Mountain Driveway Best Management Practices Manual

Prepared for

The Colorado Nonpoint Source Council

Prepared by

Wright Water Engineers, Inc.
and
Denver Regional Council of Governments

September 1999

Mountain Driveway

Best Management Practices Manual

Prepared for

The Colorado Nonpoint Source Council

Prepared by

Wright Water Engineers, Inc.
2490 West 26th Avenue, Suite 100A
Denver, CO 80211
303-480-1700

and

Denver Regional Council of Governments
2480 West 26th Avenue, Suite 200B
Denver, CO 80211
303-480-6766

Document Prepared Under Clean Water Act Section 319 Nonpoint Source Grant Funding

(Contract #WQC9808703)

June 1999 (revised September 1999)

Table of Contents

Acknowledgments

Wright Water Engineers, Inc. and Denver Regional Council of Governments would like to thank the following individuals for their contributions to this manual through donation of their time and expertise:

William Agnew, ReVeg Environmental Consulting
Tim Allen, Clear Creek County
Eugene Backhaus, Resource Conservationist
Jane Clary, Wright Water Engineers, Inc.
Russell Clayshulte, Denver Regional Council of Governments
Scott Cornell, Larimer County
Chris Crowley, Wright Water Engineers, Inc.
John Doerfer, Urban Drainage and Flood Control District
Dave Farmer, Colorado State Forest Service
R.L. Jones, Upper Clear Creek Watershed Association
Steve Krawczyk, Jefferson County
Brian Lorch, Northwest Colorado Council of Governments
Wayne Lorenz, Wright Water Engineers, Inc.
Chris Ricciardiello, Boulder County
Glenn Segrue, Boulder County

Drawings included in this manual were reproduced from the following sources:

Erosion Draw 2.0 Software. Drawings © 1994 by John McCullah.

Urban Drainage and Flood Control District, Denver, CO. Urban Storm Drainage Criteria Manual, Volume 3 Best Management Practices. September 1992.

Wright Water Engineers, Inc.

Limitations on Use of this Manual

This manual provides general guidelines on application of BMPs to driveway construction in mountain areas. This document is not a design manual and should not be used as such. Hazards and site-specific conditions in mountain areas often warrant consultation with professional engineers and scientists prior to design and construction of driveways. The preparers and reviewers of this manual shall not be held liable for its misuse.

Background

The Colorado Nonpoint Source Council is a voluntary advisory group to the Water Quality Control Division of the Colorado Department of Public Health and Environment. In 1995, the Urban and Construction Subcommittee reviewed and updated the urban and construction portion of the Colorado Nonpoint Management Program. A recommended guidance report to replace the approved urban and construction management program was presented to the Council. As part of this review process, the subcommittee identified a general need by the user community for project- or type-specific Best Management Practices (BMPs). BMPs for driveways in mountainous areas were identified as one such need.

Driveways in mountainous areas can be sources of sediment, oil, grease, household chemicals, lawn amendments (nutrients), and de-icers (salts) that can run off into streams. While BMPs appropriate for secondary roads, highways, mining haul roads, and timber harvesting trails exist, BMPs appropriate for driveways are not specifically defined. Generally, highway BMP strategies are out of scale relative to the area needed for implementation, cost, and rapid construction schedule that leaves the ground exposed for a shorter time. Driveways are often built to less stringent standards for slope, materials, and geotechnical standards, which introduces potential sources of nonpoint pollution that may not be as significant in strictly regulated highway construction projects. Construction of driveways in mountainous areas and implementation of BMPs to reduce pollutant transport to streams often requires special consideration and planning. BMPs commonly used in flatland areas may not be appropriate in the mountains for many reasons, some of which include short growing season, steep slopes, limited topsoil underlain by bedrock and sensitive streams (e.g., trout). These factors may pose special challenges when attempting to revegetate a site or install BMPs that require anchoring to the ground, such as silt fences and straw bales.

The purpose of this BMP manual is to identify and concisely compile a limited number of BMPs appropriate for driveways and provide associated design sketches. This manual can be used by county planning agencies as a reference during development plan review and as guidelines for landowners, developers, and consultants during the planning process. A brochure has been prepared in tandem with this manual to encourage public education that highlights measures that can be taken to minimize the impact of mountain driveways on receiving waters.

Introduction

This manual contains information on key BMPs appropriate for mountain driveways. The manual is organized into two sections: 1) planning considerations and 2) BMP information. Planning considerations include issues such as site constraints (e.g., slope stability, drainage, aspect and constructability), emergency access, construction timing, and local permitting requirements. BMP information follows for key BMPs identified by a voluntary committee of individuals with hands-on knowledge of BMP effectiveness in mountainous areas.

The following information is provided for each BMP:

1. Description and Purpose
2. Installation/Design Guidelines
3. Special Considerations in Mountainous Areas
4. Maintenance
5. Design Sketch.

A list of references is provided at the end of this manual for more detailed information since this manual is limited in scope. The individual constructing the driveway should always check with the local government for specific regulations regarding grading, emergency access requirements and required erosion and sediment control measures prior to beginning planning and construction.

Pre-Construction Planning

Pre-construction planning includes several steps: 1) identifying required permits, regulations and design requirements of local governmental agencies; 2) becoming familiar with and applying erosion and sediment control principles; 3) designing the driveway with performance and site constraints in mind; and 4) developing an erosion and sediment control strategy for both the construction process and maintenance after completion. Once these steps have been completed, then construction can begin. Each of these steps is described below.

Step 1. Identify Required Permits, Regulations and Design Requirements

Many counties and local governments in Colorado have requirements in place concerning driveway construction. Prior to construction, the local government should be contacted to determine any special requirements such as grading permits, driveway permits, setbacks from lot lines and streams, and emergency access requirements.

Table 1 provides a summary of some emergency access requirements in several mountain counties in Colorado.

Table 1

Selected Emergency Access Requirements

Requirement Type	Boulder County	Clear Creek County	Larimer County	National Fire Protection Act
Grade	Max 10% up to 15% for short stretches w/Colo. Eng. approval	Max 10%; do not exceed 150-ft long for 8-10%	Max 10%; do not exceed 12% for more than 200 ft	Max 10% unless mitigation provided
Width	12 ft, 10-ft mtn. w/ Colo. Eng. approval	12-ft minimum	12-ft minimum, 10-ft with County Engineering Approval	
Turn-arounds	Every 400 ft after 150 ft of drive	Required	At end of road or within 600 ft of end	Required if > 300 ft long
Switch Backs	30-ft radius	Min. 30-ft inside turn radius from centerline		
Curves	30-ft radius		Min 100-ft radius, 60-ft in steep terrain	
Drainage		Min. 15-in diameter culvert or sized for 25-yr flood	Culverts must carry 10-yr storm	
Slopes	Max. cut and fill 1.5:1; will soon be 2:1	Cut and fill slopes no greater than 1½:1	Slopes of cut & fill—2:1 or shallower	
Entry onto Main Roads	6% for first 20 ft	75-90° angle from county rd., 2% grade, 20-ft min. flare	Within 10° of perpendicular to adjoining road, if possible, for at least 50 feet	
Turn-outs/pullouts	Every 400 ft		Every 600 ft	

Step 2. Become Familiar with Erosion and Sediment Control Principles

The objective of erosion control is to limit the amount and rate of erosion occurring on disturbed areas. The objective of sediment control is to capture the soil that has been eroded before it leaves the construction site. Despite the use of both erosion control and sediment control measures, it is recognized that some amount of sediment will leave the construction site in runoff. Figure 1 provides a summary "tool box" of BMPs that may be used to help control erosion and sedimentation, minimize sediment leaving the site, and protect water quality. In addition, 15 principles to follow when planning and designing driveways in mountainous areas are listed below.

1. Fit the road to the topography. Locate roads on natural benches and follow contours. Avoid long, steep grades and narrow canyons where practical. Avoid extensive cuts, fills and steep side slopes.

2. Review available information and consult with professionals as necessary to help identify erodible soils and unstable areas and to locate appropriate road surface materials.

3. Avoid slumps and slide-prone areas characterized by steep slopes, highly weathered bedrock, clay beds, concave slopes, hummocky topography and rock layers that dip parallel to the slope.

4. Avoid wet areas, including moisture-laden or unstable toe slopes, swamps, wet meadows, and natural drainage channels.

5. Minimize the number of stream crossings and choose stable stream crossing sites. Always cross a stream perpendicular to the flow.

6. Provide a buffer between roads and streams when roads are running parallel to stream channels. This protects the road from washouts and the stream riparian habitat from sedimentation.

7. Design adequate water control devices. Shed water away from the road system by grading the road with a crown (2% cross-slope), providing water bars (temporary or limited use roads), dips and culverts (permanent and high use roads), and/or wing ditches (all roads).

8. Plan water control devices with stable outlets. Empty water bars, dips, culverts and wing ditches gently onto nonerosive, stable, vegetated areas. Use riprap aprons on steep slopes.

9. Revegetate problem areas such as steep slopes, ditches and outlets repeatedly, if necessary, until they are over 70 percent covered.

10. Minimize surface disturbance by planning and completing one portion of the work at a time.

11. Provide an all-weather surface for the road appropriate to the amount of use.

12. Meet all emergency access requirements of local fire, ambulance, and police agencies.

13. Locate the driveway so that it receives southern exposure to help keep the road free of snow and ice in the winter and promote drying in the summer, whenever practical.

14. Minimize erosion by constructing the road during minimal runoff periods.

15. Implement sediment controls before land disturbance takes place.

Step 3. Design the Driveway

Once steps one and two have been completed, then driveway design can begin. Consult references listed at the end of the manual for more information on driveway design, and consult professionals when needed.

Step 4. Develop Erosion and Sediment Control Plan for Driveway Construction

Once driveway design is completed, an erosion and sediment control plan should be developed to be followed by the contractor or individual constructing the road.

The planning process can be divided into five separate steps:

1. Gather information on topography, soils, drainage, vegetation and other key site features.

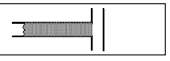
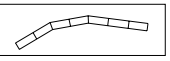
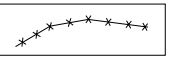
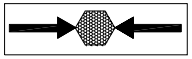
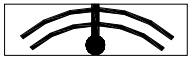
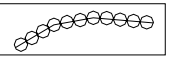
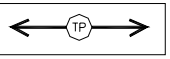
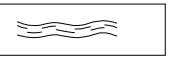
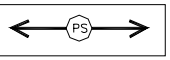
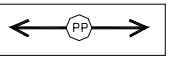
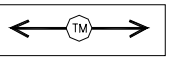
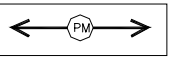
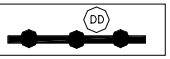
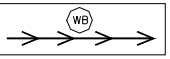
2. Analyze the information in order to anticipate erosion and sedimentation problems.

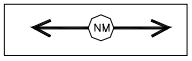
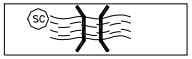
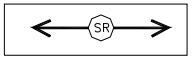
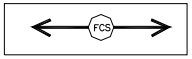
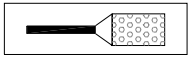
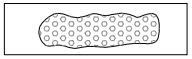
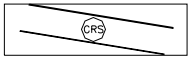
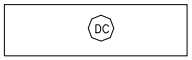
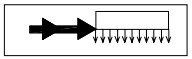
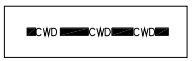
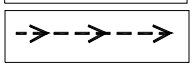
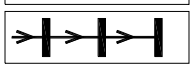
3. Devise a plan which schedules construction activities and minimizes the amount of erosion.

4. Develop an *Erosion and Sediment Control Plan* which specifies effective erosion and sediment control BMPs. Coordinate driveway BMPs with other on-site construction BMPs.

5. Follow the *Erosion and Sediment Control Plan* and revise it when necessary.

Erosion and sediment control measures include a variety of BMPs that must be adapted to specific site conditions. The remainder of this document contains descriptions of BMPs that have been found to be effective with regard to driveways in mountainous areas in accordance with the tool box shown in Figure 1.

VTC		VEHICLE TRACKING PAD — A gravel pad, located at the points of vehicular ingress and egress on a construction site, to reduce the mud transported onto roads and paved areas.
STB		STRAW BALE BARRIER — A temporary sediment barrier composed of anchored straw bales placed across or at the toe of a slope to intercept and detain sediment and decrease flow velocities from small drainage areas; applicable where sheet and rill erosion potential is low to moderate.
SBB		SANDBAG BARRIER — Temporary stabilization of ditches by placement of sandbags perpendicular to flow. Accompanied by a depression upstream for sediment retention. Good for use where soils are difficult to excavate, in areas of shallow bedrock, and in steep drainages.
SF		SILT FENCE — A temporary sediment barrier constructed of posts, filter fabric and, in some cases, a wire support fence, placed across or near the toe of a slope or in a minor drainageway to intercept and detain sediment and decrease flow velocities from drainage areas of limited size; applicable where sheet and rill or small concentrated flows may be a problem.
ST		SEDIMENT TRAP — A small ponding area, formed by constructing an earthern embankment with a gravel outlet across a drainage swale, to detain sediment-laden runoff from small disturbed areas for enough time to allow most of the sediment to settle out.
SB		SEDIMENT BASIN — A basin with a controlled stormwater release structure, formed by constructing an embankment of compacted soil across a drainageway, to detain sediment-laden runoff from disturbed areas greater than 5 acres for enough time to allow most of the sediment to settle out. Can be constructed only where there is sufficient space and appropriate topography. Temporary unless designed as a permanent pond.
BB		BRUSH BARRIER — A temporary sediment barrier composed of limbs, weeds, vines, root matter, soil, rock and other cleared materials pushed together to form a berm; located across or at the toe of a slope to intercept and detain sediment and decrease flow velocities during grading operations and removed at the time of final grading.
CD		CHECK DAM — Small, temporary berms constructed across drainageways to reduce the velocity of concentrated flows, reducing erosion of the swale or ditch. Limited to use in small open channels which drain small areas; should not be used in live streams.
TP		TREE PRESERVATION & PROTECTION — Protecting existing trees from mechanical and other injury during land disturbing and construction activity to insure the survival of trees where they are effective for erosion and sediment control and provide other environmental and aesthetic benefits.
GS		GRASS LINED SWALE — The establishment of appropriate vegetation in constructed channels to limit channel erosion and stabilize channel bottom.
PS		PERMANENT SEEDING — Establishment of perennial vegetative cover by planting seed on rough-graded areas that will not be brought to final grade for an extended time or where permanent, long-lived vegetative cover is needed on fine-graded areas. Used in conjunction with heavy mulching.
PP		PERMANENT PLANTING — Establishment of woody vegetation on rough-graded areas that have been permanent seeded or sodded where permanent, long-lived vegetative cover is desired on fine-graded areas. Used in conjunction with mulching.
TM		TEMPORARY MULCHING — Use of crimped straw, wood chips, sawdust, etc., to cover the denuded surface shortly after clearing and grubbing, grading, and construction activities. Mulching is the most effective and important erosion control practice to be used.
PM		PERMANENT MULCHING — Use of wood chips, stone, bark etc., to cover the finished graded surfaces after construction activities. Mulching within 3 days of operations to eliminate erosion and conserve moisture for plantings to enhance growth. Part of the final landscaping including drainageways, swales, etc. Used with permanent planting.
IP		INLET PROTECTION — The installation of various kinds of sediment trapping measures around inlets, culverts and structures prior to permanent stabilization of the disturbed area; limited to small drainage areas and not intended to control large, concentrated stormwater flows.
DD		DIVERSION DIKE — A ridge of compacted soil located at the top or base of a sloping disturbed area to divert off-site runoff away from unprotected slopes to a stabilized outlet, or to divert sediment-laden runoff to a sediment trapping structure.
WB		WATER BAR — Small berm and ditch combination approximately 18 inches in height and laid across a slope at 45° to 60° to reduce the velocity of concentrated flows, reducing erosion of a slope, swale or ditch. For use as a semi-permanent structure on trails, ski runs and seasonal access roads.
FB		FILTER BERM — A temporary berm or ridge constructed of loose gravel, stone, or crushed rock which slows and filters flow. May be used to direct runoff to a stable outlet, or filter stormwater in high traffic areas.

GM		GEOTEXTILE MATTING — Strong man-made mattings used to stabilize the flow on high velocity channels and swales and recently planted slopes. Also used as a reinforcement between courses on road work over soft areas. Recommended for use in retaining wall and fill slope construction as a tie-back into native materials.
NM		NATURAL MATTING — Biodegradeable materials, such as straw and excelsior bound in netting and impregnated with seed, are used on slopes where rill and sheet erosion may be a problem and where seed and mulch will not be effective. Can be utilized in temporary and permanent seeding solutions as necessary.
SC		TEMPORARY STREAM CROSSING — A temporary structural span across a stream to provide vehicular access to construction activity on either side of stream while keeping sediment out of the stream and preventing damage to the channel and banks. Used in conjunction with other measures to avoid sedimentation of the receiving water.
SR		SURFACE ROUGHENING — Grading practices such as stair-stepping, grooving slopes or leaving slopes in a roughened condition by not fine-grading them. Reduces runoff velocity, provides sediment trapping and increases infiltration; all of which facilitate establishment of vegetation on exposed slopes.
FCS		FLUSH CUT STUMPS — During timber removal operations trees are cut close to the ground to allow for crossing by vehicles and persons while leaving the root mass in place to retain the soil. Applicable on steep slopes and where fine grading and landscaping are not required. Used in conjunction with mulching, matting and seeding to further control erosive forces.
SL		SLOPE DRAIN — A flexible conduit, used before permanent drainage structures are installed; intended to convey concentrated runoff safely from the top to the bottom of a disturbed slope without causing erosion on or below the slope.
DV		PERMANENT DIVERSION — A permanent channel with a ridge on the lower side constructed across a slope to reduce slope length and intercept and divert stormwater runoff to a stabilized outlet to prevent erosion on the slope.
OP		OUTLET PROTECTION — The installation of paved or rip-rap channel sections and/or stilling basins below storm drain outlets to reduce erosion from scouring at outlets and to reduce flow velocities before stormwater enters recieving channels below these outlets.
RR		RIP-RAP PROTECTION — A permanent, erosion-resistant ground cover of large, loose, angular stone installed wherever soil conditions, water turbulance and velocity, expected vegetative cover, etc., are such that soil may erode under design flow conditions.
CRS		CONSTRUCTION ROAD STABILIZATION — Temporary stabilization with stone high traffic areas prone to erosion immediately after grading to reduce erosion potential damage caused by vehicles during wet weather and to prevent having to regrade permanent roadbeds between initial grading and final stabilization.
DC		DUST CONTROL — Reducing surface and air movement of dust during land disturbance, demolition or construction activities in areas subject to dust problems in order to prevent soil loss and reduce the presence of potentially harmful airborne substances. Includes the covering of soil stock piles and construction materials
TSP		TOPSOIL PROTECTION — Stripping, stockpiling and protecting topsoil for later use in permanent landscape activities. Stockpiles are covered with sheeting, mulch and/or seed and surrounded by a containment berm to protect them from erosive forces. Periodic "turning" of the piles is required to maintain endemic microbial soil organisms.
LS		LEVEL SPREADER — An outlet for dikes and diversions consisting of an excavated depression constructed at near zero grade across a slope to convert concentrated, sediment-free runoff to sheet flow and release it onto areas of undisturbed soil stabilized by existing vegetation.
CWD		CLEAR WATER DIVERSION — A temporary re-routing of a watercourse through a sluice or tube to reduce the amount of clean water collecting sediments from active construction operations.
INF		INFILTRATION TRENCH — A semi-permanent sub-surface drain that allows for storm water to be absorbed by the ground in a ponded area. Typically a rock and fabric lined trench on the down gradient side of a road fill or in an open area away from the roadway.
SD		SUB-SURFACE DRAINS — A perforated conduit installed beneath the ground to intercept and convey groundwater. Prevents sloping soils from becoming excessively wet and subject to sloughing.
WDS		WATERWAY DROP STRUCTURE — A permanent structure or series of structures designed to "step" water flow down a slope without causing channel erosion; applicable in natural or man-made channels with long, relatively steep reaches.

