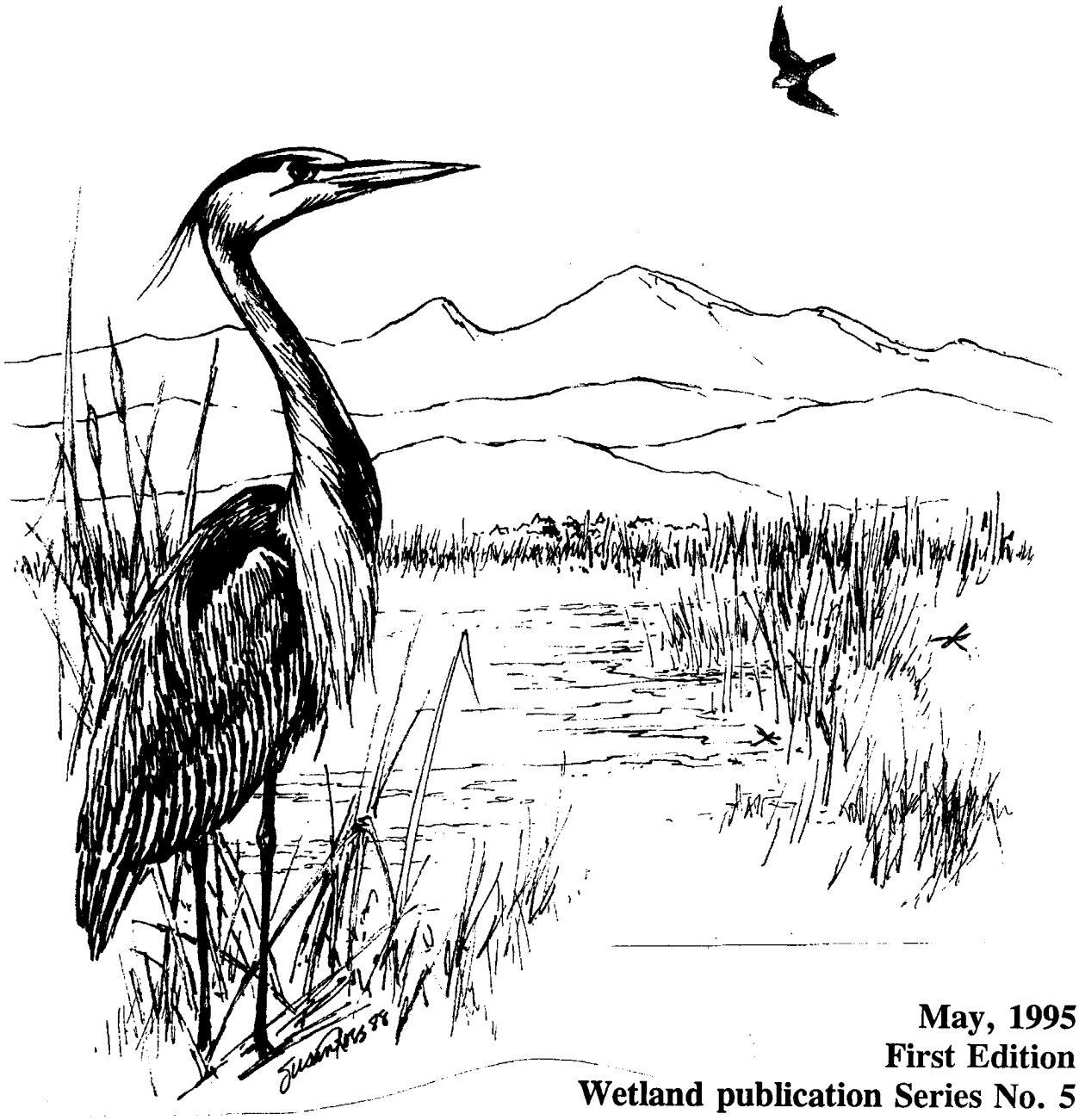
City of Boulder
Wetlands Protection Program
Best Management Practices



May, 1995
First Edition
Wetland publication Series No. 5
Rule Adopted July, 1995

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Part I SUMMARY OF RULES

Executive Summary

Part I of this document contains a summary of the regulatory framework requiring Best Management Practices (BMPs). A description of BMPs and specific BMPs for certain activities follows as Part II. Part III contains information on the standards for erosion control plans including recommended specifications for structural BMPs.

Introduction

The City of Boulder's Wetland Protection Ordinance, Section 9-12-1, et.seq., B.R.C.1981, ("the ordinance") became effective January 1, 1993. The ordinance establishes a goal of no-net-loss of wetland acreage and function by regulating activities in and around wetlands. A copy of the ordinance is available from the Planning Department.[1]

These rules apply to all regulated areas as set forth in the ordinance, including all wetlands mapped within Boulder's city limits as well as all wetlands on City owned land, and all City activities affecting wetlands regardless of location. A map showing the approximate location of the wetlands within the City of Boulder is available from the Planning Department. On the map, significant wetlands are distinguished from other wetlands. The definition of a significant wetland can be found in Section 9-12-2 of the ordinance. In addition to the wetland itself, the ordinance establishes a buffer area around wetlands. Significant wetlands have a default buffer area extending 50 feet from the wetland boundary, other wetlands have a default buffer of 25 feet. Section 9-12-4(e) and (f), B.R.C.1981. The wetland and the buffer together are considered the regulated area.

Specifically, BMP's are required in order to proceed pursuant to Section 9-12-5(c) and (d), B.R.C.1981. In addition, BMP's may be utilized pursuant to other sections of the ordinance, including, but not limited to, conditions in wetland permits, Section 9-12-9, B.R.C.1981, or as part of a mitigation plan, Section 9-12-10, B.R.C.1981. These rules set forth the appropriate BMP's for implementation of the ordinance.

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[1]Materials available from the Planning Department may be picked up on the third floor of the Park Central Building. The Park Central building is located on the northwest corner of Broadway and Arapahoe Road in Boulder. The telephone number is 441-3270.

Activities within the regulated area fall into one of three groups.

1-Allowed Activities

Any activity which does not reduce the extent of a wetland or significantly reduce the degree to which a wetland performs a function is allowed in a regulated area without a permit. Minor improvements within a buffer but outside a wetland are also allowed without a permit. Minor improvements are fully defined in the ordinance and include landscaping, placement of children's play equipment, etc.

2-Activities subject to Best Management Practices

A set of activities are permissible in a regulated area even though they may reduce the extent of a wetland or significantly reduce the degree to which a wetland performs a function when BMPs are used.

3-Activities Requiring a Permit

Any other activity in a regulated area which could reduce the extent of a wetland or significantly reduce the degree to which that wetland performs wetland functions requires a City permit.

Definition and Application of BMP'S

The definition of BMPs according to the Wetlands Protection Ordinance is:

> **Best Management Practices** are economically feasible conservation practices and land and water management measures that avoid or minimize adverse impacts to the chemical, physical, or biological characteristics of wetlands. Such practices include, without limitation, avoiding wetlands whenever practicable; controlling soil loss; reducing water quality degradation; and minimizing the impacts on hydrologically connected surface and ground water and on the plants and animals that the water supports.(Section 9-12-2, B.R.C.1981)

As set forth in Section 9-12-5(c):(d), B.R.C.1981, Best Management Practices are applicable to activities which are in the public interest, if those activities do not materially change or enlarge any road, structure, or facility. Specifically, BMPs apply to:

Maintenance of existing public or private roads, structures, or facilities including drainage facilities, water conveyance structures, dams, fences, trails, and facilities used to provide transportation, electric, gas, water, telephone, or other services;

Maintenance of existing farm ponds, irrigation ditches, fences, or drainage systems;

Weed control consistent with state and county laws; and

Continuation of existing agricultural practices such as cultivation and harvesting of hay or pasturing of livestock including changes to agricultural practices which have no greater impact on wetland functions.

Functionally, BMPs are practices designed to consider the needs and values of the community. They balance economic feasibility with biological sustainability. Agricultural practices, weed control, and the maintenance of urban services can have significant cumulative and detrimental impacts on wetlands. However, roads, public utilities and the agricultural heritage of the Boulder Valley are important values to the community. The BMPs presented in this document recognize that certain services and goals of the community are sometimes in conflict with preservation of wetlands. Through the use of the BMPs some impacts can be avoided and others minimized. This document also presents methods for compensating for wetland loss through BMPs.

The concepts of avoidance, minimization and compensation are central to the wetlands protection program. Best Management Practices have been drafted for the activities listed in Part II of the Table of Contents. For each activity listed there are practices that lead to avoidance or minimization of impacts to wetlands.

Although BMPs are requirements for certain activities, other projects could benefit from the application of the BMPs. Private landowners outside of the City, for example, are encouraged to employ BMPs wherever applicable.

Part II. DESCRIPTION OF BEST MANAGEMENT PRACTICES

General BMP'S

These general BMPs are mandatory for all activities requiring Best Management Practices.

Parties contemplating activities that will require revegetation with native plant materials should plan at least one full year in advance to allow time for determining reclamation standards and locating sources of plant materials.

AVOIDANCE

1. Examine practical alternatives to any activities which may have an impact upon wetland size or function.
2. Avoid all activities which would jeopardize the continued existence of habitat known to be used by the following species:[2]
   a. Plant, animal, or other wildlife species listed as threatened or endangered by the United States Fish and Wildlife Service;
   b. Plant, animal, or other wildlife species listed by the State of Colorado as rare, threatened or endangered or species of special concern;
   c. Plant, animal, or other wildlife species listed in the Boulder County Comprehensive Plan as critical.

MINIMIZATION

1. Conduct work on an as-needed basis rather than at specified regular intervals. (In many cases maintenance schedules have evolved to coincide with the actual requirements. In those cases, the responsible entity should explain the criteria used to determine the thresholds for maintenance activities.)
2. Protect wildlife habitat, especially dens, burrows and nesting sites identified on the site.
3. Conduct work in or around habitat critical for wildlife during times of the year when such work would not disturb the species of concern.
4. Reduce the area of disturbance to a minimum by planning access only where absolutely necessary. Install fencing (construction fencing, conventional snow fencing, cyclone fencing,etc.) along the limits of required disturbance to prevent construction equipment from entering regulated areas.

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[2]Appendix A contains a listing of species for the Boulder Valley. Listings are updated periodically and are available from the Planning Department.

5. In areas lacking a clearly established access route and staging area, fence sensitive areas such as wetlands and riparian forests to exclude unnecessary disruptive access.
6. Limit disturbance to the minimum duration possible.
7. Place heavy equipment on stabilization mats when working in wetlands.
8. Minimize use of heavy machinery in regulated areas.
9. Use the smallest available equipment that is feasible.
10. Operate equipment for handling and conveying materials during construction to prevent dumping or spilling the materials into wetlands.
11. Do not clean equipment in a regulated area, or where runoff will enter a regulated area.
12. Salvage native plant materials for reclamation where possible.
13. Accomplish work during low flow periods.
14. Agree to an acceptable erosion control plan, if applicable. (See Part III)
15. Remove excavated materials in layers and later replace in the original sequence.
16. Return disturbed areas to preconstruction grade and replant with native vegetation appropriate to the locality.
17. If disturbance occurs at a creek or stream crossing, restore stream profile, substrate and habitat to similar or better conditions than those that existed before the start of the activity.
18. Protect vegetation which is not being removed as part of the activity from mechanical and other injury during activities disturbing the land. (Technical information and suggested specifications for protecting vegetation can be found in Part II of this document).

Specific BMP's

MAINTENANCE

A. Road Maintenance

Road maintenance practices can result in sedimentation, introduction of toxic substances, as well as an increase in nutrient load, changes in pH and salinity, and oxygen balance, increases in suspended and dissolved solids and turbidity. In addition to water quality impacts, road maintenance can result in the alteration of plant and animal habitat and have an adverse impact on the aesthetic value of roadside wetlands.

1. Cleaning roadside ditches, channels and drainage structures
   a. Follow BMPs for herbicide use
   b. Rake and remove (to central composting facility, if available) mowed debris that might enter wetland where feasible.
   c. Limit the clearing of vegetation to that which is absolutely necessary to maintain the channel and eliminate site restrictions.

2. Blading and restoring unpaved berms and/or shoulders
   a. Minimize dispersal of dust by adding moisture when necessary.
   b. Use appropriate erosion control measures (see Part III).

3. Repairing curbs, gutters and paved roadside drainage ditches
   a. Avoid when probability of high winds or precipitation is high.

4. Repairing slopes, slips and slides
   a. Use appropriate erosion control measures (see Part III).

5. Repairing drainage structures
   a. Use appropriate erosion control measures (see Part III).
   b. Avoid creating conditions which result in the accelerated passage of water.
   c. Avoid creating conditions which result in the restriction or impediment to the movement of wildlife including fish.
   d. Avoid creating conditions which result in the restriction of flow
      i. do not reduce the cross sectional area of the channel.
      ii. pipes should be designed to carry normal and expected high flows according to appropriate City of Boulder, or Boulder County standards.

6. Bridge painting, cleaning and deck repairs
   a. Use nets, and shrouding systems to catch sand blasting debris
   b. Avoid sandblasting or clean bridges on high-wind days
   c. Use float straw or boom-type collectors to contain paint that may enter water where feasible.

7. Mowing
   a. Rake and remove (to central composting facility, if available) mowed debris that might enter wetland to the extent practicable.
   b. Avoid mowing wetland vegetation except where there are safety concerns such as decreased visibility and weed control requirements.

8. Planting or care of landscaping
   a. Use primarily native species appropriate to the locality. Use seed gathered from local sources if possible.
   b. Do not use invasive or noxious species of plants.
   c. Use fertilizer only when the results of soil nutrient analysis indicate that such application is necessary for establishing the approved planting.
   d. Experiment with fertilizer rates below manufacturers specifications. Do not over apply. In any event, use of fertilizer is limited to approved application rates.
   e. Use slow release type fertilizers.
   f. Avoid applying fertilizers when there is a high probability of rain.

9. Applications of abrasives
    a. Minimize use and amount of abrasives to the amount necessary to maintain safety.
    b. Use abrasives with a minimum of fine particles.

10. De-icing practices
    a. Limit use of de-icing compounds to approved application rates except under extreme weather conditions.
    b. Limit use of de-icing compounds to those products which have lowest levels of toxicity.
    c. Minimize the degree to which de-icing compounds enter waterways and ground or surface water.

B. Bikeway Maintenance

Many of the bikeways in the City have been built along the tributaries to Boulder Creek. The maintenance of the Boulder Creek Path, the Tributary Greenways and other bikeways can result in sedimentation and the introduction of toxic substances to the creek. In addition to water quality impacts, the management of the vegetation along the paths may have undesirable impacts upon plant and animal habitats as well on their visual appeal.

1. De-icing practices
    a. Minimize the use of de-icing compounds on greenways and the Boulder Creek Trail.
    b. Minimize the degree to which de-icing compounds enter waterways and ground water.
    c. Investigate temporary alternatives such as
        i. avoiding ice-covered underpasses by using at-grade crossings.
        ii. closing paths temporarily.
        iii. re-engineering drainage facilities at underpasses to prevent accumulation of water and ice.
        iv. the use of gravel to provide traction on icy areas. Gravel applied for this purpose would need to be removed periodically to avoid safety hazards and transport into creeks and wetlands.

2. Mowing and landscaping
    a. Limit the removal of vegetation to that which is absolutely necessary to maintain safety and weed control.
    b. Use primarily native species appropriate to the locality in plantings. Use seed gathered from local sources if possible.

C. Trail Maintenance

Maintenance of Mountain Parks and Open Space trails can result in the filling of wetlands and the removal of vegetation.

1. Disposal of material during maintenance
   a. Ensure proper disposal of all debris in appropriate upland site
   b. Rerouting or realignments of trails must avoid impacts to wetland area and function.
2. Preserve native material for reclamation.
3. Limit the removal of vegetation to that which is absolutely necessary to maintain safety.

D. Drainage Facilities

Urban storm drainageways are in many instances what remains of the natural erosional features which historically drained the area. Boulder Creek and its tributaries act as collectors for urban runoff. The maintenance of existing drainageways usually results in the removal of sediment including the substrate and vegetation of wetlands established in channel bottoms. Other maintenance activities can reduce the structural diversity of wildlife habitat in the areas along the creek channels.

1. Channel cleaning and restoring channel bottom grades
   a. Plan to perform instream work during winter low flows.
   b. Decrease overall impact if possible, by keeping machinery from entering the channel and by working from upland sites along the channel banks.
   c. Deposit excavated materials outside of regulated areas.
   d. Establish and carry out a program for regular removal of debris during construction to prevent the accumulation of unsightly or potentially polluted materials.
   e. Limit the clearing of vegetation to that which is absolutely necessary for the project.

