Appendix A:
Development Submittal Checklists

Drainage Memo Checklist

Project Name:			
Date:			
Cover Letter		**Included**	**N/A**
	Date		
	Name of Engineer designing the site		
	Statement of compliance with the requirements of the FCSCM		
Project Description			
	Existing Conditions		
	Proposed land uses and/or project summary		
	Description and quantification of impervious surfaces or changes		
Other			
	Other specific items that may be identified by the design engineer or Stormwater staff		

ODP Drainage Report Checklist

Project Name:			
Date:			
General Location & Existing Site Info		**Included**	**N/A**
	Section, Township, Range		
	Vicinity Map		
	Roadways within and adjacent to site		
	Master Drainage Basin that site is located within		
	Existing stormwater drainage facilities and drainage patterns		
	Existing irrigation facilities		
	Existing ground cover and/or vegetation type		
Master Drainage Basin Info			
	Reference/discussion regarding pertinent master drainage basin		
	Any master planning improvements in the vicinity?		
	General basin characteristics		
	Existing and planned land uses within the master drainage basin		
	Irrigation facilities that influence or are influenced by the local drainage		
Floodplain Information			
	Existing floodplain and floodway info		
	Other planning studies such as flood hazard delineation reports and FIRMs		
Project Description			
	Proposed land uses and/or project summary		
	Site acreage		
	Names of surrounding developments		
Proposed Drainage Facilities			
	Proposed drainage patterns		
	Location and approximate size of detention storage and outlet design		
	Area to be serviced by the drainage improvements		
	LID system considerations/options		
	Potential impacts on the project site from offsite basins under existing and fully developed basin conditions pursuant to zoning and land use plans		
	Conveyance of minor and major stormwater systems to an existing stormwater conveyance		
	Specific details and special design points, if necessary		
References			
	Referenced criteria, master plans, technical info		
Appendices			
	drainage calculations based on ODP site plan		
	detention pond volume calculations based on ODP site plan		

City of Fort Collins

ODP Drawing Checklist

Project Name:			
Date:			
Existing Drainage Info		**Included**	**N/A**
	Identification of drainage flows entering/leaving site; general drainage patterns		
	Major drainage basin boundaries		
	Any offsite drainage feature influencing development		
Existing Watercourses			
	All watercourses, rivers, wetlands, creeks, irrigation ditches or laterals located on or within 150' of the property		
Imagery and Topography			
	Include existing topo contours and/or aerial image background, if available		
Floodplain Information			
	All 100-year floodplain and floodway boundaries, cross-sections and BFE's		
	FEMA-regulated floodplains - BFE's must be reported in NAVD 1988 and NGVD 1929		
	City-regulated floodplains - BFE's shown in NAVD 1988		
Proposed Drainage Facilities			
	Proposed drainage flow directions (arrows)		
	Proposed contours, if available		
	Proposed drainage facilities (general locations) including detention ponds, water quality ponds, LID systems, storm sewers, street network, culverts, channels/swales		
Legend			
	Define map symbology		

City of Fort Collins

PDP and FP Drainage Report Checklist

Project Name:			
Date:		**Included**	**N/A**
Cover Letter			
	Include name of project, date, name of design engineer		
	Statement of compliance with the manual		
FP	Final copies required to be stamped and signed by Colorado licensed PE		
General Location & Existing Site Info			
	Section, Township, Range		
	Vicinity Map		
	Roadways within and adjacent to site		
	Names of surrounding developments		
	Master Drainage Basin where site is located		
	Existing stormwater drainage facilities and drainage patterns		
	Existing irrigation facilities (if applicable)		
	Existing land uses		
	Existing ground cover and/or vegetation type		
	Existing soils info		
Master Drainage Basin Info			
	Reference/discussion regarding pertinent Master Drainage Basin and any improvements planned for the area		
	General basin characteristics		
	Existing and planned land uses within the Master Drainage Basin		
	Irrigation facilities that influence or are influenced by the local drainage (if applicable)		
Floodplain Information			
	Refer to Floodplain Checklists for requirements		
Project Description			
	Proposed land uses and/or project summary		
	Site acreage		
Proposed Drainage Facilities			
	Discussion of proposed drainage plan, specific details that may include drainage issues at specific design points		
	Conveyance of minor and major stormwater systems to an existing stormwater conveyance		
	Detention basin and outlet design; summary table for each detention basin		
	WQCV design		
	LID systems and design		
	Maintenance access to the drainage facilities		
	Easements/tracts for drainage purposes		
Drainage Design Criteria			
	Reference to any previous drainage studies for the area		
	Four-Step process outlined and discussed		
	Using CoFC rainfall data for 2-yr and 100-yr recurrence intervals		
	Using proper design storm recurrences (2-yr and 100-yr)		
	Runoff calculation method		
	Detention calculation method		
FP	Street Capacity discussion		
FP	Inlet Capacity discussion		

PDP and FP Drainage Report Checklist

Project Name:			
Date:		**Included**	**N/A**
FP	Pipe network models discussion		
FP	Swale or channel sizing/capacity discussion		
FP	Emergency spillway sizing discussion		
Variance Requests			
	Included variance request form		
Erosion Control			
	Statement of compliance with all erosion control materials that are to be provided with final plans		
FP	Separate Erosion Control Report and Plans submitted		
Conclusion			
	Statement of compliance with manual, master drainage plans, floodplain regs, other state/federal regs		
	Summary conclusion of drainage concept and effectiveness of design		
References			
	Referenced criteria, master plans, technical info		
Appendices			
	Hydologic calculations: historic and developed runoff		
	Detention basin volume calculations		
	SDI data spreadsheet (meets detention drain time criteria)		
	SWMM models (if applicable)		
	LID exhibit and calculations		
	Floodplain maps		
	Soil survey information		
FP	Street capacity		
FP	Inlet sizing and capacity		
FP	Storm pipe network models		
FP	Erosion protection (i.e. riprap calculations)		
FP	Swale or channel sizing		
FP	Outlet structure design		
FP	Spillway design		
	Drainage map		

City of Fort Collins

PDP and FP Drawing Checklist

Project Name:			
Date:		**Included**	**N/A**
General Plan Requirements			
	Title block		
	Name of project and/or subdivision		
	Legend with symbols, abbreviations, etc.		
	Vicinity map or Key map		
	Typcial drawing scales: 1” = 20’, 30’, 40’ or 50’		
	North Arrow on all sheets		
	Date of preparation		
	City signature block		
	Ditch company signature block (if applicable)		
FP	On final plans: Stamp and signature of Colorado licensed Professional Civil Engineer in accordance with Colorado State Statutes and Board Rules		
Existing Conditions and/or Demolition Plan (if applicable)			
	Existing prominent features (waterways, irrigation ditches, vegetation, etc)		
	Existing site information (building footprints, parking lots, roadways, street names)		
	Existing boundary lines of the property, including: right of way lines, lot lines and existing easements		
	Existing utilities locations		
	Existing topography (contours should extend 50' outside of property boundary or show relationship to adjacent properties)		
	Demolition information shown and called out on this plan		
Overall Grading Plan			
	Existing prominent features (waterways, ponds, major utilities, irrigation ditches, vegetation lines, trees, natural habitat buffer zones, etc)		
	Existing and proposed site plan information (building footprints, parking lots, roadways, street names)		
	Existing and proposed boundary lines of the subdivision or project, right of way lines, lot lines, easements		
	Existing utilities locations where drainage design affects the existing utility		
	Existing and proposed contours (contours should extend 50' outside of property boundary or show relationship to adjacent properties)		
	Easements: Proposed drainage easements shown for public storm lines, detention ponds, outfall pipes from ponds, volume-based LID systems		
	LID: Type of LID and location of LID systems clearly shown and called out on this plan.		
	verify subgrade material depths meet FCU minimum requirements		
	max run-on ratio for bioswales 10:1; max run-on ratio for pavers 3:1		
	for pavers: include impervious membrane adjacent to buildings		
	underdrain included in the design and shown in the plans; min underdrain size is 4"		
	inflow forebay or level spreader included for rain gardens and sand filters		
	review landscape plan for appropriate plantings in raingardens, bioswales, sand filters		
	no trees in raingardens		
FP	Erosion control around perimeter of raingardens or other LID's - Note on grading plans: Please refer to the erosion control plan sheets and report for temporary control measures and construction sequencing that shall be used in order to prevent loading of this LID drainage facility with sediment during construction.		

City of Fort Collins

PDP and FP Drawing Checklist

Project Name:			
Date:		**Included**	**N/A**
	Underdrains: horizontal locations are shown and make sense relative to the surface or subsurface grading		
	cleanouts at bends and tees		
FP	invert elevations shown at junctions		
	minimum pipe size is 4"		
	Stormwater outfall identified on the plans		
	Proposed flow arrows and slope labels		
	Proposed spot elevations		
	Proposed storm sewers, culverts, manholes, cross-pans, other		
	Detention Basins: max slope in detention basins 4:1		
	pipe outlets (FES's) and outlet structures tucked into embankments and not sticking out		
	review landscape plan for appropriate plantings in detention basins		
	no trees in swale centerlines		
	FG at least 6" below FF elevation (varies depending on site plans)		
	max slope away from buildings 3:1		
Detailed Grading Plan			
FP	individual lot grading details: FF's, MO's, lot line swales, front and back lot grades, grade breaks		
FP	typical lot grading details		
Overall Utility Plan			
	ROW lines, property lines and easements with dimensions shown		
	Curb and gutter, cross-pans, sidewalks (attached or detached) and medians shown		
	Water, Wastewater and Storm Sewer: show the existing and proposed system layouts including sizes of all mains; a minimum horizontal separation of 10' shall be maintained between all utility mains		
	Dry Utilities: Existing and proposed gas, electric, telephone, cable, etc.		
	Proposed private subdrains (if applicable)		
	Existing irrigation ditches shown		
	Match lines with corresponding sheet numbers referenced		
	Phasing lines (if applicable)		
Storm Sewer Plan and Profile Sheets			
FP	size, type and class of all portions of storm sewer with lengths measured from manhole centers		
FP	manhole type, diameters		
FP	longitudinal stationing		
FP	matchlines with stationing and sheet numbers		
FP	phase lines (if necessary)		
FP	existing ground and proposed ground shown in profile		
FP	Manhole rim and inflow/outflow invert elevations		
FP	include 100-yr HGL's in the profile		
FP	include all wet utility crossings and dry utility crossings in the profile		
FP	identify each segment of each storm sewer as "private" or "public"		
FP	A minimum vertical clearance of 18" shall be maintained when crossing all other utilities.		

PDP and FP Drawing Checklist

Project Name:			
Date:		**Included**	**N/A**
Construction Detail Sheets			
FP	Applicable FCU standard storm sewer details		
FP	Applicable FCU standard LID details		
FP	Other stormwater details such as: emergency spillway, concrete pan, soft pan, others?		
FP	Details of special connections, crossings or construction specific to this project		
FP	Any modified details are clearly labeled or distinguished from the standard details		
Site and Landscape Plans			
	No trees shall be planted within 10' of storm sewer mains		
	No shrubs shall be planted within 4' of storm sewer mains		
	Verify that the note listing these minimum separation distances is included on the landscape plan.		
Plat			
	All existing easements shown		
	All proposed drainage easements shown		

City of Fort Collins

Appendix B:
Landscape Design Standards and Guidelines for Stormwater and Detention Facilities

City of Fort Collins

Landscape Design Standards and Guidelines for Stormwater and Detention Facilities

November 5, 2009

PREPARED BY BHA DESIGN INC.

WITH CITY OF FORT COLLINS UTILITY SERVICES

ACKNOWLEDGEMENTS:

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CIPO: Multi-Use Basin - Detention, Water Quality, Passive Recreation, Habitat Restoration


CIPO: Integrated Outfall Structure


CIPO - Habitat, Bio-Mimicry

INTRODUCTION

The following standards and guidelines have been developed to inform the design and maintenance of landscaping within storm drainage and detention facilities in Fort Collins. Currently the City of Fort Collins follows written standards for the technical design of drainage and detention facilities. These facilities represent a significant portion of open space within both public and private developments in the city. As a result, these standards and guidelines will improve the overall character of our community, storm drainage function, reduce irrigation demand, improve wildlife habitat, and promote maintenance of these open areas.

VISION AND GOALS

These standards and guidelines are part of a larger vision of both the City of Fort Collins City-Wide Sustainability Initiative and the 21st Century Utilities Initiative. This vision is:

"To inspire community leadership by reducing environmental impacts while benefiting customers, the economy and society"

In order to help achieve this vision, these standards and guidelines for landscaping have been developed with the following goals:

- Promote water infiltration and water quality
- Habitat value and plant conservation
- Improve aesthetic quality

STRUCTURE

This document includes background information and describes concepts and objectives for design of stormwater facilities to meet the goals of the 21st Century Utilities Initiative. It includes both **guidelines** (suggested recommendations for design improvements) and **standards** (mandatory requirements for design or documentation). The standards or requirements are outlined a the end of each section.

This document is intended to supplement, not supercede, current regulatory documents which may include:

- Fort Collins Land Use Code
- Fort Collins Stormwater Design Criteria Manual
- Larimer County Urban Area Street Standards
- Army Corps of Engineers
- Neighborhood Home Owner's Association Requirements
- Neighborhood Design Review Committee Requirements

VARIANCE PROCEDURES

These standards and guidelines illustrate and regulate the implementation of the concepts and objectives of the 21st Century Utilities Initiative. Their purpose is to convey these fundamental concepts, but also to foster design innovation and collaboration between city staff, developers, and design professionals. Proposed designs that illustrate the spirit and accomplish the goals, but do not conform to these standards must be approved by the City of Fort Collins Utilities Executive Director or the Director's designee. A variance request shall be submitted in writing prior to or as part of an application for development review. The variance request (s) shall include:

- **Identifying Issue**: Identification of the standard to be waived or varied and why the standard is unfeasible.
- **Alternate Design**: Identification of the proposed alternative design or construction criteria.
- **Comparison to Standards**: A thorough description of the variance request and how the new design compares to the standard.
- **Justification**: Indication of how the proposed plan (as varied) advances the purpose of the standard sought to be varied equally well or better than would compliance with such standard.

Based upon review of the plans and additional information submitted, the Director may approve or deny the variance request. If the Director of Utilities approves the variance request, the plans will continue to be reviewed and approved within the typical review process. If the Director denies the variance request, the applicant shall subsequently submit revised plans in compliance with these Standards. The Director shall provide a written response outlining the basis for all approvals or denials of variance requests.

BACKGROUND

CONCEPTS

The basic concepts of stormwater management are not complicated. The goal is to restore the hydrological cycle to the extent possible and to utilize the available precipitation to promote a naturalized environment in developed areas. This requires understanding the pre-development conditions so they can be an integrated system in the development.

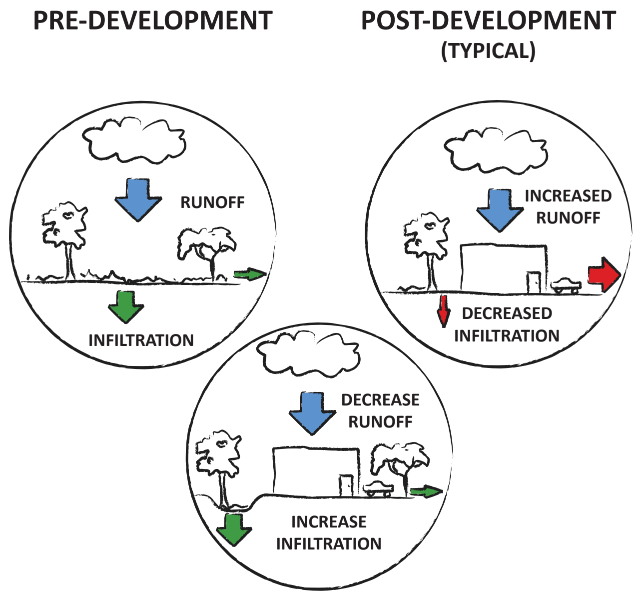
Site stormwater design should not simply focus on basin sizing and outfall rates, but should address site drainage as an integrated multi-use hydrologic system. This system may include detention, water quality treatments, stream bank erosion control, habitat creation, infiltration, energy dissipation, and/or recreational use. The concepts here illustrate specific measures which affect landscape treatments within this overall, integrated stormwater design approach.

INFILTRATION VS. RUNOFF

Infiltration is a natural process by which precipitation is absorbed into the soil. Depending on the local soil type, some of the water remains in the top layers of soil and is used by vegetation. The rest of the water percolates through the soil and bedrock, recharging the groundwater system.

Runoff occurs when the soil is saturated, has become impermeable or when structures and impermeable materials are placed on the site. Runoff tends to contain silt and pollutants that require mitigation. Excessive runoff also contributes to adverse hydraulic downstream conditions causing unnatural stream bank erosion and limited groundwater recharge.

Appropriate site design promotes natural infiltration resulting in fewer downstream impacts including excessive steam flow, exaggerated geomorphology, and reduced stormwater capacity of natural systems.



GOAL: POST -DEVELOPMENT DESIGNED FOR INFILTRATION

HABITAT VALUE

Historically the area that is now Fort Collins was a short grass prairie with a large variety of plant and animal species. Many of these species have been displaced by the onset of development. Natural waterways and drainage patterns are altered by development. This decreases the functionality of existing hydrologic systems. It is necessary to reasonably accommodate and/or reestablish the hydrologic systems that existed prior to development through the site and landscape design process.

Naturalized Planting - Improved Habitat Value

STORMWATER IS AN AMENITY

Stormwater facilities have a reputation for being functional site features without natural qualities. The basic design parameters for a detention pond design is capacity or volume and rate of discharge. These parameters combined with economic factors typically result in designs that maximize the amount of stormwater detention within the smallest possible area.

These parameters are typically accomplished by the creation of geometric basins with calculated volume and outflow rates, connected to site and local utilities through standard gray concrete and steel structures. The typical detention basin is functional as a facility, yet, provides little or no aesthetic or habitat benefits. In many cases detention basins of this kind detract from the overall project image or appeal and adversely affect surrounding properties.

Detention ponds and waterways can instead be designed to both meet the engineering requirements and provide an attractive diverse space. A detention pond can serve as a multi-use area, wildlife habitat, picturesque scene, entry experience or educational opportunity while maintaining the necessary functions of stormwater detention and water quality improvement. Stormwater facilities should be considered an opportunity for aesthetic interest and natural integration rather than solely necessary features of a development.

"Front Door" Curb Appeal - Improved Aesthetics

OBJECTIVES

In order to achieve the overall goals, the following objectives must be met:

1. INFILTRATION AND WATER QUALITY

Reduce excess runoff and downstream pollution by increasing on-site infiltration and water quality. Maintain the primary functions of detention ponds and stream drainages to attenuate flows and improve water quality while creating and improving wildlife habitat.

- Increase pervious surface area and surface conveyance.
- Decrease flow concentration.
- Take advantage of natural processes through bio-filtration and bio-retention.
- Manage vegetation to insure proper drainage functions are maintained while allowing habitat values to be expressed to the extent possible.

2. HABITAT VALUE AND PLANT CONSERVATION

Create and protect habitat for a diverse array of plants and animals; birds, mammals, insects, amphibians, and wetland plants.

- Increase plant species diversity including the number and variety of butterfly host plant grasses, forbs, and shrubs as well as the number of nectar plants and shelter plants.
- Increase the number and variety of native shrubs and trees that provide valuable cover, berries, insects, nest sites and other resources for migratory, nesting, and wintering birds.
- Increase the number and variety of wetland species that provide optimal conditions for amphibian and reptile breeding to occur.

3. AESTHETIC APPEAL

Create a beautiful landscape that people will enjoy and appreciate without sacrificing function and value for wildlife and plant habitat.

- Increase the amount of shade and resting areas along trails and open spaces while providing habitat for wildlife and viewing opportunities for visitors.
- Use plant species that maintain their beauty in a variety of seasons, such as a species with colorful and showy flowers, fall leaf color, winter texture, and grasses that persist through the winter while they provide good wildlife habitat.
- Use vegetation to frame viewsheds and enhance the natural aesthetic qualities of the site.

DESIGN GUIDELINES

GENERAL CONSIDERATIONS

A significant portion of a developed site often must be used for drainage conveyance and site detention. In planning your site, consider how the storm drainage facilities can contribute to the overall character of the project.

Developers and designers should consider:

- How will the stormwater facilities be designed to achieve the goals of this document and the needs of the project?
- How will the stormwater facilities be designed as an amenity rather than a necessary nuisance for this project?

PLANNING/SITE CONTEXT

Obtain and understand information about **site conditions** and **site context** before designing the detention facilities, including:

- Adjacent and regional drainage, recreational, and open space patterns
- On-site topography and drainage conditions
- Soil conditions
- Unique natural features, amenities or views
- Aesthetic expectations

Consider how the design of drainage facilities and detention areas can contribute to the overall plan and adjacent developments. **Collaborate** with adjacent property developers to formulate a more effective neighborhood or regional storm drainage plan. Look for opportunities to integrate storm drainage conveyance and water quality systems into the planned development. Using bioswales, linear conveyance with check dams, and inverted landscape islands throughout the project will increase **distributed infiltration** and can result in reduced land dedication requirements for larger detention ponds.

Different development types will have differing needs that can be enhanced by thoughtful design of stormwater systems that can serve **multiple functions**. Some concepts to consider for detention areas based on development types include:

- ***Residential Development*** – neighborhood greenbelts, multi-purpose recreational fields*, pedestrian trails, entry features, water features, wildlife habitat, wetland/riparian amenities, community gardens*, orchards, natural playgrounds, off-leash dog play areas*.

- ***Business / Retail Development*** – Water features, entry features, loop trails, picnic shelters*, visual buffer to screen service areas from public spaces, bioswale/ landscape islands, etc.

- ***Industrial Development*** – Visual buffer to screen service and loading areas, trail connections, recreation areas, etc.

* Structures and fences should be designed for flooding conditions.

LANDFORM AND SLOPES

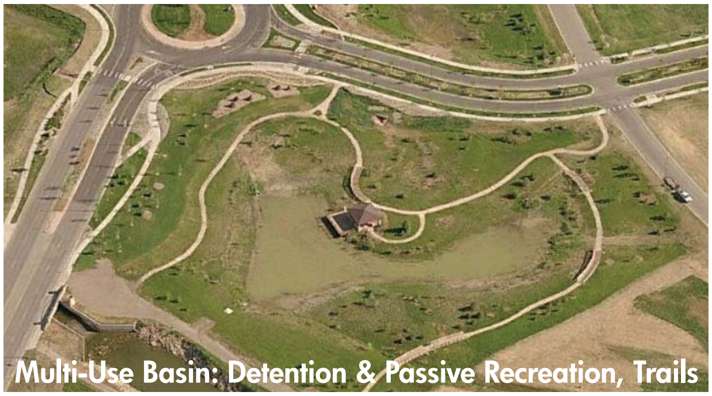
Detention ponds engineered solely to meet the minimum holding capacity of the required storm flows generally result in ponds with uniform side slopes with little natural character, or with vertical side walls that may create unsafe conditions. Design pond slopes in a way that they may also contribute to other goals.

If a detention pond is designed to also serve as a neighborhood recreation or athletic field, use **gentle side slopes** to allow for easy access to the play fields. Steeper side slopes can be designed with terraced flat areas to serve as spectator seating. Other greenbelt amenities such as picnic areas and pedestrian trails can be developed adjacent to these spaces to create a neighborhood park amenity that also serves as stormwater detention. While gentler slopes for detention may require more land for the pond, by combining the required pond area with required community uses, less land may be used for these open areas overall.

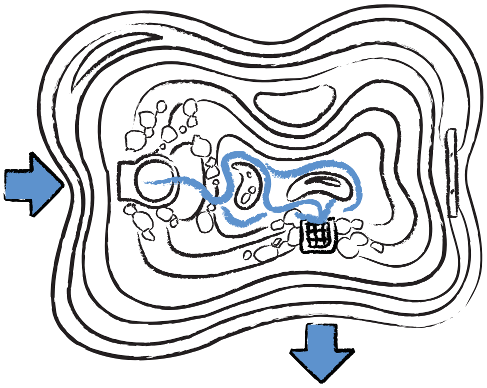

Multi-Use Basin: Detention & Passive Recreation


Multi-Use Basin: Detention & Sports Field

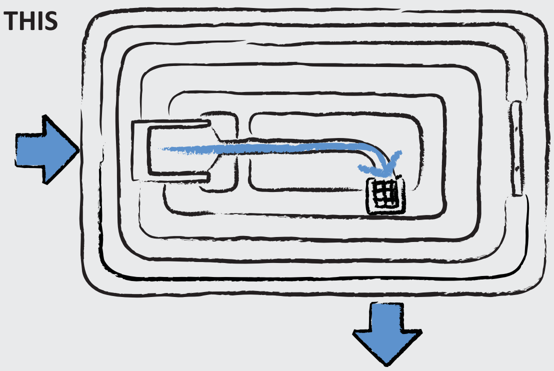

Multi-Use Basin: Detention & Passive Recreation, Trails


Multi-Use Basin: Detention & Passive Recreation, Trails

THIS



NOT THIS



Detention ponds designed to be naturalized open space should include **varied side slopes and an undulating bottom.** Varied slope conditions will promote opportunities for plant diversity and wildlife habitat by creating subtle changes in elevation above the average water level. Combine these techniques to create a wide array of diverse soil conditions and exposures for plants and animals to inhabit and "naturalize".

Design detention ponds with positive slopes (2% minimum) near the outlet to avoid standing water and limit mosquito habitat. Manicured turf areas that require regular mowing should also be sloped to drain appropriately (4:1 Max). However, flatter areas are encouraged to increase infiltration, but must be landscaped appropriately with wetland plants, forbs and shrubs that do not require regular mowing and will tolerate wet and dry conditions.

Avoid the use of concrete trickle pans in areas with well-draining soils as they reduce infiltration and promote evaporation and increased runoff. Where necessary, trickle pans shall be designed as an integrated part of the landscape. Horizontal alignment shall complement topographic character and be non linear. Embedded cobbles and/or boulders are encouraged. Color shall be a subtle earth tone.

General access is a primary **safety consideration**. Ramped access and gentle side slopes allow people and animals to evacuate the basin in the event of high water.

Access for maintenance equipment and personnel is necessary for proper care and management of stormwater facilities. Design slopes to provide appropriate access for wheeled service vehicles, utility vehicles, lawn mowers and/or brush hogs. Consider that trash and debris must be regularly removed by maintenance personnel. Periodic cleanup operations may also require the use of heavy equipment. If walls are used, they shall be limited to the minimum required height and length needed. Ideally no more than 50% of a basin perimeter should be bound by walls. All walls shall be built of suitable materials matching adjacent architecture or designed into the landscape scheme with natural stone or integral color concrete with form liner.

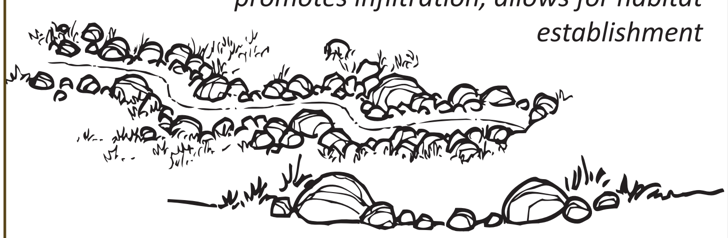
LANDFORM AND SLOPES

Required Design Standards:

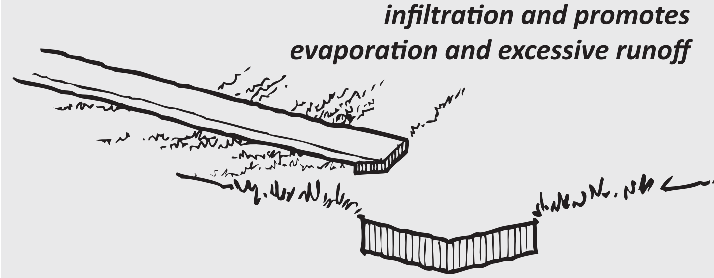
In all cases the following standards apply:

- No concrete trickle channels shall be used where free draining soils are present (Soil Group A, B). Limit their use to areas with clayey soils (Soil Group C, D) if necessary.
- Side slopes should vary and range from 4:1 to 20:1
- No vegetated slope should exceed 3:1
- Landscaped areas should slope to drain (2% minimum) or be planted appropriately so regular mowing is not required (see PLANTING DESIGN section).
- Basin area cannot be 100% bound by walls. All walls proposed for the pond perimeter are required to have a high quality visual character (such as natural stone or integral color concrete with form liner). Walls should not exceed 30" in height. Fences may be required for safety.
- Provide a minimum of one entry point for regular access by maintenance vehicles and mowers, and for occasional access by heavy equipment if necessary. Provide adequate egress to allow users to safely evacuate the area in the event of high water.

THIS *Naturalized drainage channel slows drainage, promotes infiltration, allows for habitat establishment*



NOT THIS ***Concrete trickle channel eliminates infiltration and promotes evaporation and excessive runoff***



PLANTING DESIGN

There is no universal approach to landscape design for detention areas. Planting design must respond to site-specific stormwater functions, soil types and hydrology, slopes, solar aspect, availability and type of irrigation, habitat creation, planned uses and planned maintenance. A Landscape Architect can assist with a comprehensive plan for the landscape design for your project's open space and detention areas. The following guidelines outline important criteria for the development of landscape plans for these areas.

Before finalizing planting plans and seed mixes, obtain **horticultural testing** of the on-site soils where planting will occur. Testing can be completed by the Colorado State University Soil and Crop Sciences Department for a nominal fee. Contact the Soil-Water-Plant Testing Lab at http://www.extsoilcrop.colostate.edu/SoilLab/soillab.html for more information. Often planting plans must be completed before construction activities take place, so final soil conditions for areas to be planted are not available at the time of design. If overlot grading is planned to occur after the planting plans are complete, require the contractor to incorporate 6" of topsoil from on-site or imported source into final grading operations, and indicate that the final seed mixes will be modified after final grading is complete and subsequent horticultural tests are evaluated.

Use native and adapted plants. Proper landscape design with native plants based on a site's unique conditions can:

- Reduce or eliminate need for supplemental irrigation
- Reduce fertilizer and chemical pest control needs
- Enhance wildlife habitat
- Reduce maintenance needs

Plants should be screened for invasiveness by using the Nature Conservancy's Nature Serve Explorer website at http://www.natureserve.org/explorer/servlet/NatureServe?init=Species

PLANT SPECIES SELECTION

Delineate **planting zones** with similar characteristics and proposed function. Characteristics should include slope, aspect, soil type, and moisture levels. Functions may include wildlife habitat, recreational use, or visual amenity or visual screening.

Develop a plant list for each zone type. See TABLE 1 for a sample listing of appropriate plant types.