NOTE: ADDITIONAL PRACTICES NOT SHOWN HERE CAN BE IMPLEMENTED BASED ON FIELD OBSERVATIONS AND ADJUSTMENTS FOR WEATHER, SEASON AND UNFORESEEN SITE CONDITIONS. CONTACT YOUR LOCAL PLANNING OFFICE FOR SPECIFIC SITE RECOMMENDATIONS AND FURTHER ASSISTANCE.

USE THESE CONVENIENT SYMBOLS AND DESCRIPTIONS WHEN DEVISING AN EROSION CONTROL PLAN FOR THE INTENDED PROJECT. THE SYMBOLS ARE NATIONALLY ACCEPTED WHILE THE DESCRIPTIONS ARE TAILORED FOR MOUNTAIN DRIVEWAY CONSTRUCTION.

WRIGHT WATER ENGINEERS, INC.
2490 W. 26TH AVE. SUITE 100A
DENVER, CO 80211
(303)480-1700

DESIGN –
DRAWN CMC
CHECK JKC/KAL
DATE 4/99

MOUNTAIN DRIVEWAY EROSION and SEDIMENT CONTROL BEST MANAGEMENT PRACTICES
"EROSION CONTROL TOOLBOX"

FIGURE ONE

Mountain Driveway BMPs

Minimize Disturbance of Vegetation/Wetland

Type: Permanent

Description

Sensitive areas, particularly riparian areas along streams, wetlands and steep slopes, should be protected during construction.

Installation/Design Guidelines

1. Clearly mark areas to be protected during construction at heights visible to equipment operators.
2. Many local governments require some minimum "buffer" along streams be protected. Typically, this buffer is a minimum of 25 feet on each side of the stream, except where crossings occur, but may be larger depending on local regulations.
3. Equipment operators should not clean equipment by slamming it against trees to be protected.
4. Roots, trunks and tops of trees can be protected by fencing. Install protection fences at the drip line (the extent of the tree crown projected onto the ground) of trees and shrubs to protect root systems.
5. Excavation should be performed as far away from tree trunks as possible to protect the tree roots.
6. Excess grading should be minimized.

Special Considerations in Mountainous Areas

1. Because of the short growing seasons in the mountains, it is typically more difficult and more costly to replace vegetation than to protect it.
2. Request an on-site visit by a wetland scientist and/or US Army Corps of Engineers representative concerning wetland protection, permits and plan review prior to start of work.
3. The United States Forest Service recommends a 50-foot buffer on the downhill side of roads plus four times the hillside percent slope in feet.
4. Request an on-site visit by a forester or arborist concerning protection of high value trees prior to start of work.

Maintenance

1. Ensure that vegetation to remain is protected by regular inspections.
2. Look for erosion or undercutting of vegetated areas and replace or repair as soon as possible.
3. Look for increased sediment build-up in low points in areas of special vegetation. Redirect stormwater or install a sediment trap if observed.

Stormwater Diversion During Construction

Type: Temporary

Description

A key premise to preventing water pollution during construction is to keep the water clean by minimizing contact with disturbed areas. For this reason, water should be diverted around the construction area to the extent practicable.

Installation/Design Guidelines

1. Several approaches for diverting water include:

   - Diversion Ditches. Simple diversion ditches can be created by entrenching a row of straw bales covered with plastic into the ground. Plastic sheeting or half culverts can also be used to prevent erosion within diversion ditches or across disturbed areas.

   - Culverts. Culverts may be temporarily placed on top of the ground to divert water through or around a project area.

   - Flexible Pipe. Flexible pipe is useful to transfer water down an embankment or fill slope. It usually needs a culvert inlet to intercept the water.

   - Diversion Dikes. Create temporary ridges of compacted soil at the top or base of a slope in disturbed areas. (See drawing for example.)

2. Keep ditch grades to less than two percent (¼ inch per foot or 1-ft rise per 50-ft run) unless protected with geotextiles or rock. Direct runoff to a stable outlet. The terminus of a diversion is an area likely to erode, requiring stabilization with geotextile or rock.

3. Do not direct discharge to a live stream or waterbody.

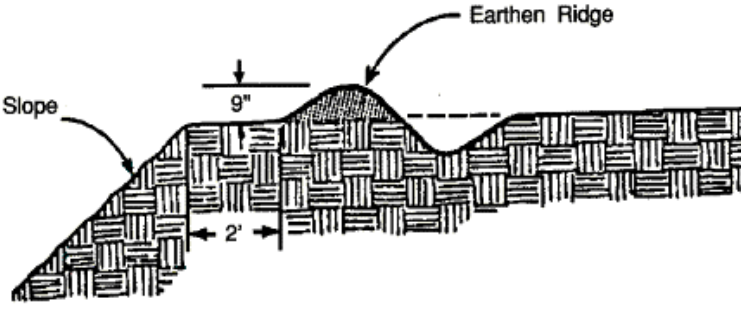
4. Vegetate ditches and berms as soon as practicable.

Special Considerations in Mountainous Areas

1. Try to infiltrate stormwater runoff by flattening a portion of the system in areas of high potential infiltration (e.g., cobble and sand).

Maintenance

1. Keep dikes free of debris and rocks over
2. Inspect before and after storms.
3. Repair structures as needed.



From: Virginia Soil and Water Conservation Commission, 1985

Type: Temporary

Vehicle Tracking Pad

Description

Vehicle tracking pads stabilize construction entrances. The controls typically consist of either a rock bed or depressed asphalt at least 50 feet long separating construction areas from public roads. The goal of this BMP is to prevent the transport of sediment by runoff and vehicles tracking it onto paved surfaces.

Installation/Design Guidelines

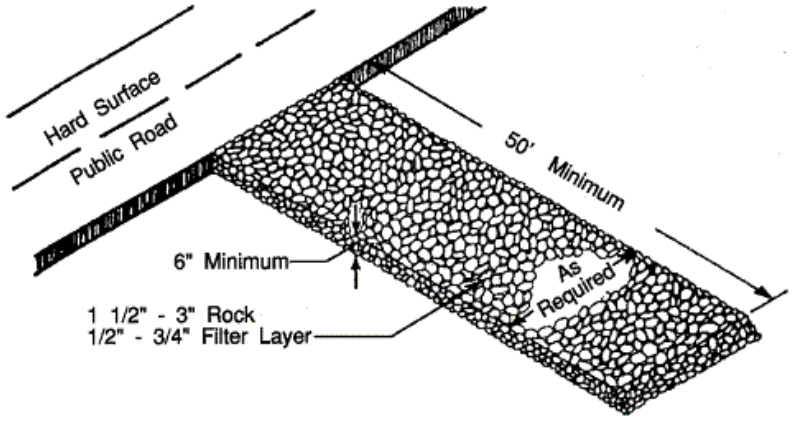
1. Vehicle tracking controls should be installed before grading begins.
2. Construct pads below finished grade so the pad materials can be left in place as a subgrade upon completion of the project.
3. Generally, size the pad to 1.5 times by 2.5 times the largest vehicle to be used on site (not less than 50 feet long).
4. Place a geotextile beneath gravel pads to avoid mixing with native soils.

Special Considerations in Mountainous Areas

1. Silty and clay soils in low-lying areas are more prone to removal from a site.
2. If a rock pad alone does not operate effectively, rinse tires and wheel wells prior to entering the roadway.

Maintenance

1. Clean paved surfaces by shoveling or sweeping at the end of each day.
2. Properly dispose of collected sediment.
3. Add rock to tracking pad as necessary.
4. Maintain pads on a weekly basis during construction.



From: Virginia Soil and Water Conservation Commission, 1985
As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Type: Temporary

Straw Bales

Description

Straw bales can serve as a temporary sediment barrier when anchored across or at the toe of a slope to intercept and detain sediment and decrease flow velocities from small drainage areas. Some local governments discourage use of straw bales because of common failures associated with their use and encourage use of silt fence instead.

Installation/Design Guidelines

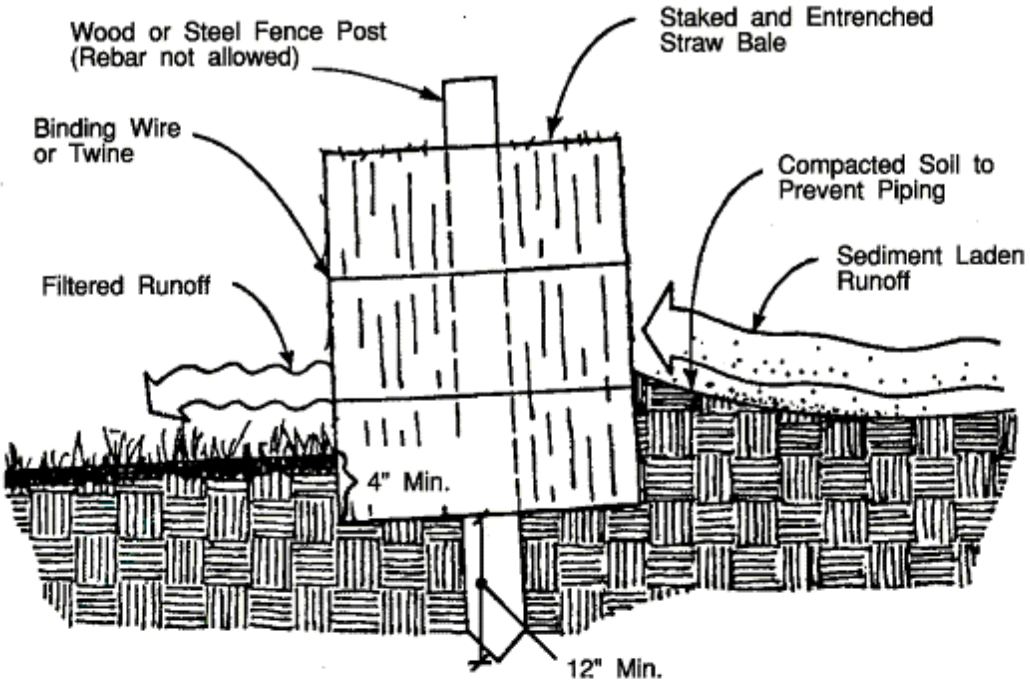
1. Use only in areas of low-velocity runoff where sheet and rill erosion potential is low to moderate. Excessive drainage area above bales can lead to failure.
2. Proper installation includes a) excavating a trench the width of the bale and length of the proposed barrier to a minimum depth of six inches; b) placing the bales in the trench; c) staking the bales by driving at least two wood stakes a minimum of six inches into the ground and towards the previously laid bale to force the bails together; and d) backfilling soil against the upgradient side of the hay bale.
3. "Chink" between bales with loose straw.
4. All bales must be either wire-bound or string-tied.
5. Straw bales should remain in place until vegetation is reestablished.
6. Use only weed-free bales, typically wheat straw rather than grass hay.

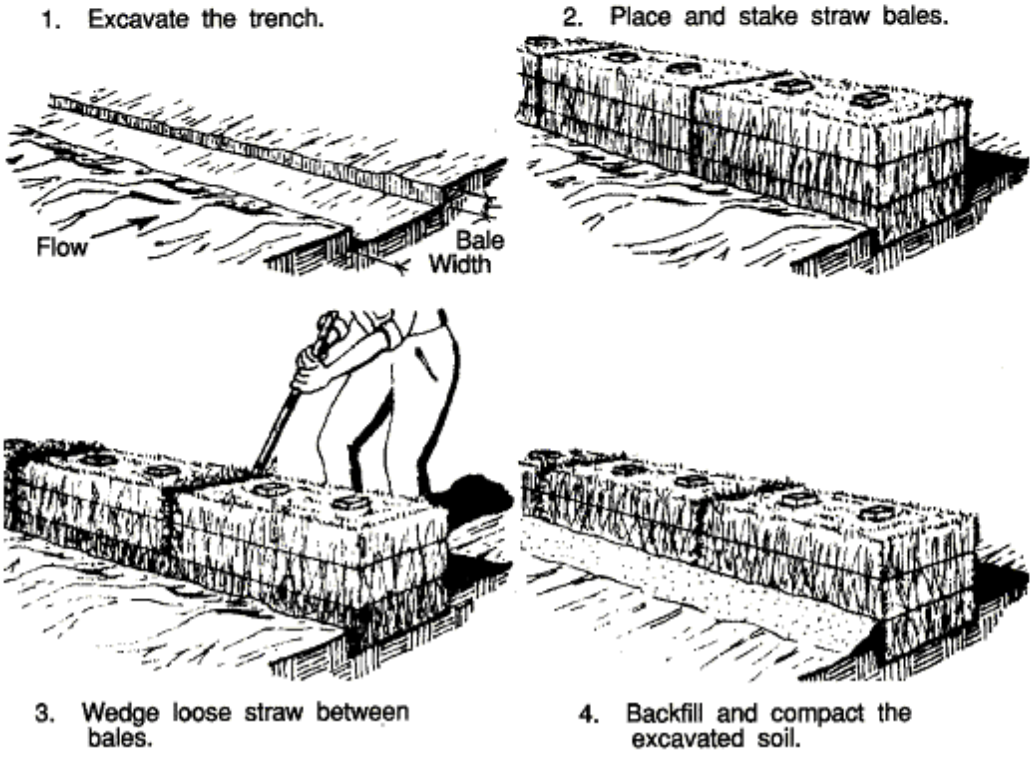
Special Considerations in Mountainous Areas

1. Thin, rocky soils may preclude the use of wooden stakes during installation.
2. If depth to bedrock is shallow, do not use this method.
3. Improved performance can be achieved by installing silt fence on the upslope side and placing it over the bales.

Maintenance

1. Remove excess sediment periodically, at a minimum when sediment reaches half of the straw bale height.
2. Repair or replace damaged bales and replace broken posts.
3. "Chink" between bales with loose straw.
4. Check weekly and after storms. Bales may only perform for a period of weeks or months. Check for rills under or around bales.





From: Virginia Soil and Water Conservation Commission, 1985

As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Type: Temporary

Sand Bags

Description

Sand bags can be used to stabilize roadside ditches or other areas by reducing velocity, ponding water or redirecting runoff to a stabilized outlet.

Installation/Design Guidelines

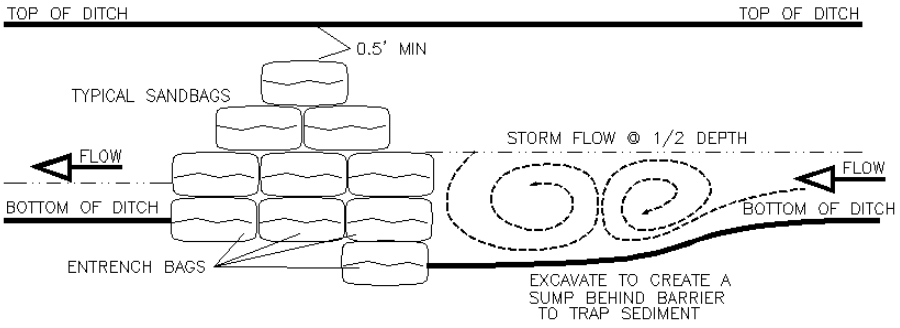
1. The base of the sand bag barrier should be at least 48 inches wide and 18 inches high.
2. Install so that flow under or between bags is prevented by overlapping the stacked bags and entrenching the bottom set.

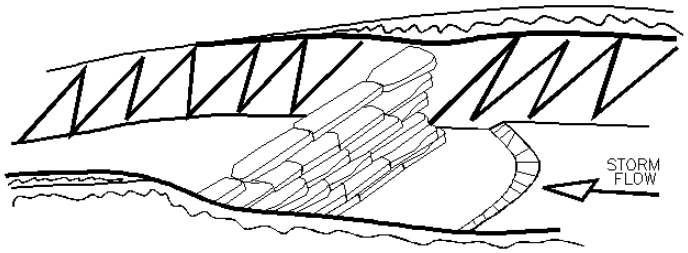
Special Considerations in Mountainous Areas

1. Sand bags can be a good alternative to silt fences and hay bales when staking is difficult due to rocky soils.
2. Visqueen or other plastic material can be used to create better pooling to settle solids.
3. Synthetic materials used for sand bags are susceptible to UV deterioration and should be inspected on a regular basis.

Maintenance

1.
2. Sand bag barriers should be regularly maintained, and any breaks or undercutting in the barrier should be promptly repaired.
3. Remove sediment behind the barrier when it accumulates to a height of six inches.
4. Replace broken bags immediately, otherwise the sand can enter runoff and become a sediment source.