2. Mowing
   a. Limit the removal of vegetation to that which is absolutely necessary to maintain safety.
   b. Rake and remove (to central composting facility, if available) mowed debris that might enter wetland where practicable.

3. Preserve native material for reclamation.

E. Irrigation Ditch Maintenance

The maintenance and repair of headgates in natural creek drainage can result in disturbances to regulated areas in and around creeks. In addition, material sidecast

from irrigation ditches into jurisdictional regulated areas can result in the introduction of sediment, fill material and other debris into regulated areas. Follow the general BMPs beginning on page 4.

Deposit excavated materials outside of regulated areas and in an appropriate location.

Drawings indicating the area of anticipated impact and access routes for headgates of irrigation ditches within the city limits are available from the Planning Department. The access routes shown are intended to avoid and or minimize impacts to mapped wetlands. Applicants are encouraged to develop alternative routes or management practices to further reduce wetland impact, or impacts to other public facilities. The designation of these access routes in no way relieves the party contemplating maintenance from obtaining the necessary permission of affected property owners or land managers.

The "areas of anticipated impact" have been drawn to indicate the maximum limits of disturbance to the wetland or the surrounding regulated area. If a party contemplating maintenance of a headgate considers the "area of anticipated impact" too small, that party shall contact the Planning Department with a proposed revision to the area of impact and a description of why the previously described area is inadequate.

F. Farm/Stock Pond Maintenance

The maintenance of farm ponds and stock ponds can result in the removal of sediment and vegetation from regulated areas. Activities of heavy machinery associated with such maintenance may introduce sediment into regulated areas as well as result in destruction of wetland vegetation and changes in surface runoff patterns. Dredging of stock and farm ponds is likely to have an impact upon wetland functions. No guidelines have been developed to address activities associated with pond maintenance specifically. Follow the general BMPs beginning on page 4.

G. Dam Maintenance

Dam maintenance can result in the removal of plants or animals living in a pond. Repair activities can result in the introduction of sediments into regulated areas. No guidelines have been developed to address activities associated with dam maintenance specifically. Follow the general BMPs beginning on page 4.

H. Fence Maintenance

Fence maintenance can result in the destruction of wetland function through the trampling of vegetation and changes in surface runoff patterns brought about by vehicular access. Vehicular access through regulated areas and the use of

machinery in regulated areas for fence maintenance are likely to have an impact upon regulated areas. No guidelines have been developed to address activities associated with fence maintenance specifically. Follow the general BMPs beginning on page 4.

I. Pipeline Maintenance

The construction activities associated with the repair of pipelines can result in damage to wetland function by changing the local hydrologic regime and by destroying nearby vegetation and disturbing wildlife habitats. Construction activities can also result in the introduction of sediments to regulated areas. Disturbances associated with the excavation of a pipeline in need of repair are likely to have an impact upon regulated areas. The use of porous coarse material such as gravel for the bedding for a pipeline could result in adverse hydrological impacts.

1. Return disturbed areas to preconstruction grade and replant with native vegetation appropriate to the locality. Use seed gathered seed from local sources if possible.
2. Use impervious barriers where a transmission line intercepts wetland hydrology to prevent wetland drainage.

J. Drainage System Repair

The construction activities associated with the repair of drainage systems, such as underdrains and tile systems, can result in damage to wetland function by changing the local hydrologic regime and by the local destruction of vegetation and disturbance of wildlife habitat. Construction activities can also result in the introduction of sediments to wetlands.

Excavated materials will be removed in layers and later replaced in the original sequence.

K. Weed and Pest Control

Weed and pest control through the use of herbicides and pesticides can result in the contamination of wetlands with pollutants. The primary modes of transport of herbicides to wetlands are direct application, surface runoff, aerial drift, volatilization and uptake by plants and animals. Predicting the fate of a pesticide in wetlands based on available information currently is difficult for many reasons. Most data dealing with the fate of pesticides are derived from terrestrial ecosystems. The ecological effects of even low levels of contamination are subtle, as well as difficult and expensive to track. Furthermore, there are no data available for many formulations and one herbicide may behave differently from those that are chemically related.

Avoidance

1. Use other weed management techniques as part of an Integrated Pest Management Plan[3] to avoid the use of herbicides in wetlands. (such as grazing, mowing and approved biological control agent)
2. Do not apply pesticides aerially in the vicinity of wetlands.

Minimization

1. Evaluate alternative herbicides to determine the highest effectiveness at the lowest toxicity to non-target organisms and the lowest persistency. In any event, use of herbicides will be limited to approved application rates in accordance with manufacturer's label instructions.
2. Apply herbicides in accordance to manufacturer's label directions.
3. Limit herbicide use to periods in the life-cycle of the weed when the herbicide is likely to be most effective and least toxic to non-target species.
4. Herbicide shall be applied only by personnel certified by the appropriate state and federal agencies.
5. Mix pesticides and calibrate application equipment accurately.
6. Improve efficiency of pesticide application.
7. Avoid applying herbicides when there is a high probability of rain or high winds and employ drift retardants whenever practical to avoid impacts to wetlands.

Agricultural Practices and BMP's

Tillage

Tillage and cropping can result in damage to wetland function directly through an annual or periodic disturbance to the vegetation, soil and hydrology in cases where wetlands are being actively farmed. Impacts to wildlife using tilled wetlands can be especially severe. Indirect effects of tilling upon wetlands include the introduction of sediments, insecticides, herbicides and fertilizers into wetlands, and the removal of hiding, feeding and nesting cover areas adjacent to wetlands.

Turbidity in lakes and wetlands is often caused by runoff from cultivated fields. Suspended solids and turbidity decrease light penetration and increase water temperature, affecting the plant growth in wetlands. Fine soil particles such as clay and silt can directly affect aquatic life such as invertebrates which filter algae from the water. Species of insects which are intolerant to such degraded water quality give way to other types of

[3]Copies of the City's IPM plan are available from the Office of Environmental Affairs (441-3090)

invertebrates which in turn results in changes to the fish populations and predators which feed upon the fish.

Fertilizers contain nutrients such as phosphorus, nitrogen and potassium. Although important for enhancing crop production, these nutrients can be pollutants in wetlands. Although wetlands can immobilize nitrogen and fix phosphorus, the capability is limited and a great deal remains to be learned about the impacts of these nutrients upon the wetlands themselves.

Insecticides pose a great threat to wetland wildlife, particularly to birds. Impacts of pesticides include reduced productivity through interference with many aspects of the reproductive biology of various bird species. Species dependent upon wetlands can be affected when traveling through an upland site which has been sprayed with insecticides.

Perhaps most important is the interaction among sediment transport, fertilizers and pesticides. Nutrients and pesticides can become bound to sediment and carried to wetlands as soil erodes. The amount of contamination associated with the silt and clay particles is often higher than the pollutant levels in the water in which those particles are suspended.

Pasture and Hayland Management

Many of the most productive hayfields and pastures in Boulder are located in the floodplains of South Boulder Creek, Dry Creek and other tributaries to Boulder Creek. The rich floodplain soils, availability of groundwater, the proximity of irrigation water and past land management practices combine to make conditions favorable for growing hay or creating rich pastures.

The management of pastures and hayfields can result in impacts to wetlands by the removal of vegetation. This can directly result in impacts to plant species as well as to the habitat of various grassland animals. Management practices can also have an effect upon the composition of the vegetation, favoring non-native plants and weeds. Management can affect native wetland vegetation depending upon the season of use. The use of fertilizers in hayfields can result in undesirable increased nutrient levels in wetlands and adjacent native plant communities.

Grazing

Impacts of grazing livestock upon wetlands can be severe. In the semi-arid western United States, grazing impacts are concentrated in wetlands. Native wetland plants are destroyed by hoof action of cattle and horses drawn to the moisture, cooler temperature and open water of wetlands. In the absence of vegetation, shorelines and creek banks erode more easily, topsoil is washed away and weedy species colonize the disturbed areas. In streamside wetlands the removal of woody vegetation to encourage grass species more palatable to livestock results in less stable streambanks and higher water temperatures. In cases of severe bank erosion and down cutting, the resulting lowering of the water table can result in wetlands being replaced with drier (usually weedy) vegetation. Manure and nutrient rich sediments are introduced into wetlands often dramatically altering the water chemistry and aquatic plant and animal communities. Nevertheless, grazing has been found to be an important process structuring native ecosystems in this region. The habitat of several local rare plant species seems to depend upon disturbances such as those caused by grazing. Grazing is also being used as an effective alternative to herbicide use for weed control.

AGRICULTURAL BMPs

Avoidance

Do not till wetlands.

Minimization

1. Limit livestock access to wetlands, streambanks and pond shorelines to the minimum necessary for watering, weed control or other management needs.
2. Use conservation tillage practices to reduce soil erosion.
3. Plant and maintain native grass filter strips between cropped fields and adjacent wetlands.
4. Maintain vegetated buffer strips adjacent to wetlands where native vegetation is present.
5. Reclaim unvegetated drainage.
6. Control soil fertility carefully so that crop needs are met, while minimizing nutrient losses to wetlands.
7. Control the timing of grazing in wetlands to coincide with physiological requirements of wetland plants.
8. Experiment with rates of pesticide and fertilizer use below manufacturers specifications. Do not over apply. In any event, use of pesticides and fertilizers will be limited to approved application rates.
9. Use slow release type fertilizers.
10. Avoid applying pesticides and fertilizers when there is a high probability of rain.

PART III: GUIDANCE FOR SEDIMENT AND EROSION CONTROL PLANS

These following materials were largely taken from the *Virginia Erosion and Sediment Control Handbook* and the *Urban Drainage Criteria Manual.* Modifications have been made to make the guidance applicable to best management practices in wetlands. The technical information and suggested specifications referred to are usually materials copied directly from these sources.

Introduction and General Information

An erosion control plan can help to mitigate soil erosion and deposition of sediment in wetlands during construction activities. Deposition of sediment can have detrimental effects upon water quality, visual appeal, vegetation and a range of biological processes. Increased turbidity, for example, decreases the amount of light available to plants in wetlands resulting in decreased productivity. Aquatic invertebrates such as insects and their kin often filter their food from organic particles suspended in the water. An influx of fine sand or silt interferes with the ability of these creatures to feed. Impacts to the invertebrates are passed on to fish and shorebirds which are dependent upon these filter feeders.

An erosion and sediment control plan is required for all activities which will result in earth disturbance or the introduction of sediment into wetlands. Completed plans primarily will be a condition of wetland permits for major construction projects where potential erosion or sedimentation presents an exceptional hazard. Most often, applicants may be asked simply to agree to acceptable erosion control methods for a particular project.

Erosion control involves planning, implementation and maintenance.

Planning

Planning of erosion control should occur at the same time as the planning of the maintenance or repair activity. Agencies must submit erosion control plans to the City on an annual basis for activities which are planned for the upcoming year. This erosion and sediment control plan is a part of the notification required under the wetlands protection ordinance [9-12-5 (d)(2), B.R.C. 1981]. To the degree it is possible, site specific plans should be submitted. Some general guidelines for devising an erosion control plan are:

1. *Minimize the extent of the area to be disturbed at a given time.*
2. *Minimize the duration of disturbance.*
3. *Use erosion control practices to minimize on-site impacts.*
4. *Use perimeter control practices to prevent downstream sedimentation and impacts from off-site runoff into the disturbed area.*
5. *Avoid runoff and sediment transport through retention.*

6. *Minimize velocities of unavoidable runoff.*
7. *Stabilize disturbed areas immediately after maintenance or repair activity.*
8. *Include a maintenance program for erosion control.*
9. *Accomplish work during low flow periods.*

These principles should be integrated into a system of structural and vegetative measures and management techniques to minimize erosion and sedimentation.

In order to develop an acceptable plan, it is important to be aware of several site characteristics. **Climate, topography, vegetation, soil type, and conditions adjacent to the site** are important site characteristics which affect the potential for erosion. Steep slopes and large drainages are more prone to erosion than flat areas and smaller drainages. Vegetated areas are less likely to be a source of sediment than barren ground because roots bind soil particles. Leaves and stems reduce the impact of rain and slow runoff. Several soil characteristics control the degree to which soils will erode. These soil characteristics include permeability, depth, texture and structure. Coarse and loose sandy soils are more likely to erode than sticky clays. Off-site impacts can cause erosion problems even on gently sloping, well-vegetated and well-drained areas. The erosion control plan for maintenance and repair activities should address potential off-site impacts if they are likely. Dry or frozen ground conditions will reduce the direct impact of construction equipment.

It is critical for the success of an erosion and sedimentation control plan to recognize that techniques for avoiding erosion are much more effective than techniques for removing suspended sediments.

Erosion Control Plans

All drawings shall be 24" x 36" in size. The erosion control plan should be incorporated with the notice regarding Best Management Practices and shall include the following:

i. Vicinity Map
ii. Pertinent soils information (S.C.S. or equal)
iii. Topography map
iv. Vegetative survey - on site
v. Details, sufficient for construction, of all erosion control devices.
vi. Locations of all erosion control devices.
vii. Location of all creeks, streams, wetlands, irrigation ditches/laterals, existing detention facilities, and major bodies of water on site or 250 feet from the property line.
viii. Erosion Control Notes:
ix. Construction sequence notes.
x. Identification of basin boundaries

Erosion control notes shall be included in the final erosion control plan, but not be limited to, the following items:

Erosion Control Notes

1. Only the smallest practical area of land shall be exposed at any one time and for the shortest time practical during development.
2. Topsoil removed by grading shall be redistributed over disturbed areas (unless concerns for weed infestations preclude the use of contaminated soil).
3. Loam, seed, and mulch all cut side slopes immediately after grading to provide control of surface runoff. Use matting/netting if conditions warrant or as determined by Planning Department staff or registered Professional Engineer.
4. Construction of channels and erosion control measures shall be completed in the initial phase of the project.
5. Control measures shall be installed during the construction of the channels and ditch lines. Such structures shall be located (as a minimum) at locations shown on plans and shall be installed per standard details. Structures are to be maintained until all vegetation is successfully established.
6. Siltation control fences shall be located as shown on the plans and shall be constructed as per the standard detail.
7. All temporary and permanent erosion control devices shall be maintained and repaired by the owner/developer as needed to assure continued performance of their intended function. Erosion control devices shall be left in place until city staff determines that suitable vegetation has been established.
8. Construction protection fences shall be installed and located as shown on the plans.

Construction Sequence Notes:

A detailed time schedule of land disturbing activities and erosion control measures shall also be included on the Erosion Control Plan. The schedule will be used by City of Boulder Planning staff to inspect construction sites for compliance with the erosion control plan. The construction schedule shall include at least, but not be limited to, the following items:

1. Land disturbing activities sequence.
2. Timing of drainage facilities construction.
3. Timing of construction.
4. Implementation of erosion control facilities. (ie. sedimentation barriers, silt fences etc.)
5. Mulching.
6. Seeding, timing and type.
7. Required maintenance of erosion control devices.
8. Wind erosion control, if applicable.

NOTE NOTE NOTE NOTE NOTE NOTE

Sediment basins, sediment barriers, silt fences, and other measures intended to trap sediment should be constructed as a first step in grading and be made functional before upslope land disturbance takes place where needed. Earthen structures such as dams, dikes, diversions, and channels must be mulched within 7 days of installation. Earthen structures that will remain in place for a period of one year shall be seeded and mulched. Construction of earthen structures should be scheduled so as to allow prompt seeding during appropriate seasons.

Erosion Control Report

The Erosion Control Report shall address, at a minimum, the following items:

1. Detailed discussion of how site characteristics (soils, topography, drainage, vegetation,) will be influenced by wind and water erosion.
2. Discussion of the type of erosion control devices that will be utilized to prevent sediments from leaving the site.
3. Determine a detailed construction sequence for all land disturbing activities that minimizes the potential for erosion and sedimentation deposition. The Construction Sequence for land disturbing activities shall be included on the Erosion Control Plan.
4. Identify the wetland(s) that could be impacted and how they will be protected from sedimentation deposition.
5. Discussion of the length and seasonal timing of the project.
6. Identification of all erosion control problem areas, and how they will be protected.

Erosion and Sediment Control Implementation

Many techniques have been developed to avoid sedimentation and erosion likely to occur during maintenance and repair activities. The following brief descriptions provide information on several methods for reducing sedimentation and erosion.

Surface Roughening provides temporary stabilization of disturbed areas from wind erosion. It is used for periods of up to one month when revegetation cannot be established and when precipitation or snow melt are unlikely. Soil surfaces are roughed in depressions two to four inches deep and spaced from four to six inches apart. This can be accomplished by using a chisel or ripping implement during or after final grading. Vehicles should not be driven over surfaces that have been roughened. Additional treatments may be necessary over time to maintain the roughened condition. *Technical information and suggested specifications for surface roughening are included in Appendix B.*

Mulching is one of the most effective means of controlling runoff and wind erosion on disturbed sites. In most cases, native grass hay is preferable to cereal grain straw for two reasons. 1. Cereal grain straws often contain large amounts of viable seed, resulting in competition for any subsequent cover crop seeding. 2. Wheat and other cool season cereals may produce toxins that limit the germination of species planted for restoration.

