2 inches deep, covering 80 percent of the soil surface. For unseeded sites, use 1.5-2.5 tons per acre, apply 2-4 inches deep, covering 90 percent of the soil surface.
- Mulch must be anchored immediately to minimize loss by wind or water. Straw mulch is commonly anchored by crimping, tracking, disking, or punching into the soil; covering with a netting material; spraying with asphaltic or organic tackifier; or tacking with cellulose fiber mulch at a rate of 750 pounds per acre.
- On small sites where straw has been distributed by hand, it can be anchored by hand punching it in the soil every 1-2 feet with a dull, round-nosed shovel. A sharp shovel will merely cut the straw and not anchor it. A mulch anchoring tool is a tractor-drawn implement designed to punch and anchor mulch into the top 2-8 inches of soil. This practice affords maximum erosion control but is limited to flatter slopes where equipment can operate safely. A set of disk harrows can be used for this purpose if the disks are straightened (not angled) so they cut the straw into the soil. Tracking is the process of cutting straw into the soil using a bulldozer or other equipment that runs on cleated tracks. Tracking is used primarily on slopes 3:1 or flatter where this type of equipment can safely operate. This is an effective way to crimp straw on fill slopes. Tracking equipment must operate up and down the slope so the cleat tracks are perpendicular to flow.

Design (cont'd)

- Netting material made of biodegradable paper, plastic or cotton netting can be used to cover straw mulch. Netting should be specific judiciously since birds, snakes and other wildlife can get trapped in the nettings.
- Polymer tackifiers are generally applied at rates of 40-60 pounds per acre, however manufacturer's recommendations vary. Organic tackifiers are generally applied at rates of 80-120 pounds per acre, however manufacturer's recommendations vary. Applications of liquid mulch binders should be heavier at edges, in valleys, and at crests of banks and other areas where the mulch could be moved by wind or water. All other areas must have a uniform application of the tackifier.

Anchoring

- Crimping, tracking, disking, or punching into soil
  - Small areas - Hand punch mulch 2-3 inches into the loose soil.
  - Larger areas – Use mulching tool on tractor to punch and anchor mulch 2-8 inches into the soil.
  - Tracking – Cut straw into soil by using a bulldozer with cleated tracks, placed such that the cleat marks are perpendicular to the runoff.
  - Typically used on slopes 3:1 or flatter for safe operation of equipment.

- Covering with netting or mat
  - Nettings or biodegradable paper, plastic or cotton netting can be used to cover straw mulch. The safety of animals (small birds, snakes and other wildlife) should be considered when selecting materials for this measure.

- Spraying tackifiers (Polymer or Organic)
  - Polymer tackifiers are typically applied at a rate of 40-60 lbs/acre, or per manufacturer's recommendations.
  - Organic tackifiers are typically applied at a rate of 80-120 lbs/acre, or per manufacturer's recommendations.
- Cellulose fiber mulch
  - Can be tacked at a rate of 750 lbs/acre

Shredded Vegetation

"Green" mulch is produced by recycling of vegetation trimmings such as grass, shrubs, and trees. Methods of application are generally by hand, although, pneumatic methods are currently being developed. It can be used as a temporary ground cover with or without seeding. The green mulch in place with a tacking agent on steep slopes and in areas where overland sheet flow is anticipated. The quality of green mulch may vary, and there is a strong potential establishing unwanted weeds and plants.

Design (cont'd)

Wood and Bark Chips

Wood and bark chips are suitable for landscaped areas that will not be closely mowed. Wood and bark chips may require nitrogen treatment to prevent nutrient deficiency. Bark chips do not require additional nitrogen fertilizer.

If there is a wood source near the project site, wood and bark chips can be very inexpensive. Caution must be used on steep slopes, since both wood and bark chips tend to wash down slopes exceeding 6 percent. Wood and bark chips are also used around trees and shrubs, or in ornamental or landscape gardens. Typical rates for placing wood and bark chip mulch are 5-8 tons per acre, at a depth of 2-3 inches.

If decomposition, soil building and revegetation are desired, increase the application rate of nitrogen fertilizer by 20 pounds of nitrogen per acre, to compensate for the temporary diversion (loss) of available nitrogen to the soil microbes.

Hydraulic Mulch

Hydraulic mulch can be made from virgin wood fibers or from recycled waste paper sources (newsprint, magazine). There are also mulches available which are a combination. In general, virgin wood fibers contain a longer fiber length than recycled paper mulch.

Hydraulic mulch is mixed in a hydraulic application machine (such as a hydroseeder or a mulch blower) and then applied as liquid slurry. The hydroseeder slurry contains recommends rates of seed and fertilizer for the site, usually specified with a tacking agent. Slurry must be constantly agitated to keep the proper application rate and achieve uniform effective coverage.

Apply at rate of 1.5 to 2 tons per acre – mixed with seed and fertilizer at recommended rates – to achieve uniform, effective coverage.

Paper mulch used to track and bind straw mulch can be specified at a lower rate (i.e. 750 pounds per acre.)

- Wood, paper or combination fiber mulches are typically applied with a hydraulic applicator (hydroseeder) at a minimum rate of 1.5 tons per acre. A typical construction specification and application for this type of mulch is as follows:Moisture content (total weight basis) not to exceed 12 percent +/- 3 percent.
- Organic matter content (oven dry weight basis) is 98 percent minimum.
- Inorganic matter (ash) content (oven dried basis) 2 percent maximum.
- pH at 3 percent consistency in water should be greater than 4.9
- Fiber must be dyed to aid in visual metering during application. The dye must be biodegradable and must not inhibit plant growth.
- Water holding capacity (oven dried basis) minimum 1.0 gallons per pound fiber.
- The mulch must be mixed with seed and fertilizer as specified and applied at rate recommended by the manufacturer to achieve uniform, effective coverage and provide adequate distribution of seed.

Rock

Rock is recommended for long slopes of 2H:1V or flatter that will not support thickly seeded grass. Install non-woven geotextile on graded slope, place rock of mixed sizes on geotextile, starting at bottom and working uphill. Generally rock is not suitable for residential or other areas where aesthetics are a design considerations

Table EPP-10-01 Recommended Rates for Mulching Materials

Mulch Product	Application Rate	Benefits	Limitations
Straw or Hay	1 ½ - 2 ½ tons per acre	Readily available and inexpensive; very effective in controlling erosion; can be applied on large sites via blower	Can carry unwanted seeds; might need trackifier or anchoring, especially on steep slopes
Wood Chips, Bark, Sawdust	5 - 8 tons per acre	Very low cost in some locations; chips effective on slopes up to 35%	High nitrogen demand when decompos away or blow away during rain storms.
Rock	200 – 500 tons or more per acre	Could be inexpensive and readily available in some localities; might be suitable for smaller sites.	Inhibits plant growth; adds no nutrients to the soil; can be costly to apply on slopes and large sites; adds "hardened" look to slopes
Hydraulic mulches and soil binders	1 ½ - 2 tons per acre	Easily and rapidly applied with sprayer equipment; can include seed, fertilizer, flexible/fiberous mulches, and soil binders.	Could be too expensive for small or very remote sites; must dry for at least 24 hours before rainfall.

Maintenance

- Must be inspected weekly and after rain for damage or deterioration.
- Inspect after episodes of high winds and significant rainstorms.
- Maintain an unbroken, temporary mulched ground cover throughout the period of construction that the soils are not being reworked. Inspect before expected rainstorms and repair any damaged ground cover and re-mulch exposed areas of bare soil.

Inspection

- ☐ All disturbed areas are properly covered per plans and specifications.
- ☐ Straw mulch has been properly crimped.
- ☐ Mulch has been replaced following intense wet weather events or episodes of high winds.

Erosion Prevention Practices	EPP-11 Channel Lining

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Description

The security measures ensured by a protective blanket or soil stabilization mat to help prevent and reduce erosion on preceding shaped and seeded swales, channels and slopes while assisting in the establishment of temporary or permanent vegetation on steep slopes, channels, or stream banks. The implementation of this BMP will create a significant reduction in sediment.

Application

- Preventing erosion of the soil surface.
- Promoting seed germination.
- Protecting young vegetation
- Preventing wind dispersal of seed or mulch
- Allowing for easy installation of seed and/or mulch.
- An erosion control blanket (ECB) or a turf reinforcement mat (TRM) should be used in all drainage channels with slopes of 2 percent or more.

Design

Selection of an appropriate mat or blanket depends on the nature of the project. Manufacturers should be consulted in selecting the product for the intended purpose.

<u>Temporary Erosion Control Blankets</u>

Temporary erosion control blankets include the following options:

- plastic netting intertwined with a natural organic or manmade mulch
- jute mesh

- Typically used to stabilize concentrated flow areas where velocities meet or exceed 5 ft/sec and slopes 2.5:1 or steeper.
- Deteriorate in a short period of time
- Provide protection of the seed and soil from raindrop impact and subsequent soil displacement.

Design (cont'd)

- Accelerates germination of grasses and legumes more completely
- Thermal consistency and moisture retention for seed.

Permanent Erosion Control Matting

Consist of permanent, non-degradable, three-dimensional plastic structures that are filled with soil prior to planting.

- Typically used to stabilize concentrated flow areas where velocities are between 5 and 10 ft/sec.
- Linings should be designed and selected by a professional experienced in the use of these materials
- Provides the same benefits as erosion control blankets.
- Protects channels from erosion within high capacity storm water conveyance channels.
- Filters fine sediment during lower flow stormwater events.

Site Preparation

- Grade and shape area of installation
- Remove all rocks, roots, clods, vegetative, or other obstructions so that the installed blankets or mats will have direct contact with the soil.
- Prepare seedbed by loosening 2-3 inches of topsoil above final grade
- Incorporate amendments, such as lime and fertilizer, into soil according to soil test and the seeding plan.

Seeding

- Seed the area before installing the blanket for erosion control and revegetation (Seeding after mat installation is sometimes specified for turf reinforcement application – check the manufacturer's instructions). When seeding before blanket installation, reseed all check slots and other areas distributed during installation.
- Where soil filling is specified for certain TRMs, seed the matting and the entire disturbed area after installation and before filling the mat with soil. Follow the manufacturer's instructions to ensure proper installation.

Anchoring

- Wire staples should be a minimum of 11 gauge.
- Metal stake pins should be 3/16 inch diameter steel with a 1.5 inch steel washer at the head of the pin.
- Wire staples and metal stakes should be driven flush to the soil surface.
- All anchors should be 6-8 inches long and have sufficient ground penetration to resist pullout. Longer anchors might be required for loose soils.
- Use biodegradable composite or wooden stakes where dislodged metal staples might cause extreme hazards, such as near airport runways or areas where future mowing might cause risk.

Installation

Dig initial check slot trench 12 inches deep and 6 inches wide across the channel (i.e. perpendicular to the flow direction) at the lower end of the project area. Seed area first, if specified for the type of TRM or ECB used.