Type: Temporary

Silt Fence

Description

Silt fences are temporary barriers constructed of woven, synthetic material attached to posts. The goal of this BMP is to pool water from an eroding area, allowing the sediment to settle. Sediment transported off-site can otherwise collect in drainages, waterways, wetlands or adjacent properties.

Installation/Design Guidelines

1. Secure filter fabric to the ground by installing wooden posts to a depth of 12 inches and excavating a trench at least six inches deep along the line of the post and upslope from the barrier. Bury lower eight inches of filter fabric into this trench and compact the backfill soil.

2. Posts should be spaced a maximum of 10 feet apart. For shallow channel flow applications, the posts should be spaced a maximum of three feet apart and reinforced with wire mesh. The base of the fence should be secured.

3. Silt fences installed across swales must have the bottom of the ends of the fence at a higher elevation than the top center of the fence.

4. Silt fences should be installed along the contour at least five feet below the base of gentle slopes in areas where upgradient disturbance is occurring.

5. Silt fences should remain in place until vegetation has been established.

Special Considerations in Mountainous Areas

1. Thin, rocky soils may preclude the use of this BMP in mountainous areas.

2. In areas prone to rockfall, install a wire mesh fence uphill 10 feet to capture rocks that may damage the fence.

3. When equipment is working near sensitive areas or when substantial movement of fill is taking place, it may be necessary to reinforce the silt fence with wire mesh.

Maintenance

1. Inspect fences weekly and before and after storms. Silt fence may only perform for a period of weeks or months.

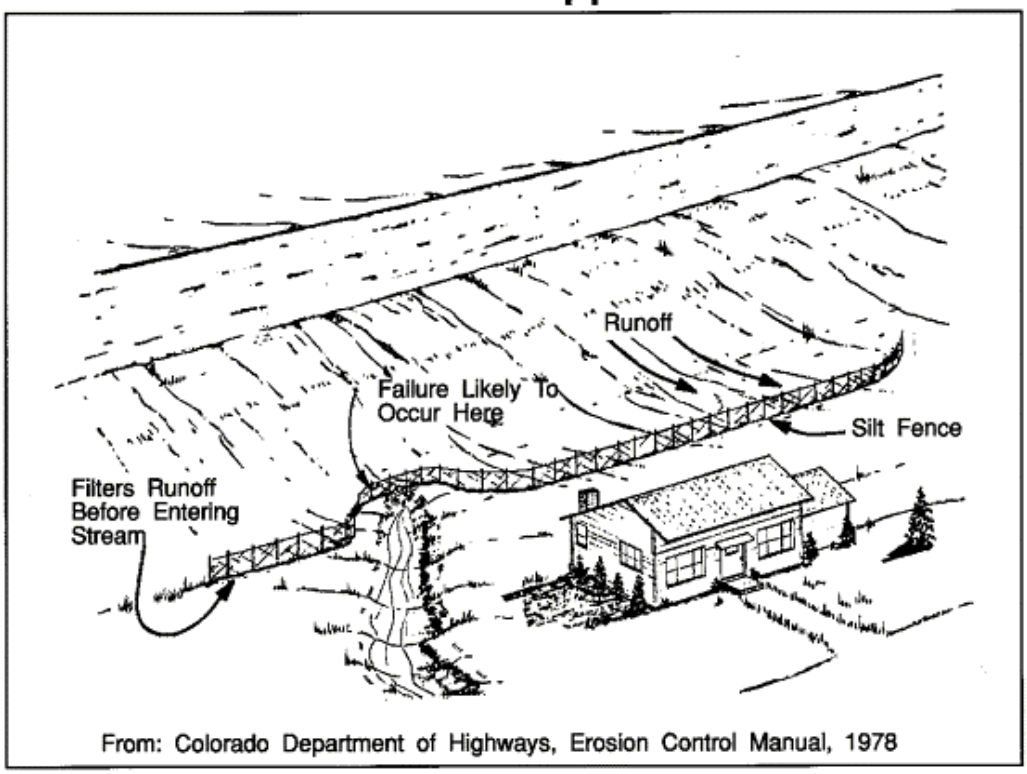
2. Look for rills under and around fences.

3. Remove excess sediment periodically, at a minimum when the sediment reaches one-fourth of the silt fence height.

4. Repair or replace damaged fence, and replace broken posts.

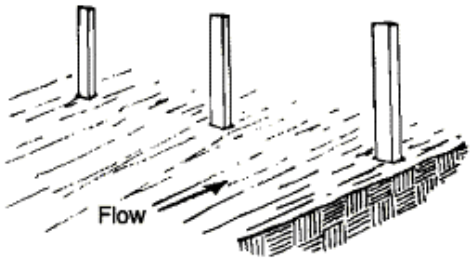
Remove silt fence when area has been successfully revegetated.

Silt Fence Applications

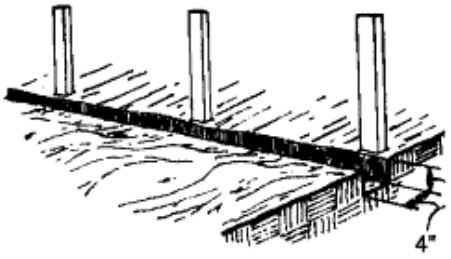


From: Colorado Department of Highways, Erosion Control Manual, 1978

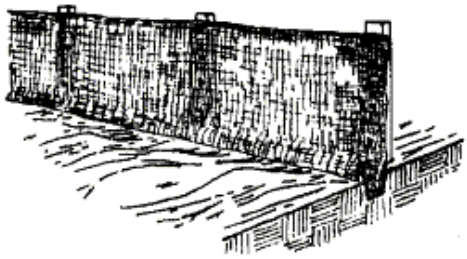
1. Set Posts.



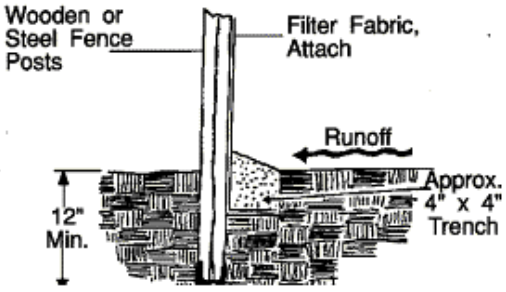
2. Excavate a 4" x 4" Trench upslope along the line of uprights.



3. Attach Filter Material to posts or insert Sewn Pockets over posts and extend it into the trench.



4. Finished section:



As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Sediment Traps

Type: Temporary

Description

Sediment traps are temporary excavated basins or embankments which allow water to pool long enough for sediment to settle. The goal of sediment traps is to capture sediment from limited runoff areas. Sediment traps can be converted into permanent stormwater management structures.

Installation/Design Guidelines

1. Locate traps at points of discharge from disturbed areas prior to construction.

2. Install sediment traps either by excavating below grade or building an embankment across an intermittent swale. Excavated traps are less prone to failure. Never construct sediment traps on a live stream.

3. Shallow, rectangular traps, with a length-to-width ratio of 2:1 or greater, are the most efficient.

4. Outlet structures should consist of a trapezoidal weir protected from scour by a combination of coarse aggregate/riprap of 6-inch to 10-inch size to provide for filtering and energy dissipation. Place geotextiles below aggregate to reduce potential scouring of the outlet.

5. The outlet crest should be at least six inches to one foot below the top to the embankment.

6. Size to hold at least 1/4-inch of erosion from tributary land areas (900 cubic feet per acre).

7. Avoid embankments consisting of silt or clay and large cobbly soil. These typically fail if not protected with plastic or geotextile.

Special Considerations in Mountainous Areas

1. Sediment traps are easily adaptable to many conditions, including thin soils and steep slopes. The size of sediment traps can vary, making this BMP flexible.

2. Place the traps where they are most effective such as before pipes, in areas where slopes flatten, and where access is easy for maintenance.

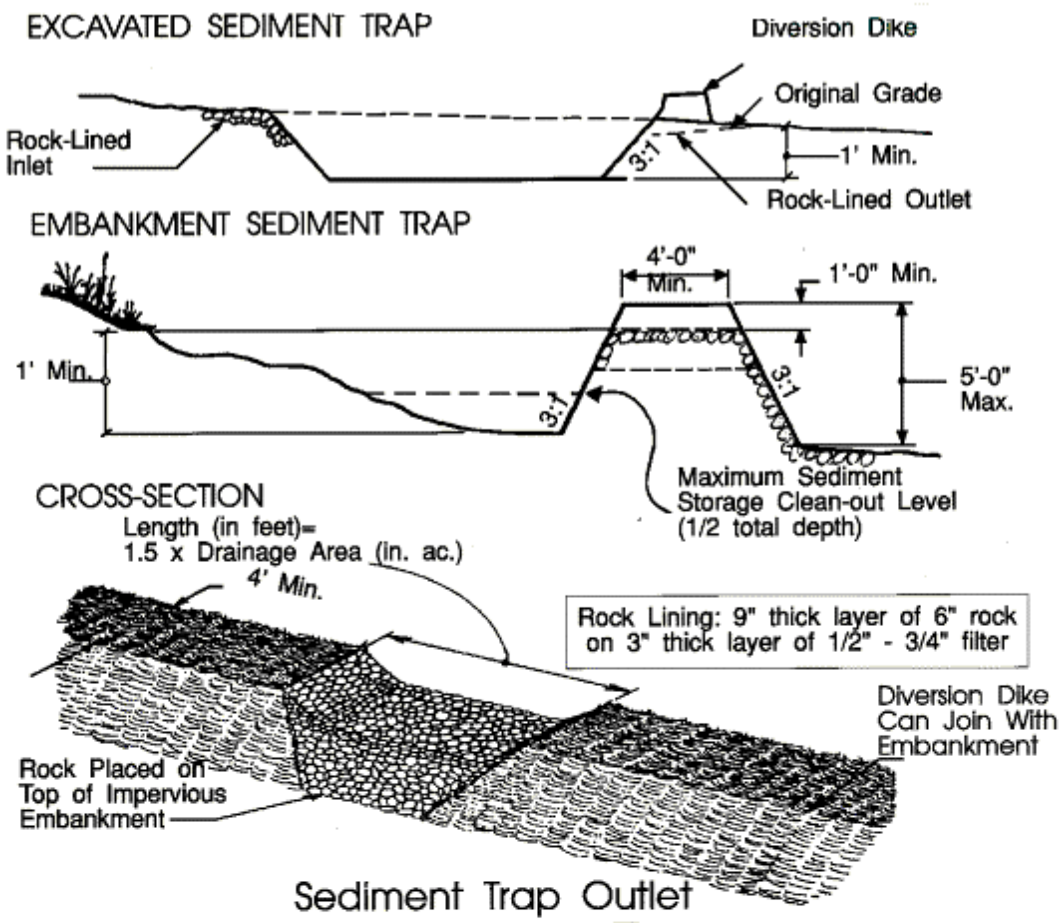
3. Install a stick or post to indicate when trap is at appropriate level for sediment removal.

Maintenance

1. Maintain sediment traps on a regular basis; check sediment levels after storms and clean out once trap is half full of sediment.

2. Repair embankments as needed, and remove debris from outlets.

3. Dispose of sediment in stable locations where it will not be reintroduced to the system.



From: Virginia Soil and Water Conservation Commission, 1985

As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Sediment Basins

Type: Temporary or Permanent

Description

Sediment basins are used to detain runoff from an area and allow settling of sediment. Sediment basins include an outlet (usually a pipe) to control the outflow rate and can be designed for temporary or long-term use. With regard to mountain driveways, sediment basins would be appropriate for use as part of BMPs implemented for the overall site development.

Installation/Design Guidelines

1. Locate sediment basins in natural drainage areas but not on live streams or in wetlands. The lowest portion of the site is typically the most logical location for installation.

2. Install them early in the construction process, allowing the BMP to be utilized for the longest period possible.

3. Basins should be long and narrow (length twice as long as width) and relatively shallow in depth to provide maximum settling time.

4. Provide a stabilized outlet downstream.

5. Install an emergency spillway to protect the embankment.

Special Considerations in Mountainous Areas

1. Possible problems may occur due to thin or rocky soils unfavorable to excavating dirt or building embankments. Smaller sediment traps or check dams may be used in these cases.

2. Permanent sediment or detention basins may be necessary for subdivisions in a mountain area but are not necessary for single-family residences.

3. If over five acres of denuded land drains to an area, a sediment basin is generally appropriate.

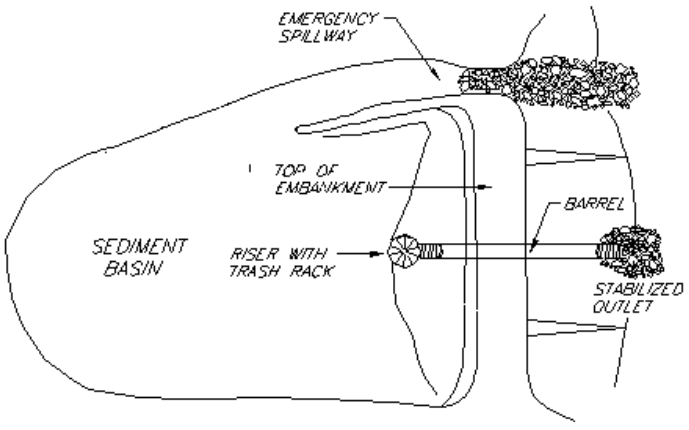
Maintenance

1. Sediment should be removed when the basin is half full.

2. Check embankments for seepage and repair them as needed.

3. Check spillways for debris and remove as necessary.

4. Clean out and periodically maintain the outlet.



As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Brush Barriers

Type: Temporary

Description

Brush barriers are temporary sediment barriers composed of limbs, weeds, vines, root matter, soil, rock and other cleared material pushed together to form a berm to intercept and detain sediment and decrease flow velocities.

Installation/Design Guidelines

1. Locate across or at the toe of the slope.
2. The height of a brush barrier should be a minimum of three feet.
3. The width of a brush barrier should be a minimum of five feet at its base.
4. Securing the barrier with geotextile fabric will improve its effectiveness.

Special Considerations in Mountainous Areas

1. Use during timber removal activities as a way to pile limbs and catch sediments.
2. Upon completion of the project, the barrier material can be chipped and applied as mulch to reseeded areas.
3. Although typically only 30 percent effective, this measure can assist in removing a portion of the sediment load prior to runoff being passed through more effective downstream measures.
4. Always use this method in conjunction with other BMPs.

Maintenance

1. Remove loose sediment that is collected behind the berm.
2. Remove barriers when they have served their usefulness and chip debris and haul off site or use as mulch. Do not burn in place.
3. Revegetate the area after removal of the barrier.

Check Dams

Type: Temporary or Permanent

Description

Check dams are small dams constructed across a drainage ditch or swale to reduce the velocity of concentrated flows. Reduced runoff velocity reduces erosion and gullying in the channel and allows sediment to settle.

Installation/Design Guidelines

1. Check dams should be installed in steeply sloped swales or in ditches where adequate vegetation cannot be established or as a temporary measure before ditches are stabilized.
2. A check dam can be built from logs, stone, or gravel-filled sand bags.
3. The maximum height of the check dam at the center should not exceed one-half the depth of the ditch or swale. The center of the dam should be at least six inches lower than the outer edges and convey flows without flowing around the dam.
4. Ensure that the maximum spacing between dams places the toe of the upstream dam at the same elevation as the top of the downstream dam.

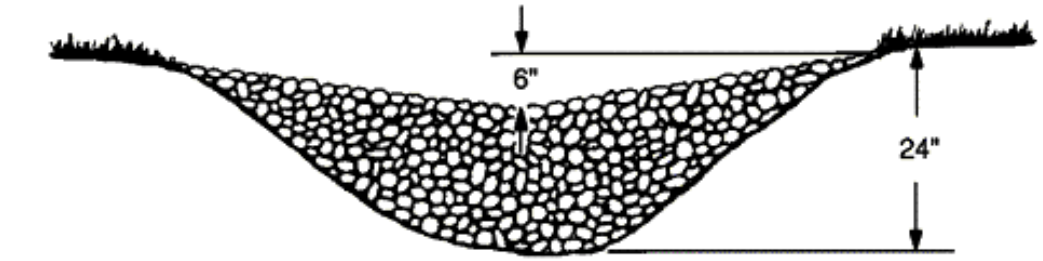
Special Considerations in Mountainous Areas

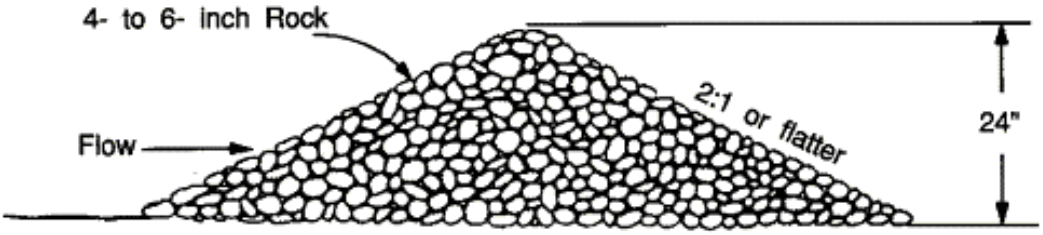
1. Check dams can be used where it is not possible to divert the flow or otherwise stabilize the channel.
2. Check dams are appropriate where thin soils or shallow bedrock exists.
3. Do not use this method on a live stream.
4. Where needed, place on a foundation of filter fabric to avoid undercutting.

Maintenance

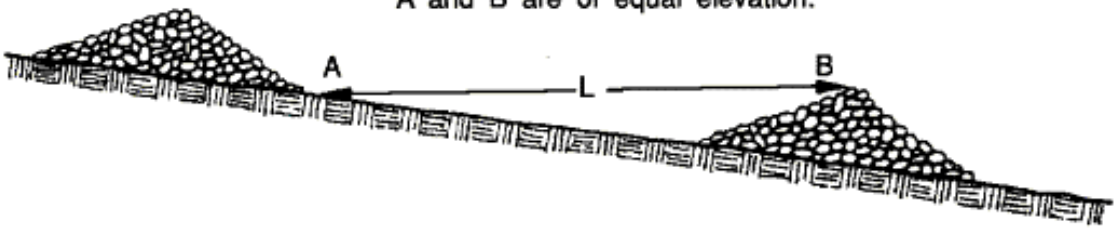
1. Remove sediment accumulated from behind the check dam when it has reached half the original dam height.
2. Erosion caused by high flows around the edges can be corrected by sandbags and should be corrected as soon as possible.
3. Temporary check dams should be removed when they are no longer useful.