Clean weed-free and seed-free long stemmed grass hay should be applied evenly at a rate of two tons per acre. At least half of the mulch should be at least ten inches long. Mulch must be anchored by crimping or with tackifiers or nets. Crimping is preferred in flat areas ($<$ 3:1 slopes) and areas outside of channels. The mulch fibers must be tucked (uncut) into the soil to a depth of four inches. Tackifiers can be used in small areas sheltered from wind and heavy runoff.

Manufactured stabilization blankets and matting can be used with mulches and are well-suited for wetland sites. Jute or coconut fiber netting must be anchored using stakes or staples. *Technical information and suggested specifications for mulching using matting and blankets are included in Appendix B.*

Revegetation of a perennial cover is an important component for erosion control plans. Each site will have different characteristics such as soil type, soil moisture, and topography. The most common and economical means of establishing cover is by seeding grasses. Seeding requires a small initial investment, little labor and is relatively easy to establish.

Only species native to the disturbed area should be used. When available, seeds derived from local stock should be used. The Soil Conservation Service, a plant ecologist or a reclamation specialist should be contacted to determine the most suitable seed mix for a specific site.

Vehicle tracking provisions must prevent the transport of mud and dirt by runoff or by vehicles tracking onto paved surfaces adjacent to areas where maintenance or repairs are taking place. Whenever sediment has been transported on a public road, the road shall be cleaned at the end of each day. Sediment shall be cleaned by shoveling or sweeping and shall be transported to a controlled sediment disposal area. *Technical information and suggested specifications for vehicle tracking are included in Appendix B.*

Sediment entrapment facilities are necessary to reduce sediment discharges into adjacent properties, creeks and wetlands. The choice of the appropriate facility depends upon the size of the tributary area, the basin slope, and slope length of the area upstream. All runoff leaving a site disturbed by maintenance or repair activities shall pass through a sediment entrapment facility before exiting the site.

	Allowable Maximum Limit		
Sediment Control	**Tributary Drainage (acres)**	**Tributary Slope (feet)**	**Tributary Slope Gradient**
Sod Filter Strips	n/a	50	6:1 (17%)
Straw Barrier or Silt Fence	0.5/100 running feet of fence/bales	150	2:1 (50%)
Sediment Trap	5.0 (not normally within the range of maintenance or repair)	n/a	n/a

When the tributary area is *less than five acres* but greater than that allowed for straw bale barriers or silt fences, runoff shall be collected in diversion swales and routed through temporary sediment traps.

Hay or straw bale barriers can be placed at the base of a slope to act as sediment barriers. Hay used shall be weed-free and seed-free grass hay or cereal straw. It is recommended that hay and straw bales shall not be used within a swale or channel when active flows present a problem of disrupting the barrier. Straw bales should only be used for short periods of time, when precipitation and snow melt are not anticipated to create significant runoff. Monitoring and maintenance of straw bales is required. *Technical information and suggested specifications for hay or straw bale barriers are included in Appendix B.*

Silt fences are made of woven synthetic material and serve to filter runoff. Silt fences can be placed, as a temporary measure, at the base of a slope. Like straw bales, silt fencing shall not be used within a swale or channel. If properly installed and maintained silt fencing can be used for up to three months. Monitoring and maintenance or silt fencing is required. *Technical information and suggested specifications for silt fences are included in Appendix B.*

Filter strips of undisturbed vegetation can reduce the amount of sediment entering waterways during projects of very limited scope. Filter strips can be used effectively and concurrently with straw bales or silt fencing. A minimum width of 20 feet of dense native vegetation is recommended.

Temporary sediment traps are ponding areas formed by an earthen embankment with a stone outlet. These sediment traps are used to detain sediment laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out. *Technical information and suggested specifications for sediment traps are included in Appendix B.*

Maintenance

All erosion and sediment control practices must be maintained and repaired by the person(s) or entity seeking BMP approval. Recommendations for maintenance are included in the specifications for the BMPs detailed in part III. The upkeep period extends throughout the length of the maintenance or repair activity to ensure continued performance of the intended function. All facilities must be inspected regularly and replaced if necessary.

ACKNOWLEDGEMENTS

Most of the information contained in this document was derived from already published documents. Information about erosion control was drawn from a draft erosion control manual developed by Greg Hogan of the City of Boulder Public Works Department. These are listed in the bibliography. Specific acknowledgement should be made to the Colorado Department of Highways, the Urban Drainage and Flood Control District of the Denver Metropolitan Area and the Virginia Department of Conservation and Recreation.

OTHER SOURCES OF INFORMATION

While many of the activities listed are allowable with BMPs under the **City of Boulder's** wetland protection program, other regulations may apply under the provisions of county, state and federal regulations. Applicants contemplating activities allowable with BMPs are encouraged to contact the applicable county, state and federal offices for more information.

United States Army
Corps of Engineers
Denver Regulatory Office
9307 State Highway 121
Littleton, CO 80123
(303) 979-4120

Colorado State Department of Public Health
and the Environment
Water Quality Control Division
4210 East 11th St.
Denver, CO 80220
(303) 692-2000

Environmental Protection Agency (EPA)
Region 8 Office
(303) 293-1570

Boulder County Land Use Department
PO Box 491
Boulder, CO 80306
(303) 441-3930

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APPENDIX A:
ANIMALS, PLANT COMMUNITIES AND PLANTS OF SPECIAL CONCERN IN THE BOULDER VALLEY

ANIMALS

Fish
Iowa darter
Johnny darter
Plains topminnow
Greenback cutthroat trout

Amphibian
Northern leopard frog

Reptile
Lined snake

Birds
Eared grebe
American bittern
Least bittern
Great egret
Great blue heron
Barrow's goldeneye
Peregrine falcon
Bald eagle
Northern goshawk
Northern harrier
Ferruginous hawk
Plains sharp-tail grouse
Bobwhite
Common barn owl
Short-eared owl
Long-eared owl
Red-headed woodpecker
Lewis' woodpecker
Least flycatcher
Willow flycatcher
Loggerhead shrike
Bank swallow
Veery
Northern mockingbird
Brown thrasher
Sage thrasher
Chestnut-sided warbler
Ovenbird
American redstart
Lark bunting
Savannah sparrow

Mammal
Prebles meadow jumping mouse

Plant Communities
Xeric Tallgrass Prairie
Wet Prairies
Great Plains Salt Meadows
Foothills Ponderosa Pine Scrub Woodlands
Foothills Ponderosa Pine Savannah
Mixed Foothill Shrublands
Great Plains Mixed Grass Prairie

Plants
Larimer aletes
Aletes humilis

American groundnut
Apios americana

Forktip three-awn
Aristida basiramea

Black spleenwort
Asplenium adiantum-nigrum

Dwarft hawksbeard
Crepis nana

Purple lady's slipper
Cypripedium fasciculatum

Showy prairie gentian
Eustoma grandiflorum

Colorado butterfly weed
Gaura neomexicana ssp. coloradensis

Wood lily
Lilium philadelphicum

Broad-leaved twayblade
Listera convallariodies

White adder's-mouth
Malaxis brachypoda

Bell's twinpod
Physaria bellii

Pictureleaf wintergreen
Pyrola picta

Toothcup
Rotala ramosior

Carrion-flower
Smilax lasioneuron

Ute ladies' tresses
Spiranthes diluvialis

Prairie violet
Viola pedatifida

APPENDIX B:

TECHNICAL SPECIFICATION FOR SOIL AND EROSION CONTROL PRACTICES

VEGETATION PRESERVATION AND PROTECTION[4]

Definition
Protection of desirable vegetation from mechanical and other injury during land disturbing and construction activity.

Purpose
To ensure the survival of desirable vegetation where it will be effective for erosion and sediment control, watershed protection, landscape beautification, dust and pollution control, noise reduction, shade, agricultural purposes, weed control, conservation of species and other environmental benefits.

Planning Considerations
Maintenance activities usually occur in vegetated areas. Unless sufficient care is taken and planning done before the maintenance occurs much of this resource is likely to be destroyed. It takes up to five years for grasslands to become re-established and up to 30 years for newly planted trees to provide the benefits for which we value trees so highly. Native vegetation performs the following functions on a site:

- Assist in stabilizing the soil and preventing erosion.
- Help to decrease stormwater runoff through interception and root zone absorption.
- Moderate temperature changes and provide shade.
- Moderate the effects of sun and wind.
- Provide buffers and screens against noise.
- Filter pollutants from the air.
- Help to remove carbon dioxide from the air and release oxygen.
- Provide habitat for animals.
- Conserve and increase property values.
- Provide psychological and aesthetic counterpoints to the man-made urban setting.

Stresses of Construction
Vegetation is alive and constantly involved in the process of respiration, food processing and growth. Construction activities expose plants to a variety of stresses resulting in injury. An understanding of these stresses is helpful in planning for tree protection.

Surface Impacts: Impacts exerted on vegetation above the ground can cause significant damage.

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[4]Adapted from:Urban Drainage Criteria Manual. Volume 3-Best Management Practices. Urban Drainage and Flood Control District and Virginia Erosion and Sediment Control Handbook, 3rd EditionVirginia Dept. of Conservation and Recreation

Wind damage - Removal of trees and shrubs from groups will expose those remaining to greater wind velocities. Woody plants tend to develop anchorage where it is most needed. Isolated trees develop anchorage rather equally all around, with stronger root development on the side of the prevailing winds. The more a tree is protected from the wind, the less secure is its anchorage. The result of improper thinning is often wind-thrown trees. Selective removal in favor of a single tall tree may also create a lightning hazard.

Excessive pruning - Unprotected trees are often "topped" or carelessly pruned to prevent interference with utility wires or buildings. If too many branches are cut, the tree may not be able to sustain itself. If the pruning is done without considering the growth habit, the tree may lose all visual appeal. If the branches are not pruned correctly, decay may set in.

Trunk damage - Tree trunks and entire shrubs are often nicked or scarred by trucks and construction equipment. Such superficial wounds provide access to insects and disease.

Leaf damage- Although resilient to impacts such as driving and the placement of stockpiled material, grasses and other low growing plants can be destroyed when these activities take place under the wrong conditions for for extended periods of time. The leaves of these plants provide nutrients for the growth and well being of the plants. When leaves are repeatedly removed or covered for extended periods during the growing season, plants weaken and die.

Root Zone Impacts: Disturbing the delicate relationship between soil, roots, and the rest of a plant can result in damage or death. The roots of a plant are established in an area where essential materials (water, oxygen, and nutrients) are present. The root system is the correct size to balance the intake of water from the soil with the transpiration of water from the leaves.

For trees and shrubs, raising the grade as little as 6 inches can retard the normal exchange of air and gases. Roots may suffocate due to lack of oxygen, or be damaged by toxic gases and chemicals released by soil bacteria. For grasses and other herbaceous plants, grade changes necessitate either salvaging "sod", replanting or reseeding the area.

For woody vegetation, lowering the grade is not usually as damaging as raising it. However, even shallow cuts of 6 to 8 inches will remove most of the topsoil, removing some feeder roots and exposing the rest to drying and freezing. For grasses and other herbaceous plants, grade changes necessitate either salvaging "sod", replanting or reseeding the area.

In the case of woody vegetation, ***deep cuts*** may sever a large portion of the root system, depriving the tree of water, weakening the plants and increasing the chance of wind-throw and disease.

Lowering the grade may lower the water table, changing the soil moisture significantly. This can result in stresses for vegetation that would necessitate reseeding or replanting with materials adapted for drier site condition. ***Typically activities which result in lowering the water table would NOT be considered Best Management Practices and would require a wetlands permit.***

Trenching or excavating through a tree's root zone can eliminate as much as 40 percent of the root system. Trees suffering from such damage usually die within 2 to 5 years. For grasses and other herbaceous plants, trenching or excavation necessitates replanting or reseeding the area.

Compaction of the soil by equipment operation, materials storage, or paving can block off air and water from roots. For trees, compaction should be avoided for five feet feet beyond the drip line. Compaction in areas of shrubs or grasses and other herbaceous vegetation will require soil conditioning (disking, chiseling, ripping, the use of a harrow) and reseeding or replanting.

Construction chemicals, fuel or refuse disposed of in the soil can change soil chemistry or be toxic to plants. Most damage to trees from maintenance activities is due to the invisible root zone stresses.

Design Criteria

No formal design are appropriate. In planning maintenance activities for an area of desirable vegetation, a number of criteria must be considered.

Which Trees, Shrubs, and Herbaceous Vegetation Should be Preserved?

Proper maintenance of an area of desirable vegetation requires completion of a plan for plant preservation before the maintenance activity begins. Plants should be identified by species and a sketch map of the areas' vegetation should be prepared. Base decisions on which types of vegetation to avoid on the following considerations:

- Native or Introduced: For the most part native vegetation is of greater value to wildlife and is better adapted for long-term survival in the semi-arid climate of the Boulder Valley. Because native plants and animals have been living together for thousands of years, native plants tend to be of greater value as wildlife habitat than introduced species.

- Consistency with Maintenance Objective While native trees may occupy a site, their presence may be incompatible with the long-term maintenance needs of a particular area. In these cases, the establishment of another type of vegetation would be preferable to the periodic and repeated disturbances caused by maintenance activities. An example of such a strategy would be the establishment of a shrub thicket beneath powerlines to preclude the growth of trees and reduce the frequency of maintenance.

Site Planning for Protection of Vegetation

In the case of excavation, trenching, or the placement of fill, salvage desirable native grass sod. No vegetation should be disturbed until the design of the maintenance project is final.

Avoid maintenance activities on steep slopes.

Locate access roadways to cause the least damage to desirable vegetation.

Minimize disturbance by planning all maintenance activities in an area for a particular and appropriate time of year.

Excavations should be kept away from the dripline of trees (figure 1).

Construction material storage areas and worker parking should be noted on the site plan, and located where they will not cause compaction or disturbance to stands of desirable plants.

When avoiding desirable woody vegetation, leave five feet undisturbed ground beyond the drip line to allow for survival.

Locate erosion and sediment control measures at the limits of the maintenance area and not in areas of desirable vegetation to prevent deposition of sediment within the area being preserved. Sediment basins should be constructed in the natural terrain, if possible, rather than in locations where extensive grading and removal of vegetation will be required.

Specifications

At a minimum, the limits of a project shall be located five feet outside the dripline of any tree to be retained and, in no case, closer than 5 feet to the trunk of any tree (figure 1).

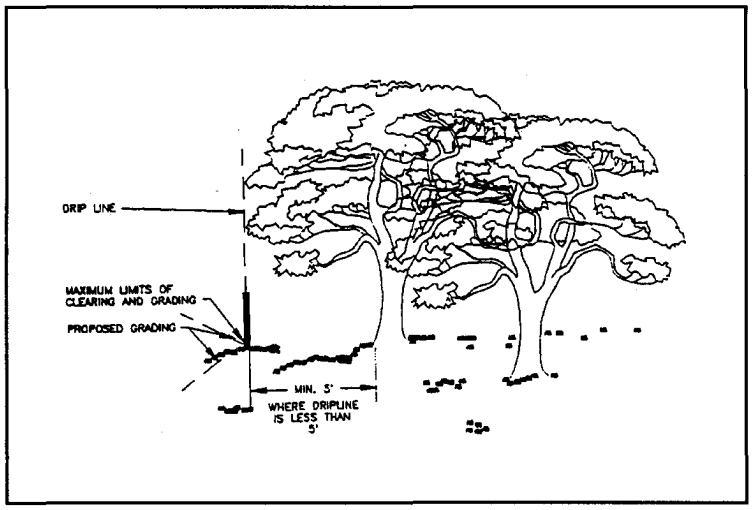

Figure 1: Construction operations relative to the location of protected trees and shrubs

Prior to starting maintenance activities, desirable vegetation to be protected and retained within the limits of the project shall be marked in a way visible to equipment operators.

Pre-Construction Conference: During any preconstruction conference,vegetation preservation and protection measures should be reviewed with the contractor as they apply to that specific project.

Equipment Operation and Storage: Heavy equipment, vehicular traffic, or stockpiles of any construction materials (including topsoil) shall not be permitted within any area designated for the protection of native vegetation. Trees being removed shall not be felled, pushed or pulled into areas being protected. Equipment operators shall not clean any part of their equipment on-site.