Installation (cont'd)

- Excavate intermittent check slots, 6 inches deep and 6 inches wide across the channel at 25-30 foot intervals along the channel.
- Cut longitudinal channel anchor slots 4 inches deep and 4 inches wide along each side of the installation to bury edges of matting. These anchor slots will mark the upper elevation of the ECB or TRM along the channel side slopes, and should be above the 10 year, 24-hour peak flow line. Whenever possible extend the ECB or TRM 1 foot or more above the crest of channel side slopes.
- Beginning at the downstream end and in the center of the channel, place the initial end of the first roll in the anchor trench and secure with fastening devices at 1-foot intervals. Note: Matting will initially be upside down in anchor trench.
- In the same manner, position adjacent rolls in the anchor trench, overlapping the preceding roll a minimum of 6-8 inches.
- Secure these initial ends of mats with anchors at 1-foot intervals, backfill and compact soil.
- Unroll adjacent mats upstream in similar fashion, maintaining a 3-inch overlap.
- Fold and secure all rolls of matting snugly into all transverse check slots. Lay the mat in the bottom of the slot then fold back against itself. Anchor through both layers of mat at 1-foot intervals, then backfill and compact the soil. Continue rolling all mat widths upstream to the next check slot or terminal anchor trench.
- Alternate method for noncritical installations: place two rows of anchors on 6-inch centers at 25-30 feet intervals in lieu of excavated check slots. Shingle-lap the spliced ends by a minimum of 1 foot with the upstream mat on top (to prevent uplifting by water) or begin new rolls in a check slot. Anchor the overlapped area by placing two rows of anchors, 1 foot apart on 1-foot intervals.
- Place the edges of outside mats in previously excavated longitudinal slots, anchor them using the prescribed staple pattern, then backfill and compact the soil.
- Anchor, fill, and compact the upstream end of the mat in a 12-inch by 6-inch terminal trench.
- Secure the mat to the ground using U-shaped wire staples, geotextile pins, or wooden stakes. (Note: some TRMs require seeding after installation—check manufacturer's requirements).
- Spread and lightly rake one-half to three-quarter inch of fine topsoil into the mat apertures to completely fill the mat thickness. Use the backside of a rake or other flat implement. Spread topsoil using lightweight loader, backhoe, or other power equipment. Avoid making sharp turns with the equipment.
- Do not drive tracked or heavy equipment over the mat. Avoid any traffic over the matting if loose or wet soil conditions exist.
- Use shovels, rakes or brooms for fine grading and touch up. Smooth out soil filling, just exposing the top netting of matrix.

Design (cont'd)

Rock Lined Ditches and Channels

Rock lining may be necessary in the following conditions:

- There is not enough time to construct, seed, and establish a stabilized vegetated channel before the channel is expected to carry stormwater flows (i.e., construction during wet seasons).
- Design velocity exceeds 2 feet per second and conditions are not suitable for channel or ditch vegetation even if TRMs are used.
- Ditches or drainage channel slopes are greater than 2 percent and located in highly erodible soils that have a low-maximum permissible velocity that cannot be overcome with TRMs.
- Channel design velocity exceeds that allowable for a grass-lined channel with ECB or TRM liners.
- The channel will continue to down-cut without protection because it is adjusting to increased flow or a new base line (outlet elevation).

Table EPP 11-1. KYTC weight and size of riprap rock

Channel Lining Riprap Class	Corresponding Size
1A	Limestone with 100% passing a 5-inch sieve, and no more than 20% passing though square openings 1.5" by 1.5"
II	Limestone with 100% passing a 9-inch sieve, and no more than 20% passing though square openings 5" by 5"
III (Cyclopean Riprap)	> 80% by volume of individual stones ranging from ¼ to 1-½ cubic feet

The channel must be designed to carry the 10-year, 24-hour peak flow using the formula below:

Q = VA, where
Q = flow
V = velocity
A = flow area

The Manning equation below must be used to determine the velocity:

V = 1.486(R)2/3S1/2/n, where
V=velocity
R=flow area/wetted perimeter
S=slope in feet/foot
n = 0.0395 (D50)1/6

The maximum depth must be determined from the following equation:

Dmax = τ / (62.4*S), where
Dmax = maximum depth of flow
S = slope in feet/foot
τ = maximum tractive force of the liner in lbs/ft2

Design (cont'd)

The values for KYTC channel lining are shown below:

Table EPP11-2. Permissible Sheer Stress for Rock Linings

KYTC Channel Lining	D_{50}	Shear Lb/ft.^{2}	Manning's *n*
Class 1A	.2	1.0	0.0302
Class II	.5	2.5	0.352
Class III	1.0	5.0	0.0395

Side slopes must be 2:1 or flatter

Riprap thickness—T = 1.5 times the largest stone diameter or as shown on the plans; 6-inch thick minimum

Foundation—Use extra-strength, non-woven filter fabric or an aggregate filter layer, if required.

The outlet must be stable with a suitable outlet stabilization energy dissipator.

Construction Specifications

- Excavate the cross-section to the grades shown on plans. Overcut for thickness of rock and filter.
- Place non-woven filter fabric or gravel filter layer, and place the rock as soon as the foundation is prepared.
- Place rock so it forms a dense, uniform, well-graded mass with few voids. Hand placement might be necessary to obtain good size distribution.
- No overfall of channel construction should exist. Grass-lined channels with riprap bottoms must have a smooth contact between riprap and vegetation.
- Channel outlet must be stabilized with a suitable outlet stabilization energy dissipator.

Grass-Lined Ditches and Channels

The channel cross-section should be wide and shallow with relatively flat side slopes (e.g., 3H:1V) so surface water can enter over the vegetated banks without erosion. Riprap might be needed to protect the channel banks at intersections where flow velocities approach allowable limits and turbulence could occur.

Cross-section designs include:

V-shaped Channels

Generally these are used where the quantity of water is relatively small, such as roadside ditches. The V-shaped cross-section is desirable because of difficulty stabilizing the bottom, where velocities may be high. A sod or grass lining protected with ECBs or TRMs might suffice where velocities are low; use rock or riprap lining to protect against higher velocities.

Parabolic Grass Channels

Often these are used where larger flows are expected and sufficient space is available. The shape is pleasing and may best fit site conditions. Riprap should be used where higher velocities are expected and where some dissipation of energy (velocity) is desired. Combinations of grass with riprap centers or turf reinforcement mat centers are useful where there is a continuous low flow in the channel.

Design (cont'd)

Trapezoidal Grass Channels

These are used where runoff volumes are large and slope is low so that velocities are nonerosive to vegetated linings. Low flow channel can be lined with turf reinforcement mats, erosion control blankets, riprap, or pavement if desired.

- Grass-lined channels must not be subject to sedimentation from disturbed areas.
- An established grass-lined channel resembles natural drainage systems and is usually preferred if design velocities are below 5 feet per second.
- Channels with design velocities greater than 2 feet per second will require that turf reinforcement mats or erosion control blankets be installed at the time of seeding to provide stability until the vegetation is fully established. It might also be necessary to divert water from the channel until vegetation is established or to line the channel with sod.
- Whenever design velocities exceed 4 feet per second a permanent type of turf reinforcement mat will be necessary.
- Sediment traps might be needed at channel inlets to prevent entry of muddy runoff and channel sedimentation.

Capacity

The channel must be designed to carry the 10-year, 24-hour peak flow using the formula below:

Q = VA, where
Q = flow
V = velocity
A = flow area

The Manning equation below must be used to determine the velocity:

V = 1.486(R)2/3S1/2/n, where
V=velocity
R=flow area/wetted perimeter
S=slope in feet/foot
n= 0.045 for grass

The maximum depth must be determined from the following equation:

Dmax = τ / (62.4*S), where
Dmax = maximum depth of flow
S = slope in feet/foot
τ = maximum tractive force of the liner in lbs/ft2

Tables EPP11-3 through EPP

Maintenance

- Inspect erosion control matting before (if anticipated) and within 24 hours following rainfall events to check for movement of topsoil, mulch or erosion. Continue checking until vegetation is firmly established.
- Inspect blankets or mats at least every 14 days.
- Inspect channels weekly and after rainfall events greater than one-half inch.
- Repair or replace netting that has been washed out, broken, eroded, and/or needing surface repair, re-seeding, re-sodding, re-mulching or topsoil replacement.
- Check the channel for debris, scour, or erosion and immediately make repairs. It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes and make repairs immediately.
- Remove all significant sediment accumulations to maintain the designed carrying capacity.
- Keep the grass in a healthy, vigorous condition at all times, because it is the primary erosion protection for the channel.

Inspection

- ❑ Channel grades are adequately managing runoff velocity.
- ❑ Staples are appropriately spaced to avoid loss of seed, topsoil and mulch to stormwater runoff and winds.

Nets are adequately covered or anchored to prevent erosion, washout, and poor plant establishment.

The following tables should be used in designing stable channels based upon sheer stress.

Table EPP11-3. Typical Permissible Shear Stresses for Bare Soil and Stone Linings

Lining Category	Lining Type	Permissible Shear Stress **T**p, lb/ft2
Bare Soil Cohesive (PI=10)[1]	Clayey sands	0.037-0.095
	Inorganic silts	0.027-0.11
	Silty sands	0.024-0.072
Bare Soil Cohesive[1] (PI≥20)	Clayey sands	0.094
	Inorganic silts	0.083
	Silty sands	0.072
	Inorganic clays	0.14
Bare Soil Non-cohesive (PI<10)	Finer than coarse sand D_{75}<1.3 mm (0.05 in)	0.02
	Fine gravel D_{75}=7.5 mm (0.3 in)	0.12
	Gravel D_{75}=15 mm (0.6 in)	0.024
Gravel Mulch	Coarse gravel D_{50}=25 mm (1 in)	0.4
	Very coarse gravel D_{50}=50 mm (2 in)	0.8
Rock Riprap	D_{50}=0.15 m (0.5 ft)	2.4
	D_{50}=0.30 m (1.0 ft)	4.8

[1]Assuming a soil void ratio of 0.5

Table EPP11-4 Ultra Short Term Channel Liner Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress T_p
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	0.25 lbs/ft^2
1.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	0.5 lbs/ft^2
1.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5 lbs/ft^2
1.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	1.75 lbs/ft^2

Table EPP11-5 Short Term Channel Liner Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress T_p
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	0.25 lbs/ft^2

2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	0.5 lbs/ft^2 (2
2.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5 lbs/ft^2
2.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	1.75 lbs/ft^2

Table EPP11-6 Extended-Term Channel Liner Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress T_p
3.A	Mulch Control Nets	A slow degrading synthetic mesh or woven natural fiber netting.	0.25 lbs/ft^2
3.B	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	2.00 lbs/ft^2

Table EPP11-7 Long-Term Channel Liner Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress T_p
4	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	2.25 lbs/ft^2

Table EPP11-8 Permanent Turf Reinforcement Channel Lining Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress T_p
5.A	Turf Reinforcement Mat	Turf Reinforcement Mat (TRM) – A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.	6.0 lbs/ft^2 (288 Pa)
5.B	Turf Reinforcement Mat		8.0 lbs/ft^2 (384 Pa)
5.C	Turf Reinforcement Mat		10.0 lbs/ft^2 (480 Pa)