TABLE 1: RECOMMENDED PLANT LIST

TREES AND SHRUBS

Upland Species – North and East Facing
Fourwing Saltbush *(Atriplex canescens)*
Rubber Rabbitbrush *(Chrysothamnus nauseosus)*
Three-leaf Sumac *(Rhus trilobata)*
Native Smooth Sumac *(Rhus glabra)*
Wood's Rose *(Rosa woodsii)*
White Snowberry *(Symphoricarpos alba)*
Western Snowberry *(Symphoricarpos occidentalis)*
Netleaf Hackberry *(Celtis reticulate)*

Upland Species – South and West Facing
Fourwing Saltbush *(Atriplex canescens)*
Rubber Rabbitbrush *(Chrysothamnus nauseosus)*
Three-leaf Sumac *(Rhus trilobata)*
Desert False Indigo *(Amorpha canescens)*
Winterfat *(Krascheninnikovia lanata)*
Yucca *(Yucca glauca)*

Species for Moist, Well-drained Areas
(2.5-6 feet above high water line or one-year storm)
Saskatoon Serviceberry *(Amelanchier alnifolia)*
Shiny-leaved Hawthorn *(Crataegus erythropoda)*
Wild Plum *(Prunus Americana)*
Western Chokecherry *(Padus virginiana var. melanocarpa)*
Western Sand Cherry *(Prunus bessyi)*
Cottonwood Tree *(Populus spp.)*
Netleaf Hackberry *(Celtis reticulate)*

Species for Subirrigated Areas
(1-3 feet above high water line)
Leadplant *(Amorpha fruticosa)*
Redosier Dogwood *(Cornus sericea)*
Golden Currant *(Ribes aureum)*
American Black Currant *(Ribes americanum)*
Peachleaf Willow *(Salix amygdaloides)*

GRASSES

Species for Upland Slopes
Little Bluestem (Schizachyrium scoparium)
Side Oats Grama (Bouteloua curtipendula)
Blue Grama (Bouteloua gracilis)
Western Wheatgrass (Pascopyrum smithii)
Green Needlegrass (Nassella viridula)
Slender Wheatgrass (Elymus trachycaulus)
Buffalograss (Buchloe dactyloides)
Bottlebrush Squirreltail (Elymus elymoides)
Sand Dropseed (Sporobolus cryptandrus)
Alkali Bluegrass (Poa juncifolia)
Sun Sedge (Carex inops ssp. heliophila)

Species for Subirrigated Areas
Big Bluestem *(Andropogon gerardii)*
Switchgrass *(Panicum virgatum)*
Yellow Indiangrass *(Sorghastrum nutans)*
Alkali Sacaton *(Sporobolus airoides)*
Green Needlegrass *(Nassella viridula)*
Western Wheatgrass *(Pascopyrum smithii)*
Nuttall Alkaligrass *(Puccinellia airoides)*
Canada Wildrye *(Elymus canadensis)*

Species for Wetland Areas
Prairie Cordgrass *(Spartina pectinata)*
Canada Wildrye *(Elymus canadensis)*
Switchgrass *(Panicum virgatum)*
Inland Saltgrass *(Distichlis spicata)*
Fowl Bluegrass *(Poa palustris)*
Nebraska Sedge *(Carex nebrascensis)*
Woolly Sedge *(Carex lanuginose)*
Creeping Spikerush *(Eleocharis palustris)*
Torrey's Rush *(Juncus torreyi)*
Baltic Rush *(Juncus balticus)*

PLANTING TECHNIQUES

Soil Preparation

Good soil is the foundation of a successful landscape. Planting areas require topsoil with appropriate levels of organic matter. Spread imported or stockpiled **topsoil** to a minimum depth of four inches over areas to be planted. For native seed areas, additional soil amendments are not necessary. Native plants are adapted to the native soils, and the additional organic matter found in soil amendments may instead promote weed growth.

Sub-grade in planting areas should be loosened to a minimum depth of twelve (12) inches overall (8” of existing sub-grade and 4” of new topsoil). Remove stones and clods that could impede planting, seeding, and mowing. Stones protruding from the soil more than 3” should be removed. Collect and legally dispose of sticks, roots, rubbish, and other extraneous matter. Repeat cultivation in areas where equipment used for hauling and spreading topsoil has compacted the soil. **Fine grade** disturbed planting areas to a smooth, uniform surface plane with a loose, uniformly fine texture. Grade to within the acceptable tolerances provided by the certifying civil engineer. Roll and rake, remove ridges, and fill depressions to meet finish grades based on grading plans.

Weeds thrive in soil disturbed by grading operations. Use of **appropriate herbicides** prior to planting can help to reduce the onset of noxious weeds and other aggressive non-desirable plants. Apply non-selective herbicides to weeds after fine grading has occurred and prior to planting. Herbicide shall be ‘Round-Up’ or similar product that will not persist in the soil and negatively affect planting operations.

Seed Mixes and Installation Techniques

Seed mixes should be developed based on the on-site soil conditions determined with the soil **horticultural tests**. Since detention and drainage areas have varying moisture conditions and slopes, develop a **diverse seed mix** with a wide ecological amplitude. When multiple seed species are used, they will tolerate a wide array of soil and moisture conditions. See TABLE 1 for a list of appropriate grass types for various planting zones.

Drill seed specified mix in two passes, each at right angles to each other. Drill half of the seed in each pass. If areas are too wet or steep to drill seed, broadcast seed in two opposite directions. Restore fine grade after seeding, and cover seed to depth of 1/4 inch by raking or dragging. Firm seeded areas with a roller weighing maximum of 100 lbs. per foot of width.

Use of **erosion control** blankets may be needed on steeper slopes (greater than 6:1), or non-irrigated south-facing and west-facing slopes to reduce erosion, improve soil moisture and seed germination. Natural fiber blankets are preferred to synthetic blankets which can entangle reptiles and amphibians in pond settings. Install erosion control blankets as per manufacturer’s recommendations.

Remaining seeded areas should be mulched to reduce seed loss and improve soil moisture and germination. Large sites without irrigation can be mulched with straw mulch. Straw mulch should be certified weed-free hay or certified weed-free straw with no seed heads, crimped into the seed bed after seeding has occurred. Irrigated sites can be hydromulched after seeding has occurred.

Wetland Plantings and Subirrigated Plugs

Concentrate **wetland plantings** in areas where erosion is anticipated or where favorable moisture zones are likely to exist. Since planned moisture levels are difficult to predict, plant species in, above, and below their ideal zone to accommodate for both high water and low water seasons. Plants are then likely to establish in their optimal conditions. Since detention areas fluctuate with storm conditions, use species with wider tolerances to moisture conditions.

Wetland plugs may be necessary in areas that cannot be seeded due to constant inundation or saturation. Plant plugs after drill seeding from mid-May through July. Planting small plugs in the fall is less desirable due to loss of plants to Canada Geese. Plug plantings can be completed immediately after seeding. Subsequent plug plantings are recommended after initial seed establishment when weeds are under control (2-5 seasons after initial construction). These later plantings can be concentrated in bare areas and those areas needing erosion control protection.

Wetland plugs may be planted 12” to 24” on center and may need protection with turf reinforcement mats, jute or similar erosion control devices. Plugs can be caged or covered with wire fabric, jute or other products for protection if damage by geese or small mammals is anticipated. In areas of standing water, grids of string slightly above the water elevation can also be installed to reduce waterfowl access to newly planted areas.

Trees and Shrubs

Concentrate or group shrubs and woody plants into beds or groups to more quickly create habitat for wildlife and to reduce weeding, watering and maintenance requirements. Select species based on the optimal moisture zones. Construct **planting wells** around each tree or group of woody plants to capture natural moisture for the plants. Use organic **mulch** in planting beds or in tree wells to increase moisture retention and to reduce weed and grass encroachment. Avoid using weed barrier around trees an shrubs.

Use shrubs and wetland plants strategically near inlets to soften the visual impact of these man-made structures without impeding storm drainage function. Avoid the use of exposed rip-rap. Rip-rap if used shall be a subtle earth tone color, not pink, and should be buried and integrated with erosion control matting, and planting to soften the visual impact and provide opportunities for habitat establishment. Other types of less intrusive erosion control materials which incorporate planting materials should be considered. Bio-engineered solutions are preferred in lieu of structural erosion control measures. Brush layering and use of live branch cuttings can restore and protect stream banks and outfall areas while creating a natural habitat and reduce the cost of structured protection measures. Seeding schedule should be per seed source recommendation. Trees and shrubs should be planted prior to seeding.

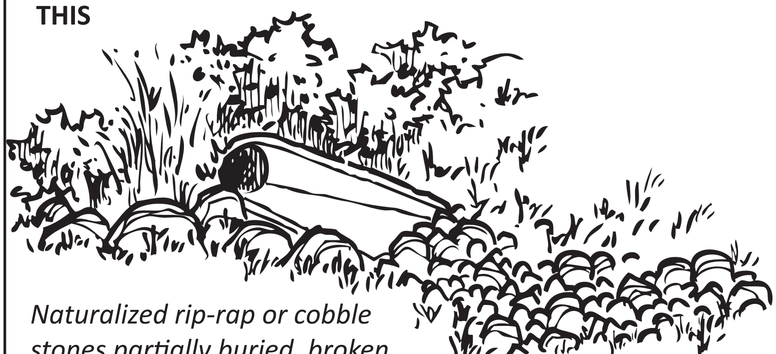
LANDSCAPE

Required Design Standards:

In all cases the following standards apply:

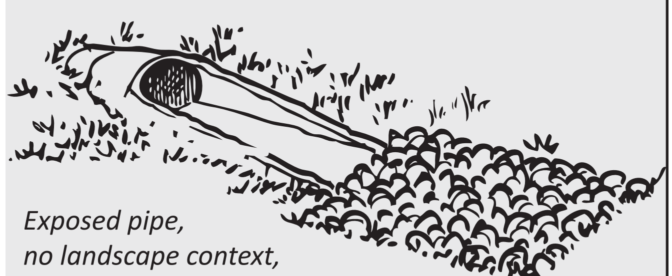
- Enlist the services of a Landscape Architect to prepare the required landscape construction plans for commercial project detention areas.
- Develop plant lists and seed mixes based on horticultural testing of site soil conditions.
- Delineate planting zones based on soil characteristics and function. Develop plant lists appropriate for each planting zone.
- Use native and adapted plants.
- Provide a minimum of one entry point for regular access by maintenance vehicles and mowers, and for occasional access by heavy equipment if necessary. Do not block access with designed landscape features.
- Stockpile and redistribute (or import if necessary) a minimum of four inches of topsoil over areas to be planted.
- Use non-persistent herbicide prior to planting to curtail weed establishment.
- Incorporate erosion control blankets and/or appropriate mulch to reduce erosion and improve soil moisture conditions for new plantings.
- Use wetland species in appropriate areas and pond bottoms likely to be too wet for regular mowing and maintenance.

THIS



Naturalized rip-rap or cobble stones partially buried, broken edges, streambed appearance

NOT THIS



Exposed pipe, no landscape context, exposed rip-rap of uniform color and size, straight edges and square corners

IRRIGATION

Since storm drainage and detention areas account for the most significant portions of open landscaped space in most projects, their design can greatly impact the amount of irrigation water demand for a project. Irrigation and landscape design should correspond to the types of uses planned for the detention areas. Areas planned for high pedestrian use such as recreational fields will require higher irrigation needs to provide regular, controlled irrigation levels. More natural areas may be able to minimize or eliminate completely the need for supplemental irrigation. Landscape designs are encouraged to respond to each site's unique soil conditions and planned hydrology to minimize or eliminate the need for supplemental irrigation.

MAINTENANCE

Weed Control

The primary method of weed control during the initial establishment period (two to three growing seasons) for seeded areas is regular mowing. **Regular mowing** helps prevent weed seeds from being produced. Careful spot spraying is also acceptable, but many herbicides affect seedling grasses and non-target plants. Always read and follow label directions. After the initial establishment period, if chemical weed controls are needed in the pond bottoms of wet detention areas, herbicides should be selected that have an aquatic label. Even herbicides approved for aquatic use should only be used during periods of dry weather and dryer conditions to reduce the amount of herbicide that gets into the water itself. Side slopes generally above the high water line can be sprayed with non-aquatic but non-persistent herbicides as per the manufacturer's recommendations.

Cattails will generally establish in created detention areas through natural dispersal. Although they are a native species, they are often so competitive that they become a mono-culture if not managed. Cattails should be suppressed for the first three to five growing seasons to allow less aggressive native species to establish.

Erosion Control

Areas of erosion should be **monitored and corrected** to prevent damage to the landscape and storm drainage structures.

Irrigation and Fertilization

Supplemental irrigation will be needed during the initial establishment period. However, once established, naturalized drainage and detention areas using native plants and species appropriate for the specific moisture regimes should not require fertilizers or supplemental irrigation after establishment. Irrigation used during establishment can either be reduced or eliminated altogether. Limit the use of fertilizers in native plant areas.

In detention basins that also serve as recreation fields or active neighborhood spaces, permanent irrigation and more standard fertilization, aeration, and weed control practices are appropriate to keep a more manicured appearance.

MAINTENANCE

Required Design Standards:

In all cases the following standards apply:

- Use regular mowing as a primary weed control method during initial establishment period.
- Limit use of chemical herbicides, and only use those appropriate for conditions. Use non persistent herbicides in upland areas, and aquatic approved herbicides near wet, wetland or water areas.
- Suppress cattails for the first three to five growing seasons to allow less aggressive native species to establish.
- Monitor and correct areas of erosion.
- Limit irrigation and fertilization to that needed for plant establishment and specific designed needs. Naturalized areas with native plants are adapted to Colorado soils so should only require irrigation during the initial establishment period, and should not require fertilization. High-use or active recreation areas will require more regular irrigation and standard fertilization practices.

APPENDICES

GLOSSARY OF TERMS & CONCEPTS

Base Flow – The portion of stream flow that is not runoff and results from seepage of water from the ground into a channel over time. The primary source of running water in a stream during dry weather.

Best Management Practice (BMP), nonstructural– Strategies implemented to control stormwater runoff that focus on pollution prevention, such as alternative site design, education, and good housekeeping measures.

Best Management Practice (BMP), structural – Engineered devices implemented to control, treat, or prevent stormwater runoff.

Bio-filtration – The use of vegetation such as grasses and wetland plants to filter and treat stormwater runoff as it is conveyed through an open channel or swale, or collects in an infiltration basin (see Bio-retention).

Biological Diversity – The concept of multiple species or organisms living together in balance with their environment and each other.

Bio-retention – The use of vegetation in retention areas designed to allow infiltration of runoff into the ground. The plants provide additional pollutant removal and filtering functions.

Detention - The storage and slow release of stormwater following a precipitation event by means of an excavated pond, enclosed depression, or tank. Detention is used for both pollutant removal, stormwater storage, and peak flow reduction. Both wet and dry detention methods can be applied.

Evapotranspiration - The loss of water to the atmosphere through the combined processes of evaporation and transpiration, the process by which plants release water they have absorbed into the atmosphere.

Filter Strip - Grassed strips situated along roads or parking areas that remove pollutants from runoff as it passes through, allowing some infiltration, and reductions of velocity.

Floodplain - Can be either a natural feature or statistically derived area adjacent to a stream or river where water from the stream or river overflows its banks at some frequency during extreme storm events.

Green Roof - A contained space over a building that is covered, partially or entirely, with living plants.

Groundwater - Water that flows below the ground surface through saturated soil, glacial deposits, or rock.

Hydrologic Soil Groups - Soil groups based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

- *Group A*. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
- *Group B*. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
- *Group C*. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
- *Group D*. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.
- If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Hydrology - The science addressing the properties, distribution, and circulation of water across the landscape, through the ground, and in the atmosphere.

Impervious surface - A surface that cannot be penetrated by water such as pavement, rock, or a rooftop and thereby prevents infiltration and generates runoff.

Imperviousness - The percentage of impervious cover within a defined area.

Infiltration - The process or rate at which water percolates from the land surface into the ground. Infiltration is also a general category of BMP designed to collect runoff and allow it to flow through the ground for treatment.

Metered Detention and Discharge - A system where stormwater is collected in a cistern pond and then slowly released into the landscape beds or the storm drain in the following hours at the rate that allows for better filtration and is less taxing to the overall community storm drain.

National Pollutant Discharge Elimination System (NPDES) - A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the EPA, a state, or (where delegated) a tribal government or and Indian reservation.

Outfall - The point of discharge from a river, pipe, drain, etc. to a receiving body of water.

Peak discharge - The greatest volume of stream flow occurring during a storm event.

Pervious - Admitting of passage or entrance. Material that permits elements such as water and oxygen to enter and or pass through.

Polluted runoff - Rainwater or snow melt that picks up pollutants and sediments as it runs off roads, highways, parking lots, lawns, agricultural lands, logging areas, mining sites, septic systems, and other land-use activities that can generate pollutants.

Porous pavement and pavers - Alternatives to conventional asphalt that utilize a variety of porous media, often supported by a structural matrix, concrete grid, or modular pavement, which allow water to percolate though to a sub-base for gradual infiltration.

Retrofit - The creation or modification of a stormwater management practice, usually in a developed area, that improves or combines treatment with existing stormwater infrastructure.

Runoff - Water from rainfall, snow melt, or otherwise discharged that flows across the ground surface instead of infiltrating the ground.

Sanitary sewer system - Underground pipes that carry only domestic or industrial wastewater to a sewage treatment plant or receiving water.

Sedimentation - A solid-liquid separation process utilizing gravitational settling to remove soil or rock particles from the water column.

Siltation - A solid-liquid separation process utilizing gravitational settling to remove fine-grained soil or rock particles from the water column.

Storm sewer system - A system of pipes and channels that carry stormwater runoff from the surfaces of building, paved surfaces, and the land to discharge areas.

Stormwater - Water derived from a storm event or conveyed through a storm sewer system.

Surface water - Water that flows across the land surface, in channels, or is contained in depressions on the land surface (e.g. Runoff , Ponds, Lakes, Rivers, and Streams).

Swale - A natural or human-made open depression or wide, shallow ditch that intermittently contains or conveys runoff. Swales can be equipped with an underdrain or other man-made drainage device. and can be used as a BMP to detain and filter runoff .

Urban runoff - Runoff derived from urban or suburban land-uses that is distinguished from agricultural or industrial runoff sources.

Water (hydrologic) cycle - The flow and distribution of water from the sky, to the Earth's surface, through various routes on or in the Earth, and back to the atmosphere. The main components are precipitation, infiltration, surface runoff, evapotranspiration, channel and depression storage, and groundwater.

Water table – The level underground below which the ground is wholly saturated with water.

Watershed - The land area, or catchment, that contributes water to a specific water body. All the rain or snow that falls within this area flows to the water bodies as surface runoff, in tributary streams, or as groundwater.

STAKEHOLDER & OPEN HOUSE COMMENTS

- A landscape plan for all stormwater facilities must be prepared by a professionally licensed Landscape Architect with experience in stormwater facility design.
- List possible techniques/solutions with examples and case studies to help appease those entering into uncharted territory (both applicants and reviewers)… this will help avoid the "pioneers get the arrows, and the settlers get the land" dilemma.
- Along with various options, include the design criteria to which City Staff will review against. If every applicant and design team needs to justify the proposed solutions on their own, and spend extra time and money getting Staff on board, it will serve as a deterrent to implementing some of these new techniques. Obviously, the guidelines cannot account for every potential option, and they need to remain fluid to allow future solutions and innovations not yet known. However, to get the ball rolling and encourage more imminent alternatives, not asking each project to 'fight the battle' so-to-speak would be a great benefit.
- Please put these boards on the website.
- More Wet Ponds, or flat bottom, because it provides additional volume
- How do you handle clay soils?
- Use appropriate landscaping materials
- If using sub drain, provide outlet
- Ponds should have concrete weir – because it provides a reference elevation
- Slow H2O down to increase infiltration.
- Remove concrete pans to assist / allow areas to be more natural. Use planting in this area to build upon drainage path.
- Reevaluate stormwater requirements to over store H2O.
- Take into account H2O uptake of plant material.
- Use of injection / percolation wells to speed absorption.
- Combine system with pervious pavement solutions to maximize usable land.
- Provide incentives for innovation.
- How can green roofs help with the reduction / delay of stormwater discharge?
- Incentive to developer to allow pond areas to be in natural state and not manicured.
- Encourage bioswales, etc. in and around site.
- Incentive to allow water to be treated at source in rain gardens / bioswales / etc.
- Provide support that will lead to decrease in required pond volumes such as narrower streets, pervious pavements, etc. Currently engineering will not allow pervious pavement or bioswales
- No pan requirements in ponds
- Don't just default to Urban Drainage; allow variation suitable to project type and size. Allow credit for developments that try several LID practices even if it can't be modeled or formulated in U.D. Let's see if it works provided downstream not affected.
- How can we quantify infiltration / to allow for smaller ponds?
- What plants can work in flat-bottom swales (no concrete pan)
- City inspectors requiring concrete pans!
- Keep in mind expansive clay soils, cannot hold / direct water across them without issues.
- Different standards (maintenance / design /aesthetics) for different uses / districts = industrial vs. retail
- Civil Engineers tend to "engineer" a solution in the least amount of space
- Integrated Design
- Go from utilitarian to "aesthetic"
- Multi use spaces included in final design
- Need more cooperation between city departments to reduce maintenance requirements (onerous) on HOA's
- Go for the more natural look.
- Materials:
  - A. No rock?
  - B. No concrete?
  - C. No vertical edges?
  - D. No irrigation? – (native and adaptive)
- Green (grass) vs. Green (money) vs. Green (sustainable)
- Flexible aesthetics per property / project
- Distributed smaller detention
- No regional pond.
- Savings from less storm sewer.
- Raised landscape islands converted to depressed landscape islands
- Incentives for:

   A. Dispersed system
   B. Water quality
- Slow down the water!
- Regional / Neighborhood detention facilities vs. each site – with fee similar to street over sizing
   A. Regional (City)
   B. Neighborhood
   C. Private
- Infill projects
   A. Smaller facilities
   B. Swales with infiltration
- Linear detention keep larger ponds sizes down
- Inverted landscape islands in parking lots
- Alternatives for wetland mitigation similar to Corp of Engineers in lieu of fee?
- May not apply to detention ponds
- LID – encourage small ponds close to source
- Concentration of surface area
   A. Less curb and gutter
   B. More infiltration
   C. *Increased surface area
   D. Greenbelts conveying and slowing water (check dams) to increase infiltration
- Native soils = little infiltration but slowing rate through bioswales still help with down stream flows
- Tucson = standards top in nation as model
- City needs to be able to accept new ideas
   A. Rocky mountain innovation
   B. Infiltration? City requires 2X capacity if case it doesn't work
   C. Include innovation process in standards
- Collaboration – encourage collaboration among project team members and between team and city
- City to take a leadership role in new techniques
- Help developer to understand benefits. *Examples of successful projects?
- Example projects schematics, concepts illustrated
- Eliminate risk by having guidelines on the books
- Access for maintenance
- Mowing (private Maintenance)
- Backhoes / Dumptrucks for sediment removal (city)
- Partnership between private and city
- Gently sloping sod, few trees
- No walls?
- Limit walls to allow maintenance
- Underground detention?
- How do you deal with long term maintenance?
- Standards vs. Guidelines
- Prescriptive vs. Proscriptive
- Requirement for Landscape Architect on design team
- Combination? If walls then upgrade
- Engineering staff on team
- LUCASS staff on team
- Life cycle vs. Front end cost
- Continue to promote growth and development
- Multiple use = multiple approaches
- Difficult with little used areas
- No fertilizer unless play fields
- No irrigation (except during establishment)
- Required ground cover
- Context for plant types
   A. Categories for use, wetland, soil type, landscape, maintenance
   B. Review Urban Drainage Standards
   C. New development vs. Infill / redevelopment

Appendix C:
LID Implementation Manual

City of Fort Collins

FINAL | JULY 2017

Low Impact Development Implementation Manual

Acknowledgments

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1

Section One: Introduction

The City of Fort Collins has developed this Low Impact Development (LID) Implementation Manual to advance the development of healthy and multi-functional stormwater management systems.

Purpose

Low Impact Development (LID) in stormwater management is used to restore the natural relationships of water, soil and vegetation, minimizing and mitigating the impacts of development on watershed resources. LID practices, sometimes referred to as Green Infrastructure (GI), manage and treat stormwater in a distributed manner at a site scale near areas where rain falls.

Our City is anticipating an increasing population, up to 250,000 by 2040, resulting in increased urbanization, development and redevelopment. Traditionally these activities increase the amount of impervious surfaces and reduce the ability of natural systems to maintain local and historical water patterns. To that end, Fort Collins and other communities are increasingly turning to LID practices to help maintain, restore and rehabilitate watershed services. The Fort Collins Low Impact Development Implementation Manual is intended to be a practical resource for planners, developers, homeowners, design professionals and community groups that will be designing, installing and maintaining LID facilities at the site scale.

In February 2013, Fort Collins City Council adopted Ordinance No. 152, 2012, amending Chapter 26 of the Municipal Code to incorporate provisions implementing LID principles. The goal is to declare that the purpose of the City Stormwater Utility is to provide an integrated, sustainable stormwater management program that reflects the community's values of protecting and restoring the City's watersheds.

Click to see full text of the updated 2016 Ordinance 007, 2016.

As stormwater crosses both jurisdictional and property boundaries, the City of Fort Collins is creating a unified community throughout the watershed by making stormwater treatment an accessible strategy for each citizen. The intent of this manual is to guide professional designers and citizens in the development and preservation of a healthy environment and ecosystem that promotes a vibrant community.

Multiple Goals with a Single Investment: The Many Benefits of LID

LID principles and practices are truly synergistic in their approach. They provide multiple benefits on a personal, societal, and ecological level. For example, landscapes that use LID practices can incorporate stormwater management as part of a site's open space and amenity areas, helping to meet code requirements, reduce greenhouse gases, provide shade and beauty, create habitat corridors for local wildlife, improve water quality, and protect streams and creeks from erosion.

Additional information about the benefits of LID can be viewed at The City of Fort Collins Storm Water Quality page. Watch a video example about how LID practices work at Library Park.

HUMAN HEALTH & WELLBEING

- Provides places of aesthetic beauty for personal and community enjoyment
- Improves public health by enhancing water quality and reducing pollutants
- Encourages pedestrian activity

SOCIETY & THE ECONOMY

- Design with visibility and ease of inspection as a goal
- Increases property values through enhanced community green space and attracts investment
- Improves aesthetics
- Benefits developers by meeting multiple code requirements
- Provides green jobs

NATURE & THE ENVIRONMENT

- Treats water at the source with less energy inputs
- Improves water quality and availability (recharging our aquifers, lakes, and rivers)
- Supports biodiversity and creates natural habitats within city proximity
- Minimizes pollution runoff
- Reduces irrigation consumption

RESILIENCY & REDUCTION OF EXTREME IMPACTS FROM CLIMATE CHANGE

- May provide relief from localized flooding
- Reduces the effect of heat island
- Cools ambient air temperature

The Water Cycle

Rain that falls on undisturbed, vegetated areas is soaked up into plants and soil; this water recharges underground aquifers, creeks, rivers, and lakes, creating natural and ecologic benefits. When development activities result in portions of the watershed being turned into impervious surfaces, less water is absorbed into the ground or evaporates. Instead rainfall is converted into runoff. This system-wide response to rainfall events contributes to increased flooding, erosion and less water in aquifers. Stormwater runoff can also collect pollutants such as pet waste, oil, fertilizers, dissolved metals and sand that not only harms aquatic habitats, it also impairs the beneficial uses of riparian corridors, rivers, streams and other water bodies.

A thorough technical explanation of the interconnectedness of development and watershed resources can be found in Volume 3 of the Urban Drainage and Flood Control District (UDFCD) Stormwater Criteria Manual and in the Fort Collins Stormwater Criteria Manual. The UDFCD Stormwater Criteria Manual also describes some of the historical challenges of trying to manage stormwater without applying LID principles.

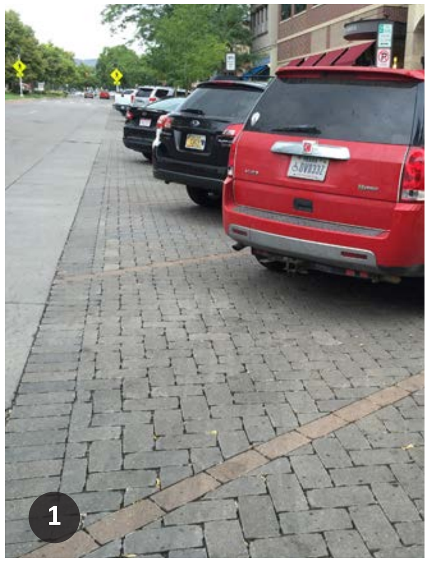
Development Review Process

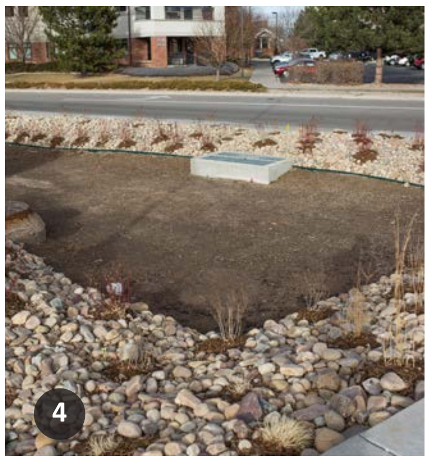
In accordance with the Land Use Code, all development and redevelopment projects are required to use LID Best Management Practices (BMPs) to manage a percentage of impervious surface runoff. Detailed LID criteria are incorporated in Chapter 7 of the Fort Collins Stormwater Criteria Manual. All of the LID BMPs described in this manual - with the exception of non-engineered rain gardens - may be used to meet the LID Criteria. The details and design considerations provided in this manual are intended to assist permit applicants develop complete plans for permit review. Additional information about how to document compliance with LID criteria is provided in Chapter 7.

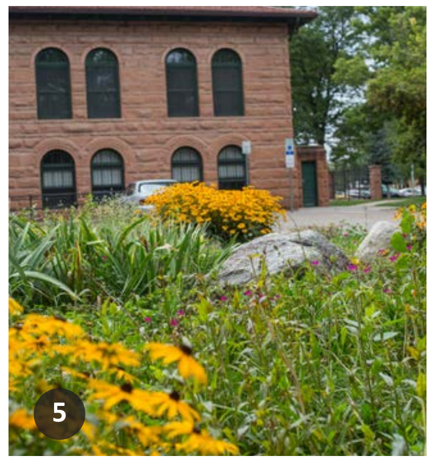
Public improvement projects within the rights-of-way are not covered under the LID ordinance. LID is encouraged when feasible for these projects, but not required.

LID Practices

1. Permeable Pavement
2. Bioretention / Bioswales
3. Vegetated Buffer
4. Sand Filter
5. Rain Garden
6. Underground Infiltration
7. Tree Filter
8. Constructed Wetland Channel
9. Constructed Wetland Pond







Commitment to Sustainability

Our City is a national leader in achieving sustainable development. It engages every City department and the philosophy is enumerated in a range of City plans, from Transportation to Nature in the City. In previous plans, the City identified the community values and critical issues for building a framework that combines traditional planning principles and land development practices through planning directives and a community vision.

The Fort Collins City Council has charged the Utilities department with the following Stormwater Purpose Statement:

"The City Council hereby finds, determines and declares the City's integrated stormwater management program is for the mutual economic, social and environmental benefits of public safety, flood mitigation, water quality and public welfare while protecting natural areas and their features, protecting and restoring the City's watersheds, its tributaries and the Cache la Poudre River."

How to Use the LID Implementation Manual

The LID Implementation Manual is organized into four sections. This document is best viewed electronically with quick links to additional information.

SECTION 1: INTRODUCTION

Section 1 is an overview of LID and this manual.

SECTION 2: LID APPLICABILITY

Section 2 is an illustrative table of contents. The illustrations show how BMPs can be incorporated in projects with various land uses. Links embedded in the illustrations can be used to jump to BMP fact sheets for additional information.

SECTION 3: LID BMP FACT SHEETS

Section 3 provides detailed information on each BMP. Each BMP fact sheet includes planning, design, construction and maintenance considerations. The fact sheets provide links to permitting and regulatory compliance including references to the Fort Collins Stormwater Criteria Manual and other City of Fort Collins standards. Typical details are provided as a reference for designers developing construction documents.

SECTION 4: DESIGN APPROACH

Section 4 provides a guide for planning and design of LID practices. This section is intended to be a reference for those who are new to LID practices.

SECTION 5: APPENDICES

Section 5 provides additional resources.

The LID Implementation Manual is designed to be updated periodically to reflect results from ongoing research and on-the-ground experience.

What strategies can I use to make my LID attractive and welcoming?


City of
Fort Collins
2

Section Two: LID Applicability

The first step of a successful LID project is selecting the right BMP for the job. This Section provides planning considerations to assist with the selection process.

Site Planning Considerations

Special consideration in the planning stage is critical for the success of LID projects. LID projects often require a more holistic design effort that responds to the site's natural features, soil and subsurface conditions, integrating all aspects of the project early in the design phase.

Explicit understanding of surface and subsurface soil conditions of the site and surrounding area is critical to the process. A reliable and accurate base map is also necessary.

LID PRINCIPLES

The City of Fort Collins encourages designers, developers, and anyone using this Manual to regard it as a starting point for creatively developing solutions to a wide variety of stormwater management challenges. There is no one solution to mitigate the impacts of stormwater on developed land. However, a core set of principles can guide everyone from the engineer to the homeowner on how a successful LID design can be incorporated into a development plan or retrofitted into an existing site.

These principles include:

- Conserve Resources
- Minimize Impact and Use Site Topography
- Maximize Water Infiltration
- Create Areas for Local Storage and Treatment
- Build Capacity for Maintenance

The project constraints and development site elements can be thoughtfully delineated to optimize as many of these principles as possible.