Storage and Disposal of Toxic Materials: No toxic materials shall be stored closer than 100 feet of an area of vegetation to be protected. Paint, acid, nails, gypsum board, wire, chemicals, fuels, and lubricants shall not be disposed of in such a way as to injure vegetation.

Fencing and Armoring: Any device may be used which will effectively protect the vegetation to be retained on the site. Personnel must be instructed to honor protective devices.

Snow Fence - Standard 40-inch high snow fence on standard steel posts set 6 feet apart.

Board Fence - Board fencing consisting of 4-inch square posts set securely in the ground and protruding at least 4 feet above the ground with a minimum of two horizontal boards between posts.

Cord Fence - Posts with a minimum size of 2 inches square or 2 inches in diameter set securely in the ground and protruding at least 4 feet above the ground with two rows of cord 1/4-inch or thicker at least 2 feet apart running between posts with strips of colored surveyor's flagging tied securely to the string at intervals no greater than 3 feet.

Plastic Fencing - 40-inch high "international orange" plastic (polyethylene) web fencing secured to conventional metal "T" or "U" posts driven to a minimum depth of 18 inches on a 6-foot minimum centers. The fence should have the following minimum physical qualities:
Tensile yield: Average 2,000 lbs. per 4-foot width (ASTM D638) Ultimate tensile yield:Average 2,900 lbs. per 4-foot width (ASTM D638) Elongation at break (%): Greater than 1000% (ASTM D638) Chemical resistance:Inert to most chemicals and acids

Fencing and armoring devices shall be in place before any excavation or grading is begun, shall be kept in good repair for the duration of maintenance activities, and shall be the last items removed during the final cleanup after the completion of the project.

Raising the grade: When the ground level must be raised the following considerations shall be

made and steps taken to adequately care for the effected vegetation.

Herbaceous Vegetation
Desirable grasses, other herbaceous vegetation, and shrubs shall be removed, stockpiled and replanted in areas where the grade is raised. In cases where there is no desirable vegetation present, the area is to be planted or seeded with native vegetation according to the specification found under permanent seeding and revegetation on page 47.

Stockpile the vegetation and topsoil in a manner where the plant material will be kept alive and conveniently replanted after grading activities. Keep the the soil around plant roots moist by covering with wet burlap and watering as necessary. Wetland vegetation should be kept ***saturated***.

Trees
A well may be created around the tree(s) slightly beyond the dripline to retain the natural soil in the area of the feeder roots (figure 2).

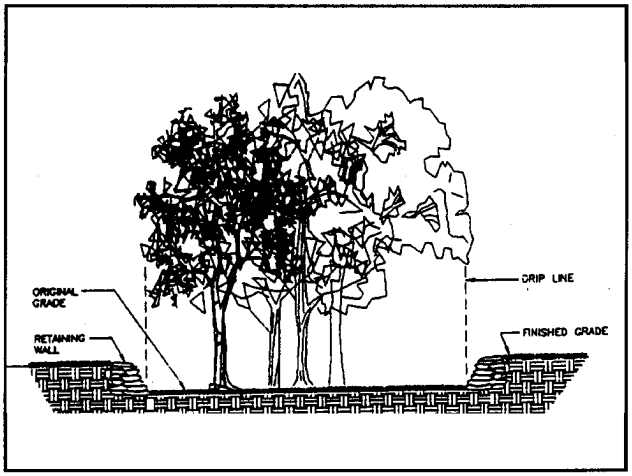

Figure 2: Tree Well

In the case of an individual tree, when the above alternative is not practical or desirable, the following method is recommended to ensure survival of the tree (figure 3).

Before making the fill, remove the vegetation, sod, leaf litter, and other organic matter from beneath the tree or trees to a distance of 3 feet beyond the drip line and loosen the surface soil to a depth of approximately 3 inches without damaging the roots.

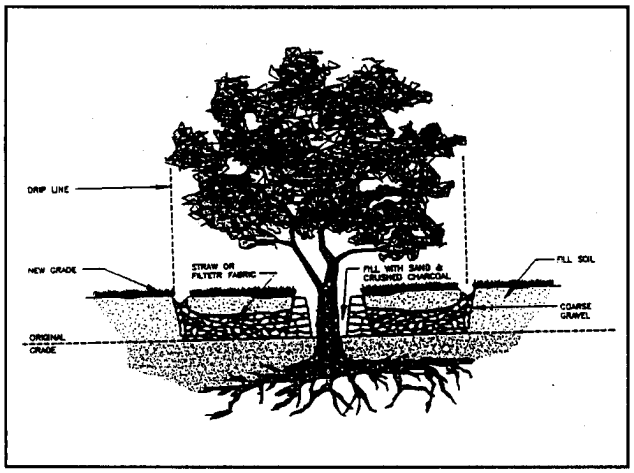

Figure 3:Tree well, alternate

In cases where the vegetation under the tree is to be preserved, stockpile the vegetation and topsoil in a manner where the plant material will be kept alive and conveniently replanted after grading activities. Keep the the soil around plant roots moist by covering with wet burlap and watering as necessary. Wetland vegetation should be kept ***saturated***.

Before shrubs or trees are placed in planting area, the pit shall be filled half full of water and left to drain. No commercial fertilizer or fertilizer tables shall be

used.

The dry well shall be constructed so as to allow for tree trunk diameter growth. A space of at least 1 foot between the tree trunk and the well wall is adequate for large, old, slow-growing trees. Clearance for younger trees shall be at least 2 feet.

The well shall be high enough to bring the top just above the level of the proposed fill. The well wall shall taper slightly away from the tree trunk at a rate of 1 inch per foot of wall height.

The well wall shall be constructed of large stones, brick, building tile, concrete blocks, or cinder blocks with care being taken to ensure that ample openings are left through the wall of the well to allow for free movement of air and water. Mortar shall only be used near the top of the well and only above the porous fill.

A layer of 2- to 6-inches of stone shall be placed over the entire area under the tree from the well outward at least as far as the dripline. For fills up to 2-feet deep, a layer of stone 8- to 12-inches thick should be adequate. A thicker layer of this stone, not to exceed 30 inches, will be needed for deeper fills.

A layer of ¾-inch to 1-inch stone covered by straw, fiber-glass mat or a manufactured filter fabric shall be used to prevent soil from clogging the space between stones. Cinders shall not be used as fill material.

Filling shall be completed with porous soil such as topsoil until the desired grade is reached. This soil shall be suitable to sustain specified vegetation.

To prevent anyone from falling in to the dry well and leaves and debris from accumulating there, the area between the trunk and the well wall shall either be of filled with a 50-50 mixture of crushed charcoal and sand. (This will also prevent rodent infestation and mosquito breeding.)

Raising the grade on only one side of a tree or group of trees may be accomplished by constructing only half of one of these systems.

Lowering the grade: When the ground level must be lowered the following considerations shall be made and steps taken to adequately care for the affected vegetation.

Herbaceous Vegetation

Desirable grasses, other herbaceous vegetation, and shrubs shall be removed, stockpiled and replanted in areas where the grade is lowered. In cases where there is no desirable vegetation present, the area is to be planted or seeded with native vegetation according to the

specifications given under permanent seeding and revegetation on page 47.

Stockpile the vegetation and topsoil in a manner where the plant material will be kept alive and conveniently replanted after grading activities. Keep the the soil around plant roots moist by covering with wet burlap and watering as necessary. Wetland vegetation should be kept ***saturated***.

Trees
Trees shall be protected from harmful grade cuts by the construction of a tree wall (figure 4).

Following excavation, all tree roots that are exposed and/or damaged shall be trimmed cleanly, painted with tree paint, and covered with moist burlap, or other suitable material[5] to keep them from drying out.

The wall shall be constructed of large stones, brick, building tile, concrete block or cinder block in accordance with the detail in figure 4.

Backfill with with topsoil to retain moisture and aid in root development. Replace salvaged plant material or reseed in accordance with the specifications for permanent seeding and revegetation on page 47.

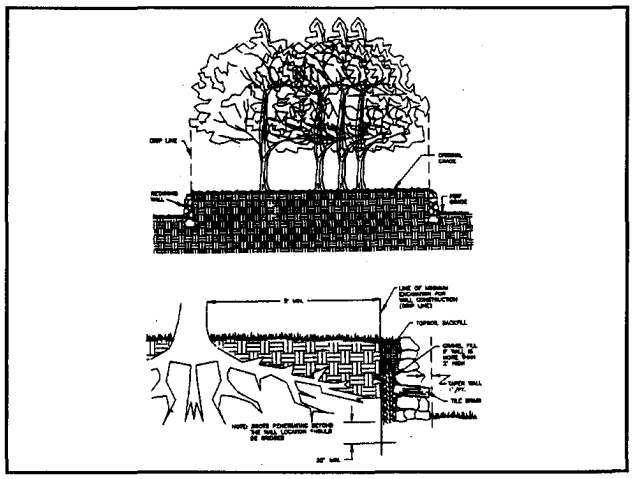

Figure 4:Tree wall

- Before shrubs or trees are placed in planting area, the pit shall be filled half full of water and left to drain. No commercial fertilizer or fertilizer tables shall be used.

Prune the tree crown, reducing the leaf surface in proportion to the amount of root loss.

- Lowering the grade on only one side of a tree or group of trees may be accomplished by constructing only half of this system.

[5]Peat moss, sphagnum or mountain peat are **not** acceptable

Trenching and Tunnelling

Herbaceous Vegetation

Desirable grasses, other herbaceous vegetation, and shrubs shall be removed, stockpiled and replanted in areas of trenching and tunnelling. In cases where there is no desirable vegetation present, the area is to be planted or seeded with native vegetation according to the specifications found in Appendix B.

Stockpile the vegetation and topsoil in a manner where the plant material will be kept alive and conveniently replanted after grading activities. Keep the the soil around plant roots moist by covering with wet burlap and watering as necessary. Wetland vegetation should be kept ***saturated***.

Trees

Trenching shall be done as far away from the trunks of trees as possible, preferably outside the branches or crown spreads of trees, to reduce the amount of root area damaged, or killed by trenching activities.

Wherever possible, trenches should avoid large roots or root concentrations. This can be accomplished by curving the trench or by tunnelling under large roots and areas of heavy root concentration.

Tunnelling is more expensive initially, but it usually causes less soil disturbance and physiological impact on the root system (figure 5). The extra cost may offset the potential cost of tree removal and replacement should the tree die.

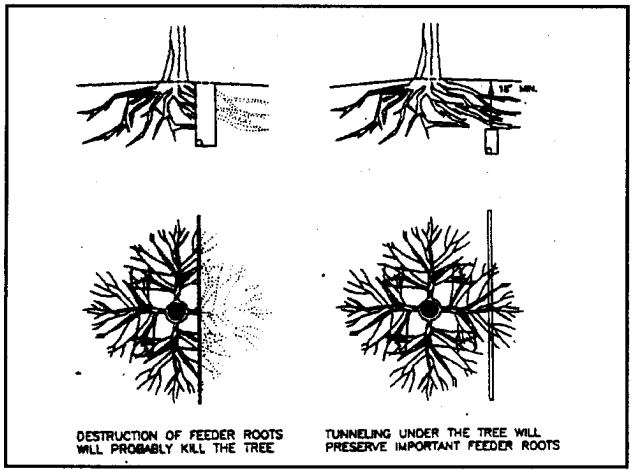

Figure 5: Trenching vs. tunneling

Tunnelling is almost always preferred over the trenching method. The tunnel should be 18 inches or greater below the ground surface and should not be located under the center of the tree (an off-center tunnel has the least impact on the roots).

Roots shall not be left exposed to the air. They shall be covered with soil as soon as possible or protected and kept moistened with wet burlap until the trench or tunnel can be filled.

The ends of damaged and cut roots shall be cut off smoothly and protected by painting promptly with a tree-wound dressing.

Trenches and tunnels shall be filled as soon as possible. Air spaces in the soil shall be avoided by careful filling and tamping.

The tree shall be mulched to conserve moisture, stimulate new root growth, and enhance general tree vigor.

If a large amount of the root system has been damaged and killed, the crown leaf surface shall be proportionately reduced to balance the reduced root system. This may be accomplished by pruning 20 to 30 percent of the crown foliage. If roots are cut during the winter, pruning shall be accomplished before the next growing season. If roots are cut during the growing season, pruning shall be done immediately.

Clean-Up: Clean-up after a construction project can be a critical time for vegetation. Plants protected throughout the maintenance operation are often destroyed by carelessness during the final clean-up. Fences and barriers shall be removed last, after everything else is cleaned-up and carried away.

Surface Roughening[6]

Definition

Provide a rough soil surface with horizontal depressions created by operating a tillage or other suitable implement on the contour, or by leaving slopes in a roughened condition by not fine-grading them (figure 6).

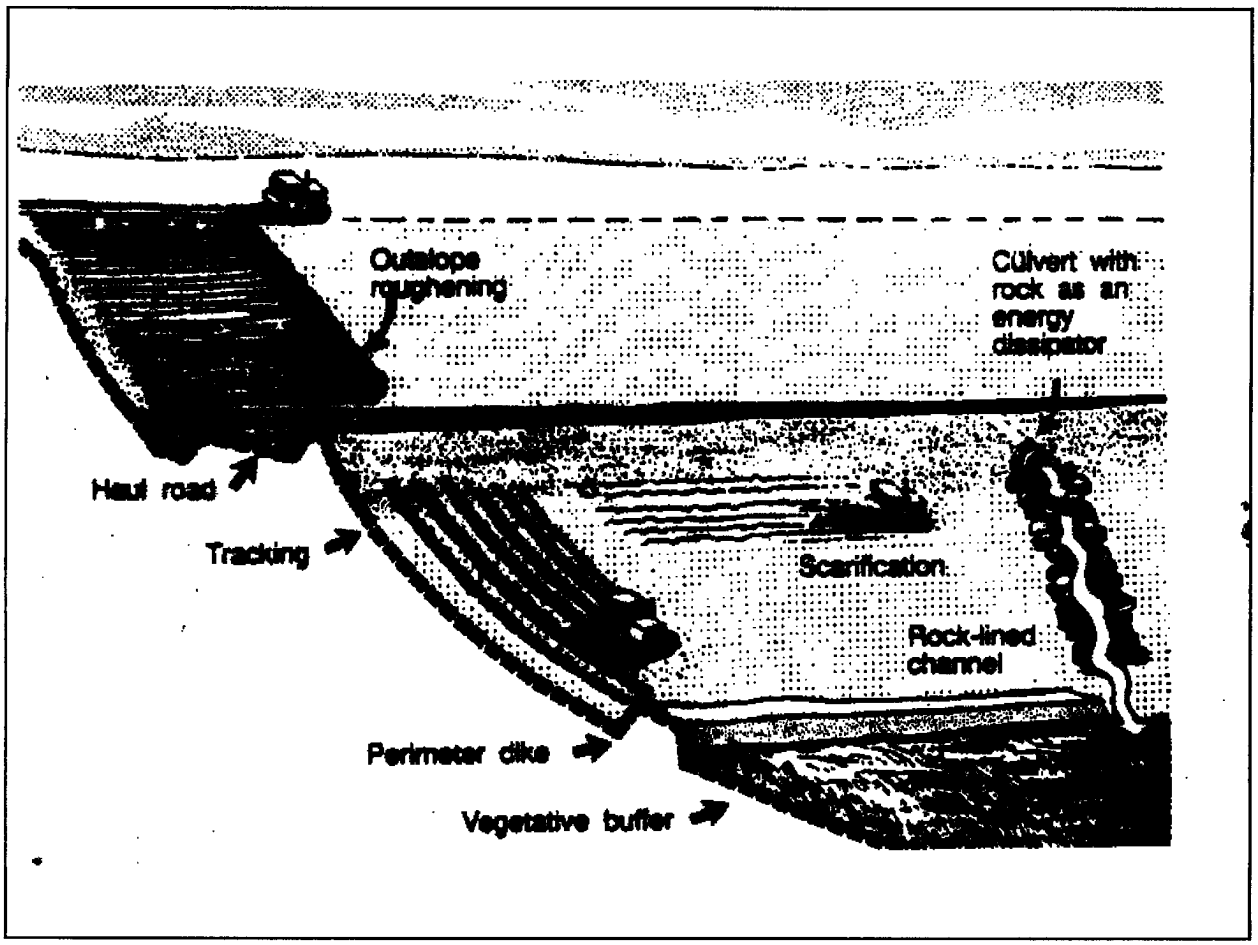

Figure 6: Surface Roughening

Purposes

1. To aid in seed bed preparation and establishment of vegetative cover.
2. To reduce runoff velocity and increase infiltration.

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[6]Taken from:Urban Drainage Criteria Manual. Volume 3-Best Management Practices. Urban Drainage and Flood Control District. and USDA, Soil Conservation Service Technical Guide Section IV, Standards and Specifications.