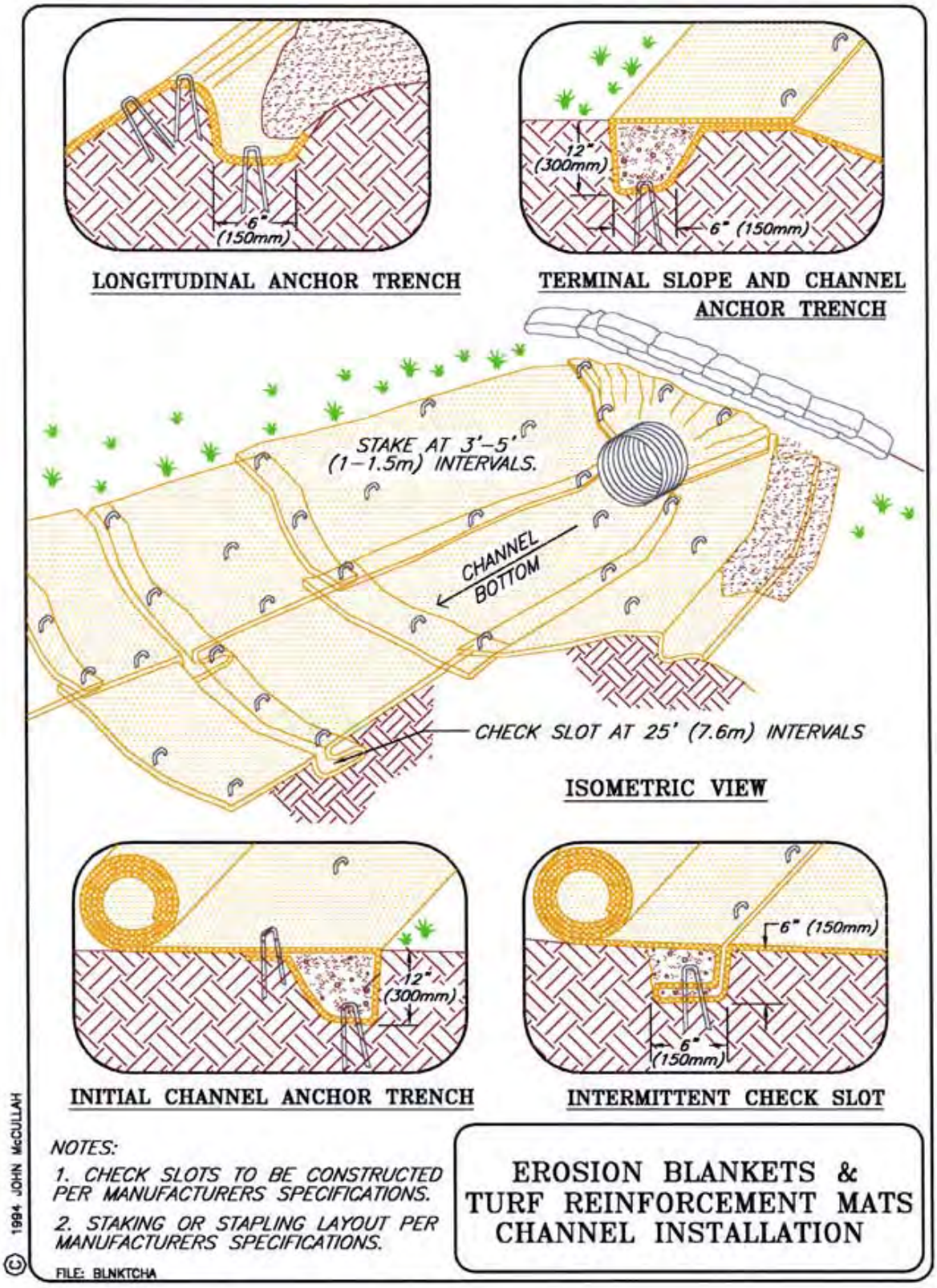

Figure EPP11-1 Blanket Installation Guidance
Kentucky Construction Site BMP Planning and Technical Specifications Manual

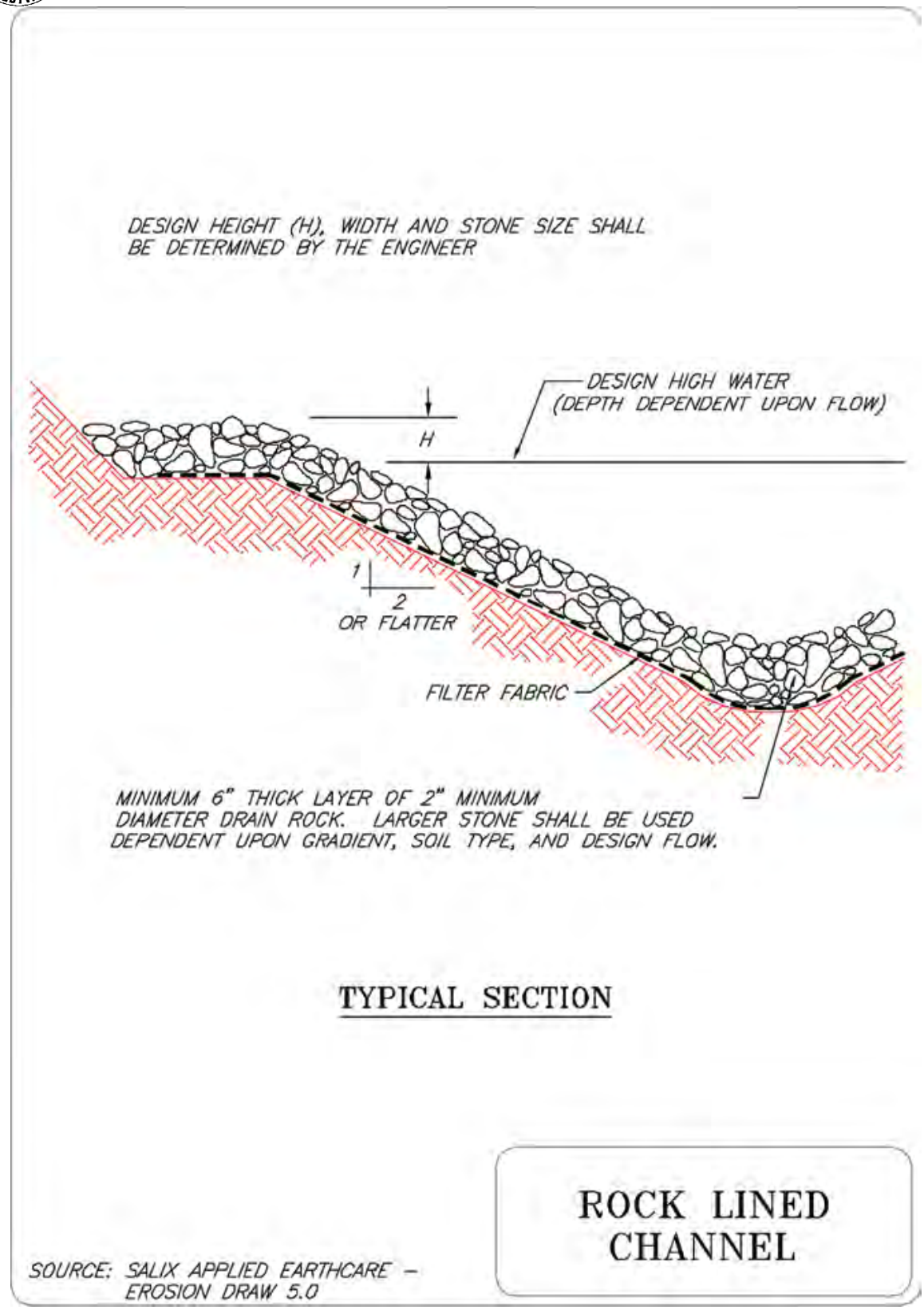

Figure EPP11-2. Rock Lined Channel Detail

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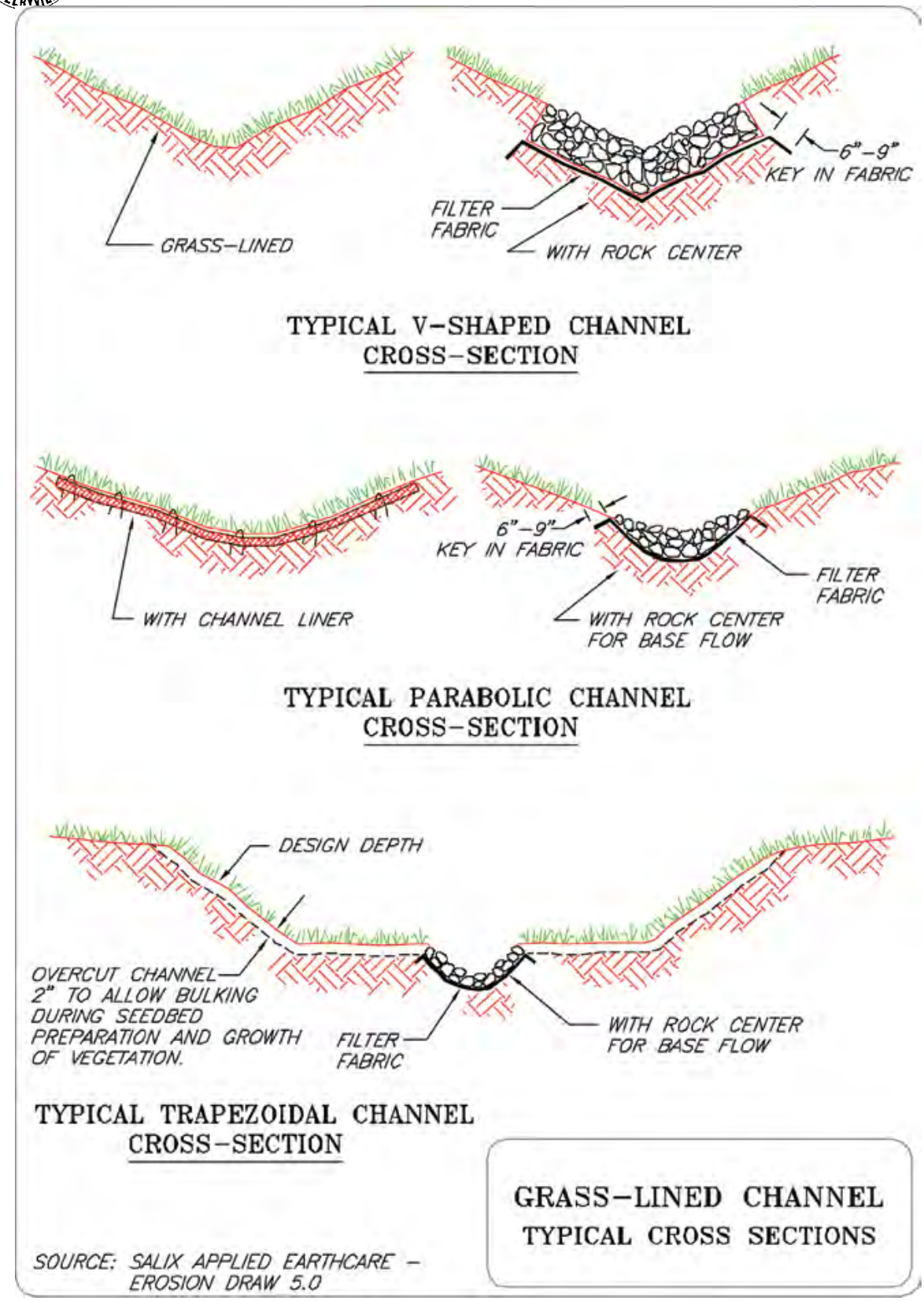

Figure EPP11-3. Typical Cross Sections for Grass Lined Channels

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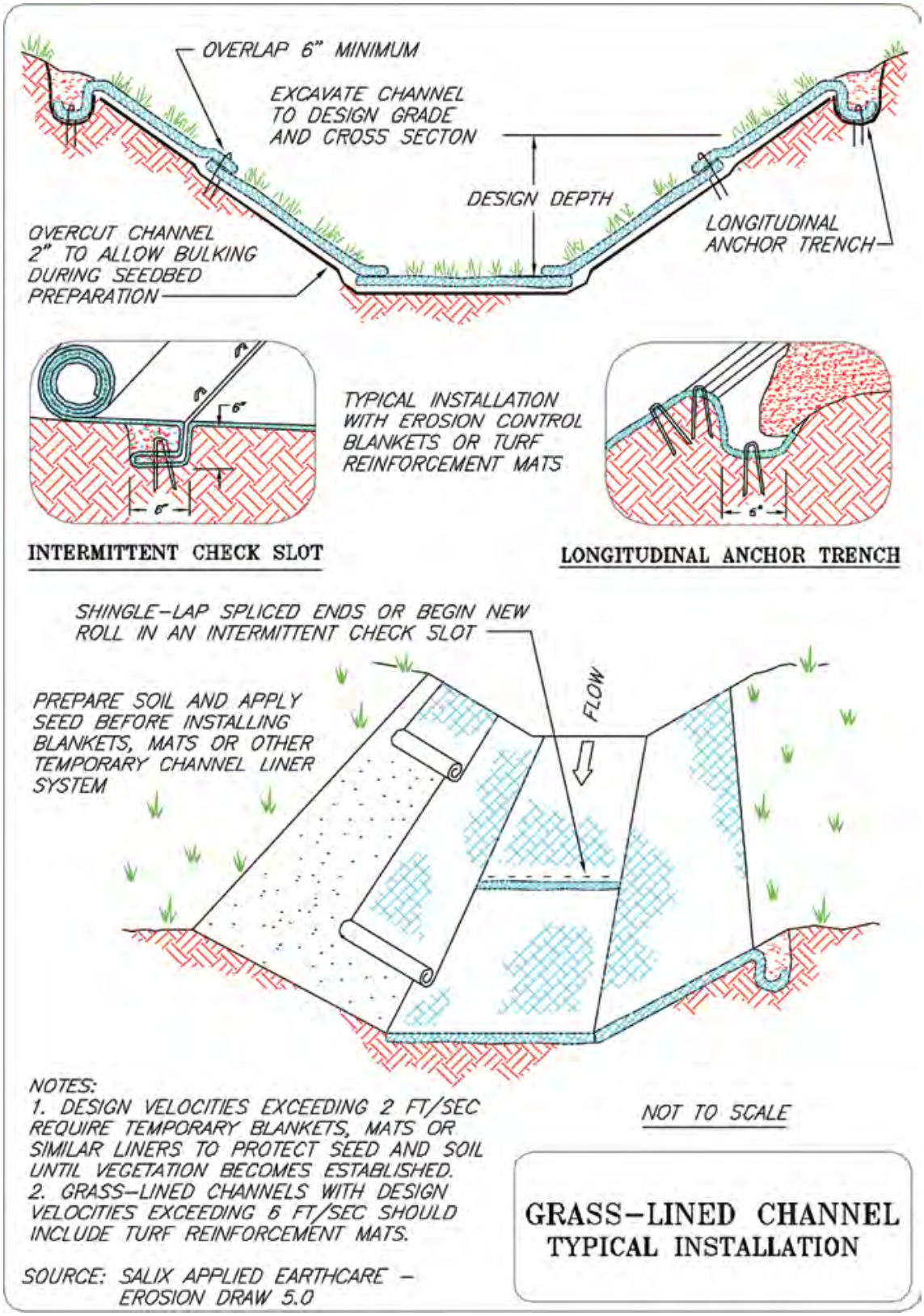