ROCK CHECK DAM





L = The distance such that points
A and B are of equal elevation.



SPACING BETWEEN CHECK DAMS

From: Virginia Soil and Water Conservation Commission, 1985

As reprinted in Urban Drainage and Flood Control District
1992 Urban Storm Drainage Criteria Manual, Volume 3.

Type: Permanent

Vegetation Buffers

Description

Buffer strips are uniformly graded and densely vegetated areas of native grass. They require sheet flow to promote filtration, infiltration and settling to reduce runoff pollutants. Grass buffer strips differ from grass-lined swales because they are designed to accommodate overland sheet flow rather than concentrated or channelized flow. They can be used to remove sediment from sheet flow runoff from impervious areas and improve infiltration.

Installation/Design Guidelines

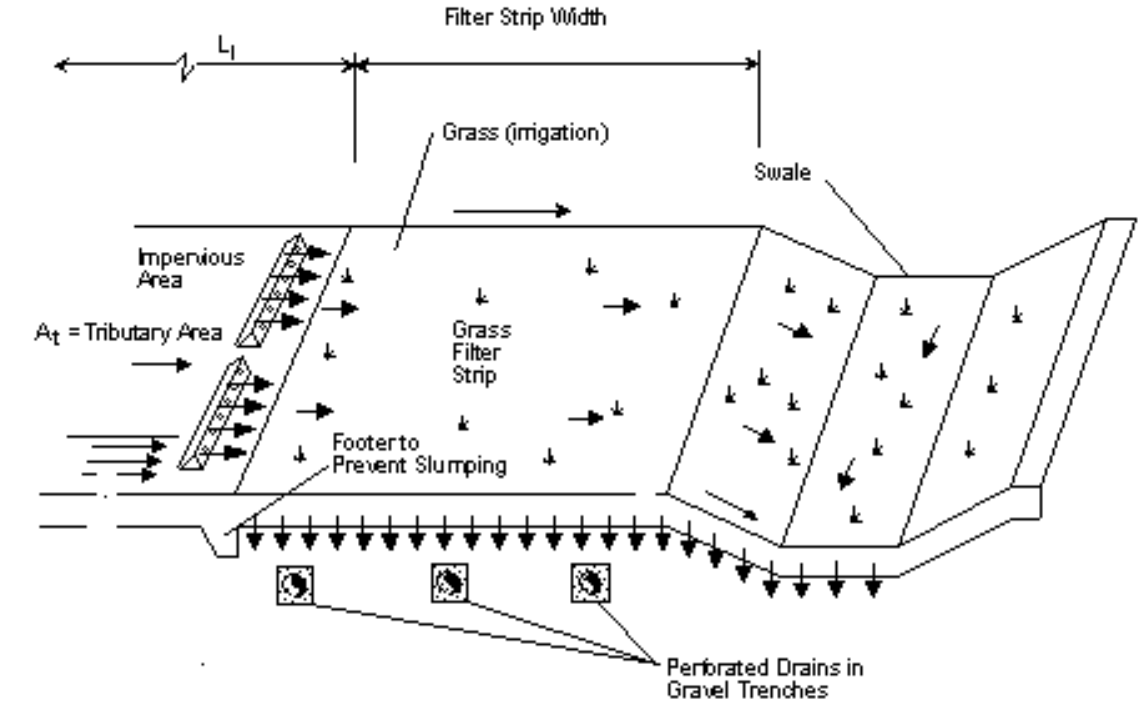
1. Concentrated runoff should be evenly distributed across the width of the buffer strip to achieve sheet-flow conditions as much as possible.
2. Buffer strips can be located adjacent to major drainageways and receiving waters and interspersed with shrubs and trees that can take up nutrients and provide shading.
3. Buffer strips should be sized to accommodate expected flow conditions.

Special Considerations in Mountainous Areas

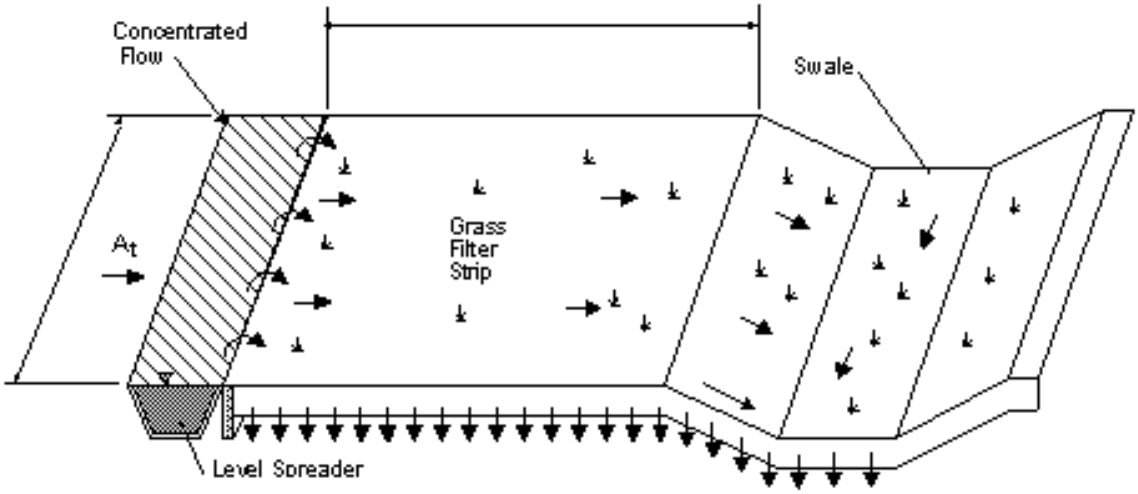
1. Native, drought-tolerant, sod-forming grasses such as western wheatgrass and streambank wheatgrass should be used in buffer strips.
2. Ensure that the vegetative cover is dense enough to protect underlying soil while causing sediment to settle.
3. Overexcavate where soils may not be sufficiently permeable and replace with sand or gravel and cover with soil.

Maintenance

1. Periodically remove accumulated sediments.
2. Mow regularly to a minimum height of six inches to stimulate root growth and close the canopy.
3. Obtain proper fertilizer recommendations on a maximum five-year cycle.
4. Repair any rills that form.



ONSITE FLOW CONTROL



CONCENTRATED FLOW CONTROL

Note: Not to Scale

As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Type: Permanent

Grass-lined Swales

Description

Grass-lined swales are densely vegetated small drainageways with low-pitched side slopes that collect and slowly convey runoff. Design of their longitudinal slope and cross-section size forces the flow to be slow and shallow, thereby facilitating sedimentation while limiting erosion.

Installation/Design Guidelines

1. Roadside swales should be designed to convey concentrated surface runoff to a receiving channel without damage from erosion.

2. Berms or check dams should be installed within the swale perpendicular to the flow as needed to slow it down and to encourage settling and infiltration.

3. Channel cross-section and lining should be considered based upon volume and velocity of expected flow. Possible cross-section shapes include "V"-shaped (low water), parabolic (high water, low velocity) or trapezoidal (high water, high velocity).

4. Establishing dense, resistant, sod-forming vegetation is essential. Erosion control blankets may be needed following seeding until vegetation is established.

5. Stabilize the outlet.

Special Considerations in Mountainous Areas

1. Grass may be difficult to establish and maintain in arid and cold areas. Riprap can be used to stabilize roadside ditches in place of vegetation, although the cost is much higher. Erosion matting can provide stability until vegetation is established.

2. Grass swales are not appropriate for steep slopes or high velocity drainages.

3. Avoid sharp changes in direction or grade.

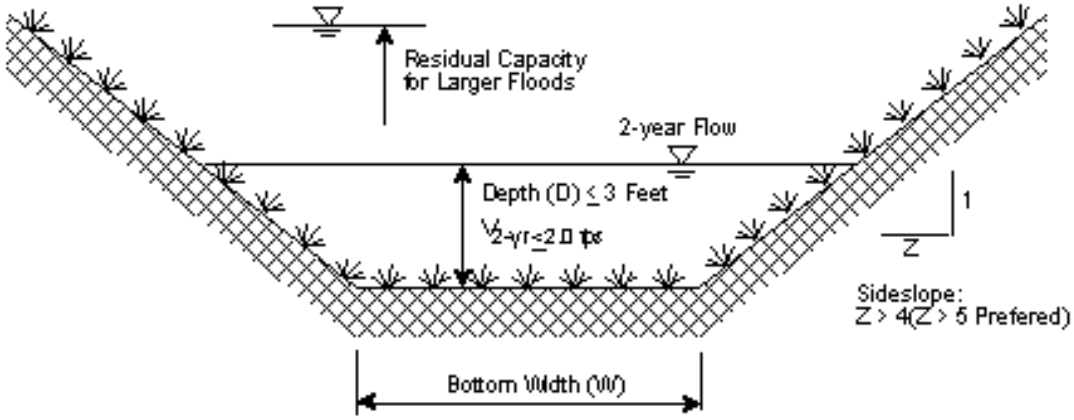
Maintenance

1. Mow no closer than six inches, and preferably taller, to increase filtering ability.

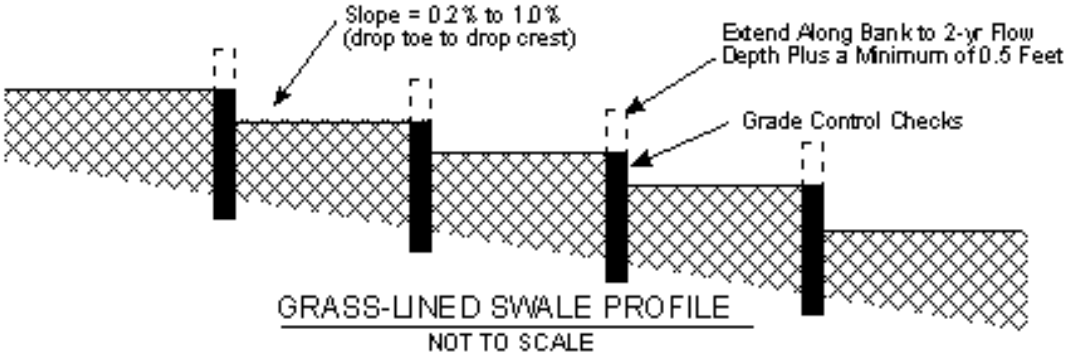
2. Wider, flatter, shallower ditches are easier to maintain.

3. Maintain center line ditch grade to be between one and two feet below the edge of roadway.

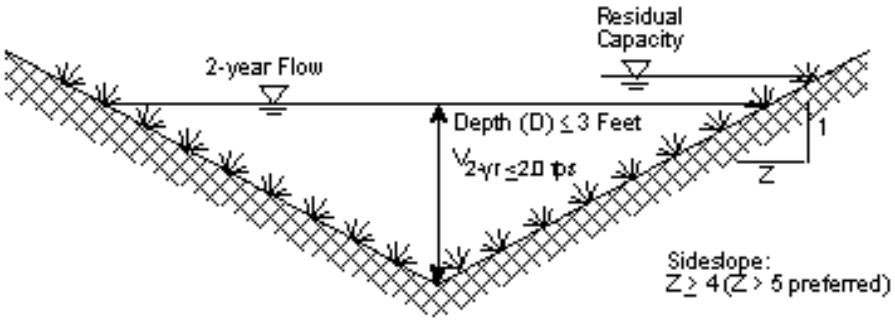
4. Keep the grass in healthy condition at all times, since it is the primary erosion protection and filtration media for the swale.



TRAPEZOIDAL GRASS-LINED SWALE SECTION
NOT TO SCALE



GRASS-LINED SWALE PROFILE
NOT TO SCALE



TRIANGULAR GRASS-LINED SWALE SECTION
NOT TO SCALE

As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Type: Permanent

Revegetation

Description

Revegetation is the establishment of vegetative cover on soil left bare by the construction process. This process includes seedbed preparation, temporary revegetation and permanent revegetation with mulching. Revegetation limits erosion and sedimentation on areas adjacent to the driveway by preventing raindrop and sheet flow erosion and weed infestation of exposed earth.

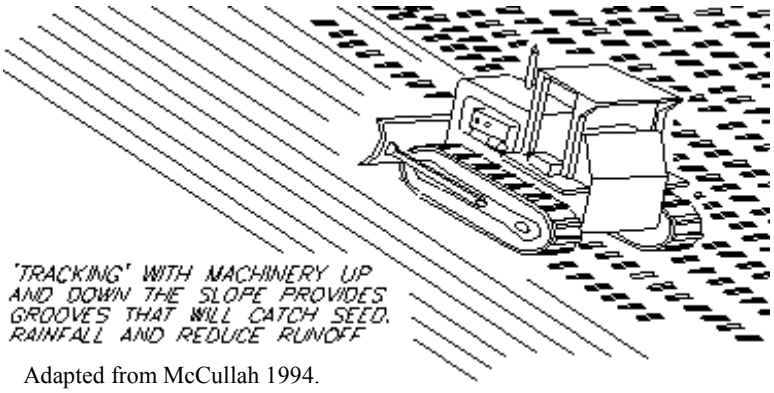
Installation/Design Guidelines

1. Use native vegetation recommended in your area. A representative list of commonly used native seed mixes in Colorado is provided in Appendix 1.

2. Check weights, seed species and purities prior to planting the seed.

3. Prior to permanent seeding, prepare soil (e.g., roughen soil surface) and incorporate topsoil, amendments and fertilizer as needed. Use stock-piled topsoil, if possible. Cover seeds to proper depth (e.g., 1/4 to 3/8 inches). Use fertilizer sparingly.

4. Apply mulch after seeding to retain moisture and protect from erosion.



Adapted from McCullah 1994.

Special Considerations in Mountainous Areas

1. Timing, soil type, fertilization requirements and availability of irrigation supply are all serious considerations prior to selecting a method of revegetation. Conduct soil tests and consult local experts as needed.

2. Steeper slopes require more attention to revegetate. Mulch should be used on slopes steeper than 3:1 and matting or hydromulch should be used on slopes steeper than 2:1.

3. Native grasses can become established without irrigation in most circumstances.

Maintenance

1. Check for growth and re-seed areas where the coverage is not complete. Vegetation is considered established when ground cover is achieved which is sufficiently mature to control soil erosion (approximately 80 percent coverage) and can survive severe weather conditions.

2. Watering should be performed as needed during the first year of installation in the absence of rainfall.

Type: Temporary

Mulching

Description

Mulching is the application of plant residue or other suitable biodegradable material to the soil surface. The goal of this BMP is to protect the soil surface, reducing raindrop impact erosion, which in turn reduces sheet flow, rill, gully and channel erosion by increasing infiltration. Mulch also facilitates the growth of vegetation by increasing available moisture, providing insulation against extreme heat and cold and shading seeds from intense sun. Mulch also reduces wind erosion.

Installation/Design Guidelines

1. To be effective, mulch must be attached to the ground by chemical tackifiers or mechanical crimping.
2. Wheat straw should consist of native grasses free of noxious weeds and seeds. Use native grass hay where practical. Avoid smooth bromegrass hay.
3. Straw or hay mulch should be long-stemmed and spread at a rate of one and a half to two tons per acre.
4. Applied mulch depth should be between one to two inches.
5. Mulch should be applied immediately after seeding.

From: Environmental Protection Agency, 1976
As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Special Considerations in Mountainous Areas

1. Mulch retains moisture, which helps to minimize water requirements for revegetation.
2. Mulch requires no removal because of natural decomposition.
3. Mulch can be blown away in areas exposed to high winds, so crimping is necessary. Blown on and unattached mulch is typically less than 30 percent effective.

Maintenance

1. Inspect mulch periodically, especially after wind and rainstorms.
2. Reapply additional mulch as necessary with the appropriate seed mix in bare and unproductive spots.
3. Spot apply weed killers to noxious weeds.
4. Mulch is not very effective on slopes steeper than 3:1. Erosion mats are a better alternative in such case.

Type: Temporary

Erosion Control Blankets

Description

Erosion control blankets and mats are strong, man-made mattings used to stabilize channels, swales and newly-planted slopes. The type and weight of these measures differ depending on slope and soil. Erosion control blankets can be used in place of mulch on areas of high velocity runoff and/or steep grade to aid in controlling erosion on critical areas and revegetation.

Installation/Design Guidelines

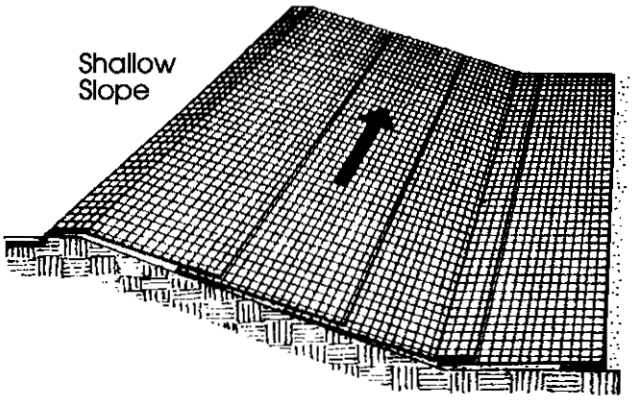
1. Use erosion control blankets where vegetation is likely to grow too slowly to provide adequate cover, in areas susceptible to rilling, and in areas subject to high winds where mulch would not be effective.
2. Smooth the ground and remove any material larger than three inches in diameter prior to application.
3. Install erosion control blankets parallel to the direction of the slope and overlap the uphill section over the downhill section.
4. In ditches, apply erosion control blankets in the direction of the flow.
5. Place erosion control blankets loosely on soil; do not stretch them.
6. The edges of the blanketed area should be anchored and buried no less than six inches deep.
7. Staple the blanket at least every three feet.
8. Always follow the manufacturer's instructions for installation.
9. Apply seed, fertilizer and mulch prior to laying blankets.

Special Considerations in Mountainous Areas

1. Use erosion control blankets to stabilize steep slopes, particularly where vegetation is difficult to establish and winds will remove mulch. Select staples consistent with soil depth.
2. Where possible, irrigate the mat areas by sprinkler the first season to promote revegetation. Do not overwater slopes where slippage can occur and erosion can begin.