3. To reduce runoff and wind erosion and provide for sediment trapping.

Conditions Where Practice Applies

On cropland that is in danger of being eroded by wind because of insufficient vegetation cover, cloddiness or roughness, or where other practices fail to control erosion.

Planning Considerations

1. A tillage speed of 3-1/2 to 4-1/2 mph will usually give the best results in producing maximum cloddiness.

2. If irrigation water is available, consideration should be given to establishing strips of fast-growing cover.

3. Straw mulching or use of chemical soil stabilizer are expensive, but are often the only effective emergency measure for protection of bare shady soils.

4. Provisions should be made to establish vegetation on unprotected soils as soon as possible.

5. Implements should be adjusted so chisel or shovel points run behind tractor tracks. Soil pulverized by the tractor is vulnerable to the wind.

6. Disks which further pulverize the soil should not be used for surface roughening.

Mulching and Soil Stabilization with Blankets and Matting[7]

Definition
The installation of a protective covering (blanket) or a soil stabilization mat on a prepared planting area of a steep slope, channel or shoreline.

Purpose
To aid in controlling erosion on critical areas by providing a microclimate which protects young vegetation and promotes its establishment.

Conditions Where Practice Applies
On short, steep slopes where erosion hazard in high and planting is likely to be too slow in providing adequate protective cover; on streambanks or tidal shorelines where moving water is likely to wash out new plantings; or in areas where the forces of wind prevent standard mulching practices from remaining in place until vegetation becomes established.

Planning Considerations
Soil stabilization blankets and mats can be applied to problem areas to supplement nature's erosion control system (vegetation) in its initial establishment. Care must be taken to choose the type of blanket or matting which is most appropriate for the specific needs of a project. Two general types of blankets and mats are discussed within this specification. However, with the abundance of soil stabilization products available today, it is impossible to cover all the advantages, disadvantages and specifications of all manufactured blankets and mats. Therefore, as with many erosion control-type products, ***there is no substitute for a thorough understanding of the manufacturer's instructions and recommendations and a site visit by a designer or plan reviewer to verify a product's appropriateness.***

Treatment-1 is a degradable soil stabilization blanket which includes "combination" blankets consisting of a plastic netting which covers and is intertwined with a natural organic or man-made mulch; or, a jute mesh which is typically homogeneous in design and can act alone as a soil stabilization blanket.

It should be used to help establish vegetation on previously disturbed slopes - normally problem slopes of 3:1 or greater. During the establishment of vegetation, **Treatment-1** *should not be* ***subjected to shallow or deep concentrated flows moving at greater than 4 feet/second.***

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[7]Adapted from:Urban Drainage Criteria Manual.Volume 3-Best Management Practices. Urban Drainage and Flood Control District and Virginia Erosion and Sediment Control Handbook, 3rd EditionVirginia Dept. of Conservation and Recreation

Treatment-1 provides the following benefits in the achievement of vegetative stabilization when properly applied over seed and required amendments:

1. Protection of the seed and soil from raindrop impact and subsequent displacement.

2. Thermal consistency and moisture retention for seedbed area.

3. Stronger and faster germination of grasses and legumes.

4. Planing off excess stormwater runoff.

5. Prevention of sloughing of topsoil added to steeper slopes.

Treatment-2 is a ***soil stabilization matting*** which consists of a non-degradable, 3-dimensional plastic structure which can be filled with soil prior to planting. This configuration provides a matrix for root growth where the matting becomes entangled and penetrated by roots, forming continuous anchorage for surface growth and promoting enhanced energy dissipation. **Treatment-2** can be used on problem slopes (normally 3:1 or greater), and in stormwater conveyance channels.

In addition to those benefits noted for **Treatment-1, Treatment-2** provides the following benefits in the achievement of vegetative stabilization and in the replacement of more traditional channel linings such as concrete and riprap:

1. Causes soil to drop out of stormwater and fill matrix with fine soils which become the growth medium for the development of roots.

2. When embedded in the soil within stormwater channels, it acts with the vegetative root system to form an erosion resistant cover which resists hydraulic lift and shear forces.

Since **Treatment-2** is non-degradable, it can be used in permanent conveyance channels and can withstand higher velocities of flow than the vegetation and soil would normally allow. However, a ***10 feet/second velocity of flow*** should be the maximum allowed in a conveyance system which utilizes **Treatment-2**.

<u>Treatment-1</u>: Soil Stabilization Blanket
allowable Velocity Range During Vegetation Establishment: 0 - 4 f.p.s.

<u>Materials</u>

1. <u>Combination Blankets</u> - They shall consist of a photo-degradable plastic netting which covers and is entwined in a natural organic or man-made mulching material. The mulching material

shall consist of wood fibers, wood excelsior, straw, coconut fiber, or man-made fibers, or a combination of the same. The blanket shall be of consistent thickness with the mulching material/fibers evenly distributed over its entire length. The mulching material/fibers must interlock or entwine to form a dense layer which not only resists raindrop impact, but will allow vegetation to penetrate the blanket.

The blanket shall be nontoxic to vegetation and to the germination of seed and shall not be injurious to the unprotected skin of humans. At a minimum, the plastic netting must cover the top side of the blanket and possess a high web strength. The netting shall be entwined with the mulching material/fiber to maximize strength and provide for ease of handling.

Because of the potential for snakes to become entangled in combination blanket, this material should not be used in areas of known snake activity, especially in the early to late spring when snakes are dispersing from their winter habitat.

2. Jute Mesh - It shall be of a uniform, open, plain weave, of undyed and unbleached single jute yarn. The yarn shall be of loosely twisted construction and shall not vary in thickness by more than one half of its normal diameter. Jute mesh shall be new and shall conform to the following:

   a. Length of jute mesh shall be marked on each roll.

   b. There shall be 0.60-inch openings (± 25%) between strands, lengthwise.

   c. There shall be 0.90-inch openings (± 25%) between strands, lengthwise.

   d. Weight shall average 0.90 lbs./square yard with a tolerance of 5%.

   As previously noted, jute mesh provides such good coverage (large surface area of strands) and contains such small openings that it can be used alone as a blanket.

3. Other **Treatment-1** Products - These shall conform to manufacturer's specifications and be approved by the Planning Department prior to being specified for a particular application. These products should be installed in accordance with manufacturer's recommendations, ***provided those recommendations are at least as stringent as this specification***.

4. Staples - Staples for anchoring **Treatment-1** shall be No. 11-gauge wire or heavier. Their length shall be a minimum of 6 inches. A larger staple with a length of up to 12 inches should be used on loose, sandy, or unstable soils.

Installation Requirements

Site Preparation - After site has been shaped and graded to approved design, prepare a friable seedbed relatively free from clods and rocks more than 1 1/2 inches in diameter and any foreign

material that will prevent uniform contact of the protective covering with the soil surface.

Planting - When using jute mesh on a seeded area, apply approximately one-half the seed after laying the mat. The protective covering can be laid over sprigged areas where small grass plants have been inserted into the soil. Where ground covers are to be planted, lay the protective covering first and then plant through the material as per planting design.

When ***open-weave nets*** are used, seeds and mulch should be applied before laying the net. When a ***combination blanket*** (such as an "excelsior" blanket) is used, seeds must also be applied ***before*** the blanket is laid.

Orientation - See figures 7 and 9 for orientation of **Treatment-1** for different topographic conditions.

Laying and Stapling: (see figure 8) - If instructions have been followed, all needed check slots will have been installed, and the protective covering will be laid on a friable seedbed free from clods, rocks, roots, etc. that might impede good contact.

1. Start laying the protective covering from the top of the channel or top of slope and unroll down-grade.

2. Allow to lay loosely on soil - do not stretch.

3. Upslope ends of the protective covering should be buried in an anchor slot no less than 6-inches deep. Tamp earth firmly over the material. Staple the material at a minimum of every 12 inches across the top end.

4. Edges of the material shall be stapled every 3 feet. Where multiple widths are laid side by side, the adjacent edges shall be overlapped a minimum of 2 inches and stapled together.

5. Staples shall be placed down the center, staggered with the edges at 3 foot intervals.

Check slots - On highly erodible soils and on slopes steeper than 4:1, erosion check slots should be made every 50 feet (see figure 9). Insert a fold of the material (separate piece) into a 6-inch trench and tamp firmly. Staple fold to "main" blanket at minimum 12-inch intervals across the upstream and downstream portion of the blanket.

Note: Many combination blankets are designed and manufactured to resist movement and uplift to a point which check slots may not be required. Plan designers and review authorities are urged to study manufacturers' recommendations and site conditions.

Joining Protective Coverings - Insert a new roll of material into an anchor slot, as with upslope ends. Overlap the end of the previous roll a minimum of 12 inches, and staple across the end of

the roll just below the anchor slot and across the material every 12 inches.

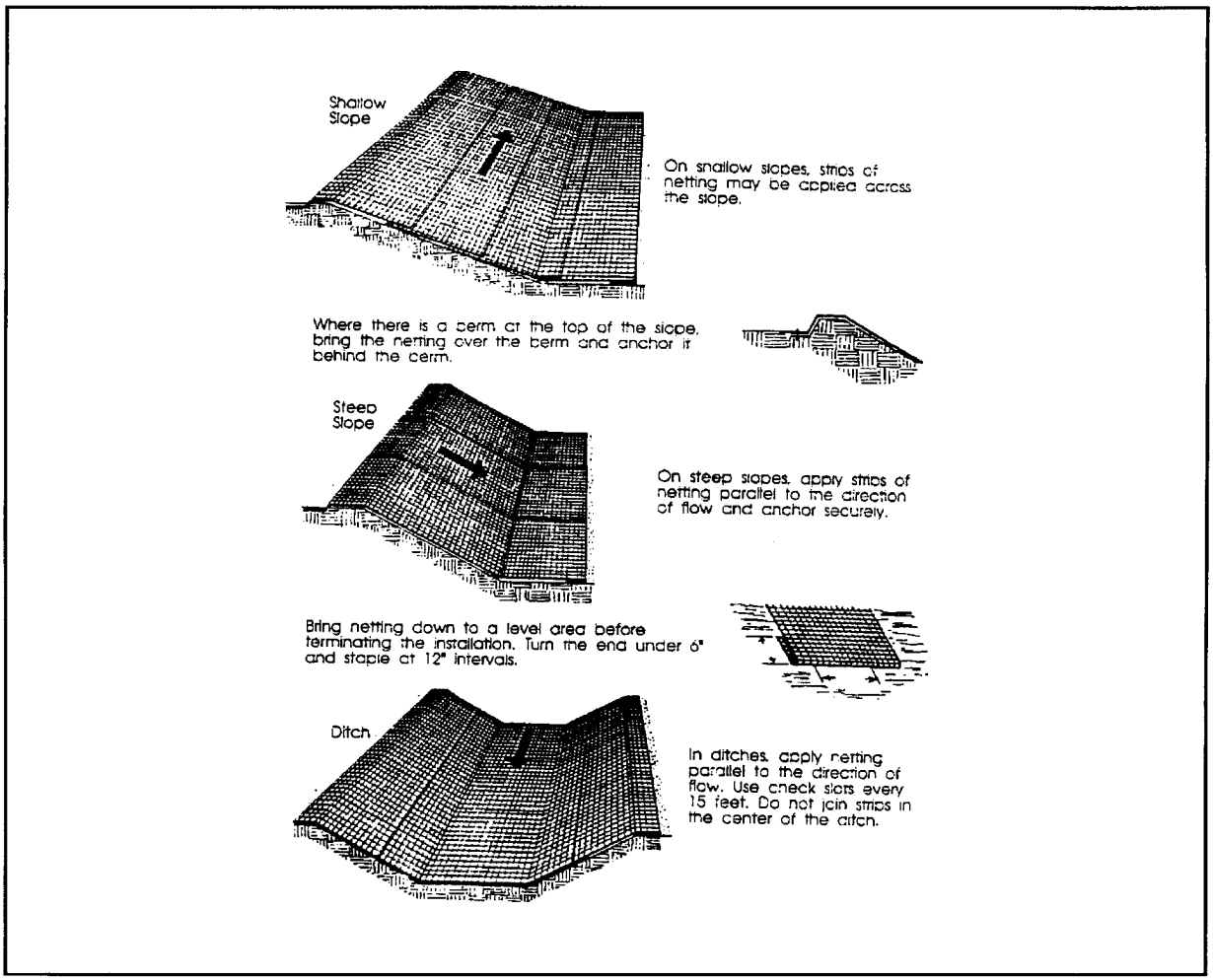

Figure 7:Typical orientation of soil stabilization blanket (treatment 1).

Terminal End - At the point at which the material is discontinued, or at which time the protective covering meets a structure of some type, fold 4 inches of the material underneath and staple every 12 inches (minimum).

At bottom of slopes - Lead net out onto a level area before anchoring. Turn ends under 4 inches, and staple across end every 12 inches.

Final check - These installation techniques must be adhered to:

1. Protective blanket is in uniform contact with the soil.
2. All lap joints are secure.
3. All staples are driven flush with the ground.
4. All disturbed areas have been seeded.

Treatment-2:Soil Stabilization Matting
allowable velocity range after vegetative establishment: 0 - 10 f.p.s.

Materials
Matting - The majority of these products provide a three dimensional geomatrix of nylon, polyethylene, or randomly oriented monofilaments, forming a mat. These products contain ultra violet (UV) inhibiting stabilizers, added to the compounds to ensure endurance and provide "permanent root reinforcement."

The three dimensional feature creates an open space which is allowed to fill with soil. The roots of the grass plant become established within the mat itself, forming a synergistic root and mat system. As the grass becomes established, the two actually "reinforce" each other, preventing movement or damage to the soil. Allowable velocities are increased considerably over natural turf stands.

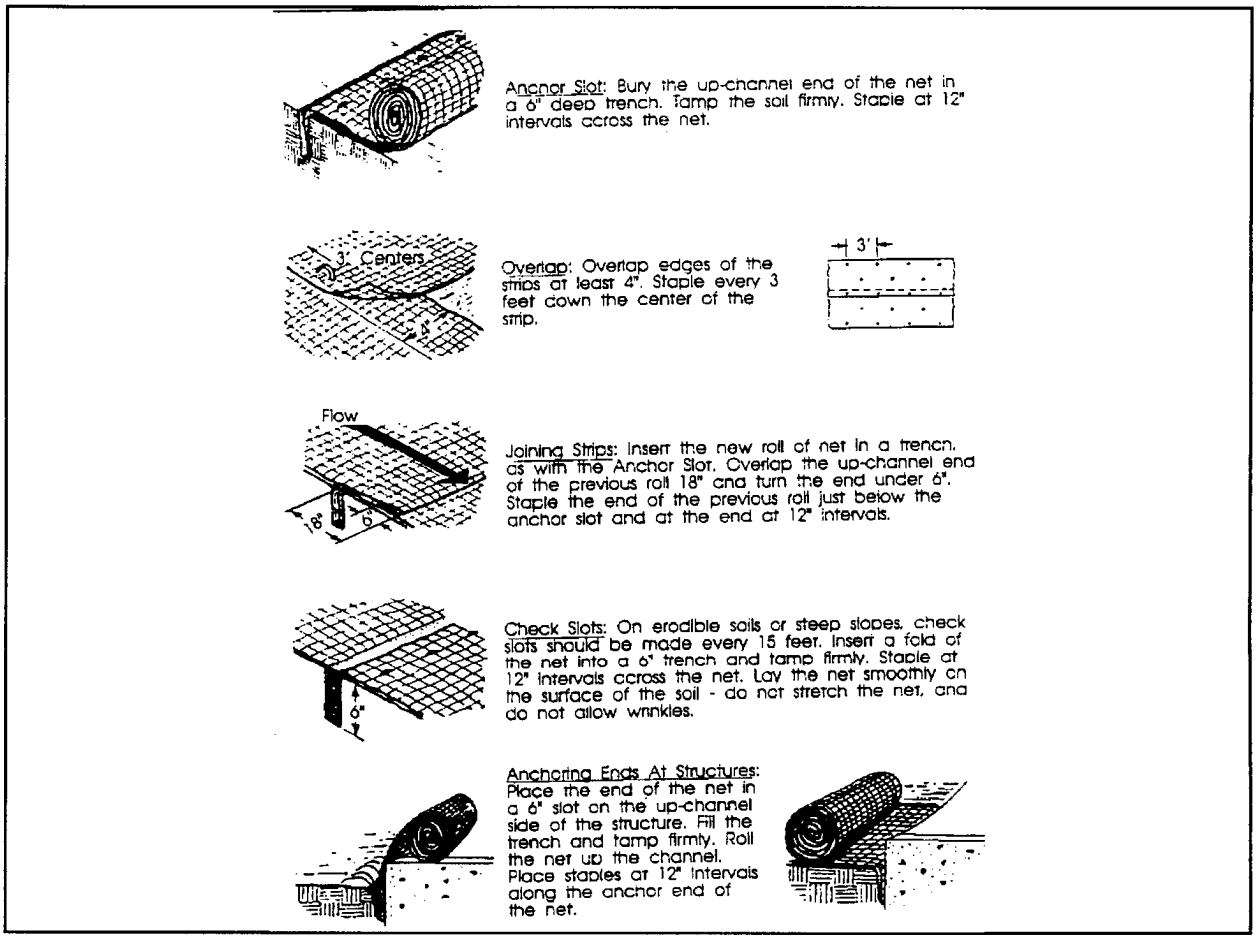

Figure 8: Installation of blankets, netting and matting.