Figure EPP11-4. Erosion Control Blanket Channel Installation

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Erosion Prevention Practices	EPP-12 ECB on Slopes

Symbol

G

Description

Geotextiles are woven or non-woven fabrics, applied between surfaces or materials, to reduce flow velocities, release runoff as sheet flow, remove some sediment from runoff and are likely to create a significant reduction in sediment. Runoff and pollution caused by construction activities can be prevented or reduced with this BMP.

Application

- Construction sites desiring stability for disturbed soils.
- Sloppy area where anchoring must take place.
- Slopes steeper than 3:1 (H:V), longer than 50 feet and/or where erosion hazard is high.
- Slow growing vegetated areas.
- Critical slopes adjacent to sensitive areas (streams, wetlands, etc.).

Design

Geotextiles provide stabilization, filtration, and separation properties. This BMP may be used when there is a need for separation between two materials or mediums that are likely to otherwise interfere with one another.

- Separating subsoil from aggregate within a subsurface drain.
- Separating subsoil from aggregate placed at the soil surface.
- Stabilization of soil surface during temporary stream diversion.
- Prevent buildup of hydrostatic pressure behind gabions, decorative, or retaining walls.

This BMP does not require design or selection by a professional experienced in geotextile applications. However, if hydrostatic pressure becomes a concern for stability of a retaining wall, then a professional should be consulted.

Design (cont'd)

- Geotextiles should be selected based on the standard specifications detailed in AASHTO M288.

Site Preparation

- Grade and shape area of installation
- Remove all rocks, roots, clods, vegetative, or other obstructions so that the installed blankets or mats will have direct contact with the soil.
- Prepare seedbed by loosening 2-3 inches of topsoil above final grade
- Incorporate amendments, such as lime and fertilizer, into soil according to soil test and the seeding plan.

Seeding

- Seed the area before installing the blanket for erosion control and revegetation (Seeding after mat installation is sometimes specified for turf reinforcement application – check the manufacturer's instructions). When seeding before blanket installation, reseed all check slots and other areas distributed during installation.
- Where soil filling is specified for certain TRMs, seed the matting and the entire disturbed area after installation and before filling the mat with soil. Follow the manufacturer's instructions to ensure proper installation.

Anchoring

- Wire staples should be a minimum of 11 gauge.
- Metal stake pins should be 3/16 inch diameter steel with a 1.5 inch steel washer at the head of the pin.
- Wire staples and metal stakes should be driven flush to the soil surface.
- All anchors should be 6-8 inches long and have sufficient ground penetration to resist pullout. Longer anchors might be required for loose soils.
- Use biodegradable composite or wooden stakes where dislodged metal staples might cause extreme hazards, such as near airport runways or areas where future mowing might cause risk.

Installation

- Begin at the top of the slope and anchor the blanket in a 6 inch deep by 6 inch wide trench. Backfill trench and tamp earth firmly.
- Unroll blanket downslope in the direction of water flow.
- The edges of adjacent parallel rolls mush be overlapped at least 3 inches and be stapled through the overlapped area at least every 3 feet on slopes less than 4H:1V and every two feet on steeper slopes.
- When blankets must be spliced, place uphill blanket end over downhill blanket (shingle style) with 6-inch overlap. Staple through overlapped area, approximately 12 inches apart.
- Lay blankets and mats loosely and maintain direct contact with the soil – do not stretch. Ensure good, consistent, direct soil contact.

Installation (cont'd)

- ECB's and TRM's must be stapled sufficiently to anchor the blanket and maintain contact with the soil. Staples must be placed down the center and staggered with the staples placed along the edges. Steep slopes (1H:1V to 2H:1V) require at least two staples per square yard. Moderate slopes (2H:1V to 3H:1V) require 1-2 staples per square yard (1 staple every 3 feet on center). Flatter slopes require one staple per square yard.

Maintenance

- Inspection to occur periodically, if any portion of the material is damaged, immediate correction is required.
- Inspections may occur prior to any anticipated wet weather events.
- Inspection to occur after significant rain storms to check for erosion and undermining.
- Repairs to the slope and re-installation should occur as a result of wash-out or breakage.
- Perform maintenance as required by the manufacturer.

Inspection

- ❑ Site is adequately prepared (grading or shaping, rocks, vegetation and debris removal, etc.).
- ❑ Seeding meets geotextile requirements.
- ❑ Anchoring is established at an acceptable depth.
- ❑ Anchoring trenches are used at the top and bottom of slopes.
- ❑ Trenches start, join and terminate geotextiles placed in channels.
- ❑ Soil filling is even and flat.

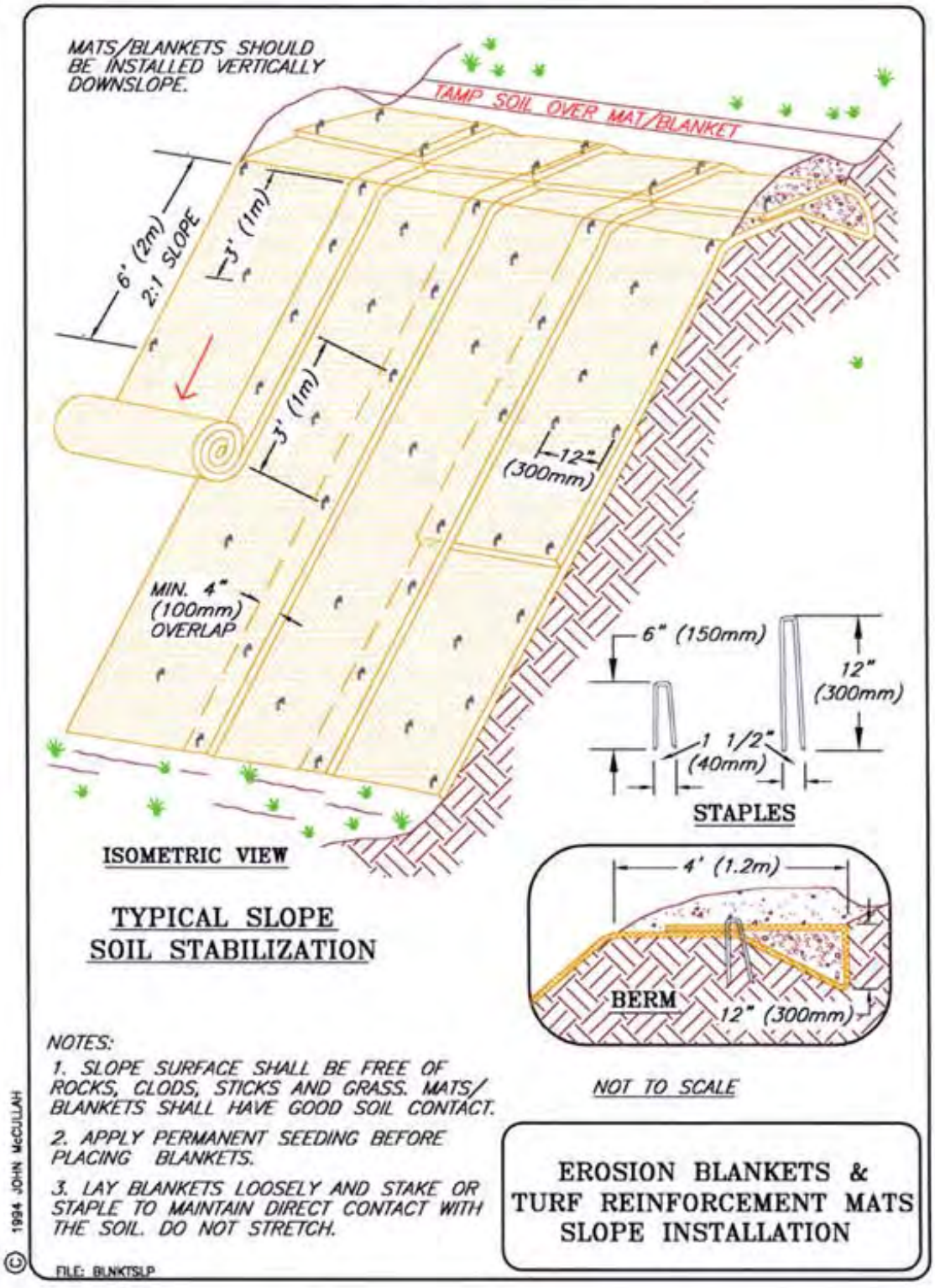

Figure EPP12-1 ECBs Installed on Slopes

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Erosion Prevention Practices	EPP-13 Terracing

Symbol

T

Description

This BMP is likely to reduce sediment by creating small areas to establish vegetation to reduce runoff velocity, increase infiltration and trap sediment. This reduces the amount of sediment leaving a site.

Application

- Cleared areas prior to temporary or permanent seeding and planting or erodible slopes steeper than 3:1 (H:V) and higher than 5 feet.
- Graded areas with smooth, hard surfaces.
- Areas where slopes need to be shortened. Adequate drainage and stabilized outlets must be a part of the design and should follow the guidelines of a licensed professional civil engineer based on site conditions.

Design

Slope roughening/terracing is performed in several ways:

- Stair-step grading
- EPP-08
- Rough grading
- No grading

On slope 3:1 (H:V) the following practices found in EPP-08 can be considered:

- Grooving
- Furrowing
- Tracking

Maintenance	➢ Periodically check the seeded or planted slopes for rills and washes, particularly after significant storm events greater than 0.5 in. (12 mm). Fill these areas slightly above the original grade, then re-seed and mulch as soon as possible. ➢ Inspect roughened slopes weekly and after rainfall for excessive erosion.
Inspection Checklist	❑ Furrows at least 6 in. deep. ❑ Furrows are spaced no more than 50 ft. apart. ❑ Horizontal distance is greater than vertical distance on stepped slopes. ❑ Stepped slopes or terraced slopes cut so that they drain in on themselves.

Erosion Prevention Practices	EPP-14 Check Dams

Symbol

CD

Description	Check dam are use to reduce the velocity of concentrated stormwater flows, small temporary constructions are built across swale or drainage ditch. Check dams reduce erosion and promotes sedimentation within the ditch line.
Application	➢ Check dams are <u>not</u> to be used in streams and rivers. However, should be used in swales or ditch lines. ➢ Check dams are a temporary or permanent means of protection against erosion during the establishment of vegetative lining. ➢ Installation of erosion-resistant lining is not practical to use for short length of service for temporary ditches or channels.
Design	The following design criteria should be used: ➢ Drainage Areas: Stone check dam (1 acre or less), Rock check dam (5 acres or less) Check dams must be limited to use in small, open ditches that drain 10 acres or less. Straw bales are not to be used as check dams because of high failure rates. ➢ Spacing: Two or more check dams should be used for areas greater than one acre. The maximum spacing should be determined by keeping the toe of the upstream dam equal to the spill-over elevation of the downstream dam (See Table SMP-01-01 or attached nomograph). ➢ Dimensions: All check dams should be 24" or less in height. The maximum height is 3 feet above the ground on which the rock is placed. The overflow point should be at least 6" lower than the outer edges. Front and back slopes shall be 2:1. The designer should take into consideration potential impacts due to impounded water (see Detail SMP-01). ➢ Key-in: Rock check dams should utilize a 6" key-in technique to aid in stabilization during peak flows.