Considerations for Designing and Implementing LID Facilities

The following items should be considered early to promote project success and reduce conflicts during detailed design.

Topography and Hydrology

- Fitting the development into the existing topography
- Existing drainage patterns
- Upstream and downstream conditions
- Groundwater conditions

Soils

- Early soils investigation
- Stormwater facility estimate during feasibility analysis
- Soil infiltration capacity
- Minimize soil disturbance (cut and fill areas)

Climate

- Extended dry periods
- Intense rain events
- Snow Storage
- Annual Precipitation

Vegetation & Habitat

- Protection of exceptional vegetation and habitat
- Protected areas for flow dispersion
- Protection of trees

Utilities

- Location of any utilities and future needs
- Connection to existing stormwater infrastructure

Surrounding Land Use

- Match the character of surrounding land uses and subsurface soil conditions

Access

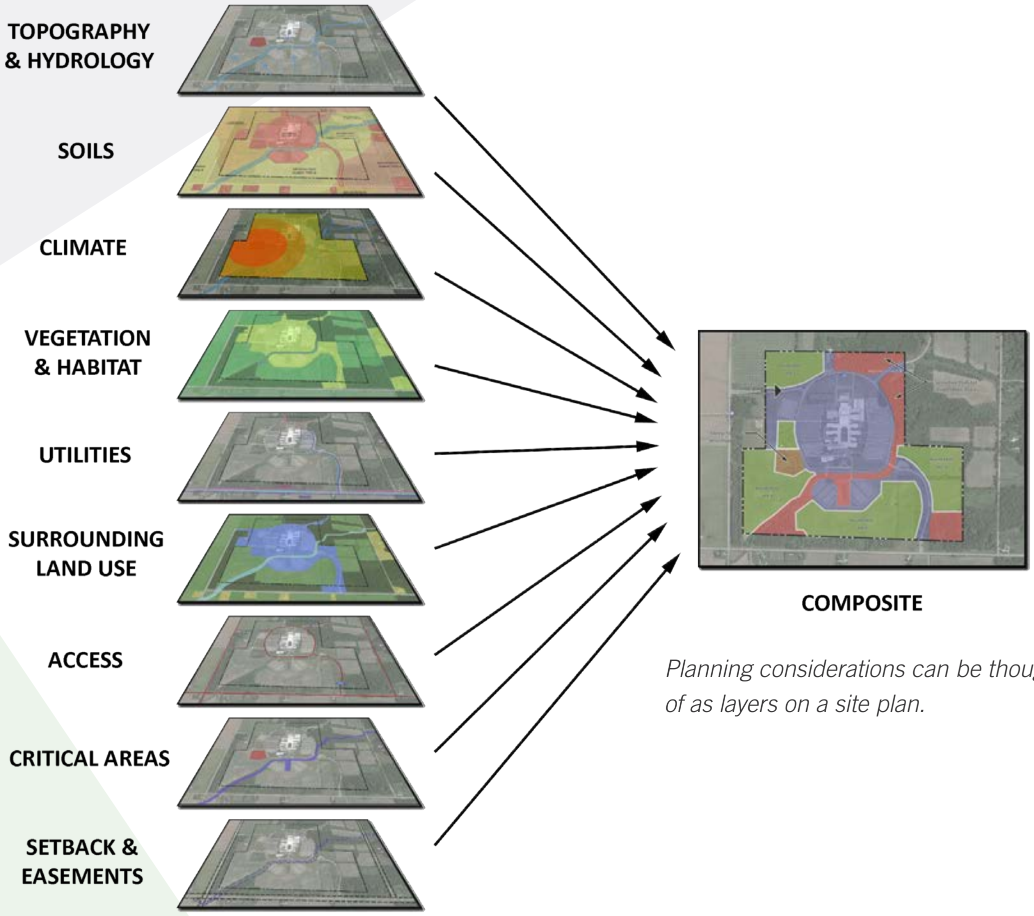
- Accessibility for inspection and maintenance
- Accessibility for users

Critical Areas

- Wetlands or steep slopes that may require setbacks
- Flood plains and riparian areas

Setbacks and Easements

- Building and property line setback requirements
- Easements



Planning considerations can be thought of as layers on a site plan.

LID Applicability Matrix

Each site is unique in both its natural characteristics and its programming needs for development. Different LID BMPs will apply for each site. The table below breakdowns the various land uses and indicates if each BMP is typically applicable or not applicable. Applicability for a specific project may vary based on site conditions.

The City of Fort Collins encourages innovative design and regular collaboration between developer, design team and the City to develop the most efficient and effective solutions.

LID APPLICABILITY MATRIX TABLE	PERMEABLE PAVEMENT	BIORETENTION	SAND FILTER	TREE FILTER	UNDERGROUND INFILTRATION	NON-ENGINEERED RAIN GARDEN	VEGETATED BUFFER	CONSTRUCTED WETLAND CHANNEL	CONSTRUCTED WETLAND POND
Right-of-Way – Arterial Street*		$$		$$$					
Right-of-Way – Non-Arterial Street*	$$$	$$		$$$					
High Density	$$$			$$$	$$$				
Medium Density	$$$	$$	$$	$$$	$$$	$	$	$$$	$$$
Low Density	$$$	$$	$$	$$$	$$$	$	$	$$$	$$$
Single Family Residential Development	$$$	$$	$$	$$$	$$$	$	$	$$$	$$$

$-$$$ Indicates relative construction cost. Does not include site specific considerations such as land value and maintenance.
** Applicability of BMPs within the rights-of-way shall be approved by the engineering department.*
*** Within parking lanes along non-arterial streets only.*

Land Use Illustrative Examples

The following pages show how land use Illustratives can be applied.

1. Right-of-Way – Arterial Street

2. Right-of-Way – Non-Arterial Street

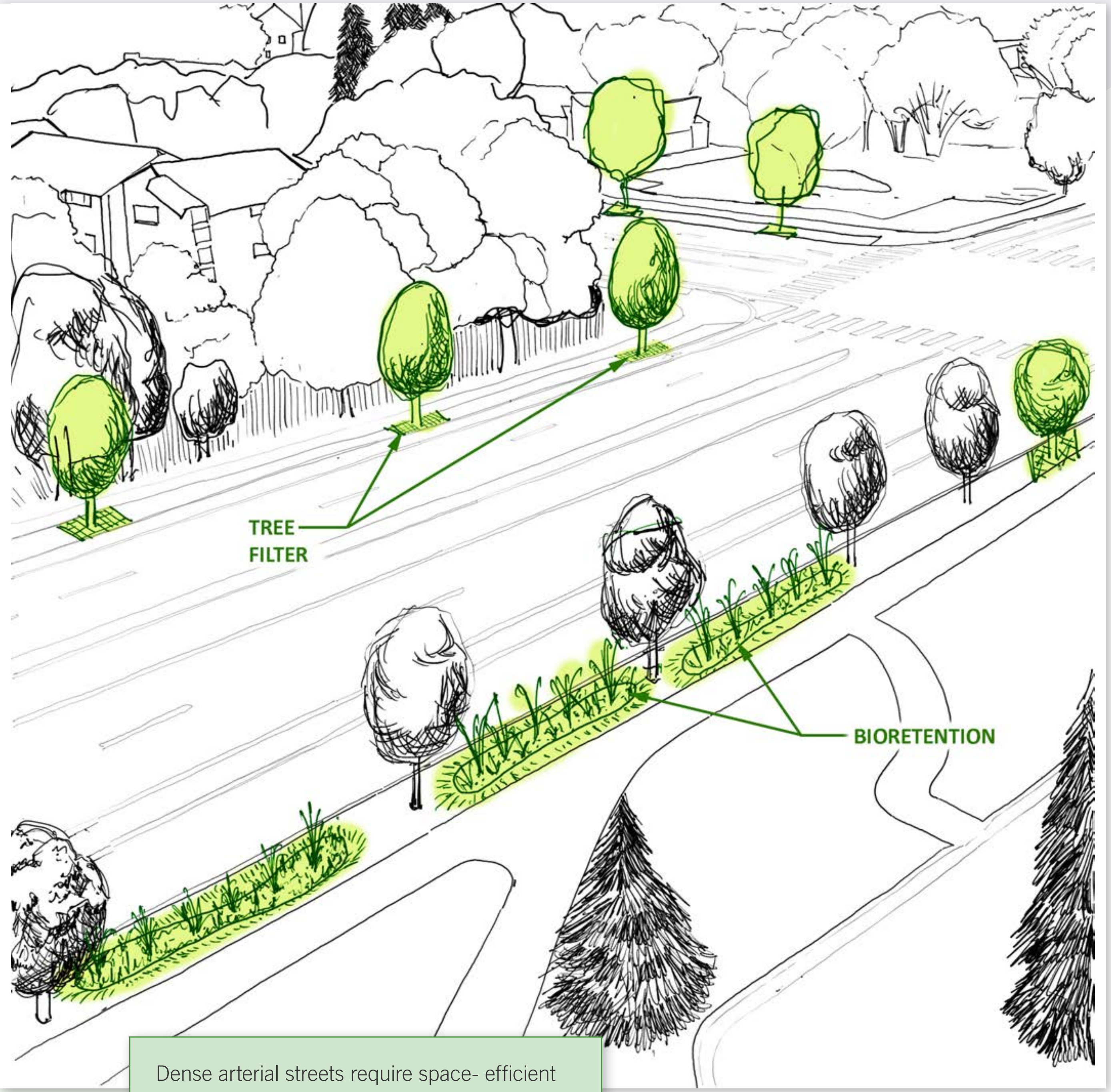
3. High Density

4. Medium Density

5. Low Density

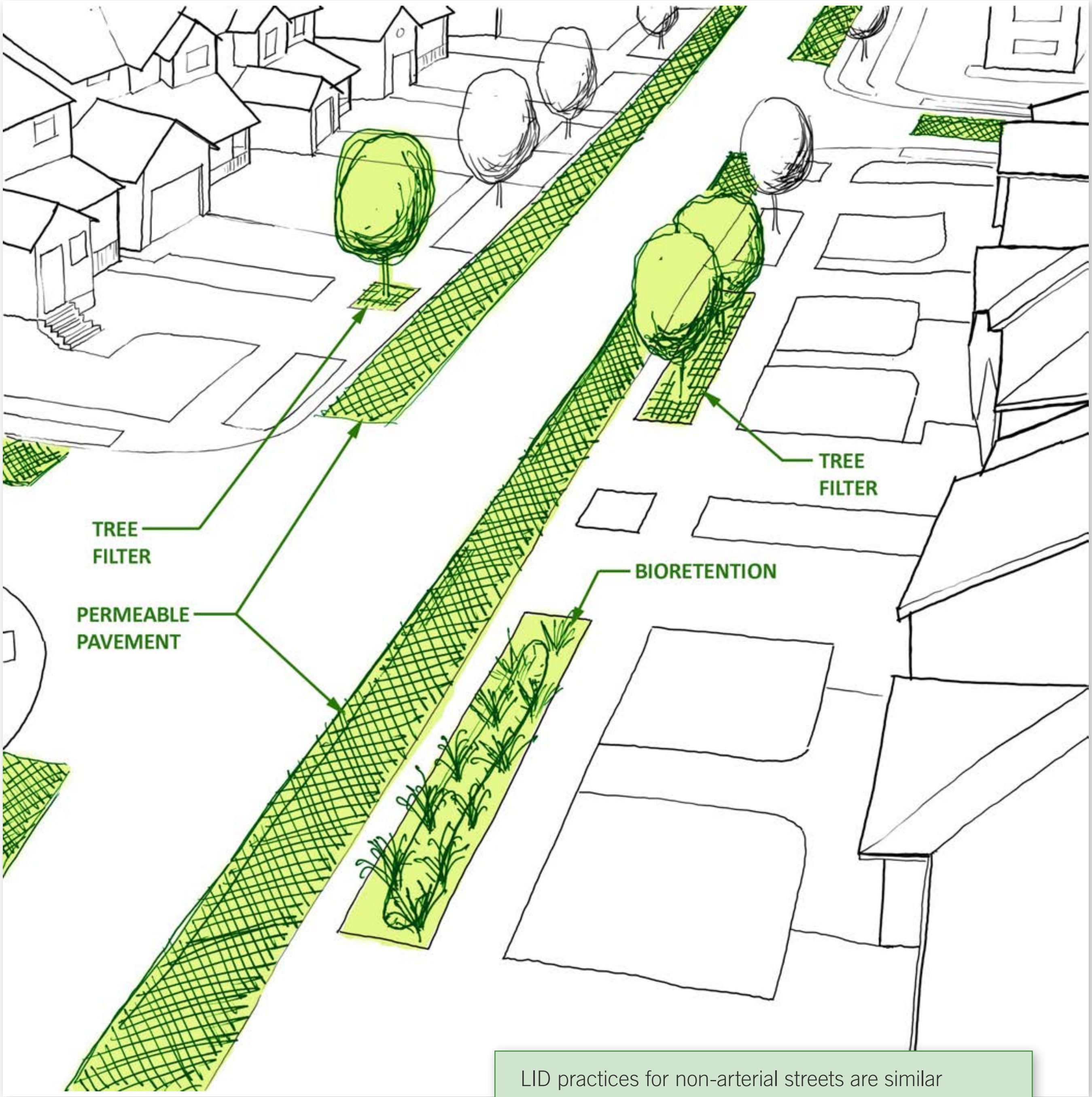
6. Single Family Residential Development

Right-of-Way – Arterial Street



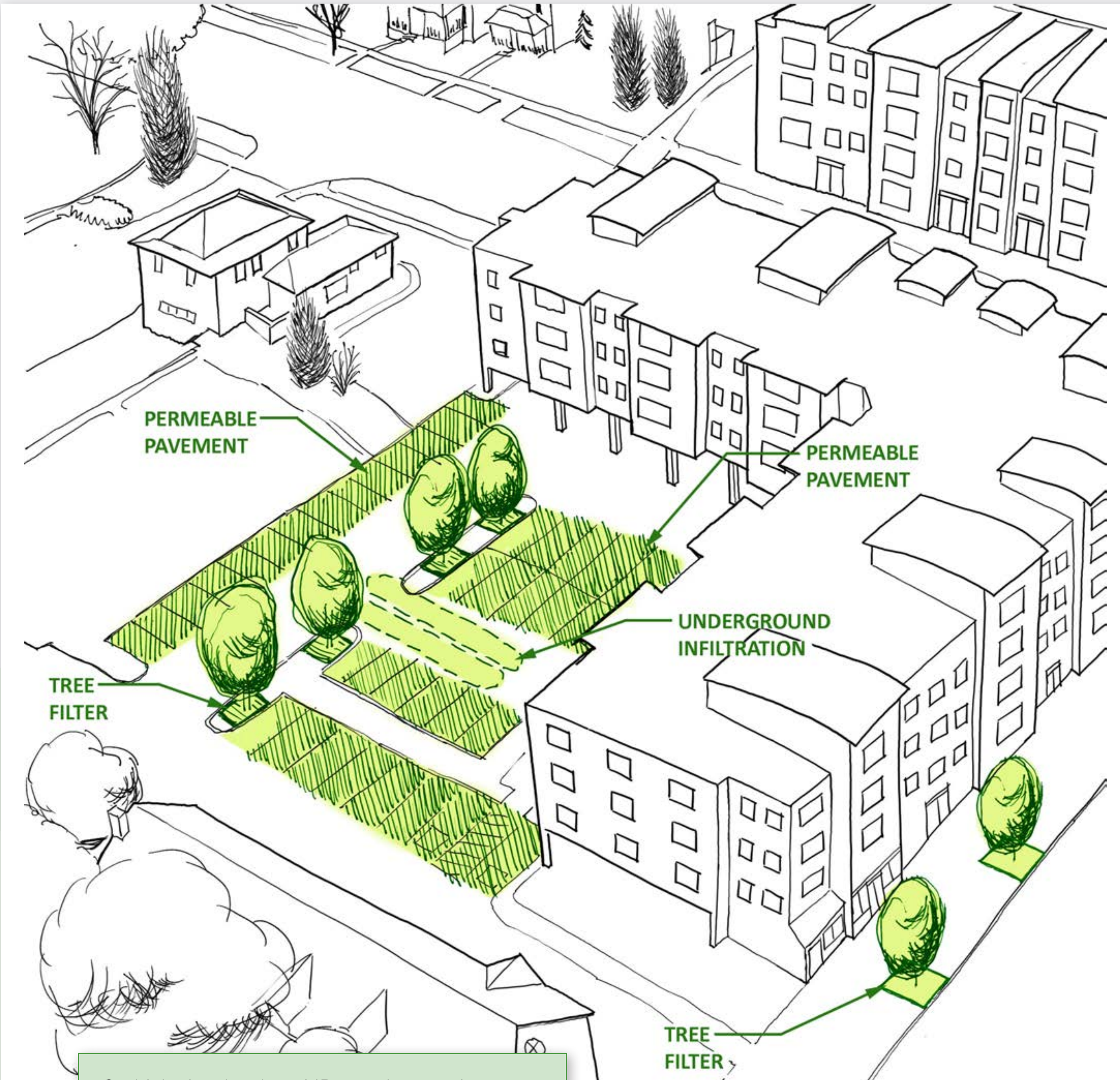
Dense arterial streets require space- efficient LID practices. Consider placing bioretention between trees and using tree filters where parkways are paved.

Right-of-Way – Non-Arterial Street



LID practices for non-arterial streets are similar to arterial streets, but in some cases, permeable pavement may be used in the parking lane. Coordinate with the Engineering Department early on to determine which LID practices are applicable for your project.

High Density



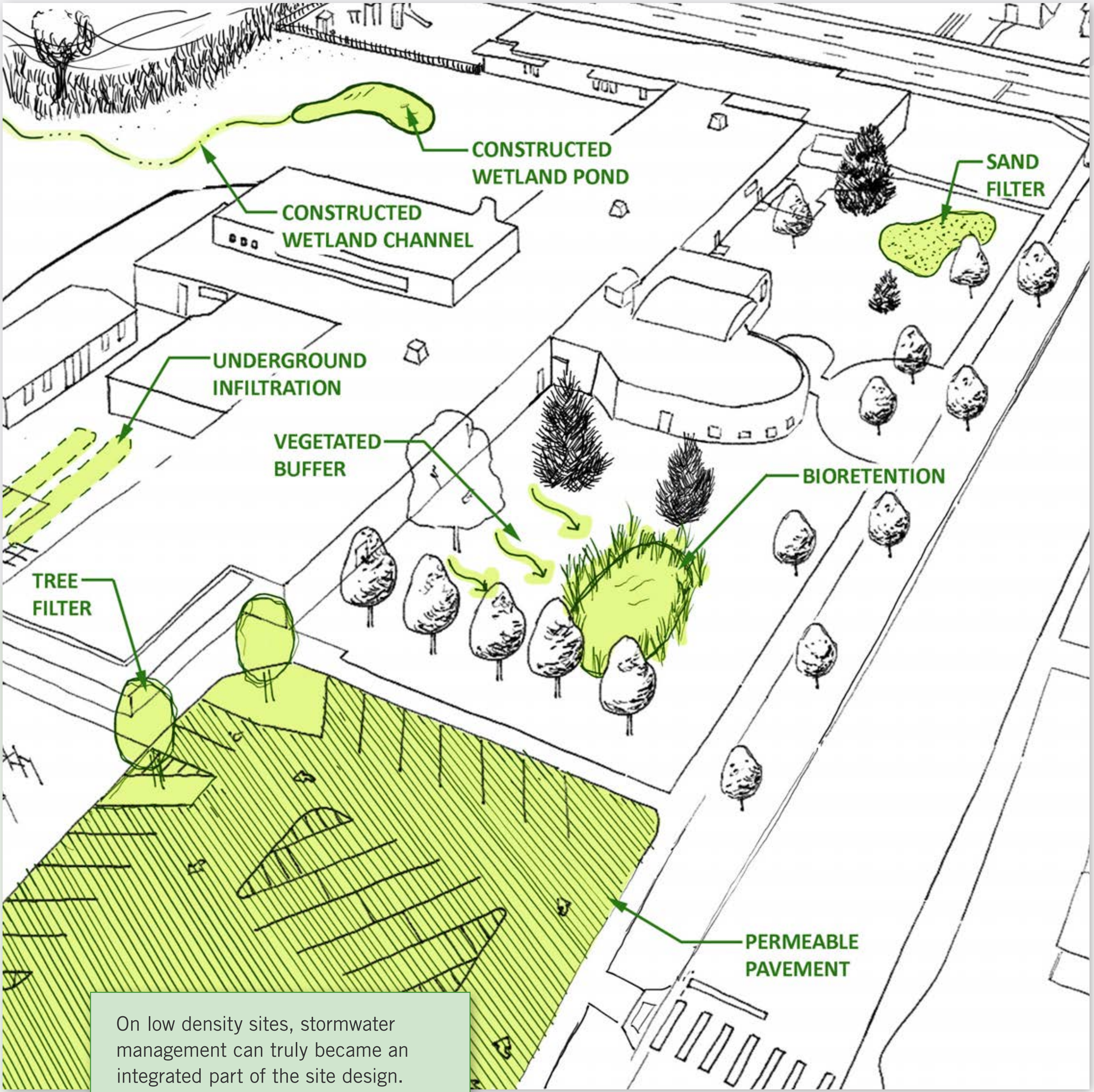
On high-density sites, LID practices such as underground infiltration allow for infiltration while also providing build over for pavement areas.

Medium Density

Medium-density sites have more options when selecting LID practices. Developing the stormwater plan will involve consideration of which LID practices will match the site use and context.

Land Use Illustrative Examples, *continued*

Low Density



On low density sites, stormwater management can truly became an integrated part of the site design. Stormwater facilities can be almost imperceptible when not storing water.

Single Family Residential Development

For single family residential development LID practices are located in shared tracts which can be maintained by a Home Owners Association, taking responsibility off individual property owners.

3

Section Three: LID BMP Fact Sheets

Each of the following fact sheets provides an overview of an LID BMP, facilitating easy comparisons of how each BMP works. The information and typical details are provided to assist with final design and planning for maintenance.

LID Best Management Practices

People involved in project implementation use a variety of specific tools to meet development requirements using LID principles. These tools are referred to as LID Best Management Practices (BMP). LID is focused on picking the right tools for the project and designing based on site context. With proper planning, analysis, design and construction, the LID BMPs described in this manual may be used to meet City of Fort Collins' LID criteria and stormwater criteria.

Two categories of LID BMPs may be used to meet the LID criteria: 1) Conveyance BMPs, which convey runoff across a Receiving Pervious Area and reduce the Water Quality Capture Volume and 2) Storage BMPs, which provide detention of the Water Quality Capture Volume. Combinations of multiple BMPs are encouraged.

LID CONVEYANCE BMPS:

- Vegetated Buffer
- Constructed Wetland Channel
- Green Roof *

** BMP Fact Sheet is not provided in this manual, refer to UDFCD Stormwater Criteria Manual.*

LID STORAGE BMPS:

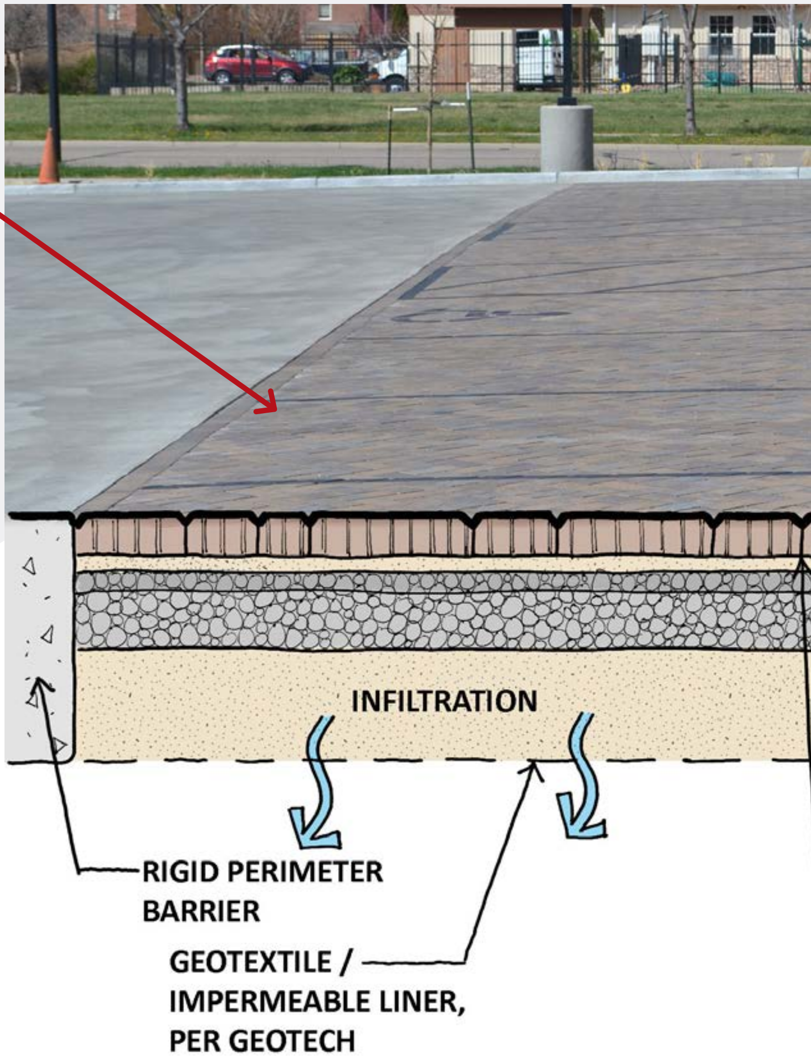
- Permeable Pavement
- Bioretention
- Sand Filter
- Tree Filter
- Underground Infiltration

Permeable Pavement

This space-saving BMP can be used for walking or driving surfaces just like concrete or asphalt pavement. Porosity in the area between pavers allows rain water to flow into a subsurface storage layer for treatment and infiltration. Set your permeable pavements up for success by limiting sources of sediment. The following permeable pavements are not currently accepted by the City of Fort Collins: porous concrete, porous asphalt.

COST AND BENEFIT CONSIDERATIONS

- **Provides durable surface and stormwater benefit in the same footprint.**
- Permeable pavements can be intermixed with different colored pavers to create varied and interesting paving patterns.
- With proper design, installation and maintenance, permeable pavements match or exceed conventional pavement life.
- Reduces sound and splash, particularly from wet weather driving, compared to concrete pavement.



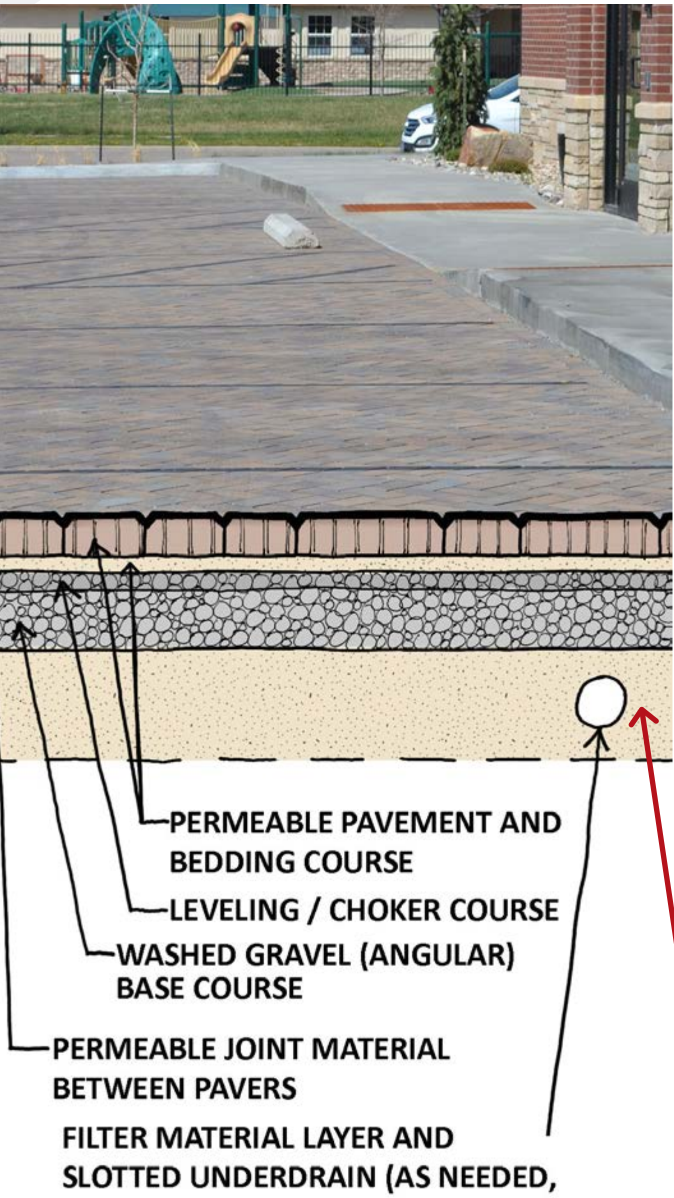
MAINTENANCE CONSIDERATIONS

- Do not sand permeable pavements or areas that run on to permeable pavements.
- Permeable pavements typically accumulate less snow and melt faster but de-icers are discouraged because they are less effective since they will not stay on the surface.
- Plan for semi-annual pavement vaccuming regeneration. More frequent maintenance may be required for high use sites.
- Regularly remove debris from the pavement surface before it breaks down.
- Identify and eliminate sediment sources.
- Pavers may be salvaged and reused for utility work.
- **Plan for redistribution of aggregates when using grid pavements.**
- Provide observation ports for inspections.

Gravel Grid Pavement Example

Notes and References

- [UDFCD Treatment BMP Fact Sheet T-10]
- [LCUASS Appendix A - Standard Drawings]



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Precedent Projects

- Odell Brewery Parking Lot
- Senior Center

DESIGN CONSIDERATIONS

- Minimize run on from areas which might carry sediment such as exposed soil or gravel parking areas.
- Distribute run on across a wide area rather than having concentrated flow sources which might overload a portion of the pavement.
- Sloped pavements may require special design such as subsurface check dams to allow water to infiltrate downward.
- Refer to Fort Collins Stormwater Criteria Manual for maximum allowable slope.
- Separate control structures may be required for each check dam.
- Coordinate design with material industry representative.
- Maximum recommended run on from other surfaces should not exceed 2:1.
- Public right-of-way may not be used to meet LID requirements for private property development.
- When BMP is allowed to be used in the public right-of-way, it may be used in parking lanes only, not in traffic lanes.
- Gravel grid pavement systems are not applicable for Right-of-Way applications.
- For public projects maintenance responsibility shall be determined during the design phase.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate permeable pavement areas prior to site disturbance to protect subgrade from construction related compaction.
- Protect finished pavements from construction sediment including landscape installation and construction traffic.
- **Avoid geotextile wrapping of underdrain pipes.**
- Identify minimum installer experience in contract, ICPI certification recommended. In lieu of experienced installers, specify test panels with material industry representative oversight.