Selection of the appropriate matting materials along with proper installation become critical factors in the success of this practice. Consultation with the supplier or the manufacturer and thorough evaluation of performance data to ensure proper selection of a soil stabilization matting are essential. Although many manufacturers claim their products may inhibit erosion associated with channel velocities of up to 20 ft./sec., it is recommended that any velocities that exceed 10 ft./sec. be properly protected with some form of structural lining.

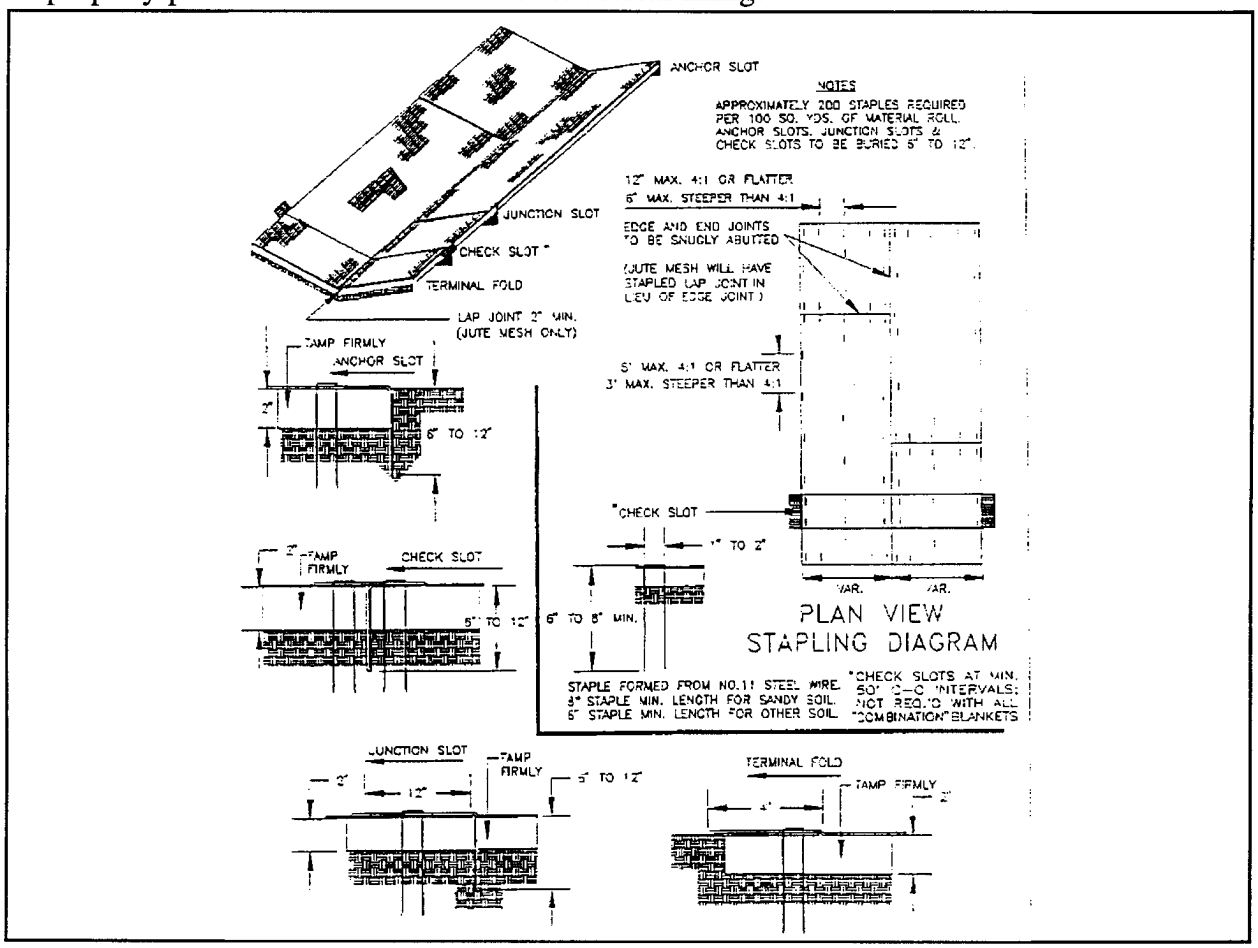

Figure 9:Typical treatment, soil stabilization blanket.

Staples - Staples or anchoring methods and recommendations vary by manufacturers. The expectation of high velocities should dictate the use of more substantial anchoring. Some of the typically recommended stakes, staples and pins are depicted in figure 10.

Installation Requirements

Site Preparation - After site has been shaped and graded to approved design, prepare a friable seedbed relatively free from clods and rocks more than 1 inch in diameter, and any foreign material that will prevent contact of the soil stabilization mat with the soil surface. If necessary, redirect any runoff away from the ditch or slope during installation.

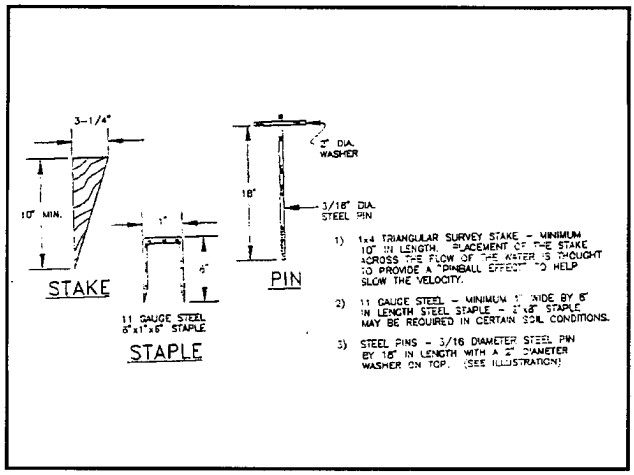

Figure 10: Stakes, staples and pins for installation of soil stablization blanket.

Planting - Seed in accordance with the approved plan, paying special attention to the plant selection that may have been chosen for the matted area. If the area has been seeded prior to installing the mat, make sure and reseed all areas disturbed during installation.

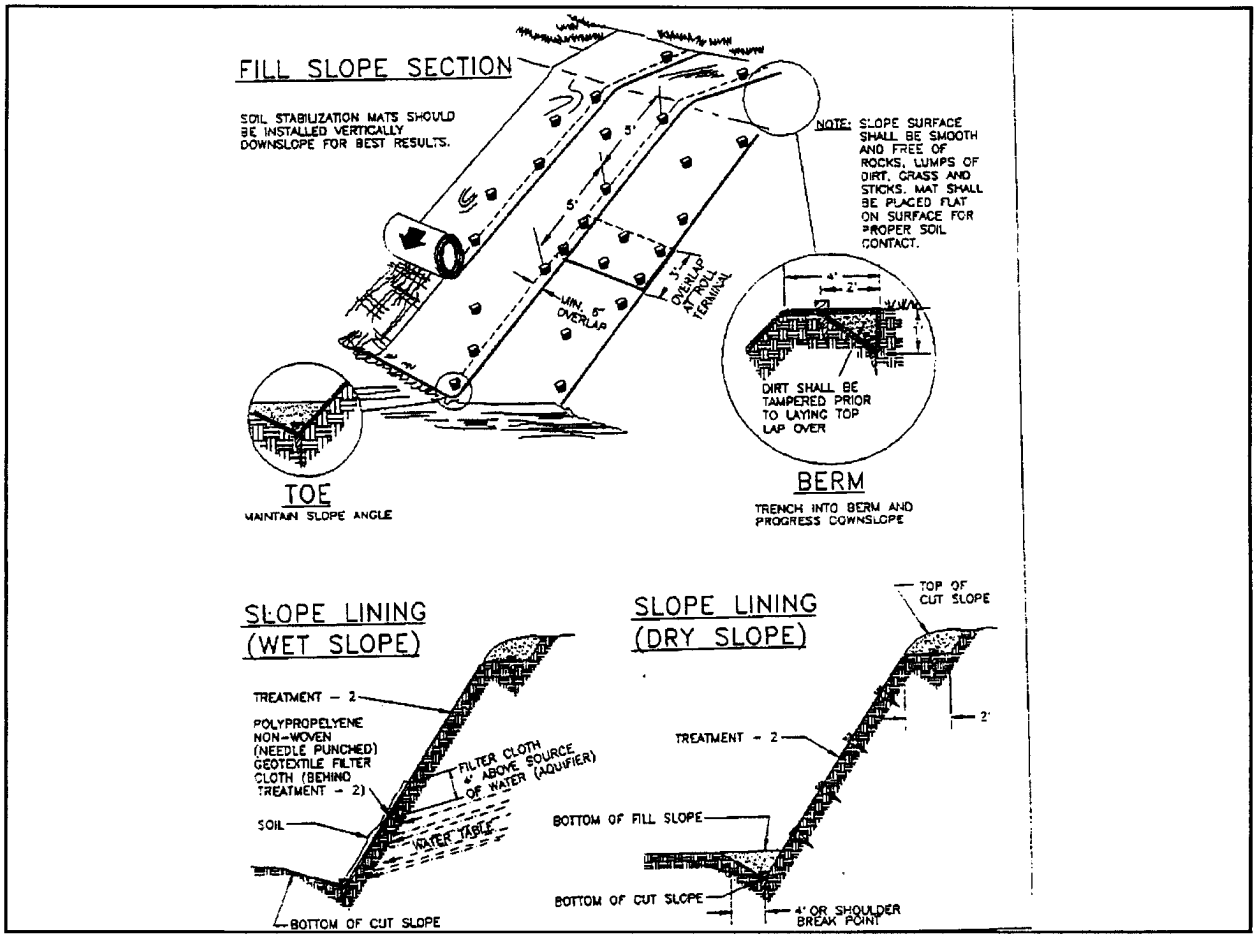

Figure 11: Soils stabilization matting, slope installation.

Mulching - Mulch should be applied following installation of **Treatment-2** at rates noted on page

Laying and Securing - See figure 11. Similar to installing **Treatment-1**, but ***manufacturer's recommendations must be followed*** as detailed. the key to achieving desired performance is dependent upon proper installation.

Check Slots - Matting manufacturers vary significantly in their check slot requirements. Similar to the installation of **Treatment-1**, a check slot may be required when laying **Treatment-2** to "correct" the flow of water if it has the potential to undermine the matting. Entrench the sides of the matting as well, creating a slope shelf for the material to rest on, preventing water form entering under the mat on the sides.

Securing the Material and Joining Mats - Again, product specifications vary - upstream and downstream terminal slots, new roll overlaps and multiple width installations differ by various products and manufacturers.

Final Check - These installation techniques must be adhered to:

1. Soil stabilization mat is in uniform contact with the soil.
2. All required slots and lapped joints are in place.
3. The material is properly anchored.
4. All disturbed areas are seeded.

Maintenance

All soil stabilization blankets and matting should be inspected periodically following installation, particularly after rainstorms to check for erosion and undermining. Any dislocation or failure should be repaired immediately. If washouts or breakage occurs, re-install the material ***after repairing damage to the slope or ditch.*** Continue to monitor these areas until which time they become permanently stabilized; at that time an annual inspection should be adequate.

Permanent Seeding and Revegetation

Definition
The establishment of perennial vegetative cover on disturbed areas by planting seed.

Purposes
1. To reduce erosion and decrease sediment yield from disturbed areas.
2. To permanently stabilize disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials.
3. To improve wildlife habitat through the use of native plant materials.
4. To enhance the natural beauty of an area.

Conditions Where Practice Applies
Disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil.

Planning Considerations

Site Clean Up
All excavated or stockpiled material, excess gravel, rock, limestone, peat, boards, stakes and any other garbage and debris remaining on-site as a result of the construction activities shall be promptly removed from the site and disposed of appropriately.

Disturbed Area Regrading
All areas disturbed during construction shall be regraded to a smooth landform which provides proper drainage through the area and which blends in with adjacent undisturbed topography.

Seedbed Preparation
Seedbeds should be well settled, firm and friable to facilitate seed placement at required depths. The area should be weed-free. This is accomplished by ripping prior to seeding. All disturbed areas including access ways shall be ripped or chiseled to a depth of four to six inches (rip cuts on maximum of 12" centers) in order to alleviate compaction and provide a suitable seedbed. Harrowing may be required after ripping to create a firm bed.

Selecting Plant Materials
Soil moisture and texture are the most important factors to consider when selecting a seed mix for a particular site. Seeding mixes are provided here as general guidelines for preparing a revegetation plan. These recommended mixes are adapted from the Soil Conservation Services Critical Area Planting guidelines. Only native species are recommended. General seeding mixes are presented for the most frequently encountered general soil types are given below. Other seeding mixes may be needed for areas with high alkalinity, shalely soils or sandy soils. Contact the Planning Department or the Soil Conservation Service in Longmont for seeding recommendations for other soil types.

WELL DRAINED GRAVELLY SOILS				
Species	**Common Name**	**Variety**	**% mix**	**lbs(pls)/acre**
Grasses				
Agropyron smithii	western wheatgrass	Arriba	20	3.2
Bouteloua curtipendula	sideoats grama	Vaughn	20	1.8
Bouteloua gracilis	blue grama	Lovington	15	0.5
Stipa comata	needle and thread		15	2.3
Sporobolus asper	tall dropseed		10	0.1
Stipa viridula	green needlegrass		10	1.0
Buchloë dactyloides	buffalo grass	Native	5	0.8
Oryzopsis hymenoides	indian ricegrass	Paloma	5	0.6
		TOTAL	100	10.3

WELL-DRAINED LOAMY SOILS				
Species	**Common Name**	**Variety**	**% mix**	**lbs(pls)/acre**
Grasses				
Agropyron smithii	western wheatgrass	Arriba	35	5.6
Sporobolus airoides	alkali sacaton	Native	25	0.4
Panicum virgatum	switchgrass	Grenville	20	0.9
Andropogon gerardii	big bluestem	Kaw	5	0.6
Agropyron trachycaulum	slender wheatgrass	Primar	5	0.6
Schizachyrium scoparium	little bluestem	Pastura	5	0.4
Elymus canadensis	Canada wildrye		5	0.5
Oryzopsis hymenoides	indian ricegrass	Paloma	5	0.6
		TOTAL	100%	9

BOTTOMLANDS				
Species	**Common Name**	**Variety**	**% mix**	**lbs(pls)/acre**
Grasses				
Panicum virgatum	switchgrass	Grenville	20	0.9
Sorghastrum nutans	Indiangrass	Llana	20	2.0
Andropogon gerardii	big bluestem	Kaw	20	2.2
Sporobolus airoides	alkali sacaton		15	0.23
Agropyron smithii	western wheatgrass	Arriba	25	4.0
		TOTAL	100%	9.33

Seeding Methods

Seed should be planted with a drill on all slopes of 33% (3:1) or flatter. The drill must meet specifications for the type of seed and seeding rates recommended. Seed may be broadcast by hand, by mechanical spreader, or by hydraulic equipment on areas that are small, or too steep and/or inaccessible for seed-drilling. Hydraulic application of seed and mulch in a single operation is not recommended.

Seeding Rates

Seeding rates are given for drill seeding. If seed if broadcast, the rates must be doubled.

Seeding Depth

Seed planted with a drill should be placed between ¼ and ¾ inch below the surface. Broadcast seed should be incorporated into the surface soil by raking or harrowing at depths not to exceed ¾ inch.

Seeding Dates

November 1 - April 30. If irrigated the seeding date can be extened to July 15.

Mulching

Clean weed and seed-free long stemmed grass hay should be applied evenly at a rate of two tons per acre. Native grass hay is acceptable if the source is known to be weed-free. At least half of the mulch should be at least ten inches long. Mulch must be anchored by crimping. The mulch fibers must be tucked (uncut) into the soil to a depth of four inches. Manufactured stabilization blankets and matting can be used as mulches. Jute or coconut fiber netting must be anchored using stakes or staples.

Seeding Requirements

a) Grass seed should be fresh, recleaned grass seed of the latest crop available.
b) Seed should meet Colorado Department of Agriculture Seed Laws (C.R.S. 35-27).
c) Seed should be from locally obtained stock when possible.