Design (cont'd)

- Check dams for larger projects with greater slopes and wider drainage swales can be constructed of trees and brush cleared from the site, gabions, large rock, or other materials. Design and structural stability requirements for these applications, which can have significant benefits, are very site specific.
- Stone check dams must be constructed of KYTC Class 2 channel lining. Fiber bags filled with gravel are also acceptable. Bags should be of woven-type geotextile fabric because burlap or cloth bags deteriorate rapidly. The fiber bags must be filled with three-quarter inch drain rock or one-quarter inch pea gravel. Fill fiber bags just over halfway, so they can be packed tightly together without large gaps.
- Commercial products such as fiber rolls, sediment dikes, and sediment fencing can be used in seeded lined (or mulched) swales with bottoms not less than 4 feet wide and slopes not more than 3 percent, if appropriate. Follow the manufacturer's instructions for placement, staking, and maintenance. Applications in areas that exceed these parameters must be consistent with product design and performance information.
- Stone must be placed by hand or mechanically as necessary to achieve complete coverage of the ditch bottom and banks and to ensure that the center of the check dam is at least 6 inches lower than the outer edges.
- Gravel bag check dams must be placed in the ditch or channel by hand, with the tied ends of the bags pointing upstream and the center overflow area at least 6 inches lower than the outer edges.
- For all check dams, ensure that the higher elevation outer sidewalls tie into the upper portion of the ditch or channel bank to prevent bypasses.
- If stone check dams are used in grass-lined channels that will be mowed, take care to remove all stone from the channel when the dam is removed. This includes any stone that has washed downstream.

Design (cont'd)

Table EPP14-1. Check Dam Spacing

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

Table EPP14-2. Rock Sizing for Check Dams

Flow Velocity	Average Rock Diameter
6 ft. per second	5 inches
8 ft. per second	10 inches
10 ft. per second	14 inches
12 ft. per second	20 inches

Maintenance

- Sediment shall be removed before it reached one-half of the devices original height.
- Any lose or displaced stone should be repaired to the original specifications.
- Erosion caused by high flows around the edges of the dam must be corrected immediately, and the dam must be extended upward beyond the repaired area.

Inspection

- ❑ Stone meets specified sizes.
- ❑ Center of dam is lower than the edges.
- ❑ Check dam spans the entire width of the channel.
- ❑ Dimensions/elevations are as specified.
- ❑ Filter fabric on upstream face is keyed into the bed (if applicable).
- ❑ Check dams are to be removed when vegetation is stabilized, or up to 30 days after the permanent site stabilization is achieved.
- ❑ Inspect check dams for sediment accumulation weekly.
- ❑ Sediment is maintained less than one-half of the original height.
- ❑ Sites with rain accumulation of 0.5" should be checked within 24 hours.

Inspection (cont'd)

- ❑ In temporary ditches and swales, check dams must be removed and the ditch filled in when it is no longer needed.
- ❑ In permanent channels, check dams must be removed when a permanent lining can be installed.
- ❑ In the case of grass-lined ditches, check dams must be removed when the grass has matured sufficiently to protect the ditch or swale.
- ❑ The area beneath the check dams must be seeded and mulched or sodded (depending on velocity) immediately after check dams are removed.

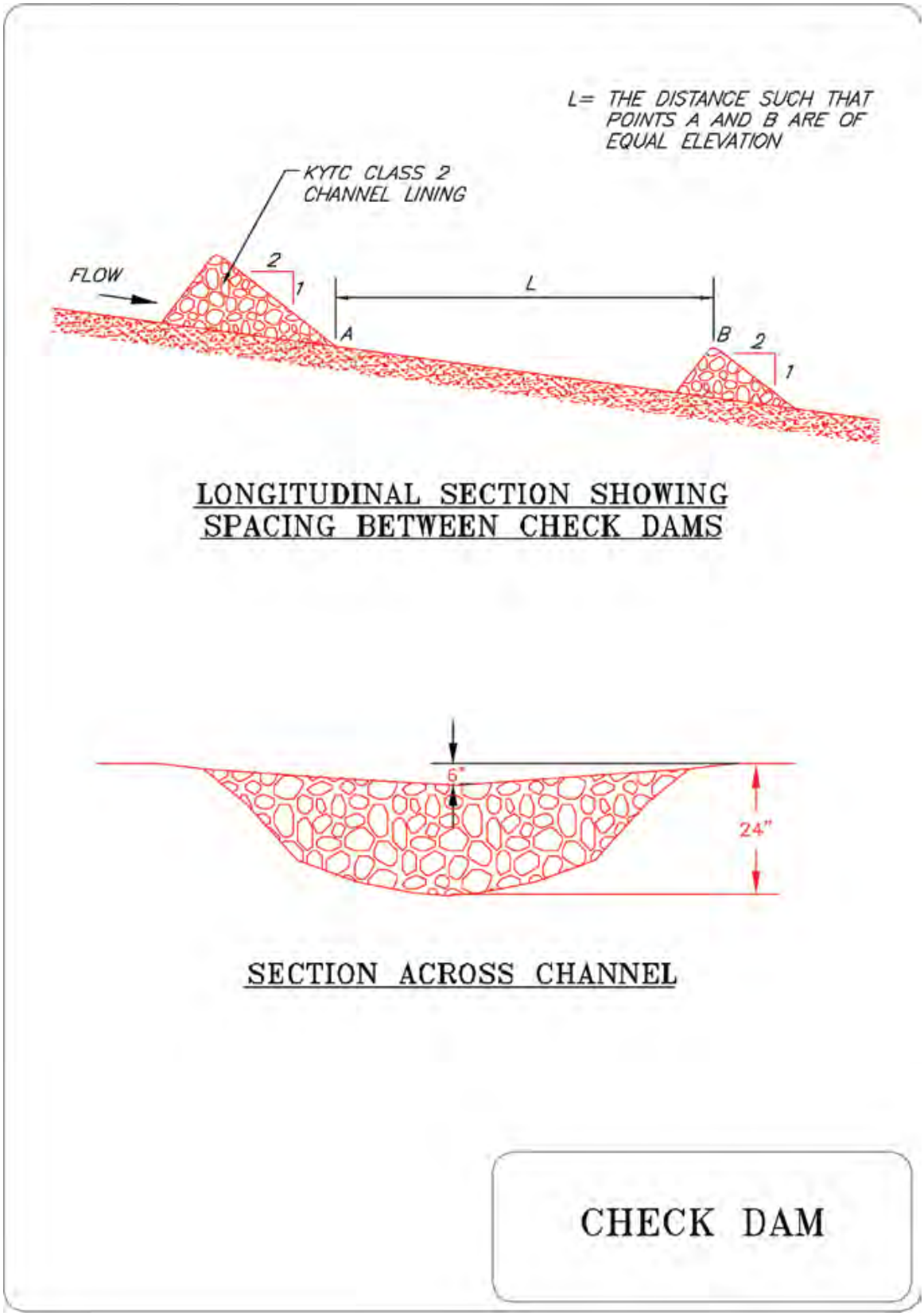

Figure EPP14-1 Check Dam Detail

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Erosion Prevention Practices	EPP-15 Bank Stabilization

Symbol

BS

Description

Bank stabilization is used to reduce erosion from stream banks by providing protective cover through the use of vegetation and other methods.

Application

- Bank stabilization practices are used for stream banks susceptible to erosion, locations with high flow rate that are subject to produce erosion, and/or actively eroding stream banks.
- Due to the nature of these practices additional permitting through the state of other agencies may be required.
- Bank stabilization practices should be designed by a Professional Engineer licensed in the Commonwealth of Kentucky.

Design

- Structural measures such as retaining walls, gabions, rip-rap or interlocking blocks.

Structural practices are used for projects in which a quick stabilization of stream banks is required. Generally speaking, these practices are more costly than bioengineer solutions. However, they usually require less maintenance than bioengineering measures.

- Bioengineering methods are commonly used for this purpose. These methods generally take longer to establish stabilization. However, they can be quite effective and economical to implement. As with any vegetative practice, careful selection of materials, installation, and maintenance is necessary to be effective.

Design (cont'd)

Several methods of Bioengineering solution are listed as follows:

Live Stake

Live stakes are the insertion of live, rootable vegetative cuttings into the ground. Live stakes are an appropriate technique for repair of small earth slumps that are frequently wet. Or they can be used to supplement other types of bank stabilization plantings. Live stakes can also be installed through existing riprap or other aggregate materials, allowing a stabilized riprap location to eventually have natural vegetation.

Live stakes can be specified for streambanks with slopes of 3H:1V or flatter. Steeper slopes will require grooving or benching and ECBs that can withstand expected shear stresses. The following table shows recorded shear stress withstood by live staking.

Table EPP15-1. Bank Materials and Shear Stress Limits (Live Stakes)

Bank Material	Shear (lb/ft^2)
Live stakes in riprap (immediately after construction)	2.04
Live stakes in riprap (after 3-4 seasons)	6.12
Coarse gravel and stone cover with live cuttings (immediately after construction)	1.02
Coarse gravel and stone cover with live cuttings (after 3-4 seasons)	5.1
Willow cuttings / willow stakes	2.1

Source: Salix Applied Earthcare – Erosion Draw 5.0

Live stakes are usually 0.5 to 1.5 inches in diameter and approximately 2 to 3 feet in length. Typical spacing is 2 to 3 feet apart. The basal end (or root) is cut to an angled point for easy insertion. The top should be cut square. Willow branches have historically been specified for use as live stakes and are well-suited to the purpose. Other types of tree branches may be selected, depending on soil type and available moisture conditions, such as ash, alder, elm or dogwood.

Gently tamp the live stake into the ground at right angles to the slope. Approximately 80 percent of the live stake length should be installed into the ground. Pack soil firmly around live stake after installation. Do not split the stakes during installation; stakes that split should be removed and replaced. An iron bar can be helpful in establishing a pilot hole for the live stake.

- Live stake harvest and installation should be performed during the dormant season, late fall to early spring.
- Use site reconnaissance to identify willow species, growth form, soil and site conditions on adjacent sites and compare their conditions to the construction site. Planting will be more successful as soil, site and species selected match stable, vegetated nearby sites.
- If native willows are not found in the vicinity, live staking might not be a good option.
- Choose plant material adapted to the site conditions and confirm the availability of plant material that will be used on site before construction begins.