Bioretention

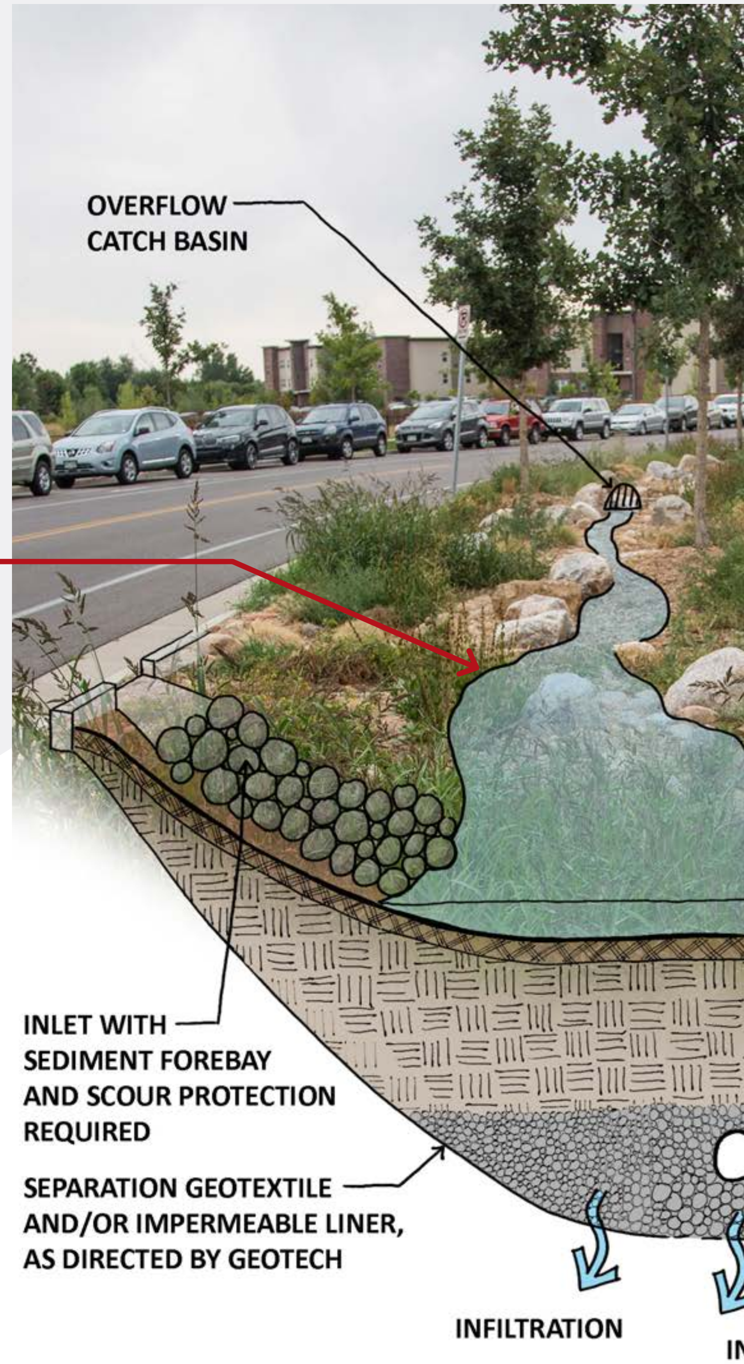
Bioretention areas (often called Rain Gardens) are depressed landscape features that are designed to collect and treat stormwater. These areas can be linear or free form depending on the site context. Bioretention areas primarily treat stormwater by filtering sediment as the water travels downward through the soil, but it is also a living system where plants and micro-organisms maintain the soil structure and break down dissolved pollutants.

COST AND BENEFIT CONSIDERATIONS

- May be used to meet landscape requirements.
- Accept concentrated flow sources.
- **Flexibility in size and shape (linear or basin) make this a popular BMP.**
- Can be combined with underground infiltration BMPs for maximizing performance in a small footprint.
- In dry weather bioretention can serve other uses such as open space.
- Sometimes used to buffer pedestrian and cyclists from roadways.
- Easier to observe and access for maintenance than underground BMPs.

MAINTENANCE CONSIDERATIONS

- Smaller cells may require more frequent maintenance and sediment removal.
- Consider maintenance practices when specifying mulchs. Floatable materials are not allowed.
- BMPs that are used for snow storage or receive flow from sanded areas require more frequent sediment removal.
- **Size forebay accordingly to maintenance frequency and adjacent context.**
- When adjacent to parking and sidewalks provide a flat level step out zone for pedestrian comfort next to the graded slope or wall.
- Group plantings of similar needs or type to simplify maintenance.
- Choose plants to fit conditions e.g. low plants along parking.
- Keep inlets clear of vegetation.



Presettling forebay example at Library Park

** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Notes and References

- UDFCD Treatment BMP Fact Sheet T-03
- Soil Media Specification (Appendix C)
- LCUASS Appendix A - Standard Drawings

Precedent Projects

- North College Market Place
- Woodward Commercial Development

DESIGN CONSIDERATIONS

- For concentrated flow applications, armor inlets against scour.
- **Scale the depth of drop from walking areas to the top of bioretention according to the site use and aesthetics, generally <18".**
- Check dams provide ponding depth and slow velocities for linear bioretention.
- Consider size, location and material of inlet pipes and overflow structures and how they affect aesthetics and impact to impervious area footprint.
- In the right-of-way, street tree requirements must be met. Trees are to be located outside of bioretention and positioned adequate distance from curb and sidewalk. Consider placing bioretention between street trees.
- Use landscape areas / islands to encourage multiple uses of space.
- Use plantings that are appropriate for the site. Native plants are encouraged.
- Public right-of-way may not be used to meet LID requirements for private property development.
- Developer-installed bioretention areas shall be maintained by the developer.
- For public projects maintenance responsibility shall be determined during the design phase.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate bioretention areas prior to site disturbance to protect subgrade from construction-related compaction.
- Plants will likely require permanent irrigation.
- Protect finished BMPs from construction sediment, including during landscape installation.
- During establishment protect BMPs from washout.
- Avoid geotextile wrapping of underdrain pipes.
- Provide adequately-sized and armored-overflow for high flow conditions.
- Ensure that rock and plant material placed near inlets do not block flow.

Sand Filter

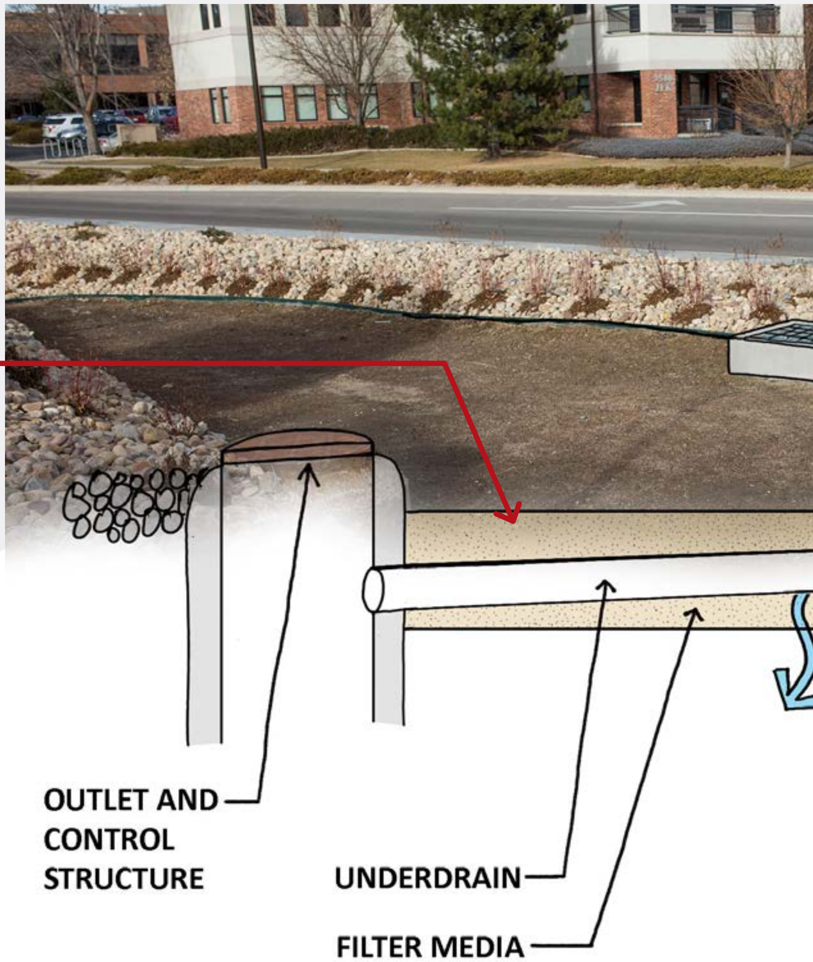
Sand Filters are a simple system that treat stormwater by passing it through a bed of clean sand. They rely on a single treatment process and do not provide as many of the multifunctional habitat and aesthetic benefits as bioretention areas.

COST AND BENEFIT CONSIDERATIONS

- Accept concentrated flow sources.
- Can be designed for deeper ponding depth and larger tributary areas than bioretention. In some cases sand filters may be used to provide the flood control volume.
- Easier to observe and access for maintenance than underground BMPs.
- **Simple design for installation.**
- Relies more heavily on mechanical cleaning and replacement of media to maintain filter rates vs bioretention which is aided by biological processes.
- Vegetation will be more difficult to establish.

MAINTENANCE CONSIDERATIONS

- Remove plant debris frequently.
- Smaller cells may require more frequent maintenance and sediment removal.
- BMPs that are used for snow storage or receive flow from sanded areas require more frequent sediment removal.
- Size forebays accordingly to maintenance frequency and context.
- **Consider using a pretreatment BMP such as vegetated buffer or vegetated conveyance swale upstream to capture sediment.**

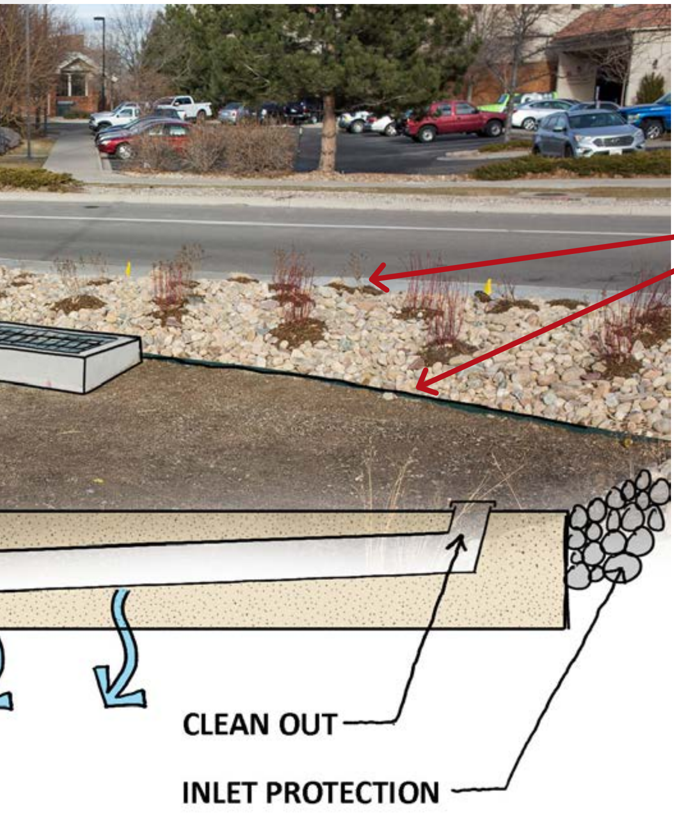


Notes and References

- UDFCD Treatment BMP Fact Sheet T-06

Precedent Projects

- Foothills Mall (south side)
- CSU Parking Structure



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- For concentrated flow applications, armor inlets against scour.
- **Scale the depth of drop from walking areas to the top of sand filter according to the site use and aesthetics, generally <18".**
- For sites with infiltration limitations BMPS are drained by underdrains.
- BMP is not applicable for right-of-way applications.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate sand filter areas prior to site disturbance to protect subgrade from construction related compaction
- Protect finished BMPs from construction sediment including during landscape installation.
- Provide adequately sized and armored overflow for high flow conditions.

Tree Filter

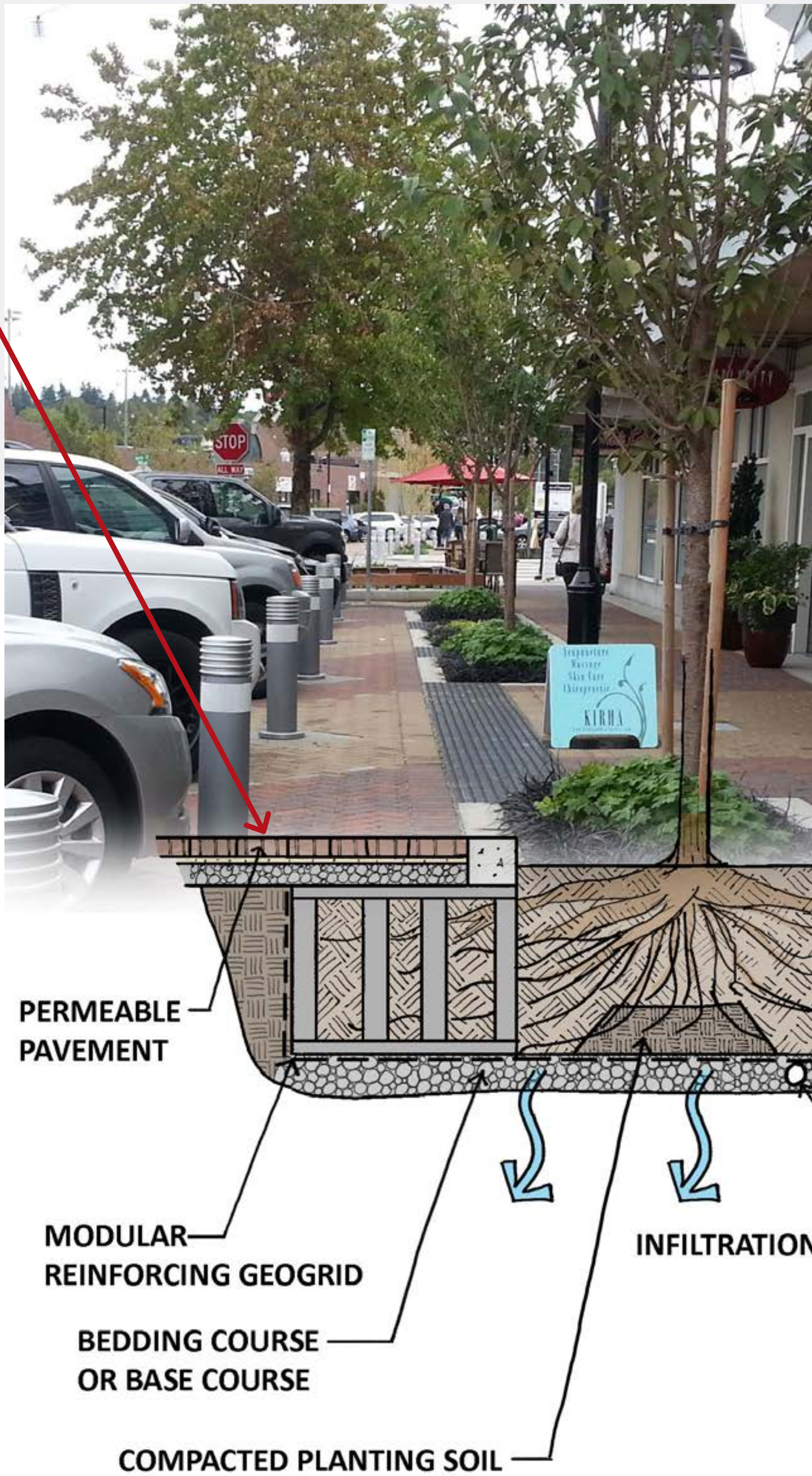
Tree Filters typically consist of a proprietary structural support system that allows uncompacted soil to be placed around the tree roots. Compared to urban trees planted in pavement settings, tree-filter trees grow faster and live longer. Tree filters also provided stormwater treatment through filtration and infiltration.

COST AND BENEFIT CONSIDERATIONS

- Tree filters cost more than traditional tree planting methods but also provide better growing conditions, promoting healthier and higher value trees.
- **Can be combined with permeable pavement to provide additional air and water transfer.**
- May be used to meet landscape requirements.
- Can be designed to accept flow through an inlet or downspout pipe.
- Applicable to dense urban applications where pavement surrounds the tree zone.
- Tree filters may also be used in situations where an underdrain is not feasible.

MAINTENANCE CONSIDERATIONS

- **Design for the lifetime of the tree. Pretreatment that protects the quality of the tree soil is therefore particularly important for this BMP.**
- Provide access to pretreatment filter for inspections and filter material replacement.
- Provide observation ports to facilitate inspection.
- Trees will require permanent irrigation.

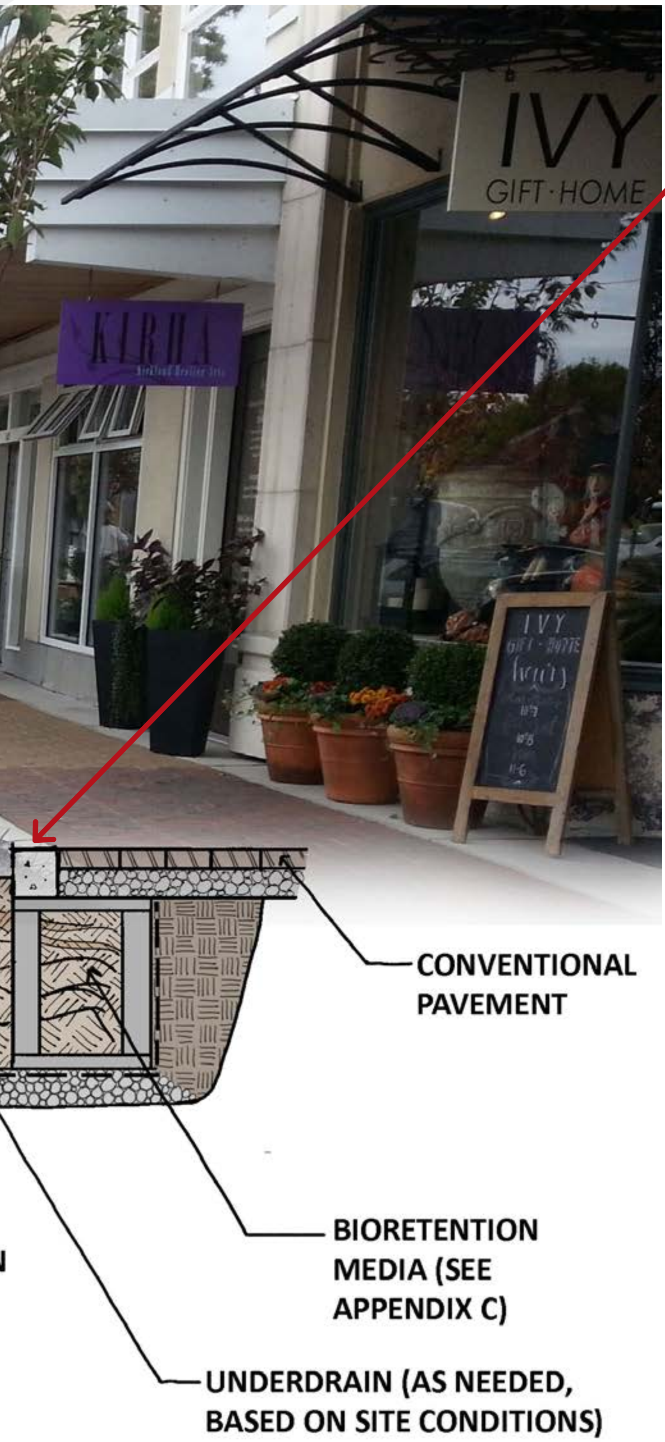


Notes and References

- [Denver Ultra Urban Green Infrastructure Guidelines "Tree Trench/Pit Fact Sheet."]
- [Soil Media Specifications (Appendix C)]
- [LCUASS Appendix A - Standard Drawings]

Precedent Projects

- City of Fort Collins Utilities
- Parking Garage



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- **Consider the relationship to the tree filter surface to the surrounding pavement. Provide edge protection as needed.**
- Consult with manufacturer to provide sufficient soil volume for tree species.
- Refer to manufacturers guide for guidance on how to calculate the WQCV for this BMP.
- Maximize lateral infiltration and distribution of water.
- Right-of-way may not be used to meet LID requirements for parcel impervious area.
- BMPs shall be located in such a way as not to conflict with street tree requirements.
- Coordinate utility setback/sleeving requirements with Engineering Department during feasibility analysis.
- Work with utility providers to determine if sleeves are needed for existing or future utilities.
- For public projects maintenance responsibility shall be determined during the design phase.
- Impermeable liner is required along vertical sides of the tree filter to the bottom of excavation if located in public right-of-way.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate tree filter areas prior to site disturbance to protect subgrade from construction related compaction.
- Protect finished BMPs from construction sediment including landscape installation. During establishment protect BMPs from washout.
- Follow manufacturer's recommendations for installation.
- Products may require protection from sunlight exposure when stockpiled.
- Place the root flare of the tree slightly higher than the overflow to prevent fungal growth.

Underground Infiltration

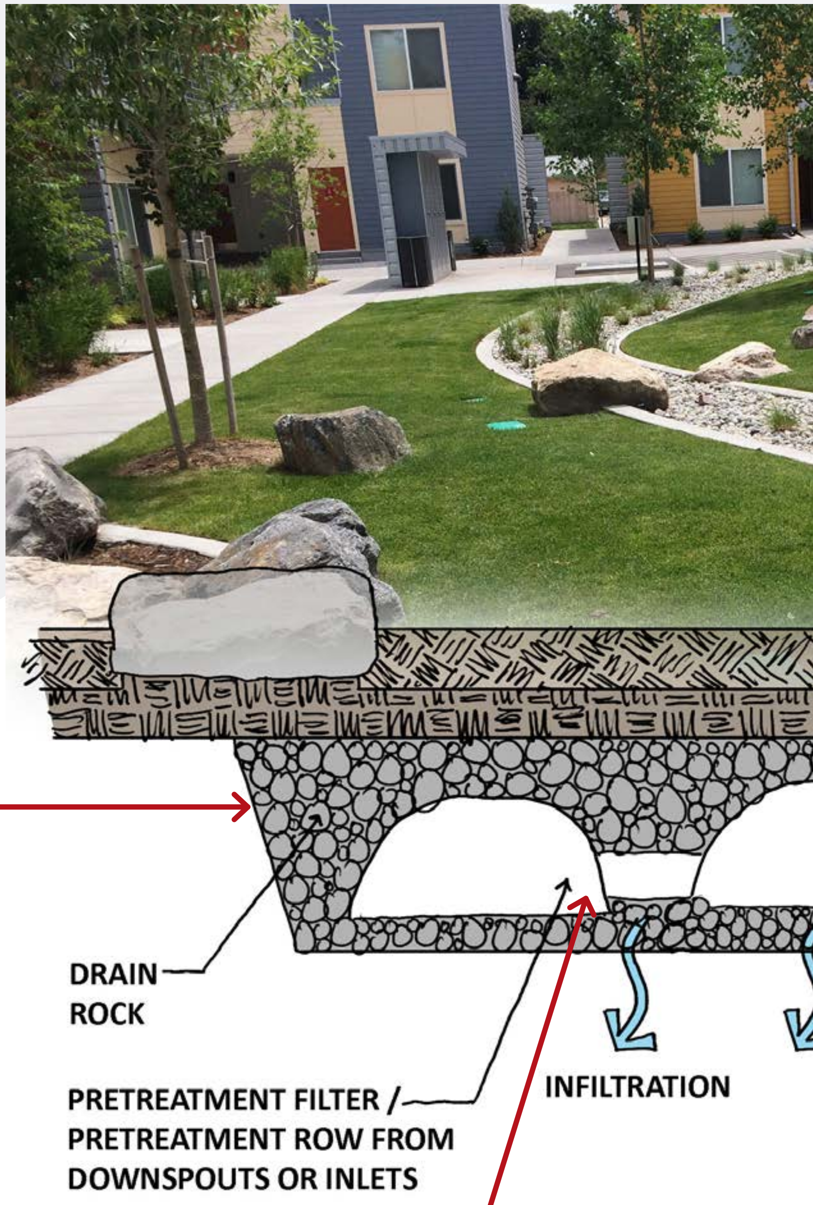
Often used at sites with little open space. It can also be used to augment other BMPs since it allows for a large amount of stormwater storage in a small footprint and allows for multiple uses in the same space.

COST AND BENEFIT CONSIDERATIONS

- Projects typically use proprietary products.
- Used as space saving technique that allows for multi-use such as in parks or below parking.
- For additional space savings, this BMP is often located in combination with other techniques such as permeable pavement or bioretention.
- Many manufacturers offer shallow units for flat sites with low drop.
- **When comparing the cost of different products, consider also the cost of excavation and gravel backfill.**

MAINTENANCE CONSIDERATIONS

- Providing inspection and maintenance access is especially critical for the long-term performance of this type of BMP since it cannot be observed from the surface.
- Inspections and maintenance may require a confined space entry per local and OSHA rules.
- **Some products require specialized cleaning equipment such as isolator row sets.**
- Reduce maintenance by presettling or filtering sediment at the inlet. Other LID BMPs can sometimes perform this function, in a 'treatment train' approach.

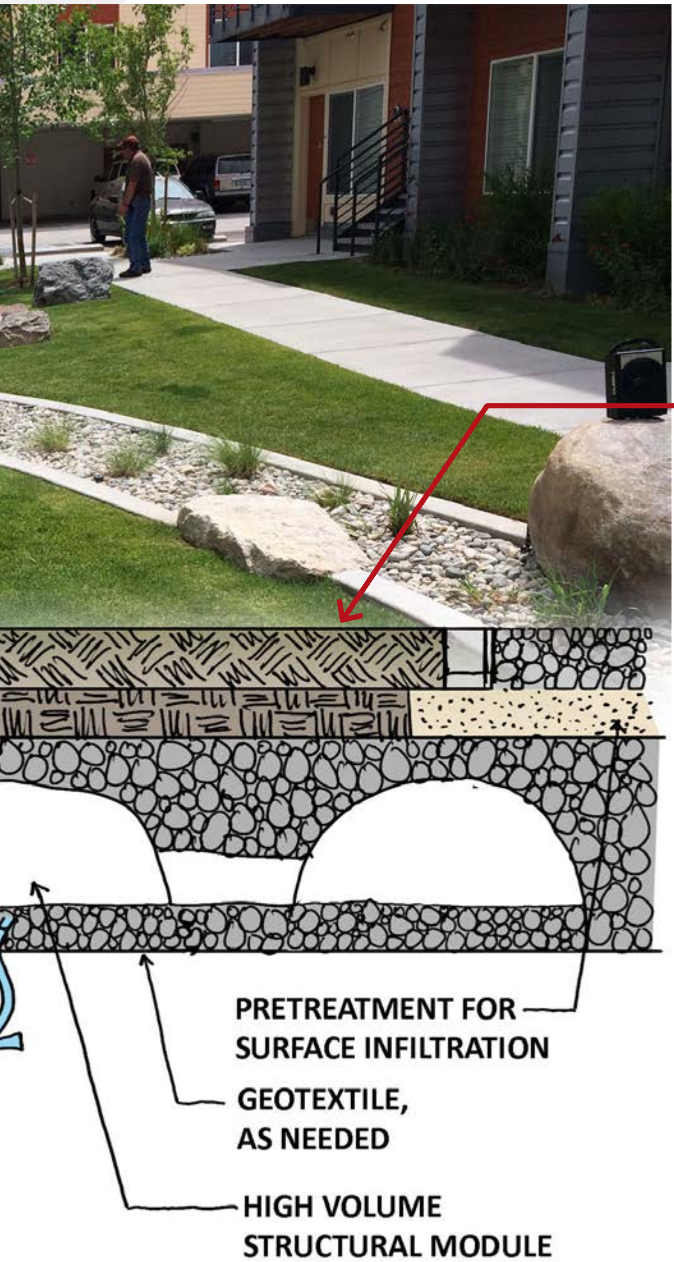


Notes and References

- Ft Collins Stormwater Criteria Manual
- UDFCD Treatment BMP Fact Sheet T-11

Precedent Projects

- The Exchange: 200 Block of N. College Avenue
- Brickstone Apartments: 201 E. Harmony Road



DESIGN CONSIDERATIONS

- Each product has different load capacities and cover requirements.
- Check-in with the manufacturer's representative often. Manufacturers may require plan review prior to construction, as well as a pre-construction meeting.
- On sloped sites modules may need to be stepped.
- **Products may have load and planting limitations over the units.**
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Protect inlets from construction sediment.
- Route construction traffic around the BMP to avoid exceeding load rating and protect the surface from construction sediment.
- Follow manufacturer's recommendations for installation.
- Products may require protection from sunlight exposure when stockpiled.

** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Non-Engineered Rain Garden

Rain Garden areas may also be installed voluntarily where they are not required by City code. Homeowners or businesses may choose to install non-engineered rain gardens for their own benefit or to support the larger City ecosystem. Non-engineered rain gardens can collect water from downspouts, patios and driveways and allow it to filter into the ground.

COST AND BENEFIT CONSIDERATIONS

- **This BMP may not be used to meet the LID Criteria. It is for voluntary installations only.**
- Does not require specialized design or engineering.
- Does not require permit or City inspection.
- Used to diversify and beautify landscaping while benefiting the environment.
- Can be used to alleviate problem drainage areas.
- Multiple rain gardens may be used to capture water from each downspout.
- May be applied to individual single family lots.

MAINTENANCE CONSIDERATIONS

- **Adjacent to paving provide a level step out zone that also prevents undermining of pavement when bioretention soil settles.**
- If erosion is causing sediment to accumulate in the rain garden, identify the source and stabilize it with mulch or plants.
- The first couple of years may require more weeding as the rain garden plants establish.
- Plants will require permanent irrigation, but may require less water than conventional planting beds.
- Size forebay according to maintenance frequency.

Notes and References

- Soil Media Specification (Appendix C)
- "Building a Rain Garden in Colorado" Colorado Stormwater Center

Precedent Projects

- Poudre River Drive & Hoffman Mill Road
- Library Park

DESIGN CONSIDERATIONS

- Use a bed of stones around inlet pipes to protect against erosion.
- **For sites with infiltration limitations, use an underdrain to prevent standing water that doesn’t infiltrate in 48 hours. Orifice controls are not required.**
- Ensure a clear flow path to the existing drainage system is provided, in case of overflow.
- Provide at least 10’ setback from buildings.
- Select plants that can thrive in both wet and dry conditions.
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Residents should call before digging, Dial 8-1-1, to locate existing utilities.
- Roughen the soil at the bottom of your excavation and minimize walking in the rain garden to prevent soil compaction.
- Allow time for plants to establish before connecting downspouts.
- **Avoid geotextile wrapping of underdrain pipes due to clogging.**

** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Vegetated Buffer

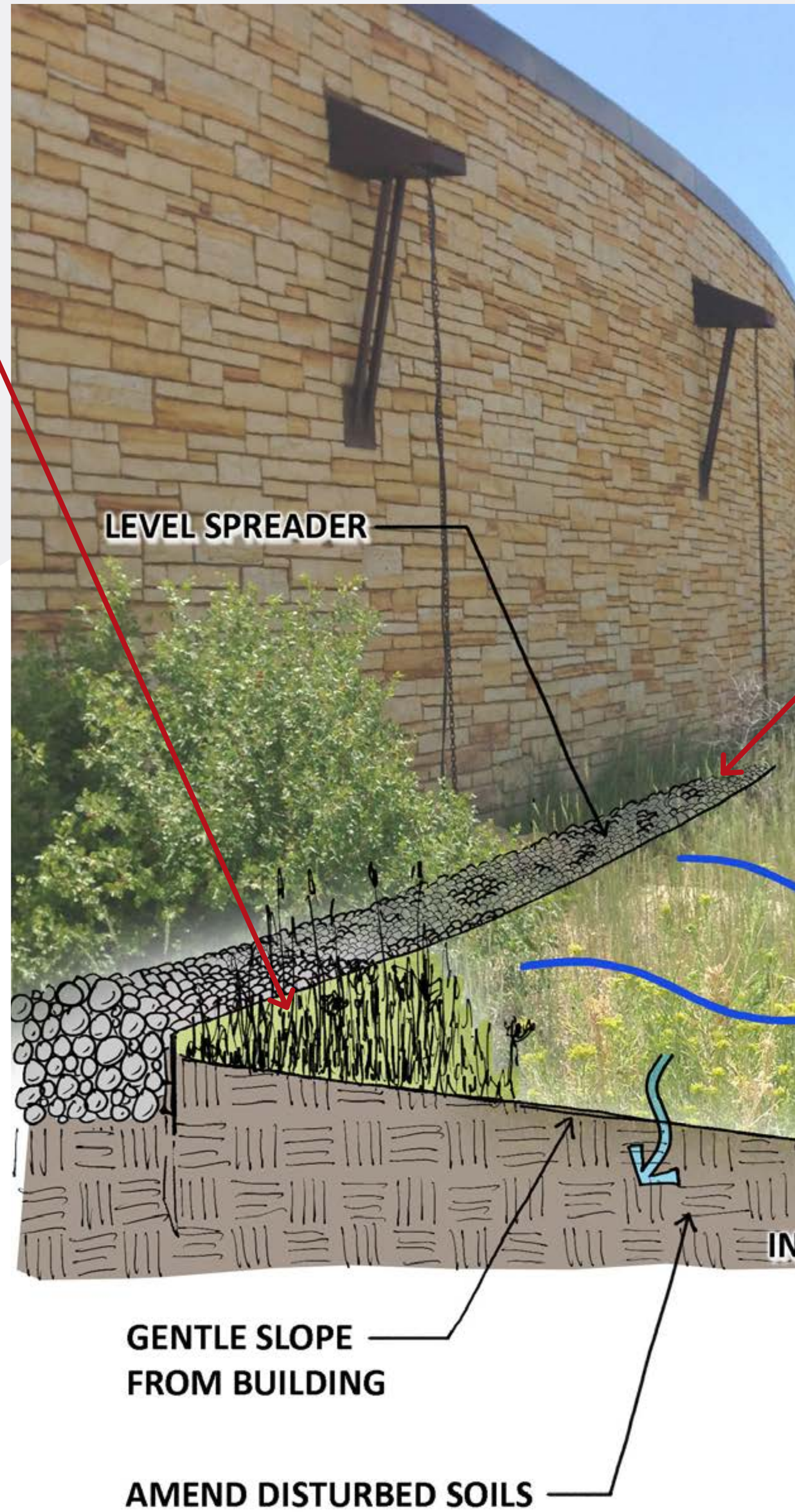
The vegetated buffer cleans stormwater runoff by catching sediment and debris between the stalks and leaves of dense vegetation. It is often used to reduce directly connected impervious areas, allow water to infiltrate and provide pretreatment for other BMPs.