Shrub Plantings

*a*Extra visual appeal and habitat diversity can be provided by planting shrubs such as skunkbrush sumac (*Rhus trilobata*-1.0)[8], fourwing saltbrush (*Atriplex canescens*-0.5) and rabbitbrush (*Chrysothamnus nasueosus*-0.25). These can be seeded or planted from rooted stock. In streamside areas revegetation should include rooted stock of American plum (*Prunus americana*), chokecherry (*Prunus virginiana*), plains cottonwood (*Populus deltoides*), hawthorne (*Crataegus macrantha, C. erythropoda*), peach-leaved, sandbar or coyote willow (*Salix amygdaloides, S. interior, S.exigua*).

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[8]Numbers following plant names indicate the seeding rates as pounds of live seed per acre (PLS).

Vehicle Tracking Control[9]

Definition

A stone stabilized pad located at points of vehicular ingress and egress on a maintenance site.(figure 12)

Purposes

To reduce the amount of mud transported onto public roads and then drainageways by motor vehicles or runoff.

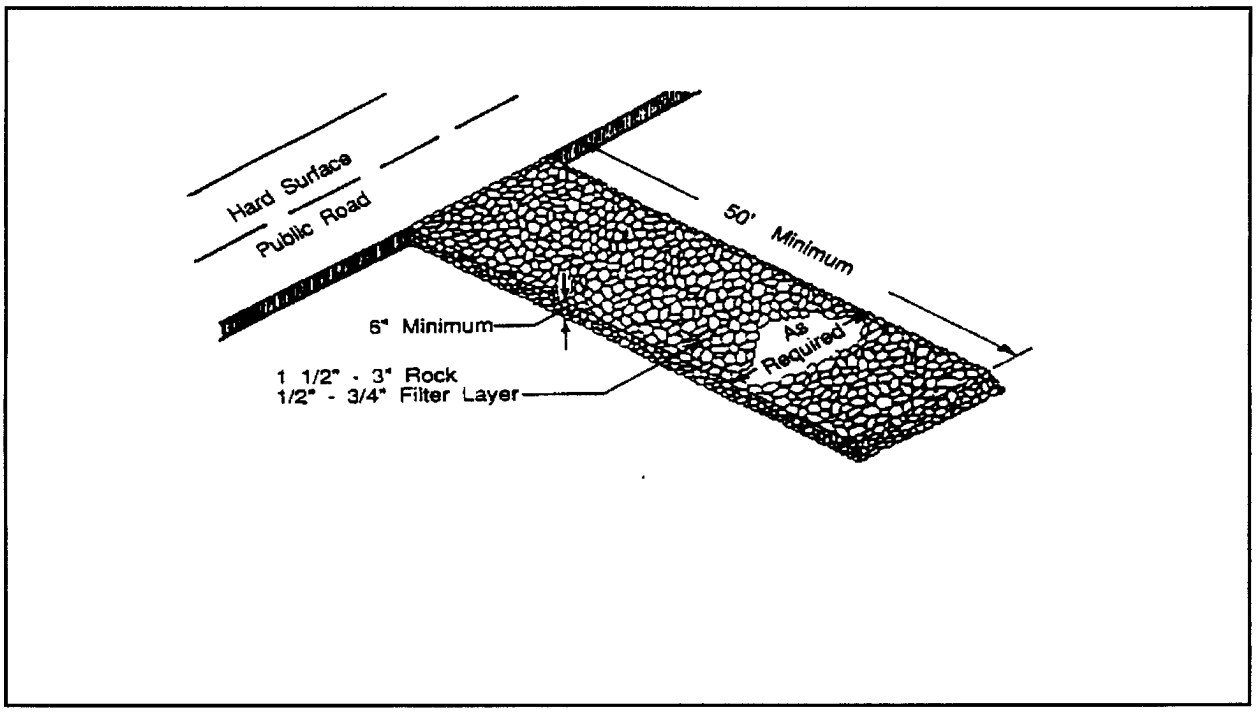

Figure 12: Detail of tracking control application

Note: Only applicable for sites greater than 2 acres in size.

[9]Urban Drainage Criteria Manual.Volume 3-Best Management PracticesUrban Drainage and Flood Control District.

Straw Bale Barriers[10]

Definition
A temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

Purposes
1. To intercept and detain small amounts of sediment from disturbed areas of limited extent in order to reduce sediment in runoff from leaving the site.
2. To decrease the velocity of sheet flows from hillslope areas.

Conditions Where Practice Applies
1. Below very small disturbed areas subject to sheet and rill erosion.
2. Where the size of the drainage area is no greater than one-fourth of an acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 50 percent (2:1).
3. Where effectiveness is required for less than 3 months.
4. Under no circumstances should straw bale barriers be constructed in live streams or in swales where there is the possibility of a washout.
5. The measure should not be used where water may concentrate in defined ditches and minor swales.
6. Straw bale barriers shall not be used on areas where rock or another hard surface prevents the full and uniform anchoring of the barrier.

Planning Considerations
Based on observations made in Virginia, Pennsylvania, Maryland and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be - especially when used to slow down and filter concentrated flows. They should be used judiciously and with caution as erosion control measures. There are three major reasons for such ineffectiveness.

First, improper utilization of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water depth and velocities have destroyed or damaged the control. Secondly, improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, has allowed undercutting and end flow. This has resulted in additions of, rather than removal of, sediment from runoff waters. Finally, inadequate maintenance lowers the effectiveness of these barriers. Trapping efficiencies of carefully installed straw bale barriers on one project in Virginia dropped from 57% to 16% in one month due to lack of maintenance.

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[10] Virginia Erosion and Sediment Control Handbook, 3rd EditionVirginia Dept. of Conservation and Recreation and Urban Drainage Criteria Manual.Volume 3-Best Management PracticesUrban Drainage and Flood Control District.

There are serious questions about the continued use of straw bale barriers as they are presently installed and maintained. Averaging from $3 to $6 per linear foot, the thousands of straw bale barriers used annually represent such a considerable expense that optimum installation procedures should be emphasized.

Design Criteria

A formal design is not required. However, an effort should be made to locate the straw bale barrier, as well as other perimeter controls, at least 5 to 7 feet from the base of disturbed slopes with grades greater than 7%. This will help prevent the measure from being rendered useless following the initial movement of soil.

Construction Specifications

1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

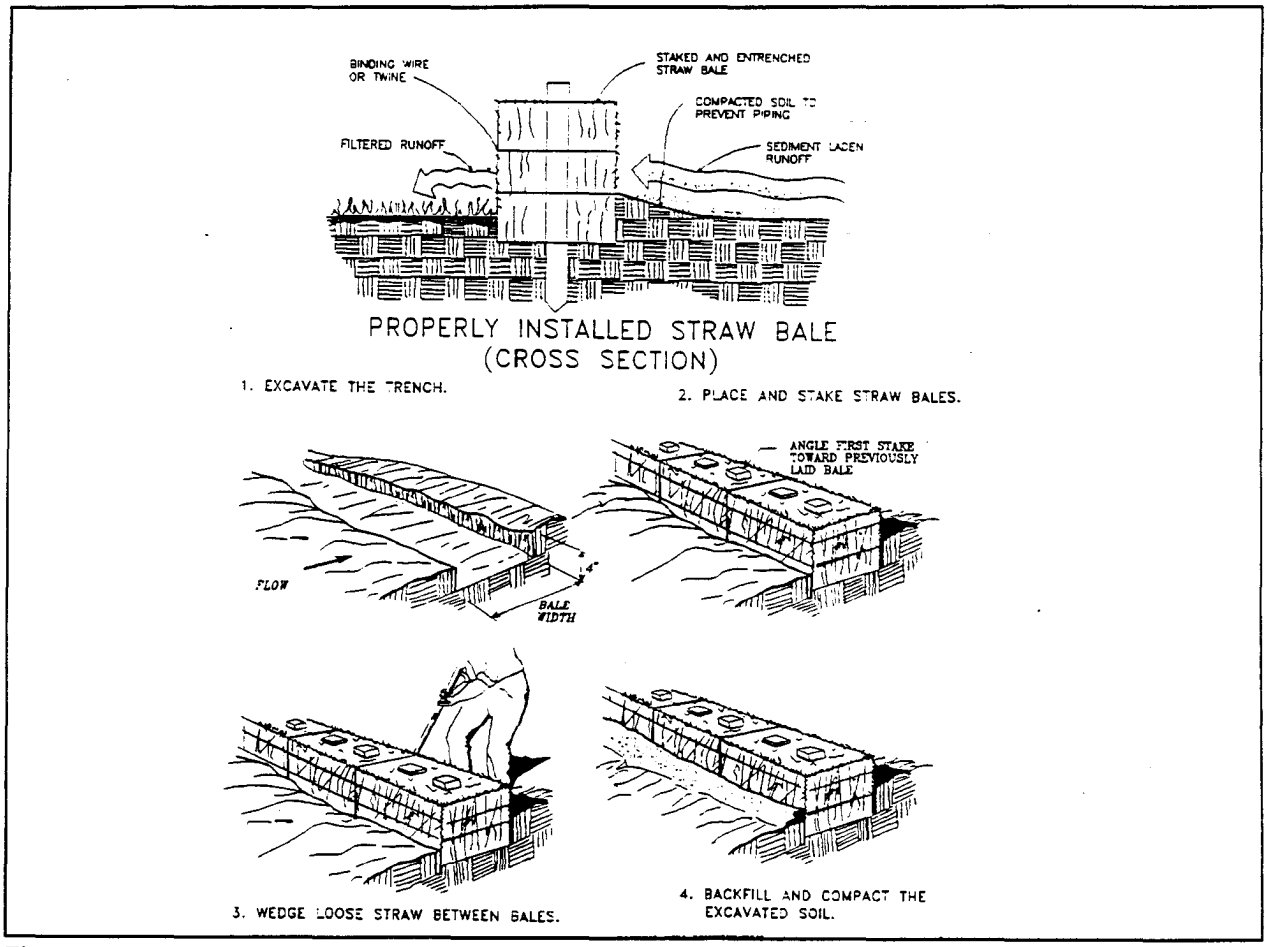

Figure 13: Construction of straw bale barrier

2. All bales shall be either wire-bound or plastic string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings (see figure 13).

3. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. After the bales are staked and chinked (gaps filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier (see figure 13).

4. Each bale shall be securely anchored by at least two stakes (minimum dimensions 2 inches x 2 inches x 36 inches) or standard "T" or "U" steel posts (minimum weight of 1.33 pounds per linear foot) driven through the bale. The first stake or steel post in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or steel pickets shall be driven a minimum 18 inches deep into the ground to securely anchor the bales.

5. The gaps between bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency.

6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

Maintenance

1. Straw bale barriers shall be inspected immediately after each rainfall and at least daily during prolonged rainfall.

2. Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales.

3. Necessary repairs to barriers or replacement of bales shall be accomplished promptly.

4. Sediment deposits should be removed after each rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.

5. Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded in accordance with the approved reclamation plan.

Silt Fencing[11]

Definition

A temporary sediment barrier consisting of a synthetic filter fabric stretched across and attached to supporting posts and entrenched.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.
2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Conditions Where Practice Applies

1. Below disturbed areas where erosion would occur in the form of sheet and rill erosion.

2. Where the size of the drainage area is no more than one quarter acre per 100 feet of silt fence length; the maximum slope length behind the barrier is 100 feet; and the maximum gradient behind the barrier is 50 percent (2:1).

3. In minor swales or ditch lines where the maximum contributing drainage area is no greater than 1 acre and flow is no greater than 1cfs.

4. Silt fence will not be used in areas where rock or some other hard surface prevents the full and uniform depth anchoring of the barrier.

Planning Considerations

Laboratory work at the Virginia Highway and Transportation Research Council (VHTRC) has shown that silt fences can trap a much higher percentage of suspended sediments than straw bales, though silt fence passes the sediment-laden water slower. Silt fences are preferable to straw barriers in many cases because of their durability and potential cost savings. While the failure rate of silt fences is lower than that of straw barriers, many instances have been observed where silt fences are improperly installed, inviting failure and sediment loss. The installation methods outlined here can improve performance and reduce failures.

As noted, flow rate through silt fence is significantly lower than the flow rate for straw bale barriers. This creates more ponding and hence more time for sediment to fall out.

Both woven and non-woven synthetic fabrics are commercially available. The woven fabrics

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[11] Sediment Control Handbook, 3rd EditionVirginia Dept. of Conservation and Recreation and Urban Drainage Criteria Manual.Volume 3-Best Management PracticesUrban Drainage and Flood Control District..

generally display higher strength than the non-woven fabrics and, in most cases, do not require any additional reinforcement. When tested under acid and alkaline water conditions, most of the woven fabrics increase in strength, while the reactions of non-woven fabrics to these conditions are variable. The same is true of testing under extensive ultraviolet radiation. Permeability rates vary regardless of fabric type. While all of the fabrics demonstrate very high filtering efficiencies for sandy sediments, there is considerable variation among both woven and non-woven fabrics when filtering the finer silt and clay particles.

Design Criteria

1. No formal design is required. As with straw bale barriers, an effort should be made to locate silt fence at least 5 feet to 7 feet beyond the base of disturbed slopes with grades greater than 7%.
2. The use of silt fences, because they have such a low permeability, is limited to situations in which only sheet or overland flows are expected and where concentrated flows originate from drainage areas of 1 acre or less.
3. Field experience has demonstrated that, in many instances, silt fence is installed too short (less than 16 inches above ground elevation). The short fence is subject to breaching during even small storm events and will require maintenance "clean outs" more often. ***Properly supported*** silt fence which stands 24 to 34 inches above the existing grade tends to promote more effective sediment control.

Materials

1. Synthetic filter fabric shall be a pervious sheet of propylene, nylon, polyester or ethylene yarn and shall be certified by the manufacturer or supplier as conforming to the requirements noted in the table below .

2. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0 F to 120 F.

3. If wooden stakes are utilized for silt fence construction, they must have a diameter of 2 inches when oak is used and 4 inches when pine is used. Wooden stakes must have a minimum length of 5 feet.

Physical properties of filter fabric in silt fence

Physical Property	Test	Requirements
Filtering Efficiency	ASTM 5141	75% (minimum)
Tensile Strength @ 20% Elongation*		Extra strength (50lbs/linear inch) Standard strenght (30lbls/linear inch) (minimum)
Flow Rate	ASTM 5141	0.2 gal/sq.ft./minute (minimum)
Ultraviolet Radiation Stablity	ASTM-G-26	90% (minimum)
*Requirement reduced by 50% after six months of installation.		

4. If steel posts (standard "U" or "T" section) are utilized for silt fence construction, they must have a minimum weight of 1.33 pounds per linear foot and shall have a minimum length of 5 feet.
5. Wire fence reinforcement for silt fences using standard-strength filter cloth shall be a minimum of 14 gauge and shall have a maximum mesh spacing of 6 inches.

Installation

1. The height of a silt fence shall be a minimum of 16 inches above the original ground surface and shall not exceed 34 inches above ground elevation.
2. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are unavoidable, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed.
3. A trench shall be excavated approximately 4-inches wide and 4-inches deep on the upslope of the proposed location of the measure.
4. When the ***wire support is used***, standard-strength filter cloth may be used. Posts for this type of installation shall be placed a ***maximum of 10-feet apart*** (see figure 14). The wire mesh fence must be fastened securely to the ***upslope*** side of the posts using heavy duty wire staples at least one inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of two inches and shall not extend more than 34 inches above the original ground surface. The standard-strength fabric shall be stapled or wired to the wire fence, and 8 inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees.