Design (cont'd)

- Stakes must be harvested and planted when the willows (or other chosen species) are dormant. This period is generally from late fall to early spring or before the buds start to break.
- When harvesting cuttings, select healthy, live wood that is reasonably straight. Harvest live wood at least one-year-old or older. Avoid suckers of the current year's growth because they lack sufficient stored energy reserves to sprout consistently. The best wood is 2-5 years old with smooth bark that is not deeply furrowed.
- Stakes should be cut so that a terminal bud scar is within 1-4 inches of the top. At least two buds of bud scars must be above the ground after planting.
- Cuttings should generally be three-quarters of an inch in diameter or larger depending on the species, and 2 to 3 feet in length. Highest survival rates are obtained from using cuttings 2-3 inches in diameter. Larger diameter cuttings are needed for planting into rock riprap. Cuttings of small diameter stock (up to 1.5 inches) must be 18 inches long minimum. Thicker cuttings should be longer.
- Make clean cuts with unsplit ends. Trim branches from cutting as close as possible. The butt end (i.e. end closest to the ground) of the cutting must be pointed or angled and the top end (away from the soil) must be cut square, to aid in soil penetration, tamping, and knowing which end is up.
- The top, square cut can be painted and sealed by dipping the top 1-2 inches into a 50-50 mix of light colored latex paint and water. Sealing the top of the stake will reduce the possibility of desiccation and disease, assure the stakes are planted with the top up, and make the stakes more visible for subsequent planting evaluations.
- Install live stakes only on streambanks that have been graded and prepared for planting. ECB installation is strongly recommended for bank areas below the 2-year peak flow line; ECBs are recommended for upper portions of the bank. Stone toe protection is recommended for the toe of the slope at the waterline.
- Stakes must not be allowed to dry out. The cuttings should be installed the same day they are harvested. If this is not possible, they should be soaked in water for a minimum of 24 hours. Stakes can be stored outdoors for a few days in a cool place under damp straw. For longer storage, refrigerate (do not freeze), keep moist, and use as soon as possible.
- Use an iron stake, bar, or other suitable instrument to make a pilot hole in firm soil.
- Plant stakes 1-3 feet apart, closer on steeper slopes and on the outside of bends, farther apart on flatter slopes and the inside of bends.
- No less than one-half of total length must be in the ground. Set the stake as deep as possible in the soil, preferably with 80 percent of its length into the soil and in contact with midsummer water table.
- It is essential to have good contact between the stake and soil for roots to sprout. Tamp the soil around the cutting. Do not damage the buds, strip the bark, or split the stake during installation. Split or damaged stakes must be removed and replaced.
- Stakes must be planted with butt-ends into the ground. Leaf bud scars or emerging buds should always point up.
- Use TRMs for temporary protection until stakes are established and to protect any bare areas.

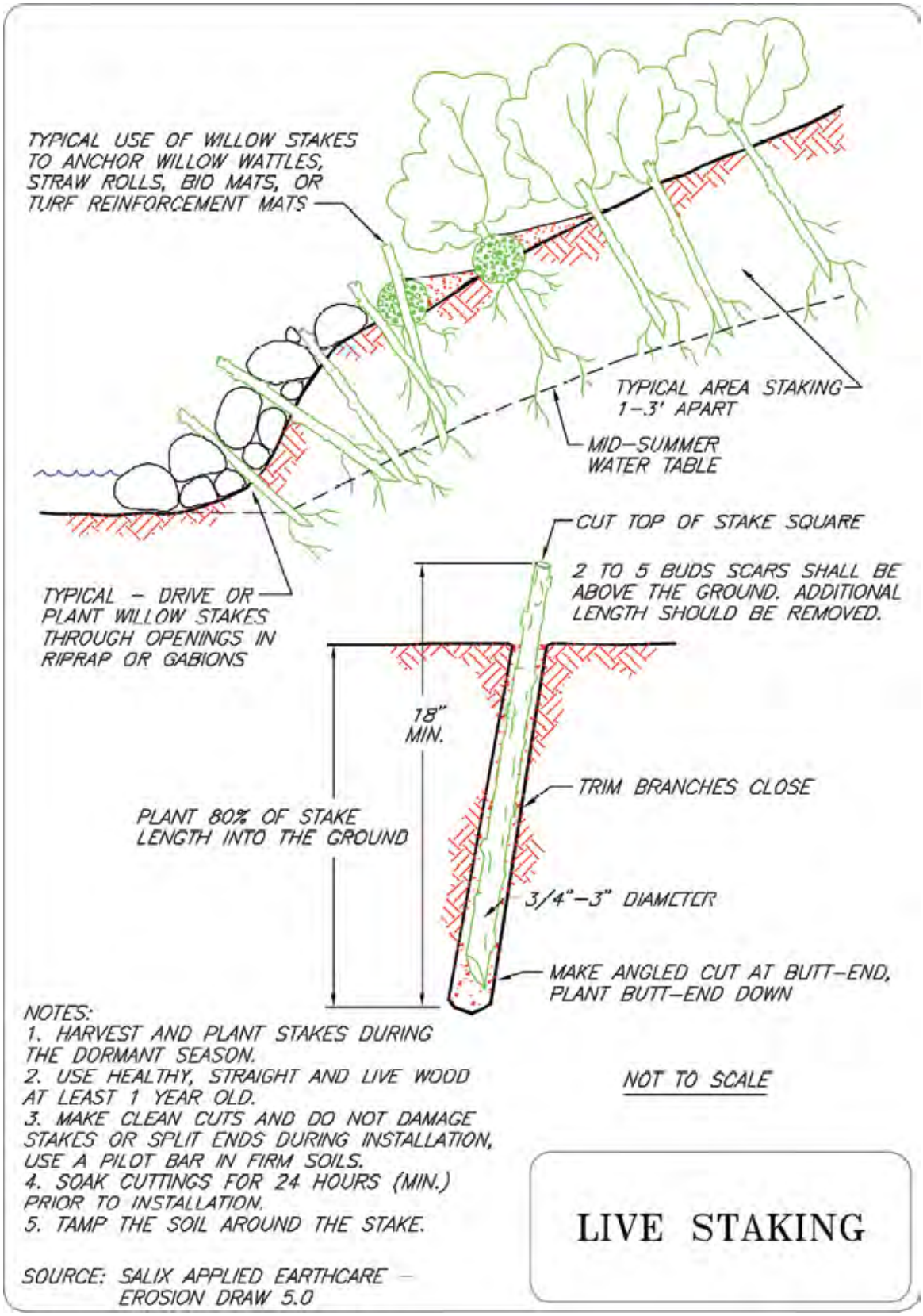

Figure EPP 15-1. Live Staking Installation Details

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Design (cont'd) Live Fascine

A fascine is defined as a bundle of sticks or branches, tied together and used for a definite purpose such as preparing a primitive house, fort, or other structure. A live fascine is defined as a bundle containing live branch cuttings bound together into sausage-like structures, and then placed to provide slope stability or prevent erosion. Cuttings must be harvested and planted when the willows, or other chosen species, are dormant. This period is generally from late fall to early spring.

Live branch cuttings should be from species that easily root and have long, straight branches with a minimum length of 3 feet and maximum diameter of 1.5 inches. A portion (up to 50 percent) of the bundle can be of material that does not root easily or dead material. Cuttings are tied together to form live fascine bundles that vary in length from 6 to 30 feet, depending on site conditions and limitations in handling. The completed bundles should be 6 to 12 inches in diameter, with the growing tips and butt ends oriented in alternating directions. Stagger the cuttings in the bundles so that tops are evenly distributed throughout the length of the uniformly sized live fascine.

- Wattle bundles must be compressed and tightly tied with rope or twine of sufficient strength and durability. Polypropylene tree rope approximately 3/16 inch in diameter provides the necessary strength and durability.
- Wattle bundles must be tied 12-15 inches apart.
- For optimum success, wattles should be pre-soaked for 24 hours or installed on the same day they are harvested and prepared. The wattles should be installed within 2 days after harvest unless pre-soaked. Wattles must be stored in the shade and under cover or under water. They are live material and should be treated as such.

Perform any slope repairs, such as gully repair, slope scaling, diversion dike, gabion, or toe wall construction, before installing the wattle. Both live stakes and dead stakes are used to install fascine bundles. Stakes should be at least 2.5 feet long on cut slopes and at least 3 feet long on fill slopes. Dead stakes can be constructed from untreated 2x4 lumber with a minimum length of 2.5 feet. A diagonal cut across the 2x4 lumber will assist in creating stakes quickly.

Prepare the live fascine bundles and live stakes immediately before installation.
Begin at the base of the slope and work upwards. Dig a trench along a level contour just deep enough to contain the live fascine bundle. Place the wattles immediately after trenching to reduce the desiccation of the soil. A typical trench size is 12 to 18 inches across and also 6 to 8 inches deep. Place the live fascine bundle into the trench.

Drive dead stakes directly through the bundle every 2 to 3 feet to securely fasten it. Overlap the tapered ends of adjacent wattles so the overall wattle thickness is uniform. Two stakes must be used at each bundle overlap such that a stake can be driven between the last two ties of each wattle. Leave the top of stakes flush with the installed bundle. Live stakes are generally installed on the downslope side of the bundle. Drive the live stakes below and against the bundle between the previously installed dead stout stakes. The live stakes should protrude 2 to 3 inches above the top of the live fascine and should be located no more than 3 feet apart. Place moist soil along the sides of the live fascine. The top of the fascine should be slightly visible when the installation is completed as shown in Figure EPP15-1.

Design (cont'd) Proper backfilling is essential to the successful rooting of wattles. Backfill wattles with soil from the slope or trench above. The backfill must be worked into the wattle interstices and compacted behind and below the bundle by walking on and working from its wattling terrace. Repeat the preceding steps for each row, up to the top of the slope. Plant the slope with other vegetation (e.g., live stakes, tree seedlings) as specified. Seen and mulch slope. Shallow slopes, generally 3:1 or flatter can be seeded and mulched by hand. Steeper slopes should have seed applied hydraulically, and the mulch must be anchored with tackifier or other approved methods if TRMs are not used.

Place straw or similar mulching material between rows. Slopes steeper than 3:1 may need erosion control matting or some type of mesh to prevent erosion. Recommended maximum slope lengths for live fascine bundles are:

Table EPP15-2. Recommended Max Slope Lengths for Fascine Bundles

Slope	Slope distance between wattles (feet)	Recommended maximum slope length (feet)
1:1 to 1.5:1	3-4	15
1.5:1 to 2:1	4-5	20
2:1 to 2.5:1	5-6	30
2.5:1 to 4:1	6-8	40
3.5:1 to 4:1	8-12	50
4.5:1 to 5:1	10-20	60

Source: Salix Applied Earthcare – Erosion Draw 5.0

A willow mattress (also called a brush mattress) is similar to a fascine roll. Willow branches and cuttings are formed into a layered arrangement approximately 4 to 6 inches thick and then tied with twine or string. Excavate an anchor trench along the bottom of the willow mattress to a depth of 3 inches, to prevent downhill sliding. Loosen the subgrade soil throughout the mattress installation location; add lime and slow-release fertilizer as needed. A willow mattress is anchored onto a slope by using dead stout stakes and twine. Place 4 to 6 inches of fertile soil upon the willow mattress and tamp firmly.