COST AND BENEFIT CONSIDERATIONS

- Reduces directly connected impervious areas.
- May be used to meet landscape requirements.
- Low construction cost.
- Flexible space for recreation and snow storage.
- **Vegetated buffers require gently sloping sites, 2% minimum to 10% maximum.**
- Applicable to sites with large open spaces.
- Uses existing areas, which reduces land consumption.

MAINTENANCE CONSIDERATIONS

- **Dense cover is required to maintain the function of this BMP. Ensure at least 80% vegetated cover.**
- Protect vegetated buffers from compaction. Prevent cars from driving onto the buffer. Amend soils that become compacted.
- Provide wheel stops or similar barrier adjacent to parking and drives.
- Trim and maintain vegetation along edges where impervious area flows to buffer.
- Monitor for invasive species and remove as needed.
- Remove accumulated sediment in level spreader to maintain dispersed flow.



Notes and References

- [UDFCD Treatment BMP Fact Sheet T-01]
- [Grass Buffer Seed Mix Specification (Appendix D)]

Precedent Projects

- Bucking Horse Apartments

** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- **Level spreaders are required for concentrated flow applications and recommended for sheet flow applications.**
- Select vegetation with uniform cover characteristics. Avoid bunch type vegetation that can result in concentrated flow between plants.
- Where feasible provide a 2-3" drop between the top of the vegetated buffer and the contributing impervious area. This drop prevents vegetation from growing against the impervious area and concentrating flow.
- Confirm vegetated flow path is not within footprint of future development.
- Permaculture techniques such as keyline design may be used to increase infiltration.
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate buffer areas prior to site disturbance to protect subgrade from construction related compaction.
- Protect finished BMPs from construction sediment including landscape installation. During establishment protect BMPs from washout.
- Construct level spreaders parallel to site contours.
- Plants will require establishment irrigation during and for a time following construction.

Constructed Wetland Channel

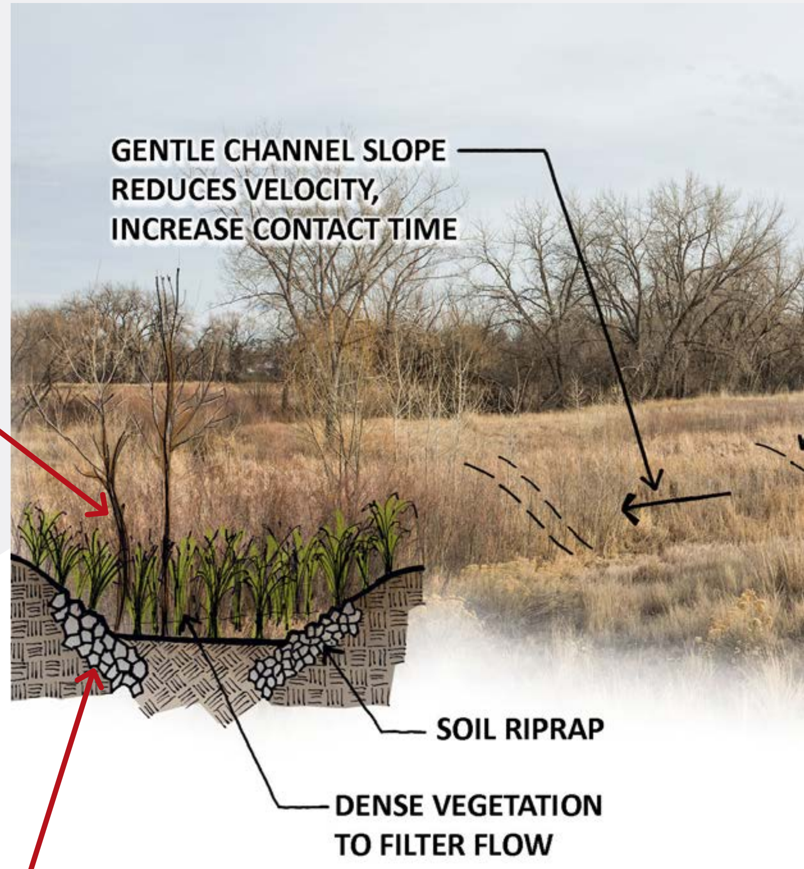
Constructed wetlands support a wide variety of vegetation and wildlife. While a primary process for pollutant removal is sediment settling, plants and microorganisms also have an extended contact time with the water allowing for removal of dissolved pollutants. This elaborate ecosystem provides high levels of stormwater treatment.

COST AND BENEFIT CONSIDERATIONS

- Not applicable to sites that do not have a sufficient baseflow.
- Provides high levels of stormwater treatment, including dissolved pollutants and nutrients.
- Channel may provide conveyance for major and minor storms.
- In addition to stormwater benefit, wetland channels also provide high habitat value.
- **Wetland plants add interest and diversity to the vegetation of the site.**
- Do not use an existing natural channel to treat stormwater.
- In some cases, can be used to mitigate impacts to existing wetlands.
- Applicable in areas close to existing natural areas, water bodies and streams.

MAINTENANCE CONSIDERATIONS

- Provide an access path along the length of the channel, at forebays, at inlets and at outlets.
- **After large storms inspect grade control structures and side slopes for erosion or scour.**
- If sediment accumulation becomes an issue, identify the source and stabilize it or install a pretreatment device.
- Vegetation should remain clear of inlets and outlets at all times.
- Providing a vegetated buffer between the active portion of the site and the channel can reduce trash accumulation.
- Monitor for invasive species and remove as needed.



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Notes and References

- UDFCD Treatment BMP Fact Sheet T-09

Precedent Projects

- Udall Natural Area
- Bucking Horse Apartments

DESIGN CONSIDERATIONS

- Ensure baseflow is sufficient to maintain year round saturated soil.
- **Wetland channels rely on gentle channel profiles in order to promote settling. Grade control structures are required for steeper sites.**
- Since channels can be difficult to access and dredge, pretreatment is required to remove most sediment.
- When placed downstream of detention, constructed wetland channels benefit from both pretreatment and attenuation.
- Nutrient removal typically increases with hydraulic residence time.
- When used to meet wetland mitigation requirements, stormwater must be pretreated prior to entering the wetland area.
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Divert baseflows during construction to allow for establishment.
- Protect finished BMPs from construction sediment including landscape installation.
- During establishment protect BMPs from washout.
- Plants (particularly upland) will require establishment irrigation during and for a time following construction.

Grade control example for a small channel.

Constructed Wetland Pond

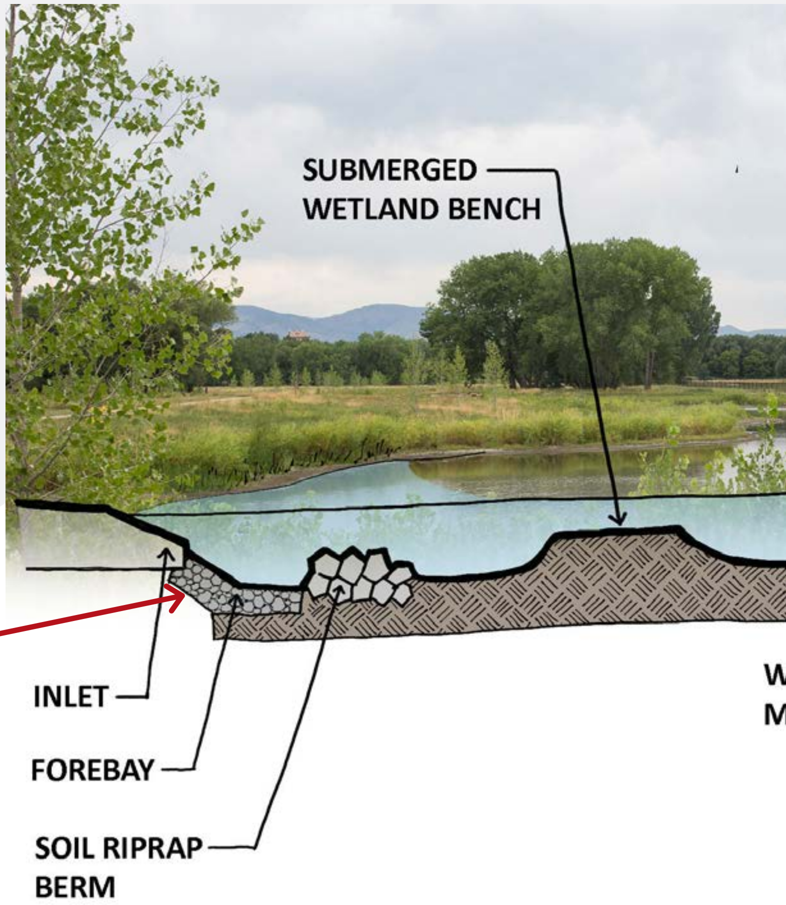
Constructed wetland ponds function similar to constructed wetland channels, by removing pollutants through a combination of settling and biological processes. They are often incorporated as site amenities and can be surrounded by walking trails.

COST AND BENEFIT CONSIDERATIONS

- Wetland are considered a retention facility and require water rights.
- Not applicable to sites that do not have a sufficient baseflow.
- May be designed to also provide detention volume.
- Provides high levels of stormwater treatment, including dissolved pollutants and nutrients.
- In addition to stormwater benefit, wetland ponds also provide high habitat value.
- Do not use an existing natural wetland to treat stormwater.
- In some cases, can be used to mitigate impacts to existing wetlands.

MAINTENANCE CONSIDERATIONS

- **Provide maintenance access, particularly at forebays and micropools.**
- Nutrient rich runoff can create algae blooms. Limit algae growth by managing fertilizer use and other nutrient sources.
- Vegetation should remain clear at inlets and outlets at all times.
- Providing a vegetated buffer between the active portion of the site and the wetland can reduce trash accumulation.
- Monitor for invasive species and remove as needed.

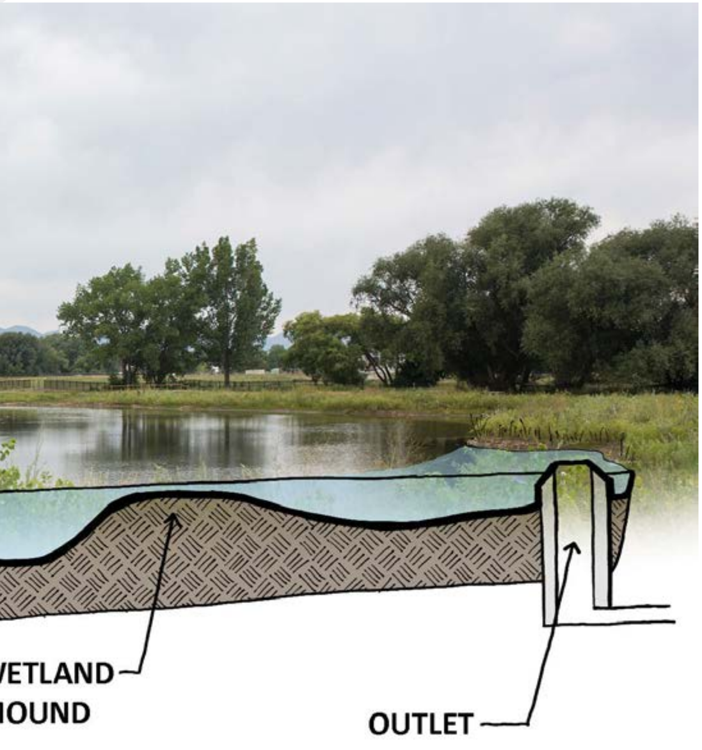


Notes and References

- UDFCD Treatment BMP Fact Sheet T-08

Precedent Projects

- Udall Natural Area
- Woodward Commercial Development



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- Ensure baseflow is sufficient to maintain year round permanent pool.
- Since ponds can be difficult to access and dredge, proper forebay sizing and maintenance access is necessary.
- Separate inlet and outlet to minimize "short circuiting."
- Provide a mechanism to drain down the pond for maintenance access.
- Nutrient removal typically increases with hydraulic residence time.
- When used to meet wetland mitigation requirements, stormwater must be pretreated prior to entering the wetland area.
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Construct the pond using diverse horizontal and vertical forms to create a natural looking site amenity.
- Divert baseflows during construction to allow for establishment.
- Protect finished BMPs from construction sediment including landscape installation.
- Plants (particularly upland) will require establishment irrigation during and for a time following construction.

4

Section Four: Design Approach

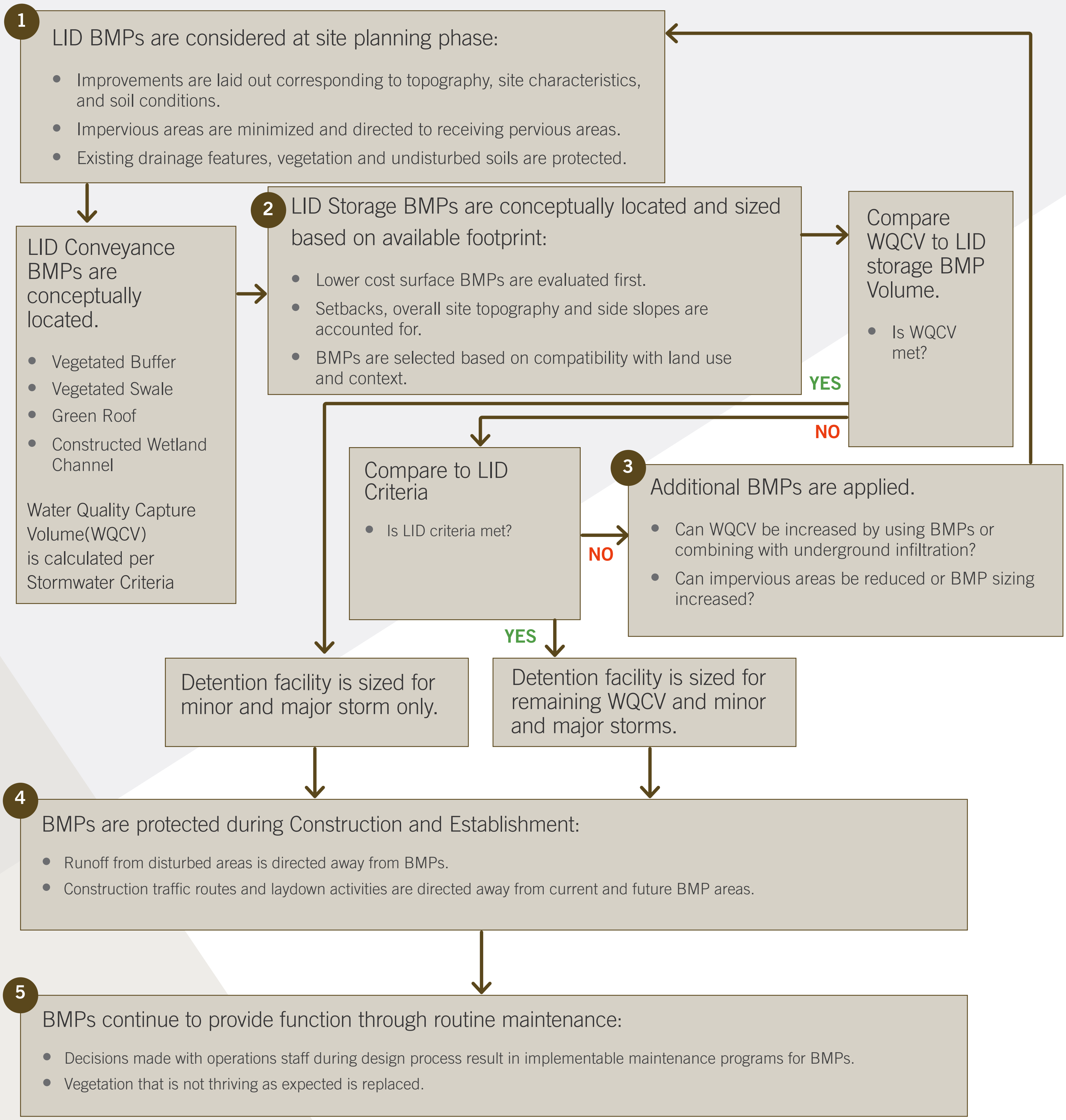
An integrated stormwater management plan that maximizes the multiple benefits of LID practices can be achieved by carefully considering stormwater impacts at each phase of the project.

Overview

The following flow chart illustrates LID considerations for each of the planning, design, construction and operations phases of a project life-cycle. This approach allows for LID practices to be used that:

- Meet multiple code requirements (stormwater criteria, landscape code, etc.).
- Are relevant to the building architecture.
- Are part of a cohesive site design.
- Increase public awareness and stewardship of rain water.

LID Consideration Flow Chart



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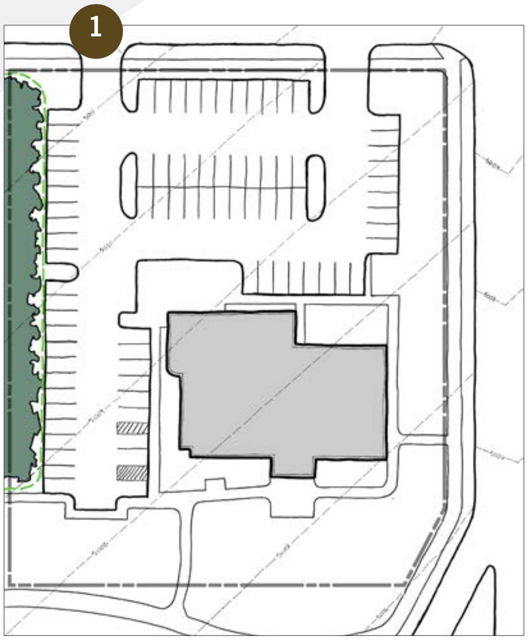

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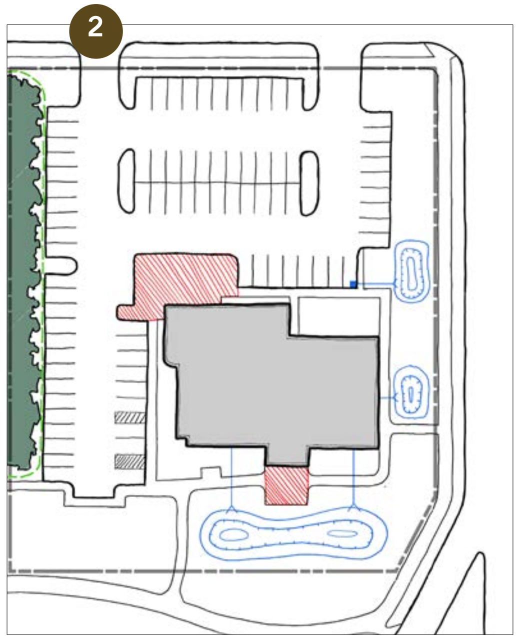

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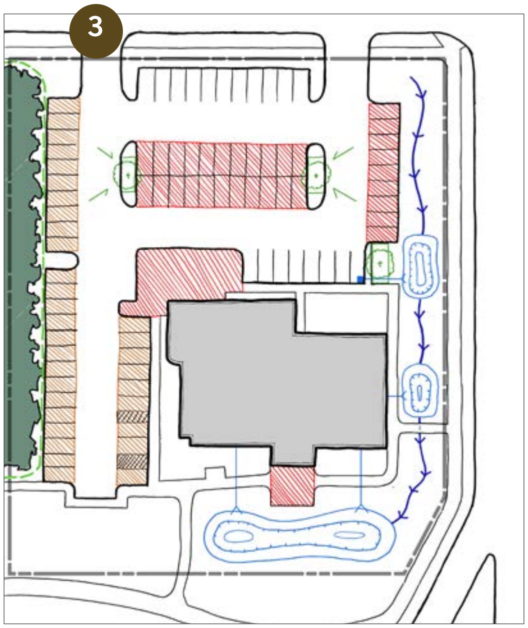

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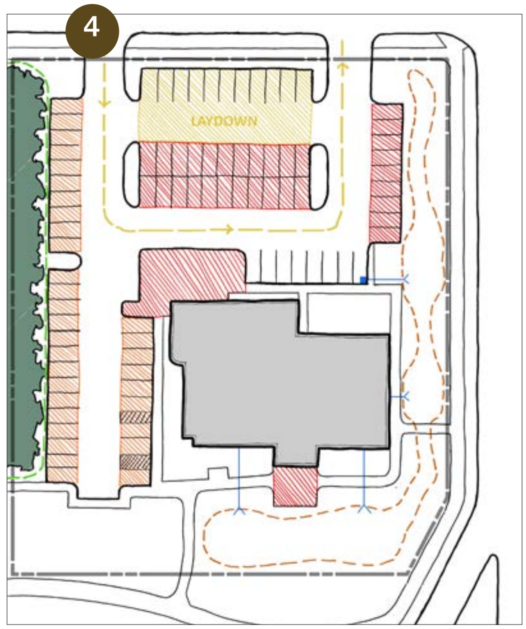
LAYDOWN

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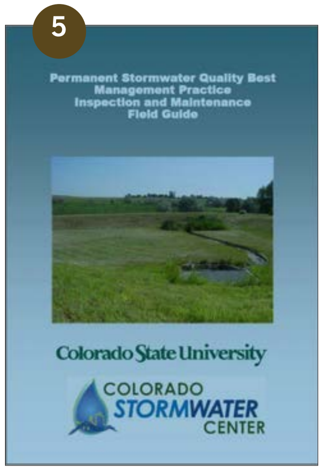
Permanent Stormwater Quality Best
Management Practice
Inspection and Maintenance
Field Guide
Colorado State University
COLORADO
STORMWATER
CENTER

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Section Five: Appendices

LID Manual Notes and Resources

- Appendix A: Glossary
- Appendix B: LID Project Locations
- Appendix C: Soil Mixes
- Appendix D: Plant Lists

Appendix A: Glossary

Note: This glossary is not intended to provide regulatory or legal definitions of terms. Instead, it is intended to provide users with a basic understanding of terms used in this manual.

Best Management Practice (BMP)
A technique, process, activity, or structure used to reduce pollutant discharges in stormwater. BMPs include source control practices (non-structural BMPs) and engineered structures designed to treat runoff. BMPs are most effective when used in combination and selected and designed based on site-specific characteristics.

Check Dam
Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment. Subsurface check dams retain water on sloped sites within the subsurface storage reservoir.

Detention
The storage and slow release of stormwater from an excavated pond, enclosed depression, subsurface reservoir, or tank. Detention is used for pollutant removal, stormwater storage, and peak flow reduction.

Directly Connected Impervious Area (DCIA)
The impervious portion of a site that drains directly to the storm sewer system. DCIA is a key component of the conceptual model used in the volume reduction calculations in the UDFCD Stormwater Criteria Manual.

Erosion
Process by which soil particles are detached and transported by wind, water, and gravity to a downslope or downstream location.

Forebay
Storage space located near a stormwater BMP inlet designed to trap incoming coarse sediments and other gross solids before they accumulate in the main treatment area of the BMP.

Fort Collins LID Criteria
Detailed LID criteria are incorporated in Volume 3, Chapter 3 of the Stormwater Criteria Manual.

Fort Collins Stormwater Criteria Manual
The Stormwater Criteria Manual sets stormwater policies and provides drainage criteria for all new stormwater design and construction activities.

Impervious Surface
A hard surface area (e.g., parking lot or rooftop) that prevents or retards the infiltration of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow relative to pervious areas.

Infiltration
The percolation of water from the land surface into the ground.

LID Practices or LID BMPs
Individual practices used as part of overall LID developments or integrated into traditional developments. For the purposes of meeting the Stormwater Criteria the following practices are considered LID: permeable pavements, bioretention areas/rain gardens, sand filters, tree filters, underground infiltration facilities, vegetated buffers, constructed wetland channels and constructed wetland ponds.

LID Conveyance BMP
An LID BMP which conveys runoff across a receiving pervious area. LID Conveyance BMPs reduce the Water Quality Capture Volume.

LID Principles
Land use management strategies that emphasize conservation, use of on-site natural features, and site planning to minimize impervious surfaces, native vegetation loss, and stormwater runoff.

LID Storage BMP
An LID BMP which provides detention of the Water Quality Capture Volume.

Low Impact Development (LID)

LID is an overall land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to mimic the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. The term Green Infrastructure (GI) may also be used, particularly in areas with combined sewer overflow (CSO) issues.

Pretreatment

The removal of material such as solids, grit, grease, and scum from flows prior to physical, biological, or physical treatment processes to improve treatability. Pretreatment may include screening, grit removal, settling, oil/water separation, or application of a basic treatment BMP prior to infiltration.

Receiving Pervious Area (RPA)

The pervious portion of a site that receives runoff from an upgradient impervious area prior to draining to the storm sewer system. RPA is a key component of the conceptual model used in the volume reduction calculations in Chapter 3 of this manual.

Runoff

Water from rain, melted snow, or irrigation that flows over the land surface.

Sediment

Fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water.

Stormwater

That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a stormwater drainage system into a defined surface waterbody, or a constructed infiltration facility.

UDFCD Stormwater Criteria Manual

A Stormwater Criteria Manual for the Urban Drainage and Flood Control District. Portions of the UDFCD Stormwater Criteria Manual are adopted by reference in the Fort Collins Stormwater Criteria Manual.

Underdrain

A perforated pipe, typically 4- to 6-inches in diameter, placed longitudinally at the invert of a stormwater facility for the purposes of achieving a desired discharge rate and controlling nuisance ponding.

Water Quality Capture Volume (WQCV)

The quantity of stormwater runoff that must be treated in stormwater quality BMPs in Denver. This volume is equivalent to the runoff from an 80th percentile storm, meaning that 80 percent of the most frequently occurring storms are fully captured and treated and larger events are partially treated.

Appendix B: LID Project Locations

Permeable Pavement

1. Odell Brewery Parking Lot: 800 E Lincoln Avenue, 80524
2. Senior Center: 1200 Raintree Drive, 80526

Bioretention

3. North College Market Place: 1820 & 1842 N College Avenue, 80624
4. Woodward Commercial Development: 1041 Woodward Way, 80524

Sand Filter

5. Foothills Mall (south side): E Monroe Drive & JFK Parkway,
6. CSU Parking Structure: S College Avenue & W Pitkin Street, 80524

Tree Filter

7. City of Fort Collins Utilities: 222 LaPorte Avenue, 80521
8. Parking Garage: 363 Jefferson Street, 80524

Underground Infiltration

9. The Exchange: 200 Block of N. College Avenue
10. Brickstone Apartments: 201 E. Harmony Road

Non-Engineered Rain Garden

11. Poudre River Drive & Hoffman Mill Road: 1199 Poudre River Drive, 80525
12. Library Park: 201 Peterson Street, 80524

Vegetated Buffer

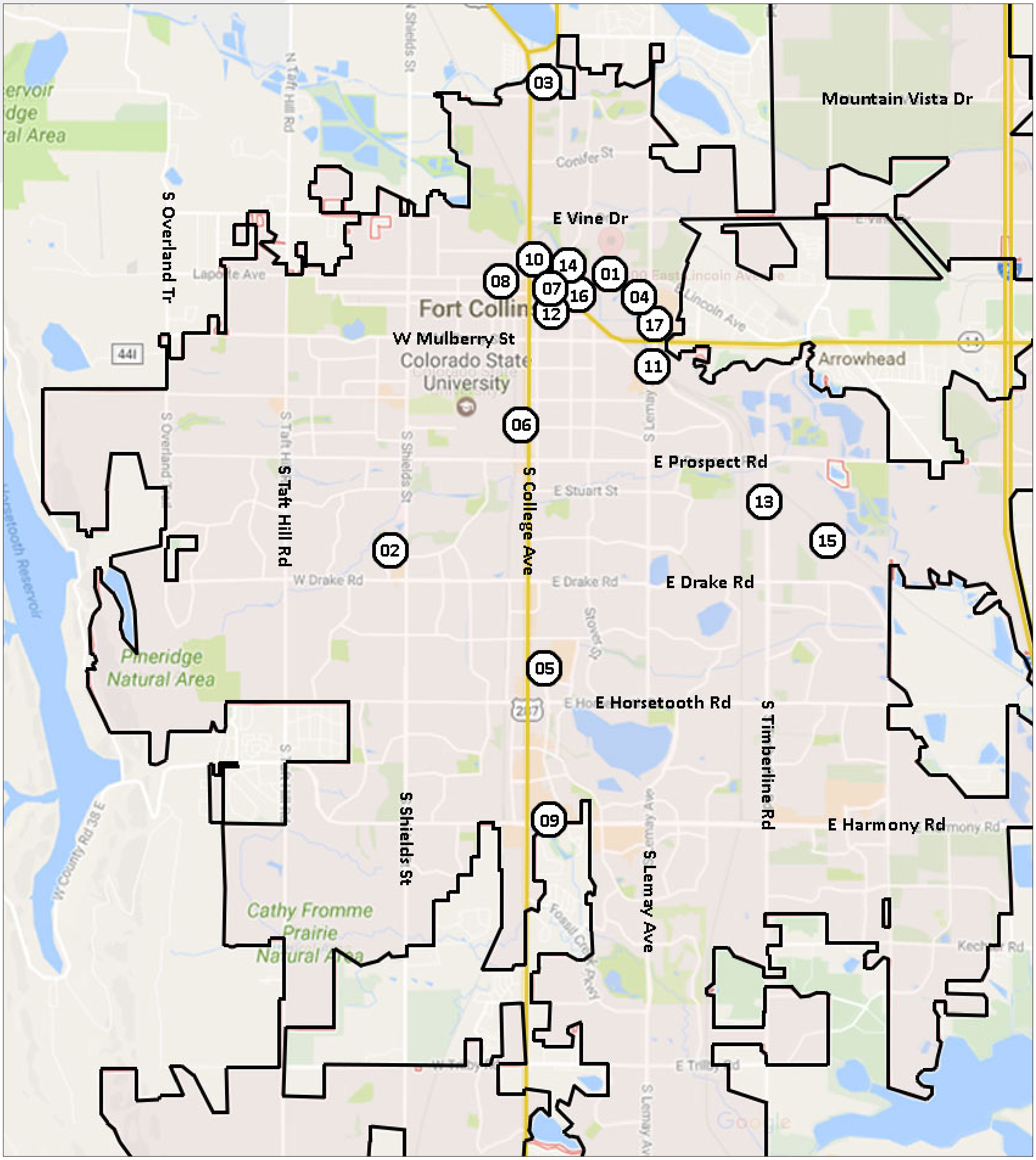
13. Bucking Horse Apartments: 1903 S Timberline Road, 80525

Constructed Wetland Channel

14. Udall Natural Area: E Lincoln Avenue & Willow Street, 80524
15. Bucking Horse Apartments: 1903 S Timberline Road, 80525

Constructed Wetland Pond

16. Udall Natural Area: E Lincoln Avenue & Willow Street, 80524
17. Woodward Commercial Development: 1041 Woodward Way, 80524



Mountain Vista Dr
E Vine Dr
Fort Collins
W Mulberry St
Colorado State University
E Prospect Rd
S Overland Tr
S Taft Hill Rd
S College Ave
S Shields St
E Drake Rd
E Horsetooth Rd
S Timberline Rd
E Harmony Rd
S Lemay Ave
Arrowhead
Pineridge Natural Area
Cathy Fromme Prairie Natural Area
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Appendix C: Soil Mixes

Soil mixes for bioretention areas and tree filters are specially engineered to support plant growth while promoting infiltration. The following mixes shall be used for projects in the public right-of-way:

Fort Collins Bioretention/Rain Garden Soil Mix

- Washed Sand: 60%
- Top Soil: 30%
- Leaf / Yardpride Compost: 5%
- Mulch: 5%

For full specifications see:
https://www.fcgov.com/utilities/business/builders-and-developers/development-forms-guidelines-regulations

Fort Collins Tree Filter Soil Mix

- Glacier Rock Sand: 55%
- Top Soil: 30%
- Ground Mulch: 5%
- Yard Pride Compost: 10%

Appendix D: Plant Lists

The following plant lists shall be consulted for every project.