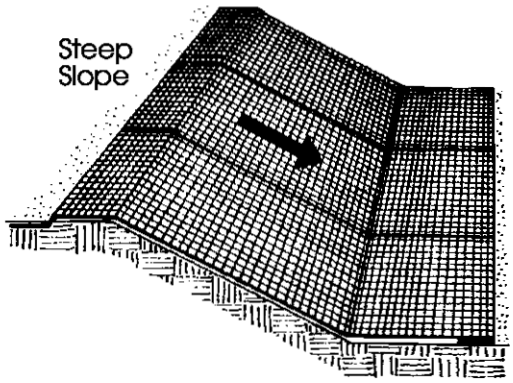
Maintenance

1. Check for erosion and undermining periodically, particularly after storms, and monitor until permanently stabilized with vegetation.
2. Repair dislocations or failures immediately.
3. If washouts occur, reinstall erosion control blankets after repairing slope damage and reseeding.



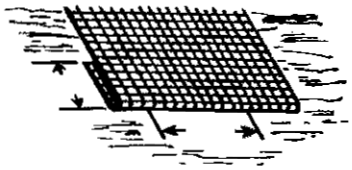
On shallow slopes, strips of netting may be applied across the slope.

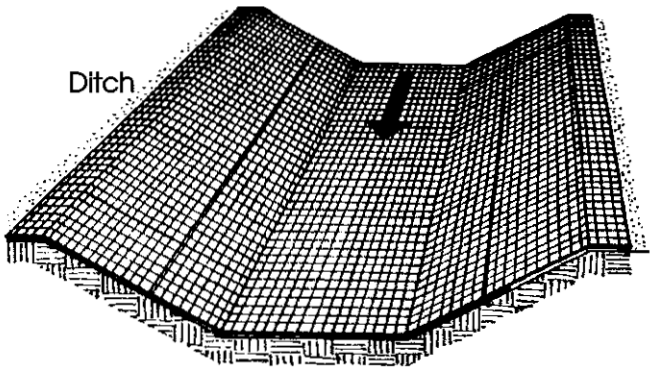
Where there is a berm at the top of the slope, bring the netting over the berm and anchor it behind the berm.



On steep slopes, apply strips of netting parallel to the direction of flow and anchor securely.

Bring netting down to a level area before terminating the installation. Turn the end under 6" and staple at 12" intervals.





In ditches, apply netting parallel to the direction of flow. Use check slots every 15 feet. Do not join strips in the center of the ditch.

From: Virginia Soil and Water Conservation Commission, 1985

As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Slope Stabilization

Type: Permanent

Description

Fill slopes, some cut slopes and spoil disposal areas will require vegetative and/or mechanical measures to ensure stable slopes, depending on factors such as slope angle, soil type, aspect and climate. Vegetative measures can include seeding, sodding and/or planting trees and bushes. Mechanical measures may include surface roughening, wattling, erosion mats/nets, terraces, side drains, riprapping, mulch, tackifiers, soil seals, soil cement and retaining walls.

Installation/Design Guidelines

1. Obtain accurate soils and geologic information on which to base maximum cut and fill slopes to handle surface and subsurface drainage.

2. Run on from off-site, runoff from the site and stream flow should be controlled so they do not reach and overtop the face of any slope subject to failure or significant erosion.

3. Concentrated flows should be discharged to a stable drainage conveyance system or be dissipated into natural forest areas.

4. Uninterrupted slope lengths should be limited. Limit continuous runs downhill to less than 50 linear feet and install waterbars, trenches, etc., to break up runs.

5. Where cuts or other excavations intercept groundwater, subsurface drainage systems should be installed. Water collected in these systems should be discharged to stable drainage systems. If possible, do not commingle this water with stormwater, which would increase volume and velocity of flow in ditches and swales.

6. Facilities conveying runoff down slopes should be designed for a 10-year storm or, at a minimum, one inch of runoff over the drainage area.

Special Considerations in Mountainous Areas

1. Stabilize slopes prior to the first winter season, when erosion is most severe.

2. Vegetation may take several seasons to become densely established and effective.

3. Where possible, slopes should be sloped back at a 3:1 ratio or flatter. (If slopes are steeper or sloughing is of concern, structural measures like retaining walls, concrete, etc., will be needed.) Check local government requirements for slope restrictions.

Maintenance

1. Slope stabilization features should be inspected and repaired as needed, especially after spring snowmelt and major storms.

2. Failures generally indicate selected method is inadequate. Rather than repairing, rebuilding or reapplying the same BMP, install an alternative, more protective method.

Slope Drains

Type: Temporary or Permanent

Description

Slope drains are flexible or rigid conduits that extend from the top to the bottom of a cut or fill slope. The goal of this BMP is to carry stormwater runoff to a stabilized outlet to avoid erosion.

Installation/Design Guidelines

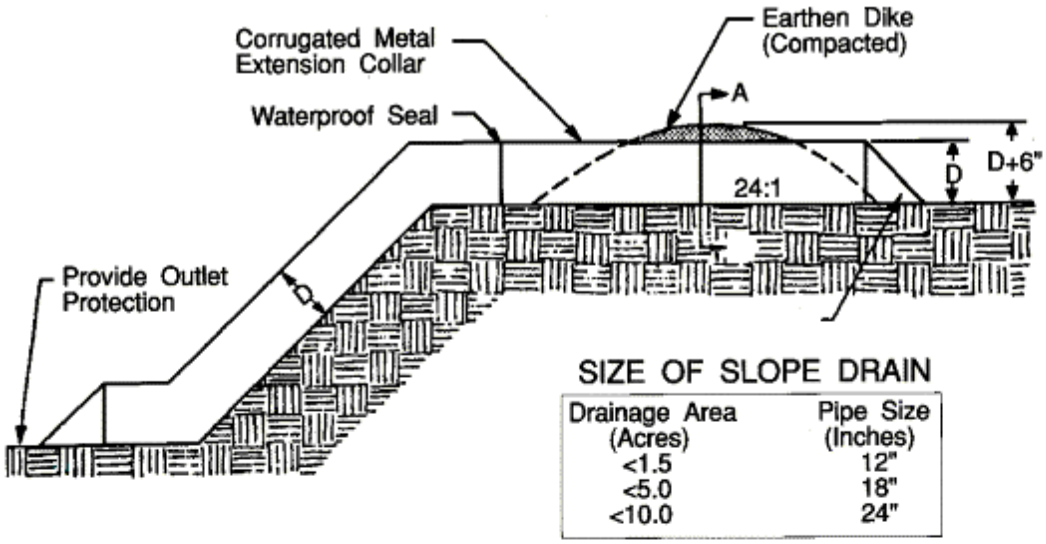
1. Slope drains should consist of heavy duty material designed and suitable for the purpose.
2. All drain sections should be securely fastened together, have water-tight fittings, and be securely anchored to the slope.
3. The minimum pipe size for slope drains should be eight inches.
4. Soil around and under inlets should be compacted.
5. The inlet and outlet of the drain should be protected with rock to prevent erosion.
6. Do not use perforated or slotted pipe sections in this application.
7. Extend the downstream end of the pipe 15 feet beyond the toe of slope before daylighting to avoid wetting the toe of slope.
8. If buried, install cleanouts at 50 feet minimum and 100 feet maximum intervals to facilitate cleanout.

Special Considerations in Mountainous Areas

1. Proper installation is very important because failure of slope drains often results in severe gully erosion on the site and sedimentation below the slope.

Maintenance

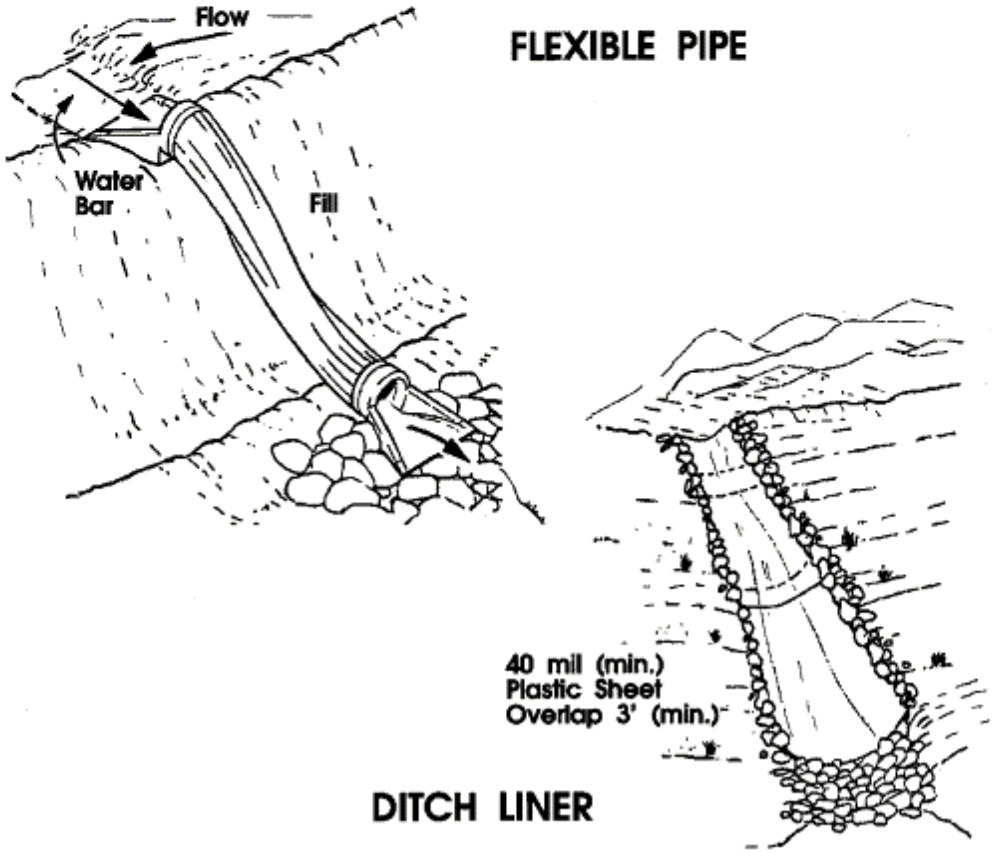
1. Replace sections that are crimped or crushed.
2. Inspect for bypass of inlet and modify to keep 95 percent of available runoff in system and not overland.
3. Maintain ditches that run to slope drains because they can be significant sources of sediment loading.
4. Leave slope drain in place until two years after revegetation reaches 70 percent cover to ensure that the slope is stable and roots are well established.



SIZE OF SLOPE DRAIN

Drainage Area (Acres)	Pipe Size (Inches)
<1.5	12"
<5.0	18"
<10.0	24"

From: Virginia Soil and Water Conservation Commission, 1985



From: Colorado Department of Highways, 1978

As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Road Drainage

Type: Permanent

Description

Proper control of road drainage is one of the most important BMPs for minimizing erosion and sedimentation in mountainous areas. A variety of approaches can be used including controlling road slopes, providing drainage dips, wing ditches, culverts, cross drainage and other measures.

Installation/Design Guidelines

1. Use crowning, outsloping, ditches, and/or culverts to drain roads.
2. Install ditches, culverts, cross drainage and wing ditches at low points in the road.
3. Provide outfall protection for cross drains, culverts and wing ditches.
4. Use diversion or wing ditches wherever possible to carry road drainage into undisturbed, stable, vegetated areas.
5. Avoid insloping and inside ditches whenever possible. (A possible exception is curves located in fill areas.) In-sloping ditches will require a culvert to transfer flow to an outside ditch or directly to the hillslope.
6. Use adequately sized culverts to carry the anticipated flow of water.
7. Water bars or rolling dips may also be installed periodically along the driveway to reduce drainage velocity and associated erosion.

Special Considerations in Mountainous Areas

1. Identify culverts with posts or poles so they can be cleared of ice and debris in winter.
2. Proper road drainage design should decrease future maintenance costs associated with erosion.
3. Where practical, locate roads to receive southern exposure to facilitate melting of ice and snow and keep the road drier.

Maintenance

1. Maintain road crown and water bars to drain surface.
2. Maintain ditch line to drain properly.
3. Clean out culverts periodically.
4. Inspect and maintain culvert and ditch outfalls after runoff events to ensure concentrated flow has not damaged hillslope stability.

Road Drainage Tips:

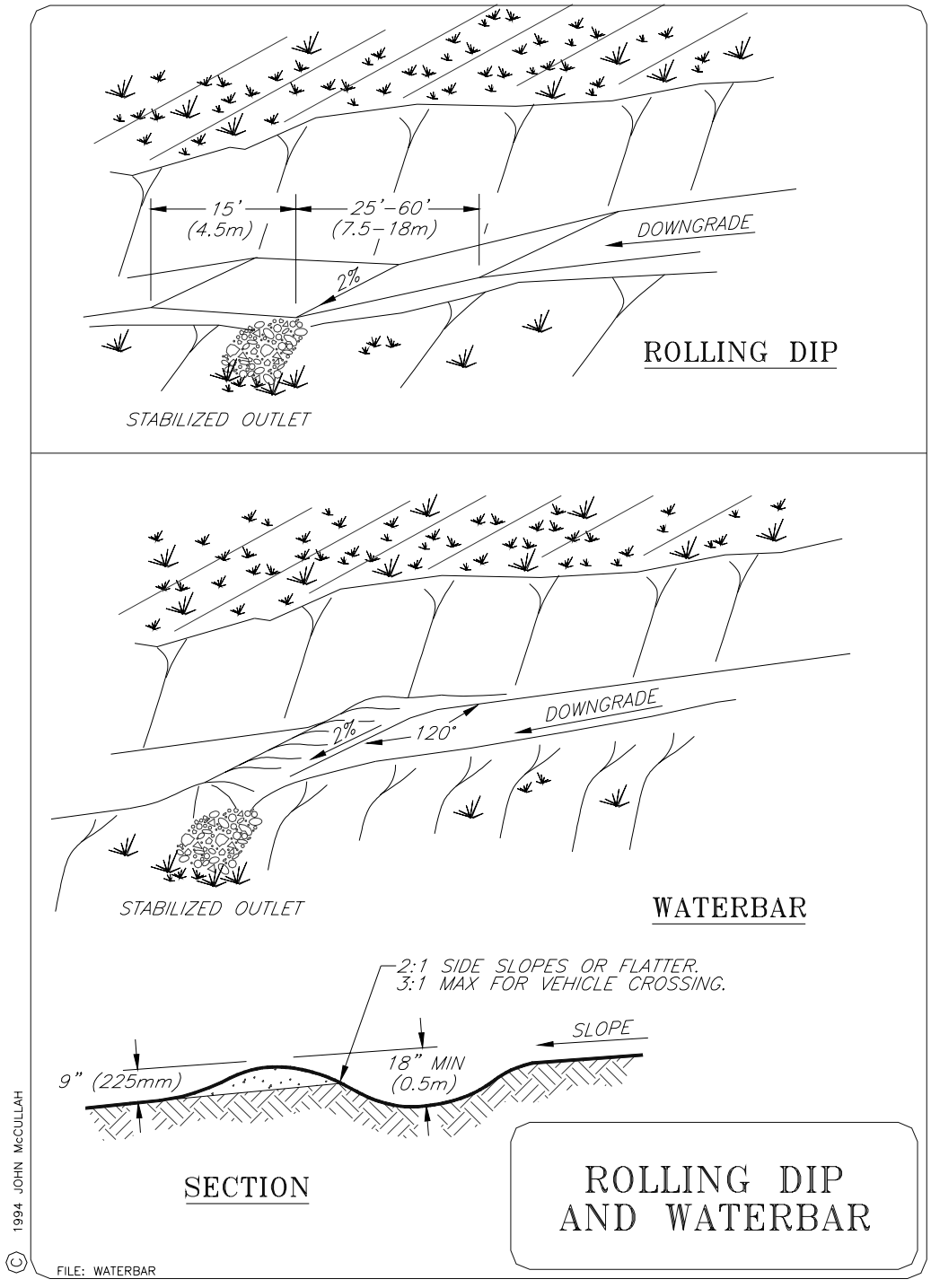
US Forest Service Recommendations for Culvert & Waterbar Spacing

Road Grade (%)	Culvert Spacing (feet)
0-4	1,000
5-6	840
7-8	600
9-10	460
11-12	380
13-14	320
15-16	280
17-18	250

	Water Bar Spacing (Feet) Depending on Road Grade and Soil Type		
	Soil Type		
Road Grade (%)	*Granitic or Sandy*	*Shale or Gravel*	*Clay*
2	900	1,000	1,000
4	600	1,000	800
6	500	1,000	600
8	400	900	500
10	300	800	400
12	200	700	400
15	150	500	300
20	150	300	200
25+	100	200	150

Notes: Road grades provided are assumed to be the average sustained grade for distances shown. Distances are approximate and should be varied to take advantage of natural features.

Source: Colorado State University Cooperative Extension, 1994. Foresters Field Handbook. Compiled and edited by Steve Larrabee, Jim Rassman, and Dennis Lynch. Publication XCM-185.


15'
(4.5m)
25'-60'
(7.5-18m)
DOWNGRADE
2%
ROLLING DIP
STABILIZED OUTLET
DOWNGRADE
2%
120°
STABILIZED OUTLET
WATERBAR
2:1 SIDE SLOPES OR FLATTER.
3:1 MAX FOR VEHICLE CROSSING.
SLOPE
9" (225mm)
18" MIN
(0.5m)
SECTION
ROLLING DIP
AND WATERBAR
© 1994 JOHN McCULLAH
FILE: WATERBAR

Type: Temporary

Drainageway Protection

Description

The goal of this BMP is to prevent sediment from entering storm drainage systems, drainageways and sensitive environments prior to permanent stabilization of disturbed areas. Drainageway and inlet protection measures may also be used during winter road maintenance practices which involve sanding and salting.

Installation/Design Guidelines

1. Use temporary stream diversions to route water from upslope areas around construction activities taking place within a waterway.
2. Construct a barrier around storm drain inlets during construction using silt fence, gravel bags, or other materials protected to prevent sediment-laden runoff from entering the conveyance system without first being ponded or otherwise treated to remove sediment.
3. Grade roadside ditches with a slight rise (± 6 inches high) downstream of culvert inlets to direct flow into the culvert.
4. Install stable outlets from storm drainage systems.