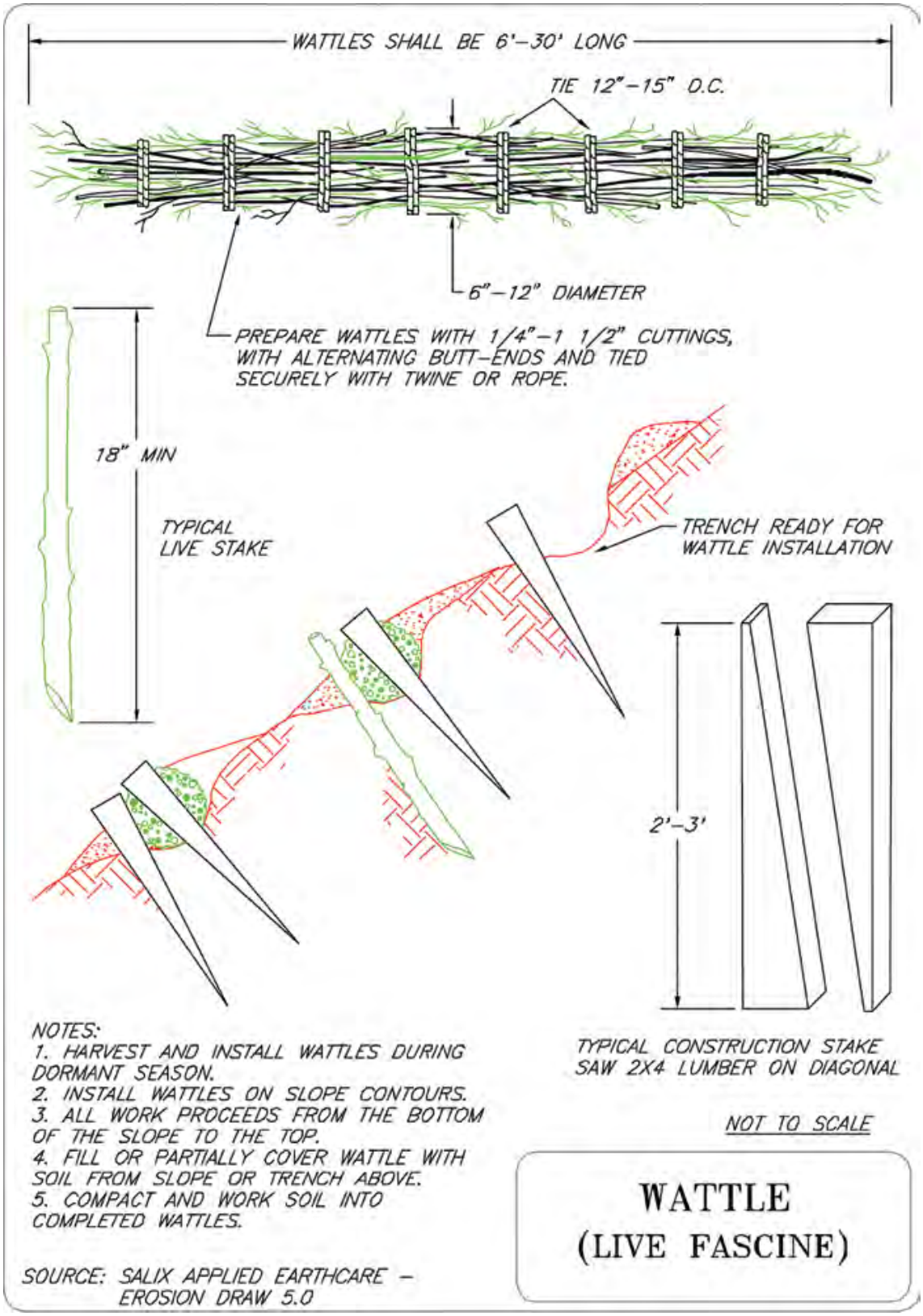

Figure EPP15-2. Wattle Installation Guidance

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Design (cont'd)

Branchpacking

Branchpacking consists of alternating layers of live branch cuttings and compacted backfill to create bank stabilization vegetation. It is often used to repair small localized slumps, gully washouts, or other small areas where the slope needs to be stabilized. Branchpacking can also be adapted as a method for planting an entire slope (see description below for brushlayering).

- Plant material harvest and installation should be performed during the dormant season, late fall to early spring.
- Use site reconnaissance to identify willow or other species, growth form, soil and site conditions on adjacent sites and compare their condition to the construction site. Planting will be more successful as the soil, site conditions and species selected match stable and vegetated nearby sites. Choose plant material adapted to the site conditions and confirm the availability of the plant material that will be used on site before construction begins.
- The ideal plant materials are those that (1) root easity; (2) are long, straight and flexible; and (3) are in plentiful supply near the job site. Will makes ideal material.
- When choosing live willow material for bioengineering applications, remember that young (less than one year old) wood or suckers will often sprout easier under optimum conditions but healthy, older wood (1 to 4 years) has greater vegetative (energy) reserves necessary to consistently sprout, and the older wood is much stronger. If possible, mix younger wood with older wood for the bioengineering application so that a majority of the material is 1-4 years old.
- Willows have several different growth forms – from shrubs to large trees. Small-to-medium sized shrub-type and rhizomatous or creeping-type willows are used for planning channel banks. Upland willow species are found in relatively dry areas and should be used on similar sites. Tree-type willows are selected for the upper bank and floodplain area.
- If branch cuttings are not pre-soaked for at least 24 hours, then they must be harvested no earlier than 48 hours before installation. Cuttings must be kept moist and cool at all times between cutting and installation. All cuttings need to be thoroughly wet and covered with moistened wrapping before being transported.

Live branch cuttings may range from 1/2 inch to 2 inches in diameter. Cuttings should be long enough to touch the undisturbed soil at the back of the trench. Wooden stakes (typically made from 2x4 lumber, untreated) are 5 feet or longer, depending on the depth of the hole and field conditions. Starting at the lowest point, drive the wooden stakes vertically 3 to 4 feet into the ground, at a typical spacing of 1 to 2 feet apart.

Design (cont'd) Place a 6-inch layer of live branch cuttings in the bottom of the hole or trench, between the vertical stakes and perpendicular to the slope face (as shown in Figure EPP15-2). Cuttings should be placed in a crisscross configuration with the growing tips generally oriented toward the slope face. Most branch basal ends should touch the back of the hole or slope. Each layer of branches is followed by a layer of compacted soil, typically 6 to 8 inches thick, to ensure soil contact with the branch cuttings. Final grade should match the existing slope, and branches should protrude slightly from the filled face. The soil should be moist so that the live branch cuttings do not dry out.

Branchpacking may not be effective in slumped areas or gullies which are greater than 5 feet wide. Examine the slope closely to determine the cause of slumped areas and gullies. Wet soils, inadequate drainage, excessive stormwater runoff or other site conditions may require additional solutions.

- Make repairs when necessary.

Bushlayering

Brushlayering is a variation of branchpacking suitable for gentle slopes with only a moderate potential for erosion. The live branch cuttings are oriented perpendicular (up and down) to the slope level contours, installed in a trench or cut slope, and then covered with soil as before. The difference is that the soil for each downhill trench comes from the next excavated trench immediately uphill. The presence of branch cuttings in the soil will limit the amount of compaction that can be obtained on a slope, so that additional erosion control measures may be necessary. Straw mulch, temporary seeding, jute mesh and erosion control mats may be necessary, particularly for slopes steeper than 3:1 Slopes steeper than 4H:1V will require turf reinforcement mats below the 2-year peak flow line. Avoid slopes steeper than 2:1 and generally limit slope lengths to 20 feet or less. Reinforced earth design guidelines suggest that the slope height should not exceede three times the width of reinforced volume. Therefore, for brushlayering with 6-8 foot long cuttings, the slope height should not exceed 18-24 feet.

- Construction personnel must be made aware that brushlayering uses live plant material and must be treated as such.
- Spacing between the brush layers is determined by the erosion potential of the slope (i.e. soil type, rainfall, and length and steepness of the slope). Spacing can be from 3 to 8 feet. On long slopes, brushlayer spacing should be closer at the bottom and spacing can increase near the top of the slope.

Table EPP15-3. Brush Materials and Shear Stress Limits (Brush Layers)

Brush Matierial	Shear (lb/ft^2)
Willow brushlayer (immediately after construction)	.41
Willow brushlayer (after 3-4 seasons)	2.86
Willow cuttings / willow stakes	2.1

Source: Salix Applied Earthcare – Erosion 5.0

Design (cont'd)

- Branch cuttings must be 4-8 feet long, ¾-2 inches diameter. Presoak cuttings for a minimum of 24 hours before installing.
- Complete grading and other work on streambank slopes. Install rock or other toe protection if specified in construction plans. Prepare first (lowest elevation) bench, removing soil or using it to backfill toe protection zone. The surface of the bench must be sloped so the outside (near stream) edge is higher than the inside (bank) edge, so that the butt ends of the cuttings angle down slightly into the slope.
- Place branch cuttings, 3-8 inches thick, in a crisscross or over lapping configuration. The growing tips must protrude 6-12 inches from the slope face with the butt end dipping into the slope.
- Immediately cover brushlayer with 6 inches of fill soil and compact according to construction specifications. For ease of installation, use soil excavated from the bench immediately upslope to cover cuttings placed in the lower bench excavations. Water the soil cover immediately to wet the cuttings and achieve adequate compaction.
- Earth moving equipment must not travel directly over the cuttings. Six inches of soil must be maintained between the brushlayer and equipment at all times.
- Fill and compact the soil placed above the brushlayer in successive lifts, maximum 6-8 inches deep. Install the next brushlayer 3-8 feet above the previous row.
- Seed and mulch the slope, or install erosion control blanket or turn reinforcement mat as needed. Shallow slopes, generally 3:1 or flatter might be seeded and mulched by hand. Steeper slopes should have seed applied hydraulically, and the mulch must be anchored with tackifier or other approved methods if TRMs are not used.

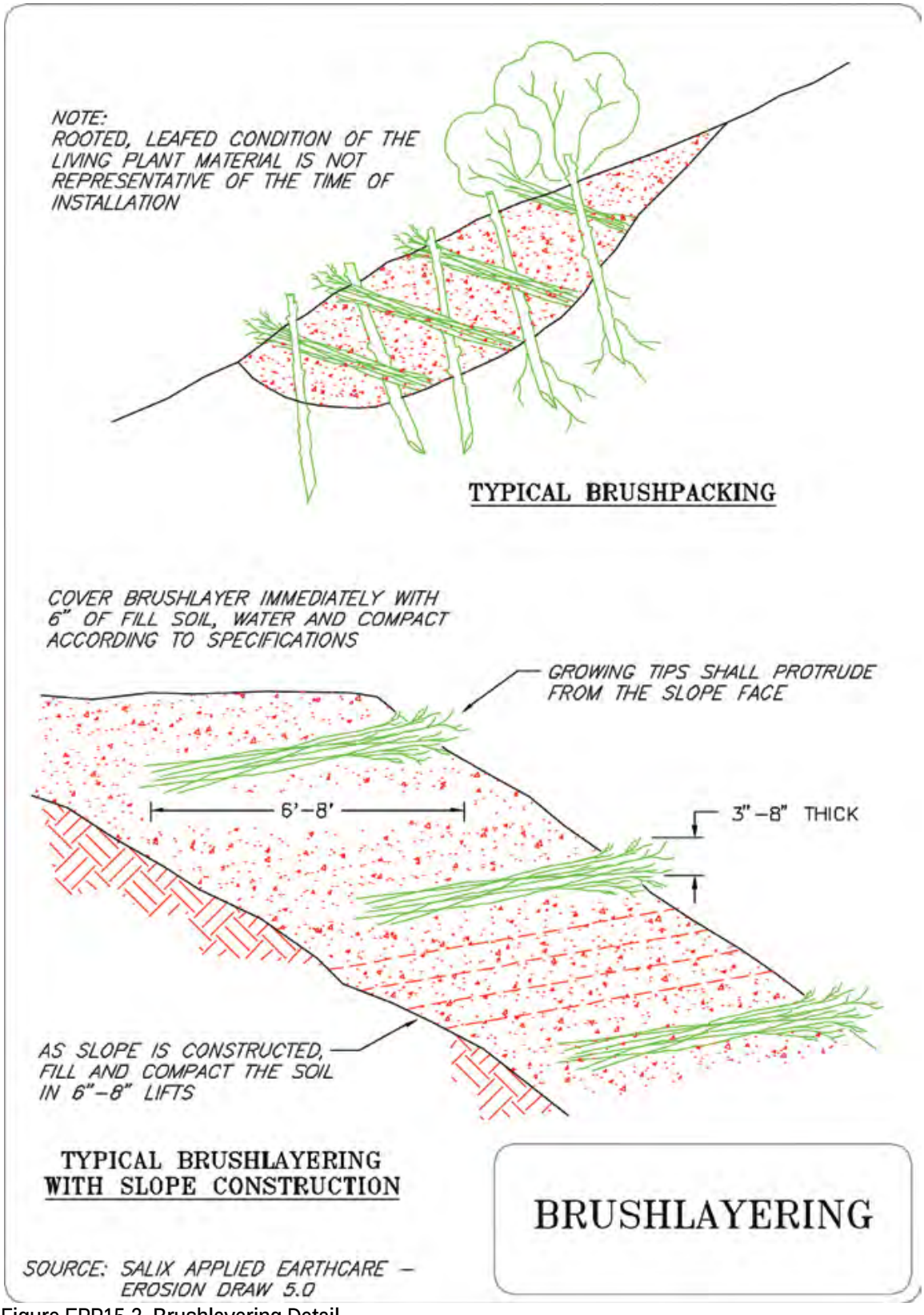

Figure EPP15-3. Brushlayering Detail

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Design (cont'd) Vegetative Crib Walls

A crib wall is a hollow, box-like, interlocking arrangement of structural members to create a retaining wall. A retaining wall is an engineered structure, with calculated loads and stresses used for the material selection and design. Crib walls made from prefabricated metal or reinforced concrete beams can be designed as very tall retaining walls that can handle large surcharge loads and traffic impacts; these types of crib walls must be designed by a professional engineer. Crib walls are filled with compacted soil or gravel, with provisions for subsurface drainage.