Fort Collins Streetscape Standards

https://www.fcgov.com/planning/streetscapedesign.php
Provides planting and layout standards for streetscapes and rights-of-way within Fort Collins.

State of Colorado Noxious Weeds List

https://www.colorado.gov/pacific/sites/default/files/NoxiousWeedList.pdf
State-wide list of List A, B and C noxious weeds, with images and key points for identification, maintained by the Colorado Department of Agriculture. Website also provides weed maps, eradication suggestions and Weed Watch List.

Fort Collins Native Plants

http://www.fcgov.com/naturalareas/pdf/nativeplants2013.pdf

Fort Collins Plant List for Development

https://www.fcgov.com/forestry/plant_list.pdf

Fort Collins Native Seed Mixes

https://www.fcgov.com/developmentreview/pdf/seed-mixes.pdf?1516225380

The following documents provide additional information about what plants are applicable for LID facilities.

Colorado Native Plant Society Database
http://intermountainbiota.org/portal/checklists/checklist.php?cl=4172&pid=77
Alphabetical database of hundreds of plants commonly found in the Front Range biome, with links to detailed fact sheets, images and plant origins.

Colorado State University: Colorado Plant Database
http://jeffco.us/coopext/intro.jsp
Searchable database with photographs and information on plant origins.

Denver Green Infrastructure Guide
https://www.denvergov.org/content/dam/denvergov/Portals/705/documents/ultra-urban-green-infrastructure-guidelines.pdf
Metro-area-based resource that provides extensive plant lists as well as planting design suggestions for Low Impact Development.

Fort Collins Residential Parkway Landscaping
http://www.fcgov.com/utilities/img/site_specific/uploads/Parkway_landscape_brochure_2015_Web.pdf
Plant suggestions and design tips for planting within the parkways along residential streets.

Fort Collins Xeriscape Demonstration Garden
https://www.fcgov.com/utilities/img/site_specific/uploads/Xeriscape_Garden_Plant_List_Brochure_KS3).pdf
Brochure with a list of suggested xeric and low-water-use plants for Xeric installations in Fort Collins. Also includes a list of demonstration gardens in the City.

Fort Collins Xeriscape Design Brochure
http://www.fcgov.com/utilities/img/site_specific/uploads/xeriscape_design_booklet.pdf
Guide to laying out rain gardens with a palette of plant materials specifically selected for each design.

PlantSelect.org Planting Database
http://plantselect.org/plants/find-a-plant/
Plant database maintained by Colorado State University and the Denver Botanic Garden on plants uniquely suited for low-water and xeric growing conditions.

Rocky Mountain Plant Matrix
https://www.harvestingrainwater.com/wp-content/uploads/2015/11/Rocky-Mountain-Plant-Matrix.pdf
Require for selecting rain garden plantings.

Appendix D:
Construction Control Measures Guidance

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1.0 Introduction

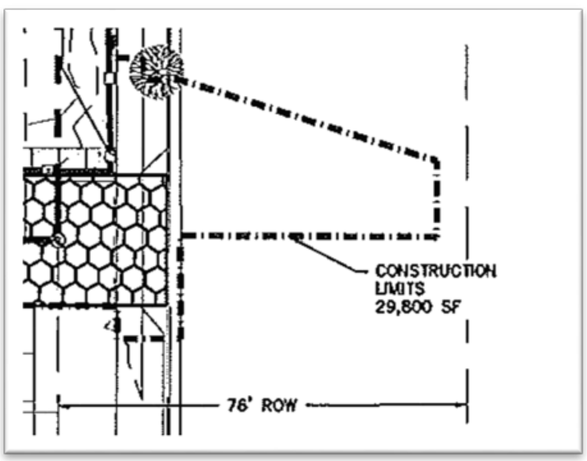
This Appendix serves as a supplement to the erosion control requirements outlined Chapters 2, 3 and 4 of this Manual. Included are examples, clarifications, and additional information that may be useful in helping to satisfy the requirements set forth in this Manual.

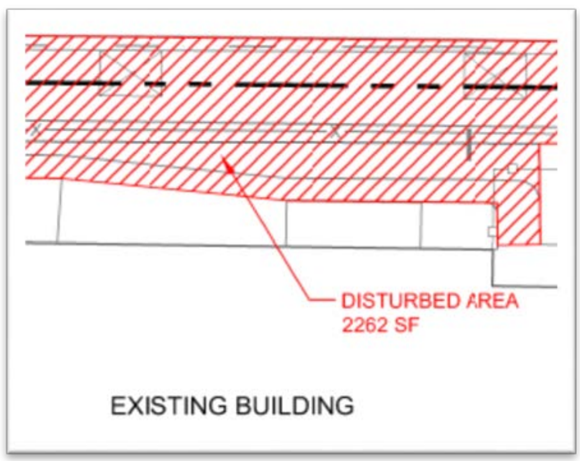
This Appendix may be referenced to clarify the Chapter requirements and may be particularly useful if the person(s) preparing the Erosion Control Materials are unfamiliar with Fort Collins regulations or need a more prescriptive explanation of the submittal document requirements. In addition, this Appendix provides some practical directions on planning ahead for the specific Control Measures warranted for the specifics of the project, and what Construction Control Measures are to be used in Fort Collins to protect waterways from erosion and sediment. Although the specific requirements are found within the Chapters of the Manual, this Appendix is intended to provide insight into the City's expectations in meeting the requirements.

2.0 Request for Project Clarification to Confirm Applicability of Requirements

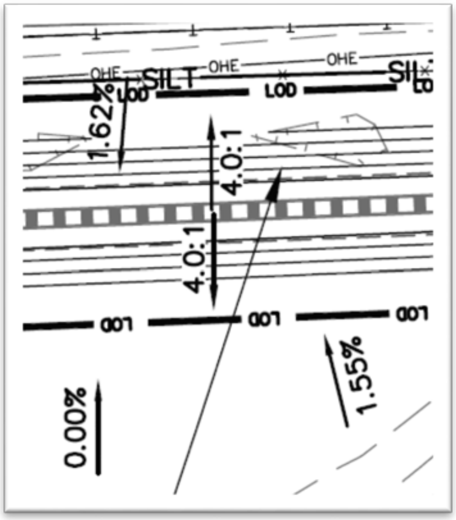
The following are examples of how informational proof may be presented in a request for clarification regarding the requirements of Section 6.1.2 of Chapter 4.

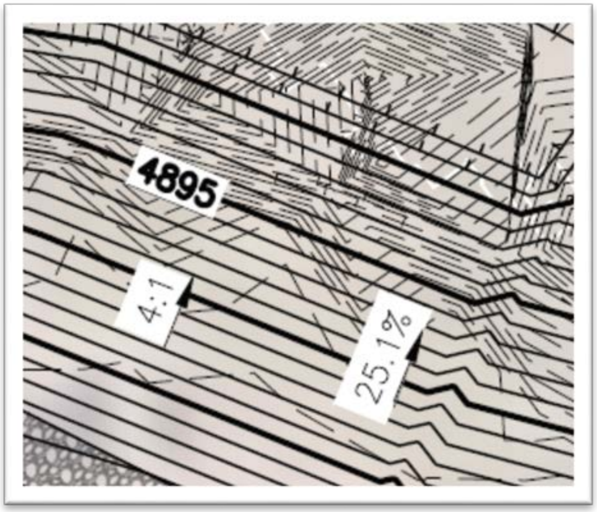
Examples of calculated areas of disturbance



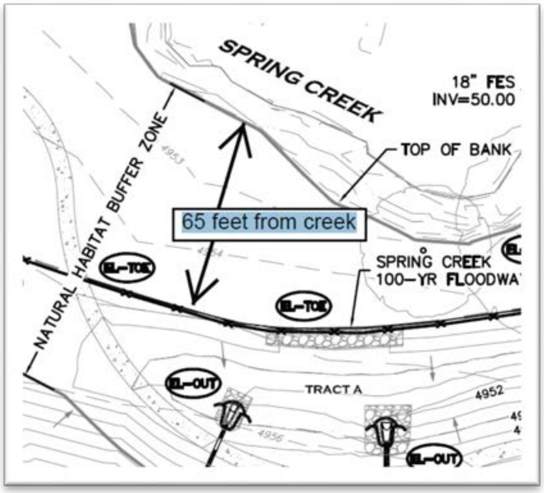


Examples of steepest slope arrow





Example of shortest distance line from the disturbed area to a sensitive area (if within 75ft)



A useful resource or tool for designers or smaller projects that may not have AutoCAD drawings or capabilities is the City's Mapping System, FCMaps.

3.0 Chart or Table of Calculations

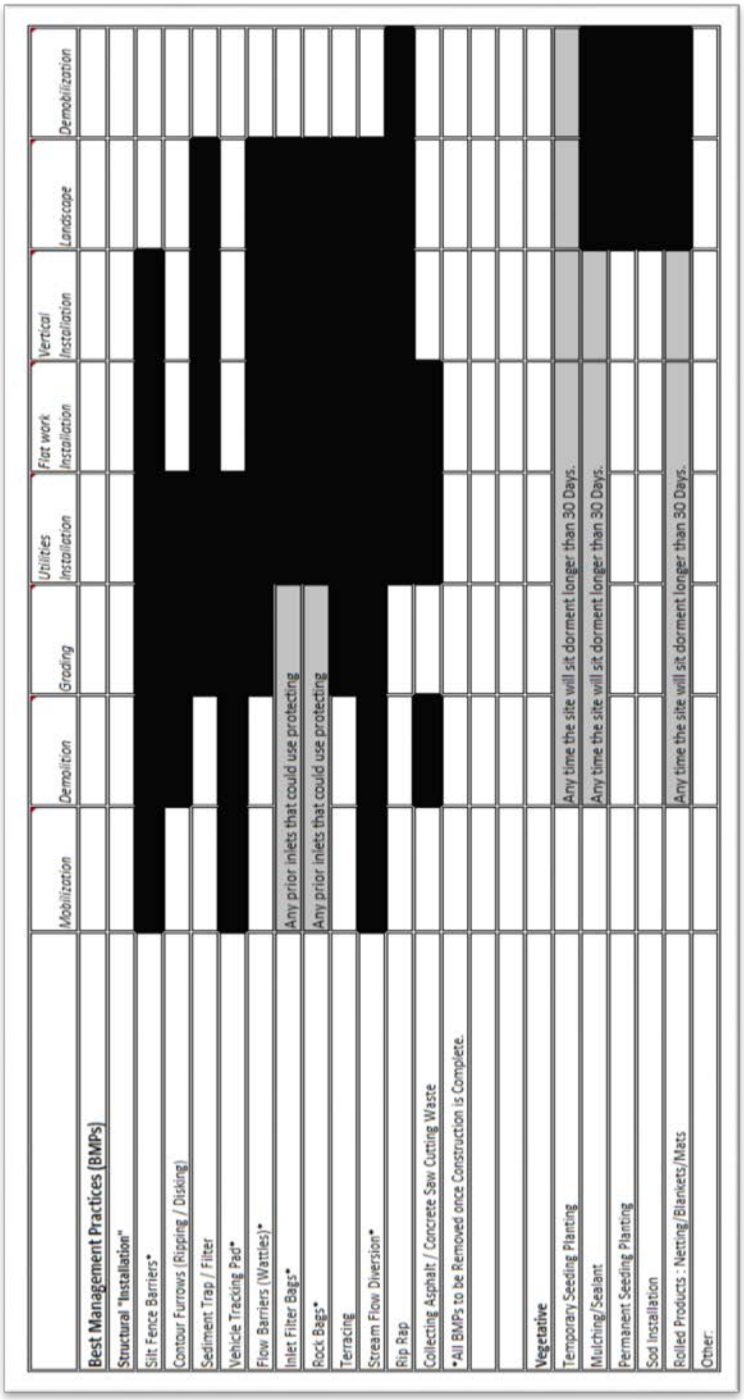
Example of a calculations chart

Total Disturbed Project Area	2.17	Acres
Total "Onsite" Area of Disturbance	1.50	Acres
Total "Offsite" Area of Disturbance	0.55	Acres
Total Storage/Staging Area	0.12	Acres
Total Haul Roads Area	N/A	
Construction vehicle traffic Area	N/A	
Est. Percent of Project Area Exposed	100%	
Est. Percent Vegetative Cover	~87%	Density
Existing Soil Type	Type C	Sandy Loam
Groundwater Depth	15	Feet
Number of Phases w/ Project	N/A	
Total volume of imported (+) / exported (-) materials	-30	Cubic Yds.
Total area of stockpiling of fill or borrow areas off site	100	Sq. Feet
Steepest Slope	5:1	H:V
Distance from a riparian area or sensitive area	65	Feet

4.0 Elements for an Erosion Control Plan

4.1 Project Sequencing

Example of construction and BMP installation sequencing chart

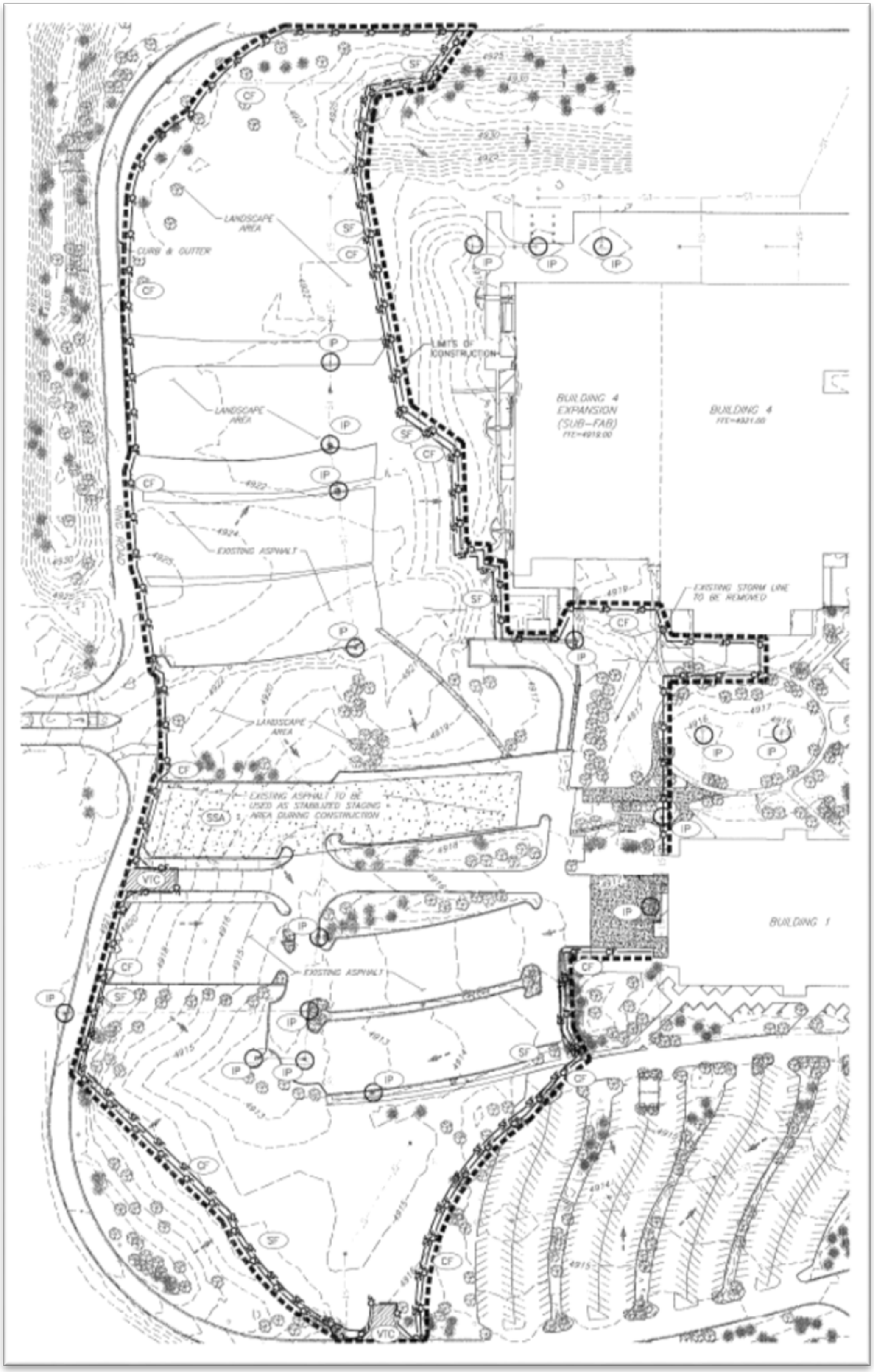


A copy of this sequence chart can be found at www.fcgov.com/Erosion

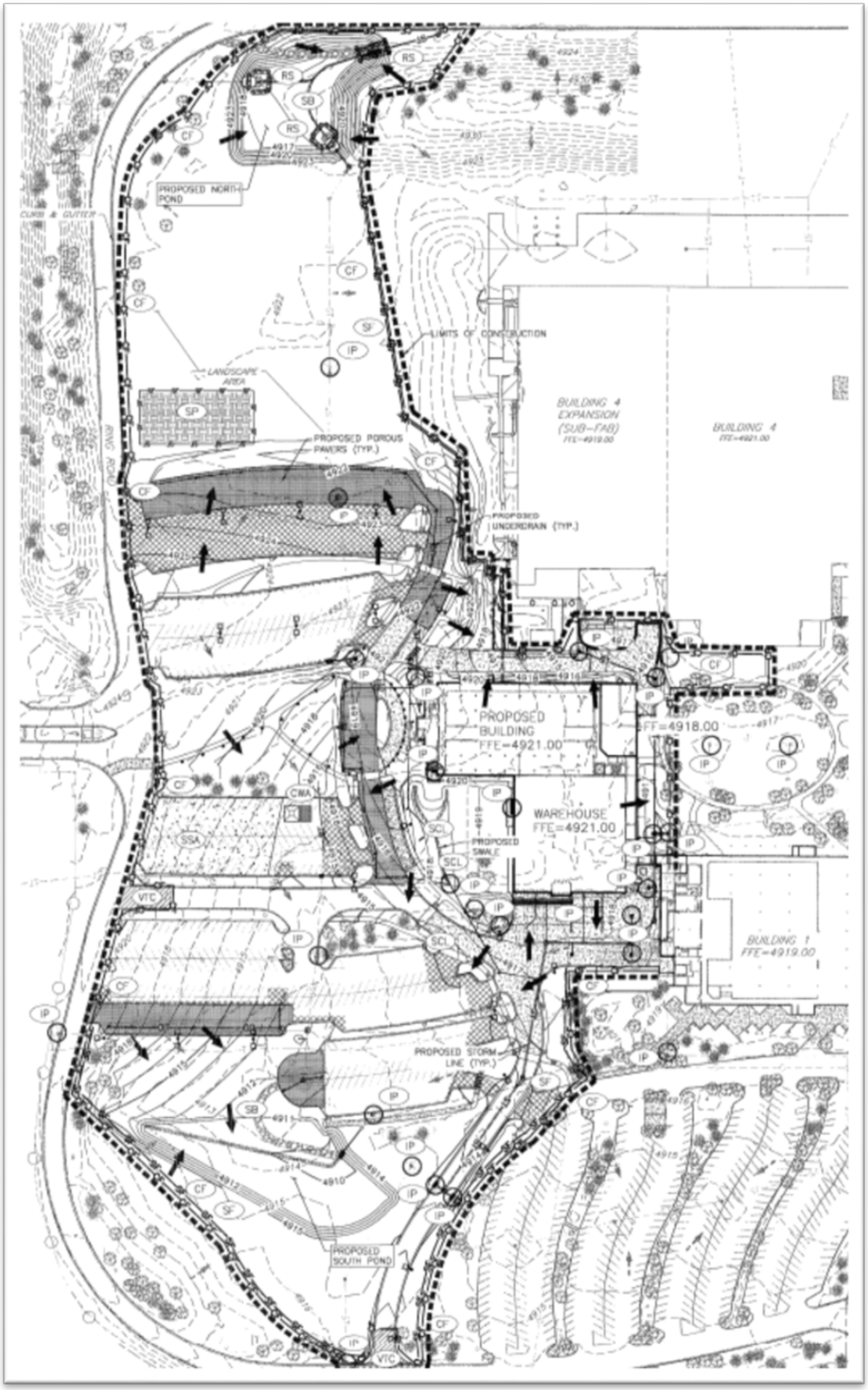
Example of a title page with sequence sheets labeled

C201	DETAILED GRADING PLAN
C202	DETAILED GRADING PLAN
C203	DETAILED GRADING PLAN
C204	INITIAL EROSION & SEDIMENT CONTROL PLAN
C205	INTERIM EROSION & SEDIMENT CONTROL PLAN
C206	FINAL EROSION & SEDIMENT CONTROL PLAN
C207	EROSION & SEDIMENT CONTROL DETAILS
C208	EROSION & SEDIMENT CONTROL DETAILS
C209	STORM SEWER PLAN & POROUS PAVEMENT PLAN A
C210	STORM SEWER PLAN & POROUS PAVEMENT PLAN B
C211	NORTH POND GRADING AND LAYOUT PLAN
C212	NORTH POND DETAIL SHEET
C213	SOUTH POND GRADING AND LAYOUT PLAN

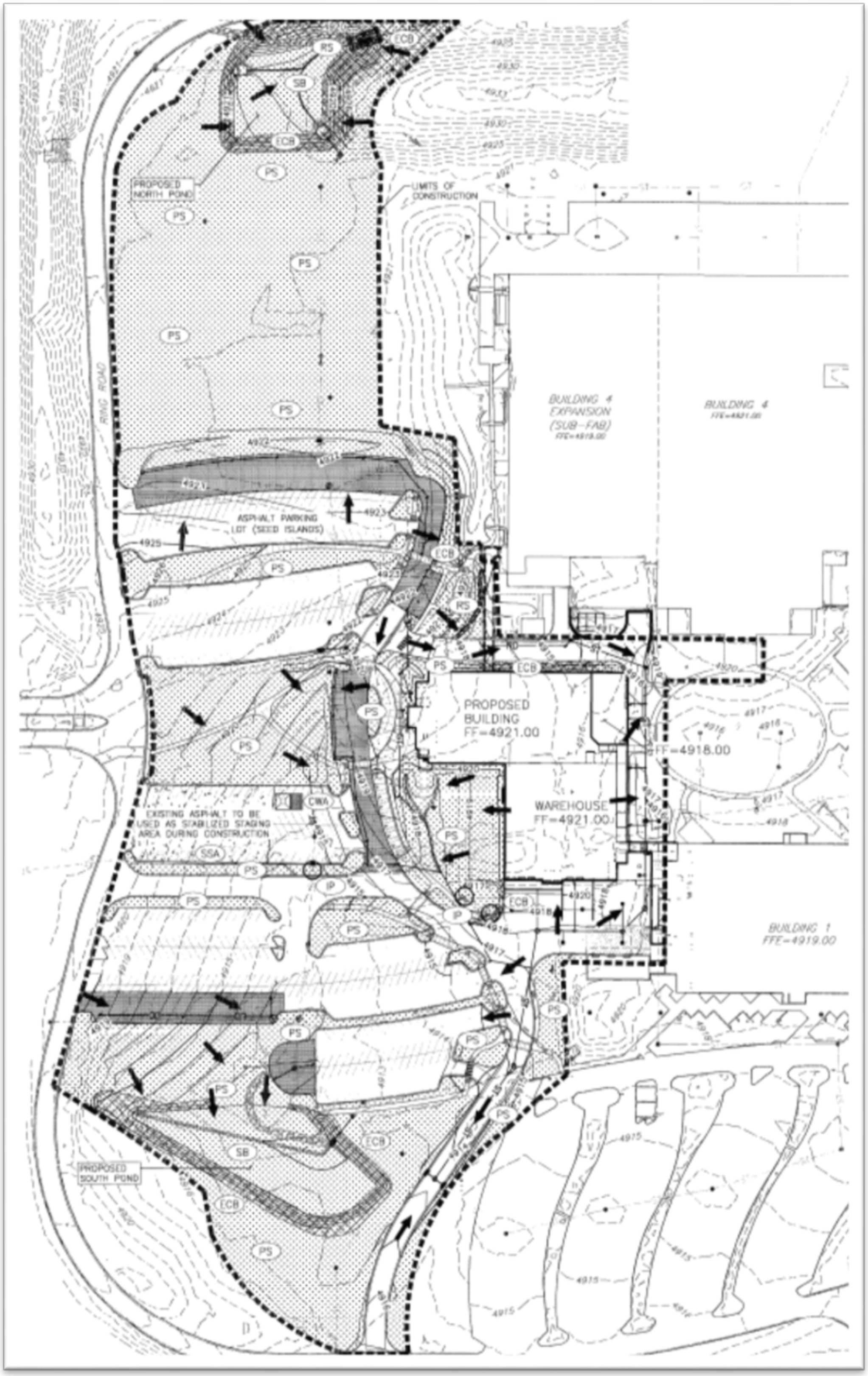
Example of an initial sequence sheet



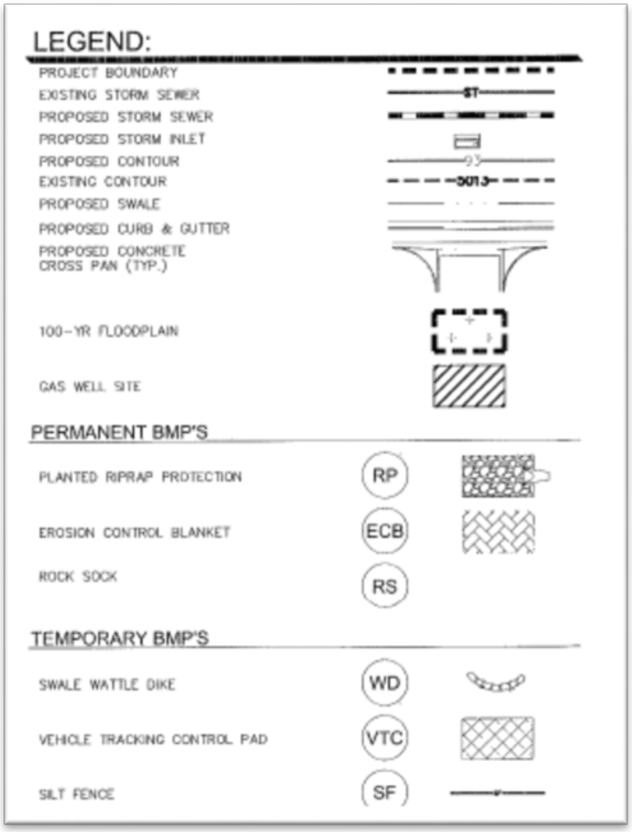
Example of an interim sequence sheet

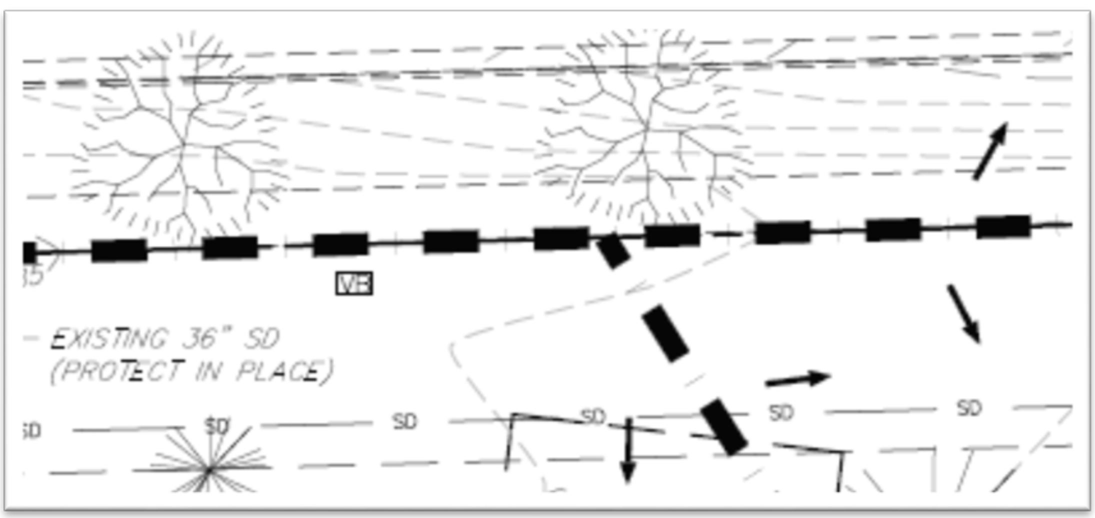


Example of a final sequence sheet



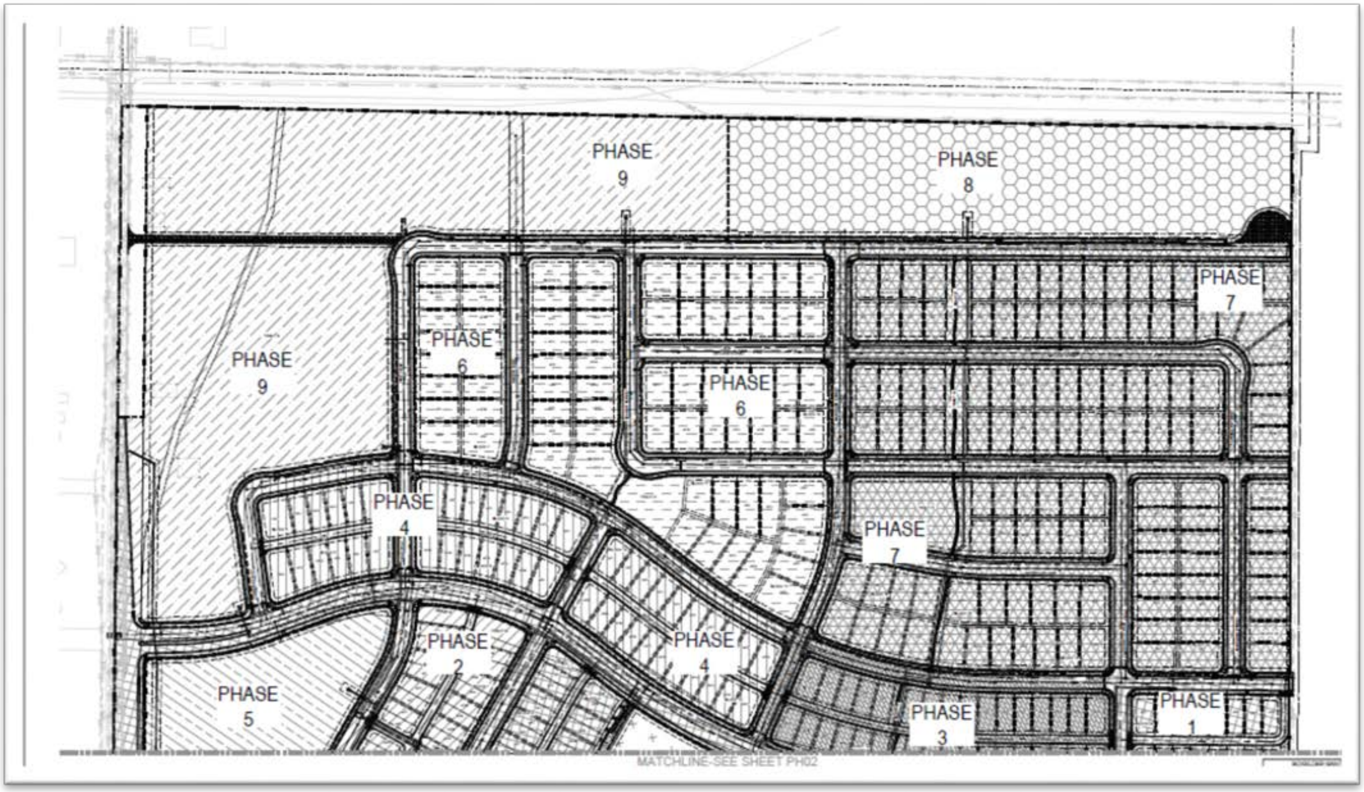
Example of a legend





4.2 Phasing and Large Sites

Example of a project phasing sheet

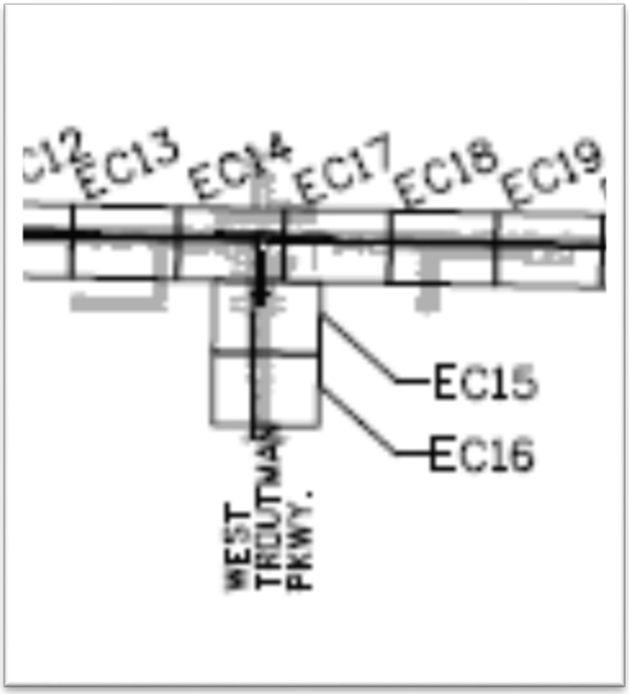


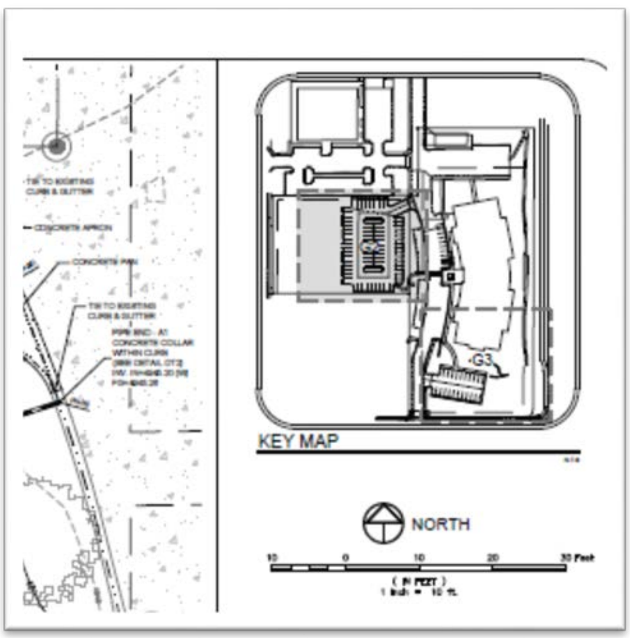
Example of phase 1 of an erosion control plan

Example of phase 2 of an erosion control plan

Example of phase 3 of an erosion control plan

Example key maps (shall indicate a to-scale view window)





5.0 Elements of an Erosion Control Report

5.1 Table of Contents (Chapter 2, Section 6.1.4.2)

The Table of Contents page should be laid out in the following style with sections labeled as shown below and should be kept in relatively the same order and grouping. By providing materials in this fashion, review is made easier and can be speed up the review time.