Special Considerations in Mountain Areas

1. Drainageway protection measures are particularly important in mountain areas because construction activities often take place near sensitive receiving waters (e.g., trout streams).
2. Mark inlets with stakes or poles so they can be cleaned out during winter.

Maintenance

1. Frequently inspect BMPs implemented for drainageway protection, particularly after storms.
2. Inspect storm drain inlet protection structures before and after each storm event to repair and remove accumulated sediment.
3. Perform maintenance prior to seasonally high flow.

Outlet Protection

Type: Permanent

Description

Outlet protection involves reducing flow velocities and sediment scour at stormwater outlets or otherwise protecting receiving channels. Representative measures include riprapping or paving channel sections or installing stilling basins.

Installation/Design Guidelines

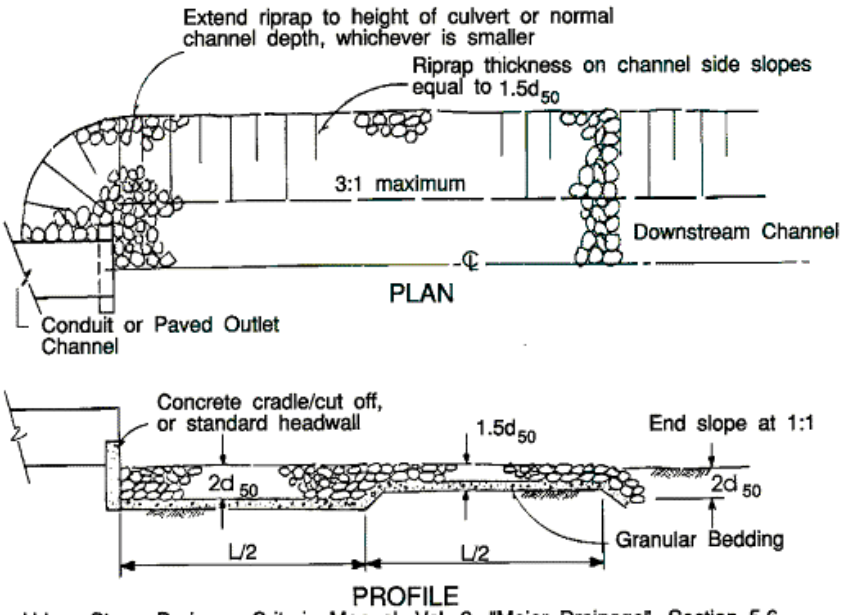
1. The grade of the stormwater outlet or apron should be zero percent.
2. The apron may be lined with grouted riprap, concrete, or asphalt.
3. A geotextile or granular filter should always be included and placed between the apron and underlying soil.
4. Geotextiles should be protected from puncture, cuts and tearing during construction.
5. Never use less than a 15-inch collar to facilitate cleaning.

Special Considerations in Mountainous Areas

1. Protecting outlets to minimize erosion and sediment contribution to streams is a particularly important consideration for sensitive streams containing cold water fisheries (e.g., trout).

Maintenance

1. Inspection should be performed after high flows for scour and dislodged stones.
2. Straighten culvert ends that are crushed or crimped.



See Urban Storm Drainage Criteria Manual, Vol. 2, "Major Drainage", Section 5.6 for design criteria.

From: Urban Drainage and Flood Control District, 1969

Type: Permanent

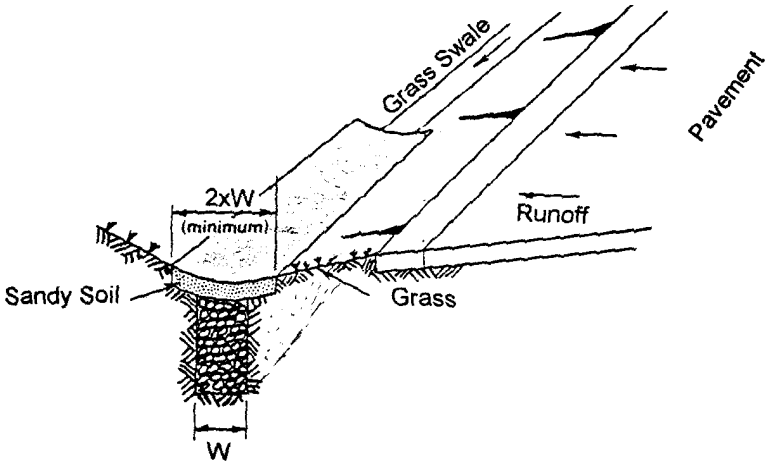
Infiltration Practices

Description

Infiltration practices include measures to percolate runoff into soils. Typical practices include rock-filled trenches or basins (dry wells). Infiltration is highly dependent on subsoil permeability; therefore, use of this BMP will have limited application in mountain areas.

Installation/Design Guidelines

1. The size of the infiltration system depends on soil permeability and runoff area. The system should be able to infiltrate one inch precipitation per hour.
2. A pre-sedimentation device is necessary for infiltration systems to avoid clogging.
3. Don't build infiltration trenches where tributary slopes are steeper than 15%. When a slope of 15% is exceeded, convey the runoff to a dry well or lateral infiltration trench located along a slope contour.



4. Grade the driveway with a 1-5% slope toward the trench. Install the trench along the low side of the driveway with a minimum width of 18 inches and a minimum depth of three feet.
5. For steep driveway slopes, install a paved ditch or french drain along the low side of the driveway and route the runoff to lateral infiltration trenches located along slope contours or to a dry well located in more level areas. Install a water bar between each section of ditch to prevent runoff from continuing downslope.
6. Do not locate a driveway on top of an infiltration trench. Avoid placing trenches where their construction will damage tree roots, cause hillslope failure, damage concrete foundations or where subsoil or bedrock conditions are not conducive to groundwater movement.

Special Considerations in Mountainous Areas

1. Do not install lateral infiltration trenches on unstable slopes or fill slopes steeper than 4:1.
2. Infiltration practices may not be appropriate in mountain areas with shallow soils where bedrock is close to the surface.

Maintenance

1. Clean out accumulated sediment and debris when the systems fails to infiltrate storm runoff.
2. If rapid clogging occurs and pre-sedimentation BMPs cannot be placed upstream, discontinue infiltration and install surface-maintained BMPs.

Type: Temporary or Permanent

Stream Crossings

Description

Stream crossings associated with mountain driveways are typically either culverts or bridges. Proper stream crossing design is important to minimize adverse impacts to the stream and man-made structures.

Installation/Design Guidelines

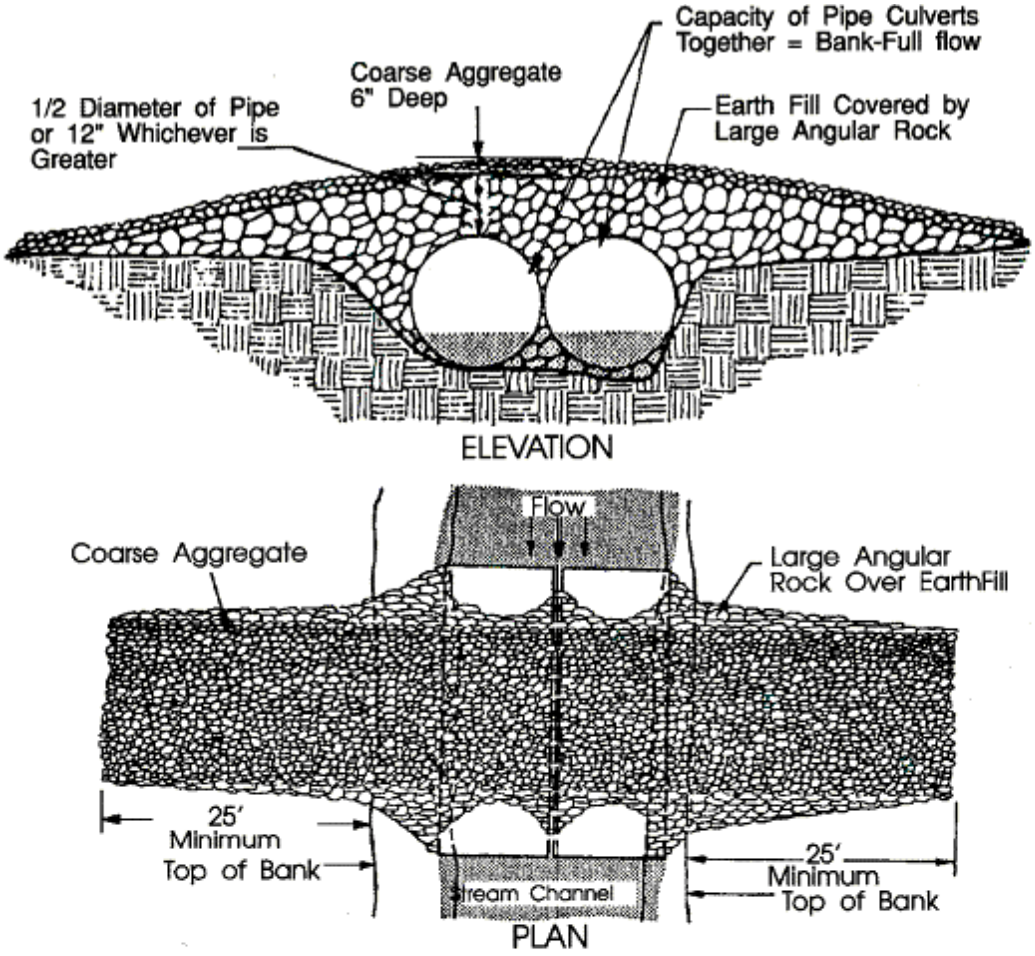
1. Consult with the U.S. Army Corps of Engineers to determine the appropriate Clean Water Act 404 permit necessary prior to construction, in addition to checking local requirements.
2. Design stream crossings to allow adequate passage of fish, to reduce impacts on water quality and to handle peak runoff and flood waters for the 25-year storm at a minimum.
3. Cross streams at right angles to the main channel whenever possible; angled crossings often fail.
4. Adequately size culverts. A minimum of 18-inch diameter with two feet of cover is recommended.
5. Adjust the road grade to drain runoff from it upstream of the stream crossing.
6. Direct roadside ditch flows away from stream crossings to stabilized vegetated areas.
7. On live streams, always consult with your local floodplain manager prior to construction to determine if the planned crossing is located in a 100-year regulatory floodplain.
8. Construct crossing out of erosion-resistant materials such as concrete, asphalt and compacted soil materials.

Special Considerations in Mountainous Areas

1. Phase timing of construction during low flows to protect fisheries and water quality.
2. Consult with a professional engineer prior to instream work.
3. Select crossing location carefully in the context of stream hydraulics—a flat and stable reach is preferable to a riffle location.
4. Unimproved stream crossings are not recommended where permanent/daily access is needed.
5. Provide a plunge pool on downstream side of crossing to aid in dispersing energy and avoid undercutting of embankment.

Maintenance

1. Keep stream crossing openings (e.g., culverts) free of debris.
2. Fortify banks upstream of a bridge or culvert and on the side slopes of a driveway embankment crossing to minimize a culvert washout during a high flow event or season.



From: Virginia Soil and Water Conservation Commission, 1985

As reprinted in Urban Drainage and Flood Control District 1992 Urban Storm Drainage Criteria Manual, Volume 3.

Source Controls

Type: Temporary or Permanent

Description

Pollutant source controls include construction staging, good housekeeping, and proper storage of fuel and chemicals. Materials are sometimes used at construction sites that present a potential for contamination of stormwater runoff. These include fuel, oil, lubricants, paints, solvents, concrete-curing compounds and other liquid chemicals such as fertilizers, herbicides and pesticides. Source controls should be applied to overall site development including both the building site and the driveway.

Installation/Design Guidelines

1. Designate an area for storage of toxic materials and petroleum products at least 100 feet away from water bodies.

2. Know and comply with regulations governing the storage, handling, application and disposal of toxic and hazardous substances.

3. Areas at the construction site used for storage of toxic materials and petroleum products should be designed with an enclosure, container, or dike located around the perimeter of the storage area to prevent discharge of these materials in runoff from the construction site. These barriers will also function to contain spilled materials.

4. Areas used for collection and temporary storage of solid or liquid waste should be designed to prevent discharge of these materials in runoff from the construction site. Collection sites should be located away from the storm drainage system and sensitive riparian areas.

5. Consideration should be given to covering waste storage areas, to containing windblown materials and to constructing a perimeter dike to exclude runoff.

6. Use drip pans as needed under construction equipment.

Special Considerations in Mountainous Areas

1. Construction areas in the mountains are frequently located near sensitive receiving waters (e.g., trout streams); therefore, special care should be taken to prevent spills and leaks from reaching these waters.

2. Toxic materials, such as wood preservatives and some road surface treatments, should be carefully considered and managed when used near streams. Non-toxic product alternatives should be used when feasible.

Maintenance

1. Inspect construction staging and materials storage areas on a daily basis for spills and leaks and clean these up as soon as possible.

Winter Maintenance: Sanding and Snow Removal

Type: Permanent

Description

Winter road maintenance including snow removal and sanding are necessary for safe and efficient use of driveways. However, plowed snow can contain residual amounts of petroleum products, salt and sediment which can adversely impact water quality. Several guidelines can be followed to minimize adverse impacts of winter maintenance as described below.

Installation/Design Guidelines

1. Do not dump or plow snow into or adjacent to stream channels, storm drains or other drainageways.

2. Create a snow storage area which promotes infiltration and evaporation to minimize contaminated snowmelt reaching stream channels.

3. Use the minimum amount of sand with the lowest possible salt content needed to enable safe use of the driveway.

4. Store sand and salt under cover or shelter to prevent washing away.

Special Considerations in Mountainous Areas

1. Check local government regulations for specific requirements for snow removal.

2. Design sedimentation facilities (e.g., traps) adjacent to driveways and parking areas to capture gravel and sand.

Maintenance

1. Remove accumulated sediment and debris as soon as possible. This may involve sweeping sand after storms.

2. Consider reuse of captured materials if sediment fines content is low.

3. Repair roadside vegetation and ditches damaged by accumulation of de-icing materials.

References For More Information

For more information on BMPs appropriate to your area, the following resources and references may provide additional guidance:

Best, Virgil, 1998. "Summit County Native Revegetation Seed Recommendation." *(can be obtained from the Summit County Community Development Division).*

Boulder County Land Use Department, 1998. Miscellaneous Publications on BMPs

Colorado Department of Transportation, 1995. *Erosion and Sediment Control Pocketbook*.

Colorado Native Plant Society Horticulture and Restoration Committee (undated). Suggested Native Plants for Horticultural Use in Northeastern Colorado.

Colorado State Forest Service, 1998. "Colorado Forest Stewardship Guidelines to Protect Water Quality-Best Management Practices for Colorado."

Denver Regional Council of Governments Urban Drainage and Flood Control District and Colorado Department of Transportation, 1998. *Keeping Soil On Site Construction Management Practices*. February.

Fort Collins Soil Conservation District, Big Thompson Soil Conservation District, USDA Soil Conservation Service (undated). Living in Rural Larimer County "An Owner's Manual."

Larimer County, 1998. Brochure for Rural Road Construction.

Salix Applied Earthcare, 1994. *Erosion Draw 2.0 Software and Erosion and Sediment Control Manual for Computer Aided Drafting*. Drawings © 1994 by John McCullah.

United States Department of Agriculture (USDA) Forest Service and Soil Conservation Service, 1992. *Building Water Pollution Control Into Small Forest and Ranchland Roads*.

Urban Drainage and Flood Control District, Denver, CO. *Urban Storm Drainage Criteria Manual, Volume 3*. September 1992.

USDA Forest Service and Soil Conservation Service, 1991. *Woods Roads: A Guide to Planning and Constructing A Forest Roads System*.

USDA Forest Service, 1992. *Winter Sports Guidebook*, June.

USDA Forest Service, 1996. *Managing Roads for Wet Meadow Ecosystem Recovery*. FHWA-FLP-96-016.

Appendix 1

Representative Seed Mixes for Revegetation in Mountainous Areas Examples Included for Northeastern Colorado, Boulder County, Larimer County, Summit County and Denver Front Range Foothill and Montane Zones

SUGGESTED NATIVE PLANTS FOR HORTICULTURAL USE IN NORTHEASTERN COLORADO

Prepared by the Colorado Native Plant Society
Horticulture and Restoration Committee P.O. Box 200
Fort Collins, Colorado 80522

Colorado produces a wealth of native plant -colorful flowering species, grasses, shrubs and trees which are particularly well adapted to our variable climate, soils, temperatures and elevations since they have evolved over many thousands of years. Some have been used in Colorado gardens and landscaping but many have been overlooked in our enthusiasm for exotic imported species which may be less well suited to our environment (or may escape and do all to well to the detriment of natives). The Colorado Native Plant Society encourages the use of native plants in landscaping, both because of their adaptability and because we like the idea of Colorado locking like Colorado with a unique regional horticulture which sets us apart from other parts of the country.

Some native seeds are available from distributors in the region. It is always better to buy seeds from as near your own area as possible. A list of regional seed suppliers follows. Other seeds would need to be gathered from the wild. Remember to obtain permission from private land owners or public land managers before collecting seed. Seed gathering is not allowed on certain public lands (National Parks, City and County of Boulder Open Space, and Boulder Mountain Parks, for example) and a special use permit is required for other public land (National Forests, for example).

Please note: Gather ONLY seeds from plants which are plentiful. Many beautiful one are. Seeds should NOT be gathered from rare or endangered species.

For sources of container-grown plants, check regional nurseries. More native are being grown all the time and as the demand increases, so will the supply. If you don't see something you want, ask for it.