Adding vegetation may or may not affect structural stability of a retaining wall in the future. It would certainly affect large structural crib walls, but should not impact small crib walls such as the type shown in Figure SMP-06-03 for a relatively short height using untreated logs or timber. The structure is filled with suitable backfill material and layers of live branch cuttings which will root inside the crib structure and extend upward into the slope or outward into the wall face. This technique is appropriate at the base of a slope where a low wall may be required to stabilize the toe.

Live branch cuttings should be long enough to reach the back of the wooden crib structure. Logs or timbers are usually 6 inches in diameter or thickness. Large nails or rebar are required to secure the logs or timbers together. Place foundation of wall 2 to 3 feet below grade, as shown on Figure SMP-06-03.

Place the first course of logs or timbers at the front and back of the excavated foundation, approximately 4 to 5 feet apart. Place the second course of logs or timbers at right angles (perpendicular to the slope) on top of the previous course to overhang the front and back of the previous course by 3 to 6 inches. Repeat course in same manner and nail to the preceding course with nails or reinforcement bars. When the crib wall structure reaches the existing ground elevation, place live branch cuttings on the backfill perpendicular to the slope. Then cover the branch cuttings using fertile soil as backfill and compact firmly.

Maintenance

- Inspect structure before and after rainfalls.
- Make repairs when necessary.
- Replace live stakes that do not sprout after 45 days if possible, or wait until the following dormant season to harvest and replant.Periodic repair and maintenance will be required during the first 2 years or until the vegetation is established.

Inspection

- ❑ Licensed Professional Engineer's stamp is clearly placed on plans in order to construct the appropriate retention structure.
- ❑ Changes to site conditions have been transmitted for review by the Project Engineer.

Erosion Prevention Practices	EPP-16 Outlet Protection

Symbol

TOP

Description

This protection outlet is constructed of rock, grouted rip-rap or concrete rubble. This practice prevents scour of the soil due to high pipe flow velocities. The dissipation of flow energy to produce non-erosive velocities is also a function of this BMP.

Application

- Areas where culverts, conduits or channels are sufficient to erode the immediate downstream reach.
- Outlets of pipes, drains, culverts, conduits, channels, locations at the bottom of mild to steep slopes, outlets of which carry continuous flows of water, short intense flows of water, lined conveyances discharge to unlined conveyance
- A sediment trap is recommended if runoff is sediment laden
- Do not use grouted rip-rap during freezing, which will cause grout to break

Design

- Should be designed and sized by a licensed professional as a part of the culvert, conduit or channel design.
- Apply a rip-rap apron for temporary use during construction. Ensure that riprap consists of a well-graded mixture of stone. Larger stone should be predominant, with sufficient smaller sizes to fill the voids between the stones. The diameter of the largest stone size should be no greater than 1.5 times the d50 size.
- Apron should consist of a zero grade, alignment with receiving stream. Avoid damaging the underlain filter fabric. Keep apron straight throughout the length of the stream, curving in the upper section of the harpoon if curve is needed. Bank reinforcement should be downstream to account for the curved apron.
- Sizing for average rock diameter and apron dimensions are found in Table EPP16-1 and EPP16-2..

Design (cont'd)

- Capacity – Design dissipaters to handle the 10-year, 24-hour peak flow event
- Tailwater Depth – Determine the depth of the tail water immediately below the pipe outlet based on the design discharge plus other contributing flows. If the tailwater depth is less than half the diameter of the outlet pipe and the receiving stream is sufficiently wide to accept the divergence flow, it is classified as a minimum tailwater condition. If the tailwater depth is greater than half the pipe diameter, it is classified as a maximum tailwater condition. Pipes that outlet onto broad flat areas with no defined channel may be assumed to have a minimum tailwater condition unless site conditions indicate otherwise.
- Thickness - The minimum thickness of riprap must be 1.5 times the maximum stone diameter.
- Stone quality – Select stone for riprap from fieldstone or quarry stone. The stone should be hard, angular, and highly weather-resistant. The specific gravity of the individual stones should be at least 2.5.
- Filter – Install a non-woven geotextile liner (filter) under the rock to prevent soil movement through the openings in the riprap. Geotextile underliners for rock outlet energy dissiptors are highly recommended to prevent erosion and undermining of the dissipator. Specify non-woven fabric tailored to the strength needed to support the rock load.
- Ensure that the subgrade for the underliner and riprap follows the required lines and grades shown in the plan. Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on the undisturbed soil can also be filled by increasing the riprap thickness.
- Filter (non-woven geotextile) cloth, when used, must meet design requirements and be properly protected from punching or tearing during installation. Repair any damaged fabric by removing the riprap and placing another piece of filter cloth over the damaged area. All connecting joints should overlap a minimum of 1 foot. If the damage is extensive, replace the entire filter cloth.
- Riprap can be placed by equipment, but take care to avoid damaging the filter.
- Immediately after construction, stabilize all disturbed areas with vegetation.

Maintenance

- Grouted or wire-tied rock rip-rap minimizes maintenance requirements.
- Inspect weekly and before and after rainfall events.
- Inspect apron for displacement and/or damage to the underlying fabric, scour beneath the rip-rap and around outlet.
- Remove devices as soon as work is completed to the construction site.
- Grouted rip-rap may break up in areas of freeze and thaw.
- Grouted rip-rap may break up from hydrostatic pressure without adequate drainage.

Inspection

- ❑ Stones that have been displaced by wet weather events have been re-set and/or replaced.
- ❑ Inspect riprap weekly and after every rainfall event greater than one-half inch to see if any erosion around or below the riprap has taken place or if stones have been dislodged. Immediately make all needed repairs to prevent further damage.
- ❑ Apron has been cleaned and properly maintained.

Table EPP16-1. Riprap Aprons for Low Tailwater (downstream depth < 0.5 x pipe diameter)															
Culvert Diameter	Lowest Value			Intermediate Values to Interpolate From									Highest Value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12”	4	7	6	6	10	6	9	13	6	12	16	7	14	17	8.5
15”	6.5	8	6	1	12	6	15	16	7	20	18	10	25	20	12
18”	10	9	6	15	14	6	20	17	7	30	22	11	40	25	14
21”	15	11	6	25	18	7	35	22	10	45	26	13	60	29	18
24”	21	13	6	35	20	8.5	50	26	12	65	30	16	80	33	19
27”	27	14	6	50	24	9.5	70	29	14	90	34	18	110	37	22
30”	36	16	6	60	25	9.5	90	33	15.5	120	38	20	140	41	24
36”	56	20	7	100	32	13	140	40	18	180	45	23	220	50	28
42”	82	22	8.5	120	32	12	160	39	17	200	45	20	260	52	26
48”	120	26	10	170	37	14	220	46	19	270	54	23	320	64	37

Source: Knoxville Engineering Department
L_A = Apron Length
Apron Width = L_A + Culvert Length

Table EPP16-2. Riprap Aprons for High Tailwater (downstream depth > 0.5 x pipe diameter)															
Culvert Diameter	Lowest Value			Intermediate Values to Interpolate From									Highest Value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12”	4	8	6	6	18	6	9	28	6	12	36	7	14	40	8
15”	7	8	6	10	20	6	15	34	6	20	42	7.5	25	50	10
18”	10	8	6	15	22	6	20	34	6	30	50	9	40	60	11
21”	15	8	6	25	32	6	35	48	7	45	58	11	60	72	14
24”	20	8	6	35	36	6	50	55	8.5	65	68	12	80	80	15
27”	27	10	6	50	41	6	70	58	10	90	70	14	110	82	17
30”	36	11	6	60	42	6	90	64	11	120	80	15	140	90	18
36”	56	13	6	100	60	7	140	85	13	180	104	18	220	120	23
42”	82	15	6	120	50	6	160	75	10	200	96	14	260	120	19
48”	120	20	6	170	58	7	220	85	12	270	105	16	320	120	20

Source: Knoxville Engineering Department
L_A = Apron Length
Apron Width = L_A + Culvert Length

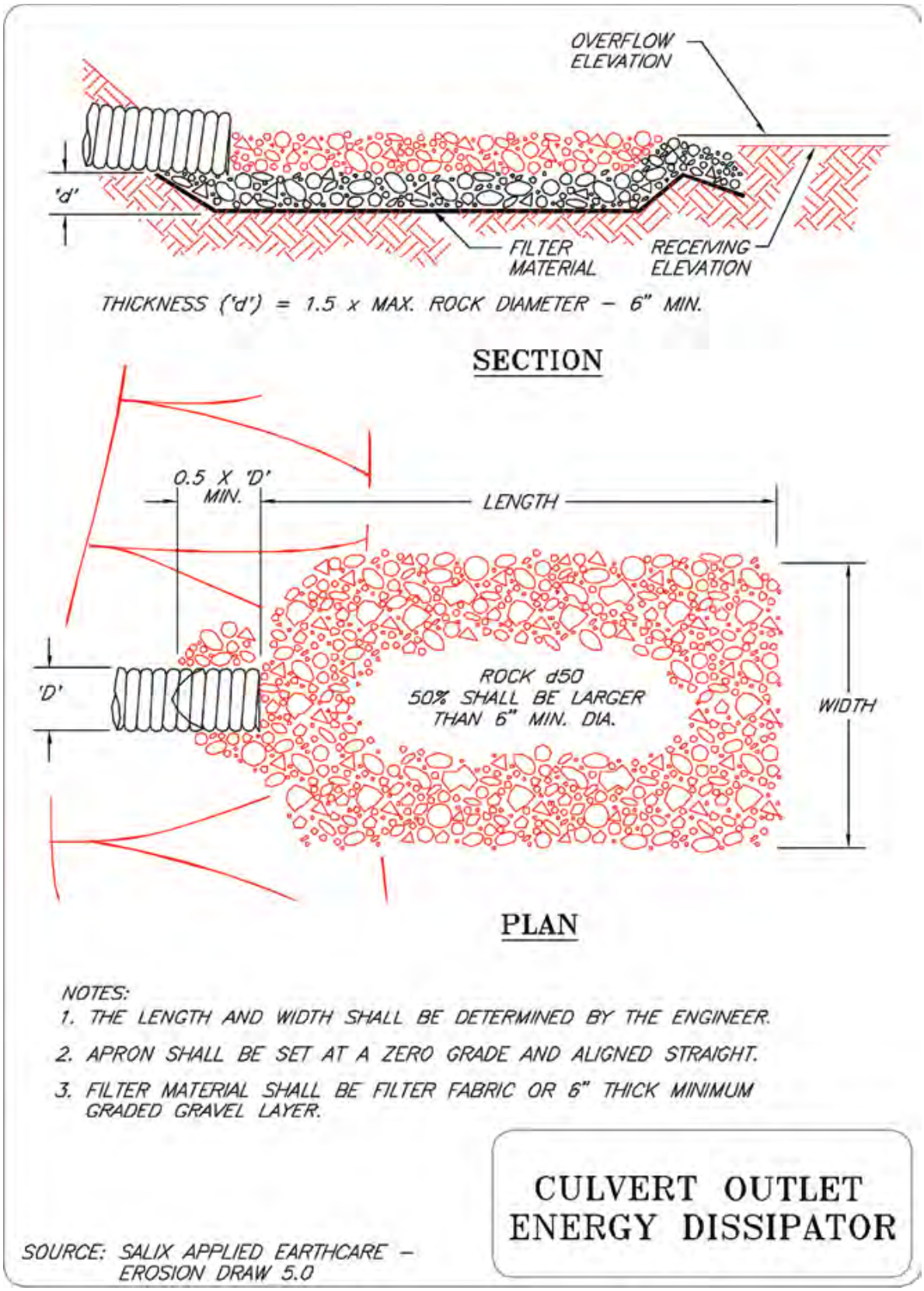

Figure EPP16-1. Outlet Protection Installation Details.

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