- Project Description and Nature of Construction
  - Site Location
  - Existing Site Condition
  - Proposed Construction Activities
- Potential Pollutant Sources
  - All disturbed and stored soils
  - Vehicle tracking of sediments
  - Management of contaminated soils
  - Loading and unloading operations
  - Outdoor storage of construction site materials, building materials, fertilizers, and chemicals
  - Bulk storage of materials
  - Vehicle and equipment maintenance and fueling
  - Significant dust or particulate generating processes
  - Routine maintenance activities involving fertilizers, pesticides, detergents, fuels, solvents, and oils
  - On-site waste management practices
  - Concrete truck/equipment washing, including the concrete truck chute and associated fixtures and equipment
  - Dedicated asphalt and concrete batch plants
  - Non-industrial waste sources such as worker trash and portable toilets
  - Saw cutting and grinding
  - Other non-stormwater discharges including construction dewatering not covered under the Construction Dewatering Discharges general permit and wash water that may contribute pollutants to the MS4
- Construction Control Measures
- Installation and removal sequence of construction measures
- Phasing (if applicable)
- Maintenance and inspection requirements
- Final vegetation and stabilization

If any additional sections are added to this report to help clarify or address other issues or requirements of other permits, then add section before or after the relevant section yet leave the titles of the other sections intact to speed up review of the required materials. The more differences there are from the standard criteria, the turnaround time for review is directly increased.

5.2 Project Description and Nature of Construction (Chapter 2, Section 6.1.4.3)

5.2.1 Example of project description and project site map

2.2 Nature of Construction Activity

The proposed project will include new construction of a 69,685 gross square foot transitional senior rehabilitation facility including drive aisles, parking areas and associated appurtenances. Utilities will be installed in support of the new building, along with appropriate stormwater facilities. Water quality to mitigate and treat stormwater runoff from the site is provided in an on-site basin located in the southeast corner of the property. Concurrently, the project also includes new construction of a 1,250 foot extension of Precision Drive including pavement, curbing and associated utilities.

Example of project site map

- A written description of the site using bounding elements (roads, railroad, creeks, etc) of the project along the limits of the project: Example: The site is bound on the north by Spring Creek the east by Timberline and south and west by the Great Western Railway.
- Legal Description or Public Land Survey System "PLSS" Using Township, Range, Section, Quarter. Example: The site is located at T07N R68W S19 Q1.
- Land Parcel Number as shown in the Larimer County Assessors. Example: The site is located on the parcel of land # 8719111904.

- Site Address. Example: 2600 S. County Rd 11
- Global Positioning System "GPS" in decimal degrees of latitude and, longitude. Example: 40.566059, -105.039771

5.2.2 Existing Site Condition

The existing site conditions in these sections of the report shall at a minimum address the following:

- Physical soil properties
  - Soil names
  - Soil types
  - Typical particle size
  - Density
  - Permeability
- Hydraulic soil properties
  - Hydrologic soil group
  - Soil structure
  - Soil erodibility
- Soil features
  - Texture
  - Depth
  - Existing site drainages and discharge points
- Pathway to the nearest State Water
  - This should not only identify the location where the water leaves the site, it should also describe the path it will follow into the storm sewer and the path to reach the nearest State water with an estimated distance to reaching the State water. This would also be the path that would need to be cleaned if a spill or other discharge was to leave this project and require clean up.
- Existing vegetated areas to impervious areas
  - *pervious area to total area*
- Estimated percent vegetative ground cover
  - Think density and how thick the grass is in those areas, 0% being bare dirt and 100% being sod.
- Existing groundwater depth
  - This should be taken when ground water is at its highest not lowest or frozen.
- Summary of ground contamination if known
  - Typically a Phase 1, Phase 2, or Environmental assessment of a site

Many of these requirements may have reports or supporting documents. When referencing these documents the information should be referenced and attached in the appendix of the erosion control report.

These items should be kept in a short description with just enough summary information to give a clear understanding or overview as to what the current site condition is before construction.

Based upon the supplied information above, a summary of the soil erosion potential shall be provided that describes the site specific soil and the potential that the soil will be displaced and suspended from rainfall impact, concentrated flows/runoff, and wind.

5.2.3 Proposed Construction Activities

This part of the Erosion Control Plan is for Construction Activities and is not the place to describe the Control Measures to be used. The Control Measures that will be used during each Construction Activity should be broken down in the "Construction Control Measures" and "Installation and Removal Sequence of Control Measures". The Construction Activities described here should be similar if not identical to the same activities described in the project sequencing included in the Erosion Control Plan Section 6.1.3.2 of Chapter 2.

- Examples of possible environmental impacts:
  - Wetlands
  - Streams
  - Threatened or Endangered Species

- Examples of possible State and Federal permits to be aware of (not an all-encompassing list)
  - State CDPHE Stormwater Permit associated with Construction Activities
  - US Army Corps of Engineers 404 Permits for Stream Crossing
  - State CDPHE Construction Dewatering Permits
  - State CDPHE Air Pollution Emission Notification (APEN) Permit
  - NEPA Regulations
  - State CDPHE 401 Water Quality Certifications Stream Crossing
  - State Division of Water Resources Dewatering and other water use permits

5.3 Potential Pollutant Sources (Chapter 2, Section 6.1.4.4)

Based upon the described Construction Activities various sources of pollutants will be present on a construction site. Below are the most commonly identified potential pollutant sources:

1) All disturbed and stored soils Section 5.3.1 of this Appendix

2) Vehicle tracking of Sediments Section 5.3.2 of this Appendix

3) Management of contaminated soils Section 5.3.3 of this Appendix

4) Loading and unloading operations Section 5.3.4 of this Appendix

5) Outdoor storage of construction site materials, building materials, fertilizers, and chemicals Section 5.3.5 of this Appendix

6) Bulk storage of materials Section 5.3.6 of this Appendix

7) Vehicle and equipment maintenance and fueling Section 5.3.7 of this Appendix

8) Significant dust or particulate generating processes Section 5.3.8 of this Appendix

9) Routine maintenance activities involving fertilizers, pesticides, detergents, fuels, solvents, and oils Section 5.3.9 of this Appendix

10) On-site waste management practices Section 5.3.10 of this Appendix

11) Concrete truck/equipment washing, including the concrete truck chute and associated fixtures and equipment Section 5.3.11 of this Appendix

12) Dedicated asphalt and concrete batch plants Section 5.3.12 of this Appendix

13) Non-industrial waste sources such as worker trash and portable toilets Section 5.3.13 of this Appendix

14) Saw Cutting and Grinding Section 5.3.14 of this Appendix

15) Other non-stormwater discharges including construction dewatering not covered under the Construction Dewatering Discharges general permit and wash water that may contribute pollutants to the MS4 Section 5.3.15 of this Appendix

16) Other areas or operations where spills can occur Section 5.3.16 of this Appendix

The potential pollutant source section shall, at a minimum, identify whether these pollutant sources will be present on the project. A simple “yes” it is present or anticipated to be present, or “no” it is not anticipated to be present on the project. Any other identified sources should also be included in this section.

Each identified source has the potential to result in runoff from a project and end up in the local storm sewer and result in discharge directly to the river untreated.

Each source identified shall describe the source, evaluate its potential to contribute to runoff and prescribe what Control Measures are necessary to be implemented on the project to reduce the potential pollutant source from contributing to a site discharge.

5.3.1 All Disturbed and Stored Soils

Describe the location of disturbed and stored soils on the project, evaluate the potential to contribute to runoff, and prescribe Control Measure to prevent.

Consider administrative controls such as sweeping and scraping activities, as well as identifying and protecting all inlets to the exposed dirt. Other examples could be minimizing disturbed area, surface roughening, and terracing, rounding top of cuts, temporary crimping and mulching, and education, along with the other structural and non-structural practices to minimize the effects of site disturbance.

Example:

> Disturbed and Stored Soil – Yes – Approximately 85% percent of this 3 acre site will be disturbed with the Construction Activities. Once soils have been disturbed they do not retain the same compaction as in their native state, therefore surface runoff can cause more soil erosion than was historically observed. Based upon the site design this site will not disturb all areas of construction until it is required to as part of the Construction Activities (phasing). Once exposed those areas of exposed soils will be kept in a roughened condition (surface roughening). In the event that these erosion control practices do not keep sediment on site a structural barrier (silt fence) will be used and is called out for on the perimeter. If soil manages to migrate from the disturbed areas onto the hard surfaces it will be swept or scraped (street sweeping) to prevent the migration of sediment. In case that sediment is washed away too quickly the curb inlets will need protection (rock sock style inlet protection). Stockpiles in the same respect do not retain the same compaction and are more susceptible to soil erosion. Stockpiles on this site shall be placed in or near the center of the site and away from any drainage swales to not require perimeter run off controls (Materials/Site Management Control). The stock pile will be kept loose, not compacted, and watered as needed to prevent dust issues (site watering). The stockpile will be monitored for signs of erosion displacement and sediment accumulation and if conditions warrant it, the stockpile will be structurally covered or if it is going to sit a long while will be reseeded (temporary seeding).

Vehicle tracking of Sediments

Describe the site access locations on the project, evaluate the potential to contribute to runoff, and prescribe Control Measure to prevent vehicle tracking from contributing to a site discharge.

Consider administrative controls such as sweeping and scraping activities, as well as identifying and protecting the closest inlet to the tracking location. Other examples could be, minimizing site access, gravel parking, paved area restriction for vehicles, wash racks, education, along with the other structural and non-structural practices to minimize track out.

Example:

Vehicle Tracking of Sediment – Yes -- Vehicle tracking of sediment may occur throughout the construction process and along all areas where the pavement meets the disturbed dirt. This occurs most often after any melt off or rain conditions when mud collects on vehicles tires and is tracked out onto the road consequently leaving site. This increases the possibility of sediment discharging to the storm system. To prevent tracking, construction fence (site barrier/site management control) will be used site wide to limit the access by the contractor and their subs to only two construction entrances (vehicle tracking pads to be installed) on the east of the site and the west of the site. There will be a gate at the entrance that will be closed before contractors come on site during the muddy days (site management control) and will only be opened to let larger deliveries drop off, otherwise subcontractor parking will be kept to the street. All contractors have signed contracts that will have them clean the streets if they are found to be tracking dirt onto the street. (site management control). The tracking pad will be monitored visually every day and if track-out becomes a significant problem a larger or more robust tracking pad may be installed. Otherwise, all track-out that reaches the street will be scraped and swept (street sweeping). Secondary controls at the closest affected combination inlets will have protection (drop inlet protection) to capture sediment not swept up in a timely manner.

5.3.2 Management of Contaminated Soils

Based upon the summarized description of site contamination in Section 5.2.2 of this Appendix, if contamination or a suspect material is identified as a possible issue, then they should be identified in this section. This section should describe what the material is, where it is anticipated to be encountered, and what quantity of material is anticipated. Evaluate the potential of the material to leave the site and prescribe procedures on how and where it will be stored on site, how it will be prevented from leaving the site, and ultimately the means of disposal along with how long it is anticipated to be retained on site once exposed.

Based upon the summarized description of site contamination in Section 5.2.2 of this Appendix, if no known contamination or a suspect material is identified as a possible issue, then this section should declare that there is none anticipated with this Construction Activity and that if inadvertently discovered on site, describe how the contractor will identify what it is and find appropriate procedures, and controls for the proper handling, management and lawful disposal of that material.

Example:

Management of Contaminated Soil – No -- Soil borings do not indicate an existing contamination and all data about the site shows that there is no known contamination on the site. If encountered, the contractor will have the material stored in a covered area (materials management control) as to not mix with the stormwater until the material can be identified and proper classification and disposal methods can be determined in accordance with the various waste laws and with good construction safety and practices.

5.3.3 Loading and unloading operations

Describe the site's traffic operations as it pertains to loading and unloading of material on site. Evaluate the potential for those operations to contribute to runoff and prescribe Control Measures to be taken to minimize potential pollutant source from contributing to a site discharge.

Example:

> Loading and Unloading Operations – Yes – During this project there will be a diverse amount of loading and unloading going on. There will be a significant amount of export leaving the site, the foundation workers will have to deliver forms to the site and deliver premixed concrete. Building materials will have to be staged around the site and Landscapers will have to pile the materials on site to complete the landscape work. Though the loading and loading vehicles will be contributing to the track out of materials, depending on the material being delivered to the site they may have a significant spill potential. In addition to the vehicle tracking of sediments section of this report, (VTC, Sweeping, etc.) contractors will be required to park their vehicles on the adjacent roadways (site management control). The only vehicles allowed on site will be fork lifts, concrete trucks, and the like (site management control). Where the project is mostly dirt and not stable semi-trailers will be directed to pull alongside the project and site loaders will be used to off load the trailers. Where the trailers must access the site an attempt will be made to keep the vehicle on the VTC or other stabilized storage areas. Where the site parking lot and private drives have been installed materials will be placed in piles along the hardscape the use of site forklifts will be more heavily used. When loading and unloading is occurring, depending on the materials, there may be an increased problem of containers being dropped, punctured, or broken. These off-loading activities will be done under roofs or awnings where possible, locating away from storm drains and will have nearby spill kits accessible. Spills on site will be addressed using spill prevention and response procedures.

5.3.4 Outdoor Storage of Construction Site Materials, Building Materials, Fertilizers, and Chemicals

Describe the location of storage activities on the project, evaluate the potential for those stored materials to contribute to runoff, and prescribe Control Measures to prevent those stored materials from contributing to a site discharge.

Example:

> Outdoor Storage Activities – Yes – It is anticipated that inert material like wood, shingles, tiles, siding insulation and stone will be stored on site and outside in the elements. It is also anticipated that materials that do not weather well (cement, mortar, etc.) will also be located outside. Chemicals are not anticipated to be left outside. As the inert materials have a lower potential to leave the site they will be monitored during inspection to make sure they are not being impacted by the exposure to the elements. (site management control) The materials that will need added attention are the cements and mortars as they quickly mix with water and cause pollution issues. These materials when not

stored inside will be placed on pallets to get above potential surface runoff and covered with tarps or plastic to prevent mixing with stormwater (materials management control). Very small quantities of chemical are needed to contaminate stormwater so the fertilizers, paints, form oils, petroleum products, and other typical chemicals, will be stored in the construction connex box, trailers, vehicles, or the like out of contact with precipitation (materials management control). If not stored in a location as described, secondary containment will be required.

5.3.5 Bulk storage of materials

Describe the location of bulk storage structures and any liquid chemical of more than 55 gallons. Evaluate the potential for those bulk liquid storage areas to contribute to runoff, and prescribe Control Measure to prevent those stored materials from contributing to a site discharge. (Note: the requirement for a single containment system is that it must have sufficient volume capacity to contain the largest container plus an additional 10%)

Example:

<u>Bulk storage of Materials</u> – Yes – The spray foam insulation used for the interior will be provided in a 55 gallon drum. The drum has little chance to contribute to runoff as the liquid would quickly turn to foam and solidify thus having little to no discharge from the site. However these materials should be stored in an area that if a rupture would occur, it is figured that the 55 gallon drum would need 1300 square feet of space to expand so the storage area will need to be located away from the drainage areas and area inlets (site management / materials management). The drums will be stored in secondary containment area with a fence so that if a spill were to happen the foam would pool in the bottom of the area and if it started to over flow the construction fence would act as a net and allow the foam to expand into the fence keeping it in the location (materials management).

5.3.6 Vehicle and equipment maintenance and fueling

Describe the location of vehicle and equipment maintenance and fueling. Evaluate the potential for those activities to contribute to runoff, and prescribe Control Measure to prevent those stored materials from contributing to a site discharge.

Example:

<u>Vehicle and equipment maintenance and fueling</u> – No – Based on the size of the site and the short window of activities vehicle fueling and vehicle maintenance is highly unlikely. As fueling and equipment maintenance usually result in small spills of petroleum products it is important to monitor these activities carefully. (site management control) Some grading companies will employee a fuel truck to fill the heavy equipment on site or require the maintenance of a broken machine. In those cases where the vehicle is not able to be maintained off site, these activities will be done in the least detrimental way possible. The maintenance and fueling will be located as far from stormwater

features as possible and at least 50 feet from a stormwater feature (site management/materials management). The fueling activity will have spill materials nearby and a bucket or other container and shovel located nearby to hang a hose after filling to catch drips, and to scoop up any dirt that inadvertently mixed with the soil (materials management). That container will have a lid and be disposed of when the activity is completed. The maintenance work will be done on a tarp or other material to prevent the residual oils and greases from mixing with the dirt (materials management).

5.3.7 Significant dust or particulate generating processes; describe the processes

Describe the particulate generation potential based on activities that may contribute to runoff, and prescribe Control Measure to prevent those stored materials from contributing to a site discharge. It is important to reference the Fugitive Dust Control Ordinance No. 044, 2016, §12-150 - §12-160 and the projects requirements to be in compliance with the ordinance.

Example:

Significant Dust or Particulate Generating Processes – Yes – This project will result in earth moving activities, street sweeping, and track-out and carry out, bulk materials transport, and saw cutting. As these activities will result in offsite transport of atmospheric pollution reasonable precautions shall be taken. The project will follow all required "BMPs" articulated in the Fugitive Dust Manual and a least one additional BMP included during each of the identified activities in accordance with City Ordinance No. 044,2016. Also a copy of the Dust Control Manual will be kept in the trailer during construction for reference. Such activities will include but not limited to watering the site, covering trucks, slower site speeds and vehicle tracking mentioned above.

5.3.8 Routine Maintenance Activities Involving Fertilizers, Pesticides, Detergents, Fuels, Solvents, Oils, Etc.

Describe the routine maintenance activities as they pertain to the construction of the site. Evaluate the potential to contribute to runoff, and prescribe Control Measures to prevent those maintenance activities from contributing to a site discharge.

Example:

Routine Maintenance Activities (Fertilizer, Pesticides, Detergents, Fuels, Solvents, Oils, etc.) – Yes – Fertilizers and Pesticides will be used during the later phases of the project when trying to establish a healthy vegetation. These chemicals are highly water soluble and are easily and unnoticeably carried in the stormwater. Proper application rates and recommended timing of application will be strictly followed and not on days, or the next day, where the weather is calling for precipitation (materials management control). As most of these types of chemicals will be brought on by the Landscaper they will be required to keep these products in their vehicles until time of application and not be allowed to leave these materials on the site (site management control). If these materials are stored on site they shall be kept inside or outside covered and above the ground to prevent the materials from mixing with water and runoff (materials management control). Detergents, paints, acids, cement, grout, and solvents will be prevalent in the interior work of the building (materials management). These materials also are typically easily mixed with water yet are typically noticeable by discolored, cloudy, or sudsy water. As such, the contractor will always keep an eye out for these types of differences in water around the site (site management control). However these materials are to be handled, operated, and cleaned up all within the inside of the structure, where external use is concerned these materials will be stored in the construction connex box, trailers, vehicles, or the like out of contact with precipitation (materials management). If not stored in a location as described secondary containment will be required (materials management). Fuels and oils might be associated with the smaller equipment used on site, chainsaws, pumps, generators, etc. As petroleum products are easily suspended in water and are spread across the top of the water surface. These products when located in water have rainbow sheen on them. They are also monitored during construction (site management controls). These products will be stored in the construction connex box, trailers, vehicles, or similar structure that will minimize contact with precipitation (materials maintenance controls). If not stored in a location as described secondary containment will be required (materials maintenance). Any untreated runoff from these activities can be detrimental to wildlife if not cleaned up.

5.3.9 Onsite Waste Management Practices (Waste Piles, Liquid Wastes, Dumpsters, Etc.

Describe the likelihood of waste on the site and their locations on the project. Evaluate how industrial waste has the potential to contribute to runoff. Prescribe Control Measures to prevent waste from contributing to site discharges.

As long as no materials are unearthed during excavation and grading then site waste will primarily be of concern once the building begins to go vertical. Wastes have ability to leachate both into the soil and with precipitation and will pollute water. These wastes also tend to float and are carried away off site frequently. Many of these wastes are also easily suspended in air and are carried away to the nearest fence line. Liquid waste should be collected and stored in a covered in a leak proof container until it can be disposed of properly.

Example:

On-site waste management practices (Waste Piles, Liquid Wastes, Dumpsters, etc.) – Yes –All large and heavy weighted waste piles (concrete chunks, excavated pipes, etc.) will be kept in a neat grouped pile until the material is to be disposed of properly. These piles will only be stored a short duration 5-10 days and will be kept 50 feet from any drainage course or inlet (Administrative Control). All dry wastes will be maintained through dumpsters and monthly hauler removal (hauler will be notified if dumpster becomes full and hauled off as needed). Where available by the hauling company the dumpster will be covered. If not practical or available by the haul company, an increased removal schedule will be followed and the “Max fill line” on the dumpster will be strictly followed. Corners of the dumpsters will be monitored for “Dumpster Juice” leaking into the soil in dry conditions and rain/melt off conditions looking for it mixing with the runoff. Dumpsters, like the waste piles, will be located at least 50 feet from any drainage course or inlet. Workers will be sent around at the end of the day to collect trash to prevent trash being left out overnight. No construction debris (including broken concrete) will be buried on site.

5.3.10 Concrete Truck/Equipment Washing, Including the Concrete Truck Chute and Associated Fixtures and Equipment

Describe the concrete washing and evaluate its potential to contribute to runoff. Prescribe Control Measure to prevent wash activities and waters from contributing to site discharges.

Example:

<u>Concrete Truck/Equipment washing</u> – Yes – Concrete will be a large portion of this project. It is anticipated that it will be used with the joints around the manholes, pour in place inlets, curb and gutter installation, sidewalks, and foundations. Pre mixed concrete trucks will be used in this process and will be delivered to the site and when pouring the foundation a pump truck will be used all of which will need to be maintained through the washing of their chutes and pump arms to prevent the concrete from hardening and ruining the equipment. This concrete wash water has a high alkaline content which is hazardous material to terrestrial and aquatic wildlife. A section of dirt near the entrance will be excavated and compacted around the sides formed to retain the concrete wash water on site (as an acceptable practice by the State) so long as the wash water is kept in the washout (concrete washout). There will be a rock pad for the truck to park on while washing as to prevent tracking from this washout (VTC). The placement of this washout will be located at least 50 feet from any drainage course or inlet. Later in the project after the parking lots curb and gutter has been poured the use of a mobile washout facility will be used on site in a similar location and after the ground has been leveled (concrete washout – mobile). The contractor (including all masonry and concrete tradesmen) shall clean out equipment within the washout area so that the runoff is not allowed to leave the washout. The only exception would be for them to wash in the next day’s pour location. All concrete workers will be made aware of the where they are to wash (site management controls & education)., If there is a significant amount of spillage when the transfer from concrete truck to pump truck occurs, a tarp or other ground cloth should be used to collect spillage. (ground cover control)

5.3.11 Dedicated asphalt and concrete batch plants

This is typically for projects with little access to a concrete or asphalt plant. As Fort Collins has no issue with access, this is typically not a concern. As most of these plants already have an alternate CDPS permit coverage they will not need to be included in the Erosion Control Report. However, if the project does intend to have an asphalt or concrete batch plant associated with the construction; describe the applicability of an asphalt or concrete batch plant to this project, evaluate its potential to contribute to runoff, and prescribe Control Measure to batch plant activities from contributing to site discharges, or else simply state that there is none associated with the project.

Example:

> Dedicated asphalt or concrete batch plant – No – there will be no dedicated asphalt or concrete batch plants erected onsite for this project. Premixed concrete and paving materials will be delivered to the site and placed.

5.3.12 Non-industrial waste sources such as worker trash and portable toilets

Describe the worker trash and portable toilets and the potential to contribute pollutants to runoff. Prescribe Control Measure to prevent these from contributing to offsite discharges.

Example:

> Non-industrial waste sources (Worker Trash and Portable Toilets) —Yes – Since facilities are not located nearby for workers to use, trash and sanitary facilities will be required on the site. Worker trash will be comingled with the industrial trash and will follow the same controls with the caveat that a trashcan will be located near the entrance of the site as the contractor will need to dump their trash from lunch, etc. and this will be emptied weekly or more frequently, if needed. If tipped over and when being cleaned, portable toilet facilities become a potential discharge if not cleaned up. If human waste is spilled, it will need to be treated as a biological hazard of untreated sewage and will need to be cleaned up in accordance with Larimer County Health Department Guidance. The toilets will be staked in a way to prevent tipping on a dirt surface and located at least 50 feet from a drainage course or inlet. If the site cannot accommodate a portable toilet on dirt, a containment pan or other secondary containment will be provided. They will also be anchored prevent from tipping. All materials shall be properly disposed of in accordance with the law.

5.3.13 Saw Cutting and Grinding

Describe the saw cutting and grinding as it applies to the site and how that potential pollutant will be controlled to prevent offsite discharges.

Example:

> Saw Cutting and Grinding – Yes – The trench work will require cutting into the City street and some of the landscape rocks will be specially cut. This project will need the use of hardened saws. These saws generate a significant amount of dust. Watering the cutting surface to prevent airborne particulates (BMP in the City's Fugitive Dust Manual) is required. The cutting slurry has a high content of fine particulates (Silica Dust, Metals, etc.) that is not allowed to discharge as runoff from the site. To

prevent slurry from discharging offsite, contractors will use the minimum amount of water needed to prevent dust and blades from overheating (site management control). Cutting slurry will be collected via vacuum or allowed to dry out and be scraped and swept up after the cutting has finished (saw cutting).

5.3.14 Other non-stormwater discharges including construction dewatering not covered under the Construction Dewatering Discharges general permit and wash water that may contribute pollutants to the MS4

Other identified pollutants might be groundwater dewatering, waterline flushing, irrigation return flows, irrigation to establish grass, dust mitigation, compaction activities, surfacing springs, large volumes of run-on water, wetland impacts, or flood plain changes. Describe the other identified source(s) as it applies to the site and how it has a potential to pollute or contribute to runoff. Then prescribe the means to control offsite discharges.

Example:

Ground Water Dewatering – No – Based upon the geotechnical data, ground water levels indicate that it will be significantly lower (about 12 feet) than the bottom of the deepest excavation. However, if encountered, dewatering activities may be required. Groundwater has in most excavations mixed with the dirt and as they are pumped they will add an increased velocity coming out of the out flow end contributing to erosion and speeding the transport of the suspended sediment particles. Also, construction dewatering activities must be identified in the Erosion Control Report if they are to be infiltrated on site. If the material is anticipated to be pumped to a stormwater conveyance the proper Construction Dewatering Permit must be pulled from the State of Colorado. If pumping activities are to occur on the site, the use of rock packs on the intake end of the pump will be used and a silt bag will be used on the outflow end of the pump to reduce the silt and sediment from leaving the activity (dewatering Control Measure). If this will be under a Dewatering Permit water samples will be collected in accordance with that permit.

5.3.15 Other areas where spills can occur

Other identified pollutants that might apply to the site and how those potential pollutant will be controlled to prevent offsite discharges.

5.4 Control Measures

For further clarification please see Section 6.1.4.5 in Chapter 2.

Example of a Control Measure would be as described below. Each Control Measure used on the site should include a description.

Example:

> Vehicle Tracking Control Pads (VTC) - Vehicle tracking control pads shall be provided to minimize tracking of mud and sediment onto paved surfaces and neighboring roadways. Location of vehicle tracking control pads will be located at any vehicle accesses. These locations will primarily be dictated by gates or openings in the temporary construction fencing that is expected to be installed. Vehicle tracking pads should be inspected for degradation and aggregate material should be replaced as needed. If the area becomes clogged, excess sediment should be removed. Aggregate material should remain rough, and at no point should aggregate be allowed to compact in a manner that causes the tracking pad to stop working as intended.

5.5 Installation and Removal Sequence of Control Measures

For further clarification please see Section 6.1.4.6 in Chapter 2.

The sequence schedule should be focused around the identified Control Measures Section 6.1.4.5 of Chapter 2 and when they should be installed for the various Construction Activities in Chapter 12 Section 6.1.4.3 of Chapter 2. The schedule shall be simple to follow, clear, and concise.

This can be done with a paragraph of each Control Measure with the anticipated activity that would trigger installation and activity that would trigger removal. This should match the Erosion Control Plan (sequence chart or sequence sheet)

Example:

> Vehicle Tracking Pad (Site Mobilization – Completion of Flat work)
> All vehicle tracking control pads shall be installed prior to any Construction Activity (stockpiling, stripping, grading, etc.) being used during any of the future construction phases. Vehicle tracking control pads are to be installed prior to site excavation or earthwork activities. Tracking pads shall be removed once activities that require going from dirt to hardscape stop on the project.