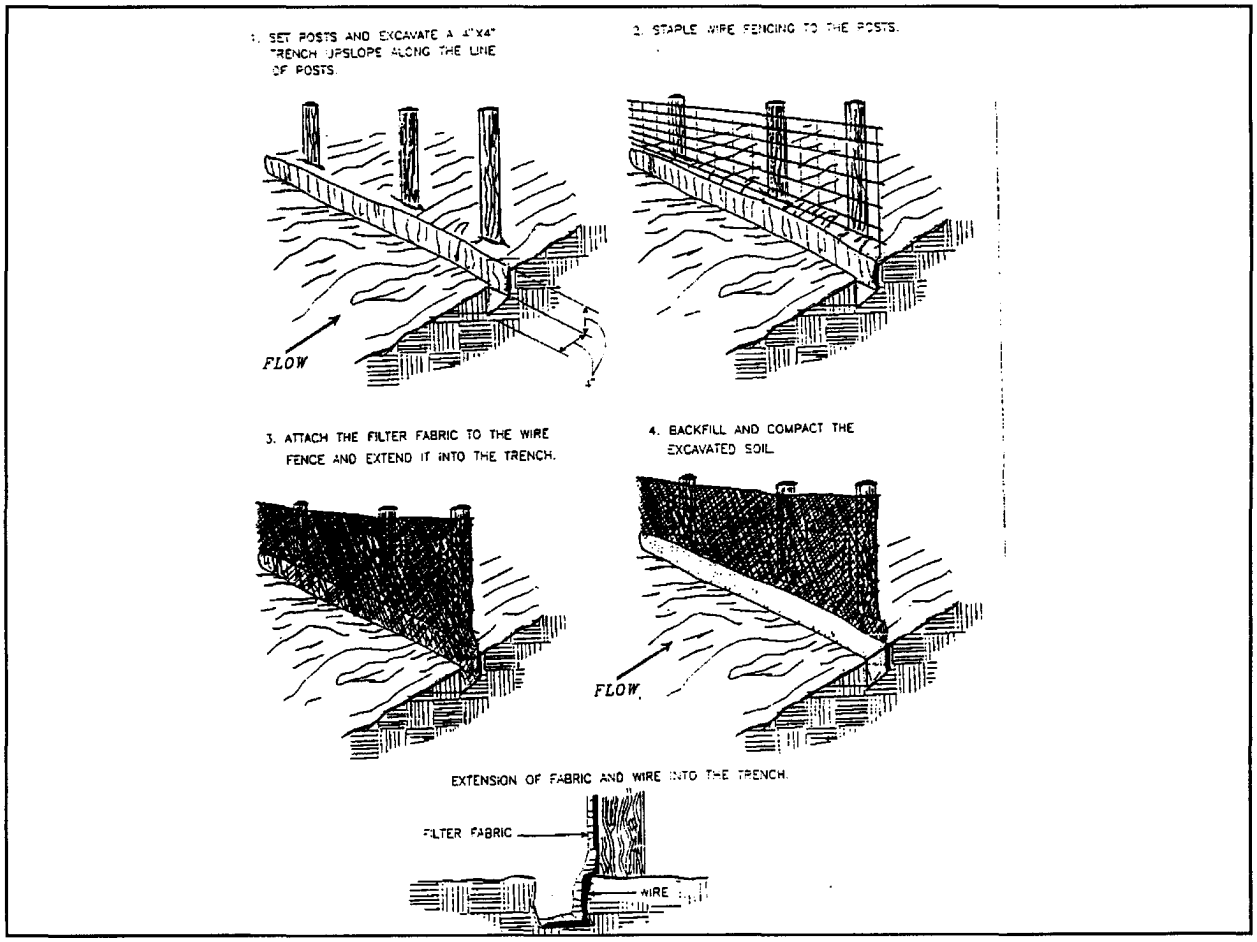

Figure 14: Construction of a silt fence

5. When ***wire support is not used***, extra-strength filter cloth shall be used. Posts for this type of fabric shall be placed a ***maximum of 6-feet apart***. The filter fabric shall be fastened securely to the upslope side of the posts using one inch long (minimum) heavy-duty wire staples or tie wires and eight inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees. This method of installation has been found to be more commonplace than #4.
6. If a silt fence is to be constructed across a ditch line or swale, the measure must be of sufficient length to eliminate endflow, and the plan configuration shall resemble an arc or horseshoe with the ends oriented upslope (see figure 15). ***Extra-strength filter fabric*** shall be used for this application with a ***maximum 3-foot spacing of posts***.
   All other installation requirements noted in #5 apply.
7. The 4-inch by 4-inch trench shall be backfilled and the soil compacted over the filter fabric.
8. Silt fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

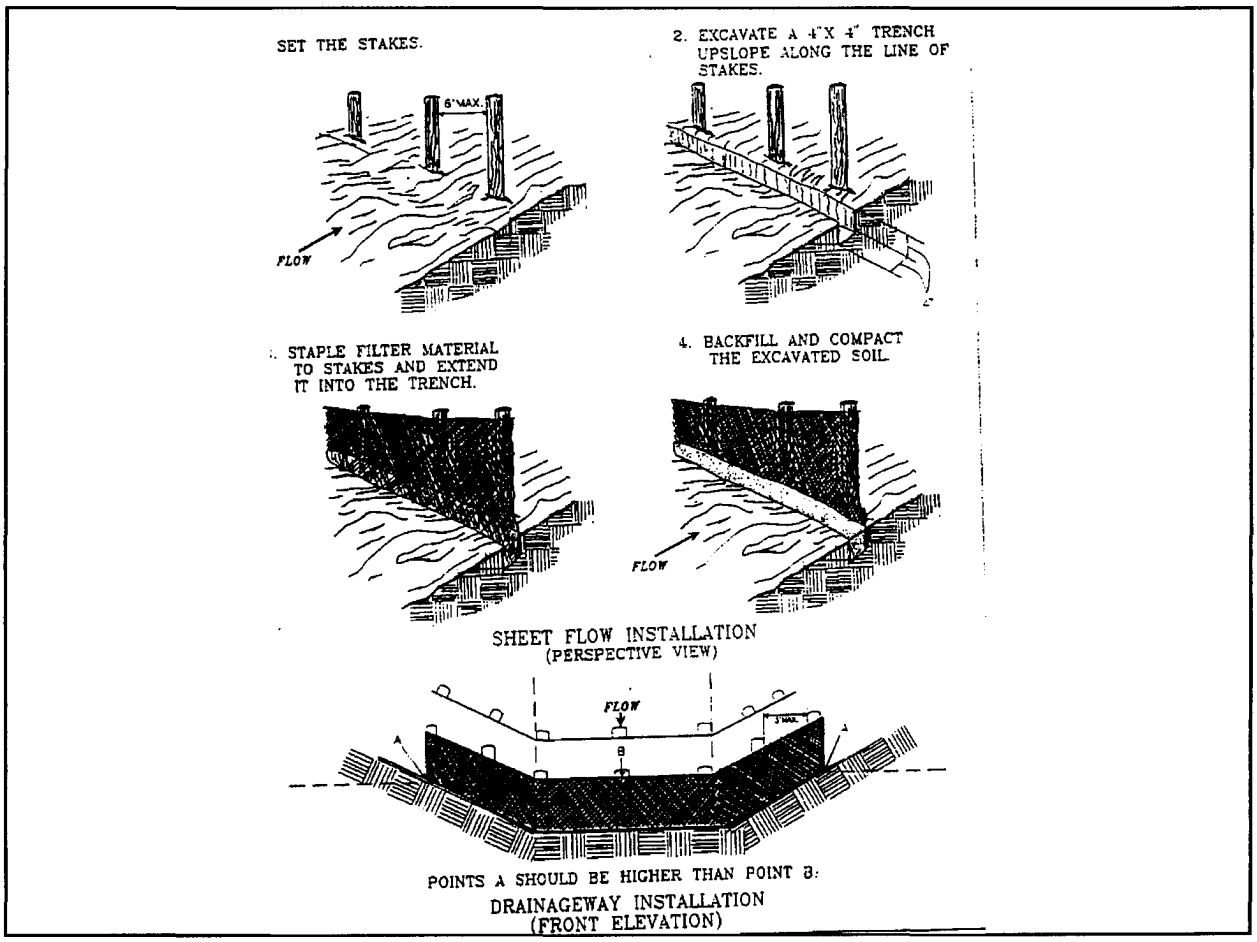

Figure 15: Construction of a silt fence (without wire support)

Maintenance

1. Silt fences shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately.
2. Close attention shall be paid to the repair of damaged silt fence resulting from end runs and undercutting.
3. Should the fabric on a silt fence decompose or become ineffective prior to the end of the expected usable life and the barrier still be necessary, the fabric shall be replaced promptly.
4. Sediment deposits should be removed after each storm event. They must be removed when deposits reach approximately one-half the height of the barrier.
5. Any sediment deposits remaining in place after the silt fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

Temporary Sediment Traps[12]

Definition
A small temporary ponding area, formed by constructing an earthen embankment with a rock-covered outlet across a drainage swale, or by excavation of a depression below original grade. Relative elevations should contain all runoff within the trap area.

Purposes
To detain sediment-laden runoff from disturbed areas long enough to allow the majority of the sediment to settle out.

Conditions Where Practice Applies
1. ***Below disturbed areas where total contributing drainage is less than 3 acres.***
2. Where the sediment trap will be used no longer than 18 months (the maximum useful life is 18 months).

Planning Considerations
Sediment traps should be used only for small drainage areas.

Sediment traps, along with other perimeter controls intended to trap sediment, shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

Recent studies have been conducted on the performance of sediment traps (and basins) which were constructed using the design criteria found in previous editions of this handbook. The studies indicate that the control measures only achieved a 46% removal of sediment which flowed into them during storm events which caused measurable outflow.

In most cases excavation will be required to attain the necessary storage volume. Also, sediment must be periodically removed from the trap to maintain the required volume. Plans should detail how excavated sediment is to be disposed of, such as by use in fill areas on site or removal to an approved off-site location.

As noted previously in these BMP specification, there are numerous other acceptable ways to design many of the erosion control practices within. This is certainly true in the case of the sediment trap. However, variations in its design should be considered judiciously by plan reviewers to ensure that the minimum storage requirements and structural integrity noted in this specification are maintained.

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[12]Virginia Erosion and Sediment Control Handbook, 3rd EditionVirginia Dept. of Conservation and Recreation and Urban Drainage Criteria Manual.Volume 3-Best Management PracticesUrban Drainage and Flood Control District.

Design Criteria

Trap Capacity

The sediment trap must have an initial storage volume of 134 cubic yards per acre of drainage area, half of which shall be in the form of a permanent pool or wet storage to provide a stable settling medium. The remaining half shall be in the form of a drawdown or dry storage which will provide extended settling time during less frequent, larger storm events. The volume of the wet storage shall be measured from the low point of the excavated area to the base of the stone outlet structure. The volume of the dry storage shall be measured from the base of the stone outlet to the crest of the stone outlet (overflow mechanism). Sediment should be removed from the basin when the volume of the wet storage is reduced by one-half.

For a sediment trap, the wet storage volume may be approximated as follows:

$$V_1 = 0.85\, A_1\, D_1$$

where,

V_1 = the wet storage volume in cubic feet

A_1 = the surface area of the flooded area at the base of the stone outlet in square feet

D_1 = the maximum depth in feet, measured from the low point in the trap to the base of the stone outlet

The dry storage volume may be approximated as follows:

$$V_2 = \frac{A_1 + A_2}{2}\, D_2$$

where,

V_2 = the dry storage volume in cubic feet

A_1 = the surface area of the flooded area at the base of the stone outlet in square feet

A_2 = the surface area of the flooded area at the crest of the stone outlet (overflow mechanism), in square feet

D_2 = the depth in feet, measured from the base of the stone outlet to the crest of the stone outlet

The designer should seek to provide a storage area which has a minimum 2:1 length to width ration (measured from point of maximum runoff introduction to outlet).

Note: Conversion between cubic feet and cubic yards is as follows:

number of cubic feet x 0.037 = number of cubic yards

Excavation

Side slopes of excavated areas should be no steeper than 1:1. The maximum depth of excavation within wet storage area should be 4 feet to facilitate clean-out and for site safety considerations.

Outlet

The outlet for the sediment trap shall consist of a stone section of the embankment located at the low point in the basin. A combination of coarse aggregate and riprap shall be used to provide for filtering/detention as well as outlet stability. The smaller stone shall be #5 Coarse Aggregate (smaller stone sizes will enhance filter efficiency) and riprap shall be "Class I." Filter cloth shall be placed at the stone-soil interface to act as a "separator." The minimum length of the outlet shall be 6 feet times the number of acres comprising the total area draining to the trap. The crest of the stone outlet must be ***at lease 1.0 foot below the top of the embankment*** to ensure that the flow will travel over the stone and not the embankment. The outlet shall be configured as noted in figgure 16.

Embankment Cross-Section

The maximum height of the sediment trap embankment shall be 5 feet as measured from the base of the stone outlet. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in figure 16. Side slopes of the embankment shall be 2:1 or flatter.

Removal

Sediment traps must be removed after the contributing drainage area is stabilized. Plans should show how the site of the sediment trap is to be graded and stabilized after removal.

Construction Specifications

1. The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat.
2. Fill material for the embankment shall be free of roots or other woody vegetation, organic material, large stones, and other objectionable material. The embankment should be compacted in 6-inch layers by traversing with construction equipment.
3. The earthen embankment shall be seeded with temporary or permanent vegetation (see Permanent Seeding and Revegetation specifications pg. 47) immediately after installation.
4. Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.
5. The structure shall be removed and the area stabilized when the upslope drainage area has been

stabilized.

6. All cut and fill slopes shall be 2:1 or flatter (except for excavated, wet storage area which may be at a maximum 1:1 grade).

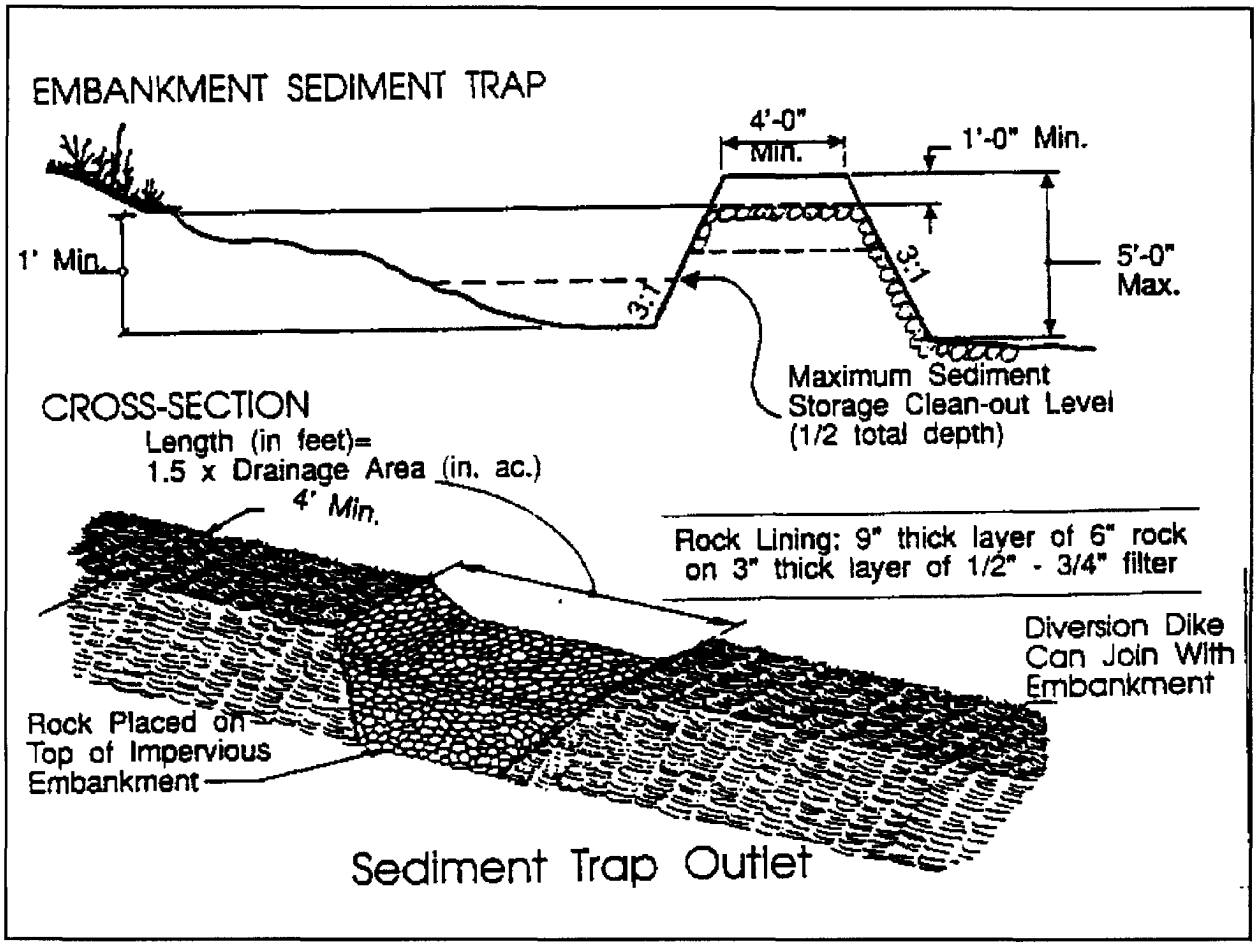

Figure 16: Temporary sediment trap

Maintenance

1. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half of the design volume of the wet storage. Sediment removal from the basin shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.
2. Filter stone shall be regularly checked to ensure that filtration performance is maintained. Stone choked with sediment shall be removed and cleaned or replaced.
3. The structure should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should be checked to ensure that its center is at least 1 foot below the top of the embankment.