SUGGESTED WILD FLOWERS FOR THE FRONT RANGE -NORTHERN COLORADO		Seed Available From:				Preferred Environment
		Abs	AS	GS	PSW	
Achillea lanulosa	white yarrow	X	X	X	X	P/Sun-Dry-Moist
Amorpha canescens	lead plant	X				Sun/Dandy
Anaphalis margaritacae	pearly everlasting	X	X	X		Sun-Dry
Antennaria parvifolia	pussytoes				X	Dry
Aquilegia coerulea	Colorado (blue) columbine	X	X	X	X	Sun/Shade-Moist
Artemisia frigida	fringed sage	X	X			Dry
Artemisia ludoviciana	prairie sage	X	X			Dry
Asclepias speciosa	showy milkweed				X	Sun-Moist
Calochrtus nutallii	Mariposa lily				X	Sun-Dry
Campanula rotundifolia	harebell		X		X	P/Sun-Moist
Cleome serrulata	Rocky Mountain beeplant				X	Sun-Dry
Dalea purpurea	purple prairie clover	X		X	X	Sun-Dry
Erigeron speciosus	aspen daisy	X	X	X	X	P/Sun-Dry/Moist
Eriogonum umbellatum	sulphur flower	X	X		X	P/Sun-Dry
Erysimum asperum	western wallflower				X	Sun-Dry
Eustoma gmdiflorum	prairie gentian		X		X	Sun-Dry/Moist
Gaillardia aristata	blanket flower	X	X	X	X	Sun-Dry
Geranium caespitosum	wild geranium	X	X			P/Sun/Moist
Ins missouriensis	Rocky Mountain wild iris	X	X	X	X	*PIS* un-Moist
Liatris punctata	spotted gayfeather	X	X	X	X	Sun-Dry
limun lewisii	blue flax	X	X	X	X	P/Sun-Dry
Lupinus argenteus	lupine	X	X	X	X	Sun-Dry/Moist
Mentzelia nuda (decapetala)	blazing star			X	X	Sun-Dry
Monarda fistulosa	wild bergamot	X	X		X	P/Sun-Dry/Moist
Oenthera caespitosa	white evening primrose		X		X	Sun-Dry
Oxytropis lambertii	Lambert's loco				X	Sun-Dry
Penstemon augustifolius	narrow-leaved penstemon					
Penstemon secundiflorus	one-sided penstemon				X	P/Sun-Dry

SUGGESTED WILD FLOWERS FOR THE FRONT RANGE -NORTHERN COLORADO		Seed Available From: Abs	AS	GS	PSW	Preferred Environment
Penstemon stridus	Rocky Mountain penstemon				X	P/Sun-Dry/moist
Penstemon virgatus						
Ratibida colunmifera	prairie coneflower	X	X	X	X	P/Sun-Dry
Rudbeckia hirta	black-eyed susan	X	X	X	X	P/Sun-Moist
Solidago missouriensis	goldenrod			X		Sun-Dry/moist
Sphaaaicea coccinea	scarlet globe mallow		X	X		Sun-Dry
Thermopsis montana	golden banner	X	X		X	P/Sun-Moist
Verbena bipinnatifida	wild verbena				X	Sun-Dry

Seed not available from commercial suppliers in the area.
Wild seed would have to be gathered.

Agaloma marginata	snow-on-the-mountain
Argemone polyanthemos	prickly poppy
Asdepias incamata	swamp milkweed
Astragalus bisculcatus	two-grooved milkvetdl
Astragalus missouriensis	Missouri milkvetdl
Delphinium nelsonii	Nelson's larkspur
Gutierrezia sarothrae	broom snakeweed
Helianthus pumilus	bush sunflower
Heterotheca fulerata	golden aster
Hymenoxys acaulis	
Madlaeranthera panersonii	tansy aster
Madlaeranthera pinnatifida	spiny goldenweed
Oenothera bradlycarpa	yellow stemless evening primrose
Opuntia compressa	prickly pear
Opuntia polyacantha	prickly pear
Oxytropis sericea	Rocky Mountain loco
Penstemon virens	greenleaf penstemon
Penstemon spp	Pensternon (several native species)
Phacelia sericea	purple fringe flower
Scutellana brittonii	skullcap
Senecio plattensis	
Senecio spartioides	butterweed or golden ragwort
Tradescantia occidentalis	prairie spiderwort
Verbena ambrosifolia	wild begonia
Verbena nastata	blue vervain

SUGGESTED NATIVE SMALL/MEDIUM SHRUBS FOR THE FRONT RANGE -NORTHERN COLORADO

Amorphia canescens	leadpaint
Arnorphia fruticosa	fasle indigo
Mostaphylos uva-ursi	kinnikinick
Atriplex canescens	four-winged saltbush
Ceanothus fedieri	Fendier ceanothus or buchbush
Ceratoides lanata	winterfat
Cercocarpus montanus	mountain mahogany
Chrysothamnus nauseosus	golden rabbitbrush
Cornus stolonifera	red osier dogwood
Jamesia americana	waxflower
Juniperus communis	common juniper
Mahonia repens	creeping Oregon grape

Physocarpus monogynus	mountain ninebark
Potentilla fruticosa	shrubby cinquefoil
Purshia tridentata	antelope bitterbrush
Rhus trilobata	three-leaved sumac or skunkbush
Ribes americanum	American black current
Ribes aureum	golden current
Ribes cereum	wax current or squaw current
Rubus deliciosus	Boulder raspberry
Rosa woodsii	wild rose or Woods' rose
Sambucus canadensis	elderberry
Sambucus racemosa	red berried elderberry
Symphoricarpos albus	snowberry
Yucca glauca	narrow-leaf or plains yucca

SUGGESTED NATIVE LARGE SHRUBS/SMALL TREES FOR THE FRONT RANGE-NORTHERN COLORADO

Acer glabrum	Rocky Mountain maple
Acernegundo	boxelder
Alnus tenuifolia	thinleaf alder
Amelanchier alnifolia	serviceberry
Betula fontinalis	river birch
Celtis reticulata	netleaf hackberry
Crataigus succulenta	western hawthorne
Juniperus scopulorum	Rocky Mountain juniper
Prunus americana	wild or American plum
Prunus virginiana	chokecheny
Prunus besseyi	sand cherry .
Rhus glabra	smooth sumac
Sorb us scopulina	mountain ash
Shepherdia argentea	Silver buffaloberry
Shepherdia canadensis	buffaloberry

SUGGESTED NATIVE GRASSES FOR COLORADO

		HEIGHT	PREFERRED ENVIRONMENT
Agropyron dasystachyum	thickspike wheatgrass	15-30*	Sandy, 5000-10000'
Agropyron smithii	western wheatgrass	15-30"	Moist or dry, loam or day, 3500-10000'
Agropyron spicatum	Bluebunch wheatgrass	25-40"	Dry, open woods
Andropogon gerardii	big bluestem	40-80"	Prairies, foothills, 3500-6500'
Andropogon hallii	sand blustem	40-60'	Plains, sand hills. 3500-5200'
Andropogon scoparium	little blustem	20-60"	Prairies, foothills
Bouteloua curtipendula	sideoats grama	20-30"	Prairies, rocky hills, 3500-7500'
Bouteloua gracilis	blue grama	10-20"	Plains, foothills, 3500-9000'
Buchloe dactyloides	Buffalo grass	4-6"	Dry plains, 3500-6000'
Caiamovilfa longifolia	prairie sandreed	20-70"	Sandy prairies. hills, 3500-7000'
Oanthonia parry	Pany oatgrass	10-25"	Mountains. 6000-10000'
Oeschampsia caespitosa	tufted hairgrass	30-50"	Mountain meadows, 7000-10000'
Oistichhs spicata stricta	inland saltgrass	5-15"	Alkaline, boggy 3500-9000'
Elymus canadensis	Canada wildrye	40-60"	Plains, foothills, 3500-9000'
Festuca arizonica	Arizona fescue	15-40" .	Mountains. 6000-1000'
Koelena cristata (macrantha)	Junegrass	15-25"	Prairies, foothills to subalpine, 3500-10000'
Lycurus phleoides	wolftail	10-25"	Plains, rocky hills, 4000-8000'

Muhienbergia asperifolia	scratchgrass	5-20"	Alkaline, moist, 3500-8000'
Muhlenbergia cuspidata	Stonehill muhly	10-15"	Prairies, stony slopes, 5000-6000'
Muhlengergia montana	mountain muhly	10-25"	Foothills, lower mountains, 5600-10000'
Muhlenbergia wrightii	spike muhly	10-25"	Plains, open slopes, 5000-8000'
Qryzopsis hymenoides	Indian ricegrass	15-25"	Sandy plans, mesas, 3500-9500'
Panicum virgatum	switd1grass	40-80"	Marshes, prairies, foothills, 3500-7000'
Poa canbyl	Canby blugrass	20-50"	Dry, sandy, 4500-9000'
Poa sandbergii (secunda)	Sandberg bluegrass	10-25"	Dry plains, rocky slopes, 4500-12000'
Pucinellia nuttallii	alkaligrass	15-25"	Moist, alkaline, 4500-9000'
Redfieldia flexulosa	blowout grass	25-40"	Sand hills, 3500-8000'
Sorgastrum nutans	Indian grass	40-100"	Sand hills, rocky foothills, 3500-6800'
Spartina pectinata	prairie cordgrass	40-80"	Marshes, wet meadows, 3500-7000'
Sporoboius airoides	alkali sacaton	20-40"	Damp.. alkaline, 3500-8000'
Sporobolus cryptandrus	sand dropseed	15-40"	Sandy or loam, 3500-8000'
Sporobolus heteroiepsis	prairie dropseed	15-30"	Prairies, foothills, 5000-7200'
Stipa comata	needle-and thread	15-25"	Plains, dry hills, sandy, 35008500'
Stipa neomexicana	New Mexico feathergrass	15-30"	Mesas, canyons, rocky slopes, 5000-6500'
Stica viriduia	green needlegrass	25-40"	Plains, dry slopes, loam or day, 3500-9000'

WILDFLOWER SEED SOURCES WITHIN THE REGION

Abs
Absoroka Seed
Route 1 Box 97
Manderson, WY 82432
(307) 568-3325

AS
Applewood Seed Co.
5380 Vivian St.
Arvada, CO 80002
(303) 431-6283

GS
Granite Seed
P.O. Box 177
Lehi, UT 84034
(801) 768-4422
(801) 531-1456

PSW
Plants of the Southwest
930 Baca Street
Santa Fe, NM 87501 .
(505) 988-1548

GRASS SEED SOURCES IN NORTHEASTERN COLORADO

Arkansas Valley Seed Co.
4625 Colorado Blvd.
P.O. Box 16025
Denver, CO 80216
(303) 320-7500

Casterline Seed Co.
3 Collins Ave.
P.O. Box 309
Eaton, CO 80615
(303) 454-3484

Garrison Seed Co.
923 D Street
P.O. Box 1604
Greeley, CO 80632
(303) 356-7002

Rocky Mountain Seed Co.
1325 15th St.
P.O. Box 5204
Denver, CO 80217
(303) 623-6223

Sharp Bros. Seed Co.
101 East 4th Street
Greeley, CO 80631.
(303) 356-4710

Wilbur Ellis Co.
1211 Linden
Longrnont, CO 80501
(303) 651-7700

Plant Species Not to Use in Gardening, Reclamation and Restoration
Prepared by the Colorado Native Plant Society, Boulder Chapter

Correspondence may be sent to: CONPS
P.O. Box 200
Fort Collins, CO 80522

The plants listed below are weedy, invasive species which threaten or potentially threaten natural areas, agricultural lands and gardens. A(*) by a plant name indicates that the species is considered a critical problem for habitat(s) in Colorado, and/or is well established as habitat generalist. This is a preliminary working list of species which have escaped from landscaping, reclamation projects and agricultural activity. All problem plants may not be included. If you are unsure about introducing a new plant into your garden or reclamation/restoration plans, maintain a conservative approach. Try to research a new plant thoroughly before using it, or omit it from your plans.

COMMON NAME	SPECIES NAME	PROBLEM	HABITAT
FORBES/FLOWERS			
purple loosestrife* (morden's pink, rose queen, the rocket, purple spire, etc...)	*Lythrum salicaria*	escapes gardens and displaces native vegetation; threatens cattail marshes and other wetlands in Colorado	wetlands; uplands (ie., gardens)
Mediterranean sage	*Salvia aethiopis*	garden escapee; forms monoculture and out competes natives	grasslands, pastures, meadows, range-lands
Myrtle spurge/ Mercer's spurge	*(Euphorbia myrsinites)*	escapes gardens and displaces native vegetation; poisonous to touch (for some people) and if ingested, xeriscape planting	meadows in plains, foothills
Cypress spurge	*Tithymalus cyparissias (Euphorbia cyparissias)*		
Dalmatian toadflax*	*Unaria genistifolia ssp. Dalmatica (Unaria dalmatica)*	escapes gardens and displaces native vegetation; spreads easily *from* seed or stolon	disturbed, open areas (roadsides, trails); plains, foothills, mountain
toadflax/butler & eggs*	*Unaria vulgaris*	escapes gardens and displaces native vegetation	like Dalmatian toadflax, but reaches higher elevations
ox-eye daisy	*Leucanthemum vulgare (Chrysanthemum leucanthemum)*	garden escapee; displaces native vegetation; well established	habitat generalist found from plains to alpine
perennial sweetpea	*Lathyrus latitolius*	escapes and displaces native vegetation	common on urban fringes
dame's rocket/sweet rocket	*Hersperis matronalis*	garden escapee; displaces native vegetation	riparian, wet meadows
dame's rocket/sweet rocket	*Hersperis matronalis*	garden escapee; displaces native vegetation	riparian, wet meadows
soapwort / bouncing bet	*Saponaria officinalis*	escapes and displaces native vegetation	roadsides, trails, homestead sites; mesas and foothills
	Grosshemia macrocephela	escapes and displaces native vegetation	plains, foothills, mountain
sulphur cinquefoil	*Potentilla recta*	adventive	
creeping / Denver bellflower	*campanula rapunculoides*	escapes and displaces native vegetation	foothills, plains, esp. shady places

COMMON NAME	SPECIES NAME	PROBLEM	HABITAT
St. John's wort Klamath weed	*Hupericum perforatum*	competes with, displaces native vegetation; poisonous to some animals	open areas in foothills
Japanese knotweed or buckwheat	*Reynoutria japonica (Polygonum cuspidatum)*	escapes and displaces native vegetation	populated areas at base of foothills
scentless chamomile	*Matricaria perforata*	adventive; competes with native vegetation	mountain roadsides, pastures and town sites
sweet-clover (white and yellow)	*Melilorus alba Melilotus officianalis*	reclamation escapee	roadsides, trails
chicory	*Cichorum intybus*	adventive; competes with native vegetation	roadsides, trails, open areas
oriental virgins bower	*Viticel/a orientalis (Clematis orientalis*	adventive; competes with native vegetation	foothills, mountain: Clear Creek Valley and Canyon
wild carrot. Queen Anne's lace	*Daucus* carota	garden escapee; competes with native vegetation	roadsides, plains, foothills
GRASSES			
thread grass	*Stipa tennuifolia*	becoming a popular xeriscape plant, volunteers readily; potential weed of the future	foothills, grasslands
smooth brome	*Bromopsis inermis (Bromus inermis)*	reclamation, pasture grass; competes with native vegetation via extensive underground roots	plains, foothills, mountain -
crested wheat grass	*Agropyron cristatum*	reclamation grass, persistent	roadsides, trails
Timothy grass	*Phleum pratense*	pasture escapee; competes with native vegetation	dry to wet, habitat generalist
orchard grass	*Dactylis glomerata*	pasture escapee; competes with native vegetation	dry to wet, habitat generalist
SHRUBS			
scotch broom	*Cyisus scoparius*	escapes gardens and displaces native vegetation	a problem on the west coast of U.S.A.
buckthorn	*Frangula alnus*	garden escapee; competes with native vegetation	riparian, plains. urban
TREES			
Russian-olive*	*Eleagnus angustifolia*	escapes and displaces native vegetation; seed commonly dispersed by birds	riparian corridors; lower elevations in Colorado
tamarisk*	*Tamarix ramosissima (Chinensis) T. Parviflora*	escapes and displaces native vegetation; uses large amounts of water	riparian corridors; a particular threat to Western Slope riparian communities
crack willow	*Salix tragilis*	originally cultivated along streams; established and displaces native willow, cottonwood, etc...	riparian corridors, plains, cultivated valleys
white willow	*Salix alba va,. Vitel/ina*	same as So Fragilis	similar to S. fragilis

Boulder County Foothills Native Seed Mix For Dry Slopes

COMMON NAME	SCIENTIFIC NAME	VARIETY	#PLS/A*
Grasses			
Sideoats grama	*Bouteloua curtipendula*	Vaughn	2.7
Bluegrama	*Bouteloua gracilis*	Hachita or Lovington	1.1
Mountain brome	Bromus marginatus	Bromar	5.0
Canada wildrye	*Elvmus conadensis*	Native	3.0
Slender wheatgrass	*Koeleria macrantha*	San Luis	2.2
Western wheatgrass	*Pascropvron smithii*	Arriba	4.8
Beardless wheatgrass	*Pseudoroegneria spicccata ssp. inermis*	Whitmar	4.5
TOTAL			23.3

*#PLS/A = Pounds of Pure Live Seed per acre.

Orders should be made in Pure Live Seed pounds, not bulk pounds.

BOULDER COUNTY HIGH ALTITUDE SEED MIX

COMMON NAMES *Species* "Variety"	Approx. Seeds/Lb.	% of Mix	Total #PLS/ft2	% of Mix #PLS/ft	Total #PLS/A	% of Mix #PLS/A
SIDEOATS GRAMA (Common Names) *Bouteloua curtipendula (Species)* "Vaughn" (Variety)	191,000	15	70	10.5	15.96	2.39
BLUEGRAMA *Bouteloua gracilis* "Hachita", "Lovington"	825,000	15	70	10.5	3.70	0.55
MOUNTAIN BROME *Bromus marginatus* "Whitmar"	70,000	15	70	10.5	43.56	6.53
CANADA WILDRYE *Elvmus conadensis* "Native"	115,000	15	70	10.5	26.51	3.98
JUNEGRASS *Koeleria macrantha* "Native"	2,315,000	10	70	7.0	1.32	0.13
WESTERN WHEAT GRASS *Pascropvron smithii* "Arriba"	110,000	15	70	10.5	27.72	4.16
BEARDLESS WHEATGRASS *Pseudoroegneria spicccata ssp. inermis* "Whitmar"	117,000	15	70	10.5	26.06	3.91
TOTAL		100				21.66

= pounds

PLS = Pure Live Seed

#PLS/ft2 = Number of Pure Live Seed per square foot

#PLS/ A = Pounds of Pure Live Seed per acre (Rate of Application)

SUMMIT COUNTY
NATIVE REVEGETATION SEED RECOMMENDATION

Prepared by
Virgil O. Best II
Restoration Ecologist
PO Box 8202 Breckenridge
Colorado 80424

The following lists of native plant species are specifically recommended for native revegetation in Summit County. All of the species listed are common in the various habitat types found throughout the county. These are general lists intended to provide a basis for revegetation that is not detrimental to adjacent native habitat areas. These lists do not provide specific recommendations for every situation in every type of habitat in the county. Further, these lists contain only grass plant species, although there are many native flowering species suitable for native revegetation, the number and variety would overburden this recommendation. For specific recommendations depending on site specific ecological characteristics, a professional knowledgeable in local native plant species should be consulted.

The two following lists are divided according to standard species composition and dominance in open areas for 1) High elevation and 2) Low elevation. High elevation is defined here as 9100' to ~10,000'—(Dillon Res. to Blue River or Keystone), and low elevation as 9100' to ~8000' —(Dillon Res. to Green Mtn. Res.). In the middle elevation zone the two lists can overlap, and composition and dominance can be varied between the two. Because of the broad range of soil types, slopes, aspects, exposures, moisture regimes, and other specific ecological dynamics on any given site these lists do not attempt to define the "best" native revegetation that may be possible for the site. However, each of the species listed are suitable for the general ecological conditions prevalent in Summit County and will thrive and persist in these conditions.

These lists include a range of plant species that are early and late germinating, fast and slow growing, moderately aggressive and slow dominating. A seed mix resulting from the listed species should be successful in most situations. In cases of high potential for erosion other measures of remediation should also be employed.

Summit County High Elevation Native Plant Species—9,100' to ~10,000

Plant species are grouped in decreasing order of dominance (group 1 =highest dominance, last group = lowest dominance).

Group 1	
Idaho Fescue	*Festuca idahoensis*
Thurber's Fescue	*Festuca thurberi*
Arizona Fescue	*Festuca arizonica*
Alpine Fescue/Rocky Mtn. Fescue	*Festuca saximontana/Festuca Brachyphylla*
Alpine Poa/Bluegrass	*Poa alpina*
Group 2	
Canada Bluegrass	*Poa compressa*
Tufted Hairgrass	*Deschampsia cespitosa*
Group 3	
Junegrass	*Koeleria macrantha*
Parry's Oatgrass	*Danthonia parryi*
Group 4	
Bluebunch Wheatgrass	*Agropyron (Pseudoroegneria) spicata*
Needle-and-Thread Grass	*Stipa (Heterostipa) comata*
Ricegrass	*Stipa (Oryzopsis) hymenoides*

Summit County Low Elevation Native Plant Species—9,100' to ~8,000'

Group 1	
Western Wheatgrass	*Agropyron (Pascopyrum) smithii*
Bluebunch Wheatgrass	*Agropyron (Pseudoroegneria) spicata*
Needle-and-Thread Grass	*Stipa (Heterostipa) comata*
Ricegrass	*Stipa (Oryzopsis) hymenoides*
Junegrass	*Koeleria macrantha*
Canada Bluegrass	*Poa comptressa*
Group 2	
Tufted Hairgrass	*Deschampsia cespitosa*
Idaho Fescue	*Festuca idahoensis*
Arizona Fescue	*Festuca arizonica*
Alpine Fescue/Rocky Mtn. Fescue	*Festuca saximontana/Festuca Brachyphylla*
Thurber's Fescue	*Festuca thurberi*

Note: This is a list of recommended grass species suitable for native revegetation. This recommendation encourages that whenever and wherever possible, a revegetation seed mix be comprised fully of these natives. Or, at a minimum, that some of these species be incorporated within a seed mix.

AGGRESSIVE AND INVASIVE NON-NATIVE PLANT SPECIES DISCOURAGED FROM USE IN REVEGETATION IN SUMMIT COUNTY

BACKGROUND

Coupled with those plant species defined as Colorado Noxious Weeds, a wide variety of other aggressive and invasive plant species present further concern in local habitat quality.. As Summit County grows into the formerly remote and secluded areas of our high mountain environment, many aggressive and invasive plant species push the fragmenting effects of development beyond property boundaries. When introduced in revegetation of disturbed areas these plant species can invade the surrounding native habitat and disrupt areas important for breeding and nesting activities by pushing out the native plant communities. Many of the plants listed here may be of higher importance than certain "noxious weeds" because of their current abundance and distribution in native areas.

Revegetation with native plant species can be more appropriate as a means to integrate development with the native surroundings. By reducing further fragmentation of habitat by aggressive plant species that would damage native plant communities, native revegetation can ameliorate certain effects of growth and development.

By remediating the effects of disturbance on native areas, native revegetation can provide peripheral habitat for plant, bird, and animal species that might otherwise be eliminated from development areas. Increasing the overall disturbed land area revegetated with native plant species can help to integrate human use areas with the surrounding native habitat.

Aggressive, non-native plant species strongly discouraged from use.

Most of the plants on these lists were introduced or improved to be used as fast growing and high productivity plants for improved forage on ranges and in hay meadows. Some of the plants listed here may be native to the US and even in parts of Colorado, however, even these "native" plants are either naturally very aggressive or improved to be aggressive. Because of their adaptation to disturbed soil, fast growth and aggressive characteristics they pose a threat to the remaining native habitat here in Summit County.

The following plant species are considered **very aggressive and invasive**. If introduced in revegetation seed mixes they are capable of disrupting many of the natural balances of Summit County's high alpine environment. These plants can be as equally disruptive as those identified as noxious weeds, these plants are strongly discouraged from use as staple revegetation species.

These plants are strongly discouraged from use as standard revegetation species in Summit County because of their aggressive and invasive characteristics.

GRASSES & WETLAND PLANT SPECIES

Bluegrass- Kentucky, Big
Known as *Poa pratensis/P. ampla/P. secunda/P. nevadensis*

Brome-Smooth, Meadow, Red, Japanese, Canada, & Rescuegrass
Known as various species of *Bromus/Bromopsis.* Aliens, Eurasia & other origins.

Brome-Mountain, Nodding, Fringed
Known as *Bromopsis* (or *Bromus) pumpelliania* or *B. carinatus* or *B. marginatus* & *B. porteri,* or *B. anomalus,* & *B. ciliatus* or *B. canadensis.* These are very aggressive native species.

Bulrush
Known as *Scirpus pallidus* & *S. microcarpus.* Natives only to low elevations.

Common Reed/Reed
Known as *Phragmites australis.* Native only to low elevations.

Foxtail/Meadow Foxtail
Known as *Alopecurus pratensis.* Native only to Eurasia.

Orchardgrass
Known as *Dactylis glomerata.* Native only to Eurasia.

Redtop/Bentgrass
Known as *Agrostis gigantea* & *A. stolonifera.* Natives only of Eurasia and North Africa.

Reed Canarygrass/Miliet

Known as *Phalaris arundinacea* Alien, origin unknown.

Timothy-Alpine, Meadow
Known as *Phleum alpinum/P. pratense.* Natives only of Eurasia.

Alpine Timothy
Known as *Phleum communtatum.* A native species, but easily confused with European " Alpine Timothy" which is a very aggressive alien.

Wheatgrass-Crested, Dwarf, Streamside, Intermediate, Tall, & Quackgrass
These are most commonly known as species of *Agropyron &* Elytrigia. Natives only to Eurasia.

LEGUMES & other Flowering Plants

Alfalfa/Medic(Black Medic)
Known as *Medicago sativa/M. lupulina.* Aliens, origin unknown, escaped from cultivation.

Birdsfoot Trefoil/Lotus
Known as *Lotus tenuis/L. wrightii.* Aliens, origins unknown. *L. wrightii,* possibly native to other US regions.

Clover/Prairie Clover/Alsike/Red/Dutch
Known as various species of *Trifolium (possibly Dalea).* Aliens, various origins.

Cicer Milkvetch
Known as *Astragulus cicer.* Alien, origin unknown.

Lupine/Russel Hybrids
Known as various species of *Lupinus.* Russel hybrids are cultivated perennials, escaping from garden beds, though short-lived, they may cross with natives and limit native populations.

Loosetrife/Purple Loosetrife
Known as *Lythrum salicaria.* Alien, origin unknown, a garden escapee, invasive in wetlands.

Oxeye Daisy
Known as *Chrysanthemum leucanthemum.* Alien, origin unknown. An ornamental escapee, populations on Vail pass (possibly introduced in a seed mix) may now be threatening adjacent native habitat areas.

Sweetclover
Known as *Melilotus alba/M. officinale.* Aliens, origin unknown.

LARIMER COUNTY

FOOTHILLS SPECIES

Grasses		
	Pounds of *PLS per acre	**Percent
Species		**of mix**
blue grama	3	5-20
sideoats grama	9	20-50
western wheatgrass	16	20-40
green needlegrass	10	5-20
switchgrass	45	0-20
big bluestem	11	0-15
yellow indiangrass	10	0-10
little bluestem	7	5-15

Consider the following species for severely disturbed sites where quick establishment is critical.

streambank wheatgrass	11
prairie sandreed	6
[1]hard fescue	4
[1]Canada bluegrass	3
[1]annual ryegrass	10

*PLS = Pure Live Seed - the portion of the seed that is a live seed of the desired kind
**Percent of mix - ranges are suggested percentages and by no means absolute
[1] Introduced species

Shrubs		
honeysuckle	chokecherry	lilac
skunkbush sumac	Woods rose	buffaloberry
golden currant	serviceberry	mountain mahogany
red-osier dogwood	rubber rabbitbrush	

Trees		
eastern red cedar	Rocky Mountain juniper	ponderosa pine
pinon pine	narrowleaf cottonwood	

LARIMER COUNTY

MOUNTAIN SPECIES

Grasses		
	Pounds of *PLS per acre	****Percent**
Species		**of mix**
mountain brome	19	0-20
needleand thread	15	0-15
slender wheatgrass	11	5-10
western wheatgrass	16	5-15
Sandberg bluegrass	3	0-10
bluebunch wheatgrass	14	5-15
Indian ricegrass	13	0-5
big bluegrass	3	0-10
streambank wheatgrass	11	0-25

Consider these species for severely disturbed areas where quick establishment is critical.

thickspike wheatgrass	11
[1]intermediate wheatgrass	15
[1]hard fescue	4
[1]Canada bluegrass	3
[1]timothy	2

*PLS = Pure Live Seed - the portion of the seed that is a live seed of the desired kind

**Percent of mix - ranges are suggested percentages and by no means absolute

[1] Introduced species

Shrubs		
shrubby ciuquefoil	Woods rose	common juniper
thimbleberry	wax currant	skunkbush sumac
golden currant	chokecherry	buffaloberry
mountain mahogany	serviceberry	snowberry
bitterbrush	holly grape	kinnikinnik

Trees		
ponderosa pine	Colorado blue spruce	Douglas fir
Engelmann spruce	lodgepole pine	white fir
bristlecone pine	aspen	alder

LARIMER COUNTY

WILDFLOWERS

Another way of adding color to an area while keeping maintenance to a minimum is to seed wildflowers. Like native grasses, native wildflowers will thrive in areas where other commercial species will not. Many species have the additional benefit of being perennials. To determine which wildflowers are indigenous to your area, refer to "Wildflowers of America," by H. W. Rickett (an 11-volume series available at your local library). Below are some suggested wildflowers.

PLAINS		
yarrow	lance leaved coreopsis	plains coreopsis
perennial gaillardia	annual gaillardia	baby's breath
blue flax	prairie coneflower	smooth aster
New England aster	golden aster	prairie aster
blazing star/gayfeather	scarlet globemallow	plains wallflower

FOOTHILLS		
pasque flower	silky lupine (poisonous to sheep)	Indian paintbrush
sulphur flower	perennial lupine (poisonous to sheep)	blue flax
yarrow	blazing star/gayfeather	harebell
low fleabane	plains wallflower	penstemon

MOUNTAINS		
pasque flower	Colorado blue columbine	sulphur flower
rose pussytoes	Indian paintbrush	baby's breath
bellflower	wallflower	fleabane daisy
perennial gaillardia	silky lupine (poisonous to sheep)	dame's rocket
blue flax	perennial lupine (poisonous to sheep)	penstemmon
catchfly	yarrow	Rocky Mountain iris
arrowleaf balsam		

A QUICK GUIDE TO GRASSES FOR THE DENVER FRONT RANGE FOOTHILL AND MONTANE ZONES

SPECIES	VARIETY	NATIVE/INTRODUCED	BUNCHGRASS/SOD FORMING	COOL/WARM SEASON	MINIMUM PRECIPITATION IN INCHED	ELEVATION	HABITAT	ACID TOLERANCE	HIGH WATER TABLE TOLERANCE	MATURE HEIGHT IN FEET	SOIL TEXTURE	COMMENTS	BROADCAST LBS PLS/AC.
Arizona fescue	Redondo	N	B	C	14	6,500-10,500	open woods, rocky slopes	M	L	1 to 3	G, SL	b	9
alpine bluegrass	native	N	B	C	20	8,500-13,500	tundra, gravelly slopes,	H	L	<1	G, SL		6
big bluegrass	Sherman	N	B	C	10	5,000- 9,500	meadows, hills, valleys	M	M	>2	G, SL		6
big bluestem	Kaw	N	B	W	15	3,500- 7,500	prairies, meadows, foothills	M-L	M	3 to 6	SL	a	22
blue grama	Lovington/ Hachita	N	B	W	12	3,500-10,500	plains, prairies, hills	L	L	<2	G, SL	a	6
bluebunch wheatgrass	Secar	N	B	C	8	5,000- 8,000	dry slopes, rocky hills, open woods	M	L	1 to 2	G, SL	b	28
Canada bluegrass	Reubens	I	S	C	15	3,500- 9,500	open ground, thin woods, waste places	H-M	M	1 to 2	G, SL		2
Canada wildrye	Native	N	B	C	12	3,500- 9,000	open woods	L	M	>2	SL		32
Canby bluegrass	Canbar	N	B	C	10	4,500- 9,800	dry meadows, hills, open woods	M	M	1 to 2	G, SL		6
crested wheatgrass	Hycrest/ Ephraim	I	B	C	10	4,500- 9,000		M	M-L	1 to 3	SL		20
green needlegrass	Lodorm	N	B	C	15	3,500- 8,000	plains, dry slopes, hills	M	H-M	1 to 2	SL		20
hard fescue	Durar	I	B	C	16	6,500-12,000		H-M	L	1 to 3	G, SL		8
indian ricegrass	Nezpar/Paloma	N	B	C	9	4,000- 9,500	plains, canyons, hills	M	L	1 to 2	G, SL	b	25
intermediate wheatgrass	Amur/ Oahe	I	S	C	14	4,500- 9,000		M	M	2 to 4	SL		30
little bluestem	pastura/Camper	N	B	W	14	3,500- 8,000	prairies, dry hills, open woods	M	L	1 to 4	G, SL	a	14
mountain brome	Bromar	N	B	C	16	5,000-10,000	open woods, meadows	M	L	>2	SL	c	38
needleandthread	native	N	B	C	10	3,500- 8,500	plains, prairies, dry hills	M	L	>2	SL		30
prairie junegrass	native	N	B	C	12	3,500-11,500	prairies, open woods, rocky hillsides	L	L	1 to 2	SL		2
pubescent wheatgrass	Luna	I	S	C	14	4,500- 9,000		M	M	1 to 2	SL		28
red fescue		I	B	C	18	7,000-10,000		H-M	L-M	1 to 3	G, SL	d	8
redtop		I	S	C	20	3,500- 9,000	meadows, wet meadows, streamsides	H	H	>2	SL		1
Sandberg bluegrass	native	N	B	C	8	4,500-12,000	plains, dry woods, rocky hillsides	L-M	L	1 to 2	G, SL		6
sheep fescue	Covar	I	B	C	10	6,500-12,000	open woods, stony slopes	H-M	L	1 to 2	G, SL		8
sideoats grama	Vaughn/ Butte	N	B	W	8	3,500- 9,000	plains, hillsides, valleys	M	M	1 to 3	G, SL	a	18
slender wheatgrass	San Luis/ Primar	N	B	C	16	4,500-12,000	hillsides, meadows	M	M	1 to 2	G, SL	c	22
smooth brome	Lincoln! Manchar	I	S	C	12	4,500-10,000		M	M	2 to 4	SL		26
streambank wheatgrass	Sodar	N	S	C	8	4,500- 9,000	meadows, hills	M	M-L	>2	SL		22
thickspike wheatgrass	Critana	N	S	C	8	5,000-10,000	plains, sandy or gravelly soil	M	M-L	1 to 2	SL		22
tufted hairgrass	native	N	B	C	20	7,000-13,000	bogs, wet meadows	H	H	1 to 2	SL		2
western wheatgrass	Rosanal Arriba	N	S	C	10	3,500-10,500	hills, plains	M	H	1 to 3	G, SL		32

NRCS 1999

ADAPTABILITY RATINGS:

H = High

M = Moderate

L = Low

SOIL TEXTURE:

G = Decomposed granite, Gravel

SL = Sandy loam

COMMENTS:

a = Should be planted on south and west facing slopes, or open areas that receive direct sunlight.

b = Not recommended for north facing slopes

c = Short-lived perennial

d = Very shade tolerant

EXAMPLE FOR DETERMINING SEEDING RATES IN MIXTURES:

Species	Variety	Mix %		Broadcast Lbs. PLS/Acre		Desired Seeding rate
Arizona fescue	Redondo.	30	X	9	=	2.7
Slender wheatgrass	San Luis	15	X	22	=	3.3
Blue grama	Lovington	15	X	6	=	0.9
Streambank wheatgrass	Sodar	30	X	22	=	6.6
Indian ricegrass	Nezpar	10	X	25	=	2.5

BIBLIOGRAPHY:

Arkansas Valley Seed Co., Seeding Information For Pasture And Reclamation Species

Grassland West, Reclamation Products Catalog

Harrington, H.D., Manual Of The Plants Of Colorado

NRCS, Standards & Specifications: Critical Area Planting #342

NRCS, Colorado Agronomy Note #61: Seeding Rates

NRCS, Plant Materials Note #59: Recommended Grass Cultivars In Colorado

Weber, William A. Colorado Flora Eastern Slope

NRCS 1999 (continued)

Wright Water Engineers, Inc.
2490 W. 26th Avenue
Suite 100A
Denver, Colorado 80211
www.wrightwater.com

Denver Regional Council of Governments
2480 W. 26th Avenue
Suite 200B
Denver, Colorado 80211
www.drcog.org