The description of the Control Measure and the installation/removal sequencing of Control Measures may be combined. (Section 6.1.4.5 of Chapter 2 and Section 6.1.4.6 of Chapter 2)

Example:

> Vehicle Tracking Pad (Site Mobilization – Completion of Flat work)
> Vehicle tracking control pads shall be provided to minimize tracking of mud and sediment onto paved surfaces and neighboring roadways. All vehicle tracking control pads shall be installed prior to any Construction Activity (stockpiling, stripping, grading, etc.). Vehicle tracking control pads will be located at any and all existing and future vehicle accesses being used during any of the construction phases. These locations will primarily be dictated by gates or openings in the temporary

construction fencing that is expected to be installed. Vehicle tracking control pads are to be installed prior to site excavation or earthwork activities. Vehicle tracking pads should be inspected for degradation and aggregate material should be replaced as needed. If the area becomes clogged, excess sediment should be removed. Aggregate material should remain rough, and at no point should aggregate be allowed to compact in a manner that causes the tracking pad to stop working as intended. Tracking pads shall be removed once activities that require going from dirt to hardscape stop on the project.

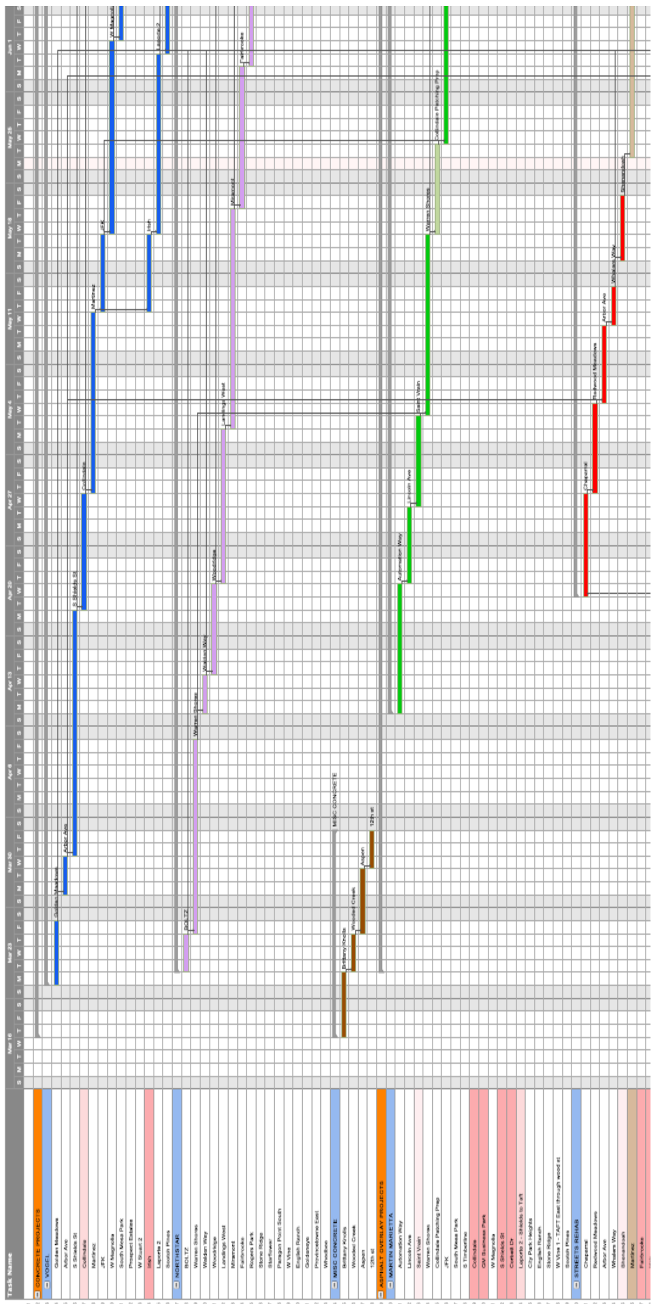
The requirements of this section can also be done in a matrix. This should only be done if the content can be simply followed and understood for when the Control Measures are to be implemented/ installed and when they can conclude/ removed throughout the entirety of the project. The following is an example of such a chart.

Control BMP and Application	Symbol	Description	BMP as Designed	In use on site	Sequence: Initial 1	Interim 2	Interim 3	Interim 4	Interim 5	Interim 6	Final 7
Dust Control	DC	Provides minor detention of sediment.	X		x	x	x	x	x	x	x
Erosion Control Blanket/Temp or Final Stabilization	ECB	A fibrous blanket of straw, jute, coconut, or excelsior material trenched in and staked down over prepared, seeded soil. The blanket reduces both wind and water erosion to help establish vegetation.									
Mulching	M	Placed as a surface cover for erosion control and or seeding establishment to limit soil detachment. Typically includes laying and crimping of straw or spraying the disturbed and/or seeded area with a fiber bonded slurry (i.e. hydromulch).									
Preservation of Vegetation	PV	Used to protect existing stable cover and minimize impact to vegetation.	X		x	x	x	x	x	x	x
Protection of Trees/Protected Resources	TP	Placed prior to construction to protect existing vegetation to remain.	X		I	M	M	M	M	M	R
Scheduling	SC	Provides plan to minimize disturbance and minimize area of disturbance.	X		x	x	x	x	x	x	x
Seeding	S	Provide soil protection through new plant growth (i.e. native seed). Can be drilled and/or broadcast and raked into the prepared soil.									
Sod/Landscape Stabilization	LS	Provide soil protection through new plant growth (sod), plantings, trees, mulching (rock or wood mulching).	X								I,M
Soil Binder		Placed as surface treatment to provide temporary erosion control									
Stabilized Construction Road	SCR	A temporary stabilized roadway (i.e. granular material surface) method to control sediment runoff, vehicle tracking, and dust from heavily used roads during construction activities.									
Staging Area	SSA	Consists of spreading a layer of granular material (gravel, roadbase), or utilizing existing stabilized area (i.e. paved, graveled, etc.). Location for construction management functions (office trailers), storage of materials, location of equipment refueling and maintenance activities.	X		I	M	M	M	M	R	
Surface Roughening	SR	Creating a series of grooves or furrows on the contour in disturbed, graded areas to trap rainfall and reduce the formation of rill and gully erosion. Also, used to minimize sediment transport via wind.									
Sweeping	SW	Utilized to remove sediment on pavement surface and to prevent sediment from entering storm drainage system.	X		x	x	x	x	x	x	x
Turf Reinforcement Mat/ Final Stabilization	TRM	Placed in channels or on slopes for erosion control, channel liner and seeding establishment .									
Vegetative Buffer	VB	Filter sediment laden runoff from disturbance area.									
Other											

Use Legend: I - Install, M - Maintain, R - Remove, E - Utilize and Maintain Existing Measure

Sequences: 1 - Pre-Disturbance & Site Access, 2 - Demolition, 3 - Clearing, Grubbing, Grading, and Excavation, 4 - Utility and Infrastructure Construction and Paving, 5 - Building Construction, 6 - Final Grading, 7 - Landscaping & Installation of Final Stabilization Measures

This requirement can also be fulfilled in a project Gantt chart. This should only be done if the content can be simply followed and understood for when the Control Measures are to be implemented/ installed and when they can conclude/ removed throughout the entirety of the project. The following is an example of such a chart.



5.6 Final Vegetation and Stabilization

For further clarification please see Section 6.1.4.9 of Chapter 2.

This section should include a short description of how the site will be stabilized. Areas should include any xeriscape, sod, temporary seed, lawn/irrigated seed, native seed, rock beds, streets, sidewalks, buildings, road base, etc.

These areas are usually exemplified in the Landscape plans and may be referenced to in this section. A convenience copy of the landscape plans, if referenced, shall be kept in the appendix of the Erosion Control Report.

Example:

> *Exposed dirt in areas that contain Hardscapes, Buildings, and Rock bed will be considered to be stabilized immediately upon installation and would prevent future Erosion to those areas. Those areas where sod will be installed as per design, will require soil amending in accordance with §12-132 and irrigated as a permanent feature to the project. Upon installation of those sod areas they will be considered stabilized and will prevent further Erosion to those areas. Those areas would then be under warranty. All areas to be seeded as outlined in the Final Landscape Plan, or required by the City in the disturbance of other properties, will have the area amended in accordance with §12-132 of City Municipal Code and be seeded based upon the specs called out in the landscape plan. A convince copy is provided below. All seeded areas will be crimped and mulched same day or next day after seeding in accordance with the Temporary and Permanent Seeding Details associated with this project as seen in the appendix, and in accordance with the City of Fort Collins Erosion Control Criteria. Once installed there will be no temporary irrigation system so all seeding will be monitored until the site has reached a vegetative cover (density) of 70%. It is anticipated that this site will be seeded in the spring of 2017 and will be fully established in the fall of 2018. At the point the vegetation has reached 70% density, and confirmed by the City of Fort Collins, the warranty period for Erosion Control will begin, all stormwater infrastructure will be cleans and removed of any sediment deposits and any remaining temporary Control Measures will be removed.*

Species	*Common Name*	*Seed Rate (lbs/acre)*	*Pure Live Seed (PLS)/Acre*	*Drill Depth*
Nassella Viridula (Trin.)	*Green Needle Grass*	*1*	*181,000*	*½ - ¾ inches*

6.0 Erosion Control Escrow

6.1 Example of Erosion Control Escrow Calculation for Phasing

The following is an example of a phased Erosion Control Escrow calculation.

Erosion and Sediment Control Escrow/Security Calculation for The City of Fort Collins

4/23/2014

Project: [redacted] **Phase #1** **Disturbed Acres:** **28.30**

EROSION CONTROL BMPs	**Units**	**BMP Amount Estimated Quantity**	**Unit Price**	**Total Price**
Check Dam	LF	36.288	$24.00	$870.91
Concrete Washout Area	EA	2.016	$1,000.00	$2,016.00
Curb Socks	EA	6.8544	$20.00	$137.09
Inlet Protection - All types	EA	16.128	$300.00	$4,838.40
Perimeter Erosion Control BMPs (Lot)	EA	1.2096	$500.00	$604.80
Outlet Protection	EA	3.2256	$250.00	$806.40
Sediment Control Log	LF	2016	$3.00	$6,048.00
Sediment Trap	EA	1.6128	$600.00	$967.68
Silt Fence	LF	0.8064	$1,700.00	$1,370.88
Vehicle Tracking Control	EA	1.6128	$1,000.00	$1,612.80
Mobilization (required on all projects)	LS	1	$2,016.00	$2,016.00
Street Maintenance	LM	0.6048	$1,500.00	$907.20
Maintenance	LS	1	$5,549.04	$5,549.04
(add all other BMPs for the site in this list)			Sub-Total:	$27,745.20
			1.5 x Sub-Total:	$41,617.80
			Amount of security:	***$41,617.80***

Reseeding Amount

Unit Price of Seeding per acre:	$1,497.27	Total Acres x Price/acre:	$42,378.34
		Sub-Total:	$42,378.34
		1.5 x Sub-Total:	$63,567.50
		Amount to Re-seed:	***$63,567.50***

Miniumum Escrow Amount

Minimum escrow amount: ***$3,000.00***

Final Escrow Amount

Erosion Control Escrow: ***$63,567.50***

"The amount of the security must be based on one and one-half times the estimate of the cost to install the approved measures, or one and one-half times the cost to re-vegetate the disturbed land to dry land grasses based upon unit cost determined by the City's Annual Revegetation and Stabilization Bid, whichever is greater. In no instance, will the amount of security be less than one thousand five hundred dollars ($1,500) for residential development or three thousand dollars ($3,000) for commercial development"

Erosion and Sediment Control Escrow/Security Calculation for The City of Fort Collins

4/23/2014

Project: [redacted] **Phase #2** **Disturbed Acres:** **13.13**

EROSION CONTROL BMPs	**Units**	**BMP Amount Estimated Quantity**	**Unit Price**	**Total Price**
Check Dam	LF	16.839	$24.00	$404.14
Concrete Washout Area	EA	0.9355	$1,000.00	$935.50
Curb Socks	EA	3.1807	$20.00	$63.61
Inlet Protection - All types	EA	7.484	$300.00	$2,245.20
Perimeter Erosion Control BMPs (Lot)	EA	0.5613	$500.00	$280.65
Outlet Protection	EA	1.4968	$250.00	$374.20
Sediment Control Log	LF	935.5	$3.00	$2,806.50
Sediment Trap	EA	0.7484	$600.00	$449.04
Silt Fence	LF	0.3742	$1,700.00	$636.14
Vehicle Tracking Control	EA	0.7484	$1,000.00	$748.40
Mobilization (required on all projects)	LS	1	$935.50	$935.50
Street Maintenance	LM	0.28065	$1,500.00	$420.98
Maintenance	LS	1	$2,574.96	$2,574.96
(add all other BMPs for the site in this list)			Sub-Total:	$12,874.82
			1.5 x Sub-Total:	$19,312.22
			Amount of security:	***$19,312.22***

Reseeding Amount

		Total Acres x Price/acre:	$19,665.15
Unit Price of Seeding per acre:	$1,497.27	Sub-Total:	$19,665.15
		1.5 x Sub-Total:	$29,497.72
		Amount to Re-seed:	***$29,497.72***

Miniumum Escrow Amount

Minimum escrow amount: ***$3,000.00***

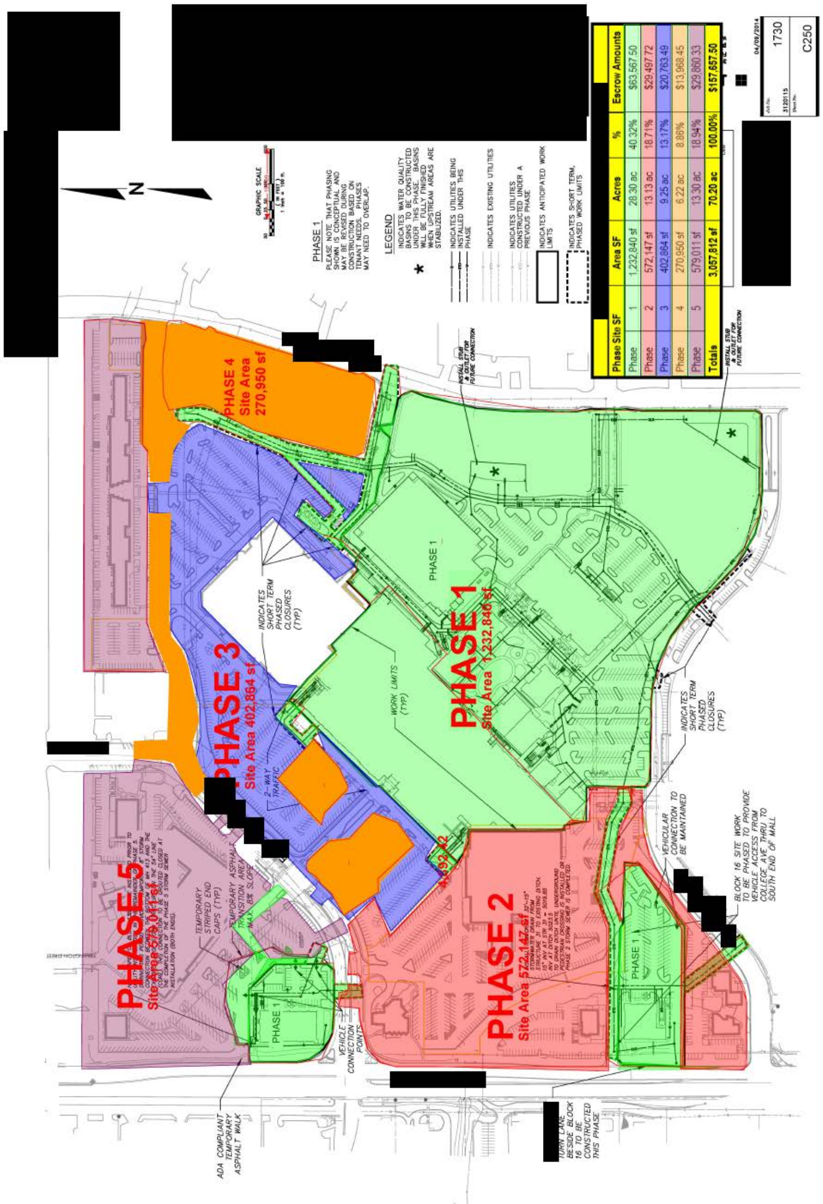
Final Escrow Amount

Erosion Control Escrow: ***$29,497.72***

"The amount of the security must be based on one and one-half times the estimate of the cost to install the approved measures, or one and one-half times the cost to re-vegetate the disturbed land to dry land grasses based upon unit cost determined by the City's Annual Revegetation and Stabilization Bid, whichever is greater. In no instance, will the amount of security be less than one thousand five hundred dollars ($1,500) for residential development or three thousand dollars ($3,000) for commercial development"

6.2 Example Phasing Map for the Erosion Control Escrow for an Exhibit in the DA

The following is an example of a phasing map.



Control Measure Selection and Planning

For further clarification please see Section 5.0 of Chapter 4.

Effective construction site stormwater management planning involves the following:

Identify all the pollutant sources

Collecting and analyzing site-specific information and environmental concerns through a site assessment may identify various environmental concerns or clarify an increased/ or decreased need based upon the project's existing site conditions. To select appropriate Control Measures for a site, you must identify the pollutants of concern.

Brainstorm all the Construction Activities that will occur on site and the associated possible pollutants might be.

- Ex. Grading would expose dirt, track sediment, require maintenance and fueling, have minor repairs, possible leaks and spills, and possibly kick up dust.

- Ex. Interior construction might have worker parking, materials loading and unloading, material storage, portable toilets, possible spills, and wash water locations (painting and cleaning tools)

The State of Colorado has identified typical pollutant sources. Start with the identified pollutant sources from Section 6.1.4.4 of Chapter 2 (a site may have additional pollutant sources or some pollutants may not apply) and work from there to describe the methods to control that material.

Ask the following questions:

- Will there be exposed area?
- Will there be storing of materials on site (i.e. stockpile)?
- Will vehicles be coming on and off my site?
- Will there be worker parking?
- Will delivery trucks be dropping off materials?
- Will those materials likely have vehicle tracking in order to get the materials stored on site?

Each of these activities results in potential pollutants. The overall goal is to prevent pollutants from leaving the construction site and impacting the Poudre River and its tributaries.

Remove identified pollutant sources where practical

Is this material really needed on the site and are there ways these materials can be removed completely? If pollutant source not on site, or has no exposure, it will not need Control Measures.

In some cases vehicle tracking can be prevented by not allowing vehicles on or offsite and only leaving a fork lift and a few lifts on-site that can off load material from vehicles on the street. In these cases by not allowing any site traffic on and off site the pollutant source of vehicle tracking can be a real option that results in less Control Measures and reduced maintenance.

Another example would be when chemicals are used on a project and are simply being kept inside trucks, trailers, connex, and or work offices, will prevent the pollutant from mixing with stormwater.

Where practical with the type of Construction Activity, an effective stormwater planner asks: do we need this on site? If so, where can we store the pollutant material that prevents it from coming in contact with stormwater and site drainage?

Address each pollutant source when it can't be removed from a project

Since this <insert pollutant sources > is needed for this project now we have to address it. The following questions should be addressed in the report:
What can we do to reduce the material exposure to stormwater?
What is being done to promote the stormwater to infiltrate?
What can we do to reduce flows from concentrating and facilitating the transportation of pollutants?
What can we do to prevent the materials from moving from where we want them?
What will we do if the material is transported?

Control Measures will attempt to do at least one of the following: reduce the impact to soil, promote the infiltration of stormwater in place, slow flows and increase infiltration time, and/or control the stormwater. The Control Measures Control Measureshould be implemented in that order as the prior controls are more effective than the latter at slowing run-off and sediment transport. If only stormwater flows are controlled, the sediment is already suspended in stormwater and potentially flowing offsite.

Construction Control Measures shall be selected, designed, installed, maintained, and removed based upon site-specific conditions and in accordance with good engineering, hydrologic, and pollutant control practices. Identify the Control Measures that can solve those environmental concerns Section 8.2 of this Appendix

Control Measures shall be selected based on the physical layout and site conditions that will exist during each stage (sequence) of construction. Because site conditions change through the various stages of construction, the Control Measures will also need to change. It is important to predict the appropriate timing of installing and removing Control Measures for each sequence and in each phase of the project.

The Erosion Control Material shall be consistent with other plans because as they change so too shall the Erosion Control Materials. Ensure plans are consistent with other design documents (Section 8.4 of this Appendix).

Effective construction stormwater management should also review contractual mechanisms to ensure the contractors will be taking the correct steps to prevent erosion, sediment and pollutant discharges from the site.

Sites with work in waterways, linear projects, underground trenching, and native seed, all have unique cases that should be evaluated based upon their unique conditions and the nature of their Construction Activities.

6.3 Site Assessment

Early awareness of site-specific factors that make a site particularly prone to erosion problems can prevent serious problems later during the construction process. A site assessment should include attention to these factors, prior to selection of Control Measure:

- Visit the site, take pictures, and know the physical characteristics of the site.

- **Tributary Area/Catchment Size/ Drainage Basin**: The overall size of these areas should be evaluated prior to design. As these areas will contribute and be a key determining factor in selecting the types, sizes, spacing and other design requirements for sediment controls appropriate for each drainage area. If drainage flows are inundating the site, there will be a need to responsibly calculate the volumes and handle those flows. This can be solved by diverting flows around the site or through the project site in a fashion that minimizes the runon from making contact with the exposed dirt (i.e. the use of a pipes, lined diversion, pumps, etc.). Where diverted flows cannot be removed from interacting with the exposed dirt, consider slowing velocities (i.e. through rock check dams or other velocity dissipaters, and rolled blankets). As a last resort, the use of Sediment removal devices such as wattles, gabion structures, sediment traps, and sediment basins may be used. Any flows in contact with construction site pollutants are the Developer's responsibility to manage. The less stormwater that makes contact with pollutant sources, including dirt, the fewer Control Measures (and costs) will be needed to control the pollutant.

- **Slopes/Topography and Topographic Changes Due to Grading**: Slope length and steepness are two key factors in identifying the types and placement of both Erosion and Sediment Control Measures. Where possible, slope lengths should be shallower as the steeper the slopes the more costly to protect and reestablish the site. Also the Design Engineer should evaluate slopes as they change throughout the various sequences of construction as grading is conducted. This may change Control Measures used on the perimeter or when inlet protection is implemented or the need for onsite basins.

  For example, if an area has no run off at the beginning of the project but by the middle of the project will have a run off that area will need to add runoff Control Measures mid-project. The opposite can be said if an area that once drained off a project now clearly drains back onto the project. There may no longer be a need for runoff perimeter controls, however now those flows will be directed to a ditch, swale, rain garden, LID or detention facility which may require additional changes to the control method for the new flows.

Understanding the hydrology of a site is important in the design of Erosion and Sediment Control Measures. Consider water flow onto the site. Offsite run-on as well as drainage patterns within the site should be thoroughly assessed, thinking about concentrated flows and where those flows will cause scouring erosion and where they will slow and deposit sediment. The configuration of hill slope areas and waterways, in the context of planned roads and buildings, will determine which Erosion and Sediment Controls will be needed and at each sequence of construction that they should be implemented.

- **Soils**: Regardless of soil type, all disturbed soils require Erosion Control Measures. NRCS soil maps and geotechnical reports for the development, as covered in Section 6.1.4.3 in Chapter 2, can be used to identify soil conditions where erosion may be particularly difficult to control. For example, in silt and clay soils dirt particles stay suspended in water for longer times and may require more substantial Control Measures to reduce the discharge of sediment laden water from a project. Knowing the soil composition of a site allows proper design Control Measures and additional layers of protection to drop out as much of the suspended dirt as possible.

- **Preserving Vegetation:** Onsite vegetation should be left undisturbed as long as possible. Vegetative areas should be clearly identified in the Erosion Control Materials and/or the construction plans. Construction fence or other access control should be installed to avoid disturbance and compaction of these areas. This is particularly important for protection of mature trees, natural riparian buffers and wetlands, natural open space, or other areas specifically identified to be protected from compaction as part of Low Impact Development (LID) designs. Maintaining a vegetative buffer, in combination with other perimeter Control Measures, can be effective for minimizing transport of Sediment off-site.

- **Sensitive Site Conditions**: Where construction occurs in sensitive aquatic habitat, impaired waters, upstream of drinking water supplies, or near areas where threatened and endangered species are of concern, additional layers of protection may be specified by the City, the State or the Federal government. These may include additional redundant Control Measures or restrictions on times, or times of year, that Construction Activities are allowed.

- **Do your homework**: Look out for any former environmental studies conducted on the project. Document and keep copies of your research findings. Consider, based upon those environmental studies, if the site will have a difficult time keeping impacted materials from discharging off site. Those sites, depending on the contamination, may require baseline water quality measurements to demonstrate a reduction in off-site transport of the pollution after construction improvements occur. There also might be abandoned debris or old trash heaps under a project. Determine steps to be taken to assess site debris, garbage, or pollution that exists prior to construction, and what will be needed to deal with those abandoned materials in a responsible fashion. Is there a disposal plan?

- **Existing site conditions can considerably affect costs**. For example, when there are steep slopes, additional measures or more costly measures on a steep site will need to be planned for ahead of time. Another example is a project near a floodplain. The project may have to plan work around times of the year that are not "flood season." Areas exposed during flood season will need to be protected with added thought to prevent large inundations of flood waters, which usually mean more robust controls and higher cost for the control. If a project encounters asbestos contaminated soils or an abandoned underground tank, those too can affect the costs of a project by orders of magnitude.

- **Social Awareness/Social Climate or atmosphere around the site**: How close are neighbors and how sensitive might they be to various Construction Activities is important when planning. Is dust or air pollution a consideration, will they complain, what steps might be taken to reduce those impacts? Will working on weekends or at night cause noise pollution and an added layer of tension? What steps can be planned for a head of time to reduce citizen impact and complaint potential? Do the neighbors support this project or do they see it as blight? It might be needed to structure the erosion control and subsequent contract bids accordingly as neighbors can cause increased responsibility and attention to a site and will require extra controls or workers time to remedy.

6.3.1 Using the Revised Universal Soil Loss Equation

The "Revised Universal Soil Loss Equation" (RUSLE) and the "Modified Universal Soil Loss Equation" (MUSLE) are two erosion prediction methods that have evolved over time by empirical research of erosion and sediment transportation from sites. A detailed discussion of R/MUSLE factors is beyond the scope of this Manual, however, it is important these equations set up a method to help break down and deal with various aspects of exposed soils to reduce off site transport of materials. Neither the RUSLE or MUSLE equation is required for submittal but is a useful tool to use in some circumstances.

The big take away from these equations are, although construction managers have no control over the Rainfall runoff erosivity factor, the slope length, slope steepness, cover and effectiveness of the Control Measure can be altered by implementing practices that reduce sediment loading.

One technique to reduce the slope length and steepness is to terrace. For example, if a portion of a construction area has a slope length of 500 feet it can be terraced into three or four equal sections to reduce the erosivity of the water coming down the slope. This factor can also be used to guide placement distances for silt fence, wattles and other practices that serve to break up the slope length.

To better clarify that section of slope length please refer to Section 7.1.2 of this Chapter on "Slope–length and runoff considerations".

As another example, construction managers can vary cover management practices to decrease the impact to the soil and reduce sediment transport. Cover values vary, depending on the type of cover (grass, matting, mulch) implemented.

6.3.2 Slope-Length and Runoff Considerations

Cut-and-fill slopes should be designed and constructed to minimize erosion. This requires consideration of the length and steepness of the slope, the soil type, upslope drainage area, groundwater conditions and other applicable factors. Slopes found to be eroding excessively will require additional slope stabilization until the problem is corrected. The following guidelines should assist site planners and plan reviewers in developing an adequate design:

- Roughen soil surfaces enhance infiltration and/or lengthen the travel path or runoff, reducing runoff velocity. See the Surface Roughening Control Measure Fact Sheet in Appendix E.

- Temporary diversion dikes should be constructed at the top of long or steep slopes. Diversion dikes or terraces reduce slope length within the disturbed area. See the Earth Dikes and Drainage Swales Control Measure Fact Sheet in Appendix E

Temporary diversion dikes should be provided whenever:
$S^2L > 2.5$ for undisturbed tributary areas; Equation 7-1
$S^2L > 1.0$ for disturbed tributary areas; Equation 7-2
$S^2L > 0.25$ for paved tributary areas; Equation 7-3

where:

S = slope of the upstream tributary area (feet/foot)
L = length of the upstream slope (feet)

As an example, runoff from a developed area runs on to an area that will be disturbed. A diversion dike would be required if the length of the flow path was greater than 625 feet and the slope of the flow path was 2%.

- Concentrated stormwater (e.g., pipe outflow, channel, swale) should not be allowed to flow down cut or fill slopes unless contained within an adequately-sized temporary channel diversion, a permanent channel, or temporary slope drain. See the Temporary Slope Drain and Diversion Ditches/Channels Control Measure Fact Sheet in Appendix E

- Wherever a slope face crosses a water seepage plane that endangers the stability of the slope, adequate drainage should be provided.

- Provide Sediment basins or barriers (silt fence) at or near the toe of slopes to trap sediment or to reduce slope lengths. When flows are concentrated and conveyed down a slope using a slope drain or channel, energy dissipation measures will be required at the conveyance outlet at the toe of the slope. At no time should silt fence be used in these concentrated flows. See the Sediment Control Measure Fact Sheet in Appendix E for several options for controlling sediment at the base of slopes.

6.4 Control Measure Functions

Understanding the intended function of a Control Measure is critical to proper Control Measure selection. Control Measures should be selected based on both the intended function of the Control Measure and consideration of whether the Control Measure can provide the desired function based on the site-specific conditions. It is also important to understand how Control Measures' functions are related to maintenance. For example, when silt fence is initially installed, it provides a filtration function, but over time, the fabric can become clogged, leading to ponding and sedimentation behind the fence as the primary function rather than filtration.

Sediment Control Measures such as sediment basins can provide some settling of sediment from runoff, but must be combined with Erosion Control Measures throughout the site in order to be effective. Sediment basins, inlet protection, and other Sediment Control Measures should not be solely relied upon as "end-of-pipe" treatment systems.

Detailed Construction Control Measure Fact Sheets are provided in Appendix E and contains information on each Control Measures' applicability, installation, maintenance, and design details, along with notes.

The fact sheets are intended to be stand-alone documents that can be used for reference or inserted directly into submitted Erosion Control Materials.

Knowing a Control Measures strengths and specifications is only one layer in selecting the Control Measure.

Thoughts and feedback from the contractors is important too and should be gathered when using any product as they are the ones who will install, and maintain the Control Measure and have seen where and how Control Measures fail in differing circumstances.

Many products should be selected or avoided based upon some of the following:

- Ease of proper installation (and vs improper installation): Some Control Measures are easily installed while others require time and effort and are very difficult to install correctly to begin with and to specification.

- Productivity concerns: Some Control Measures are counterproductive to the work occurring on site and get in the way.

- Minimal maintenance / reduced labor costs: Some Control Measures require more intensive maintenance and cannot be left unattended for extended periods. Others vary in cost of installation.

- Size of application: Some Control Measures are better suited for larger application and some are more effective in smaller locations.

- Accessibility to the product: Some products are not available or cost prohibitive to import to the site.
- Does the City/State/Federal authorities allow or prohibit the use of this product? Not all Control Measures are accepted in all areas
- Is it even effective at preventing erosion or stopping sediment? Not every Control Measure on the market is effective or as effective as another control.
- Cost of the control: Some Control Measures cost substantially more than others or vary based upon the initial investment costs and long term and replacement costs
- Product Resiliency: Some Control Measures will hold up for years some only a month
- High turnover rates of contractors: how easy is it to teach contractors to use a Control Measure. If something is overly complicated, it may take more time teaching others how to maintain the control rather than another control.
- Redundancy: Some Control Measures will not function as a stand-alone Control Measure and multiple treatments or treatment trains are needed. Other times an entire treatment train can be eliminated just by the use of a different Control Measure.
- Disposability and end of use life cycle: Some Control Measures can be simply cut open, or left in place to bio or photodegrade, while others require full removal and revegetation application after.
- Appearances: Some Control Measures contribute to a site appeal and can increase the value of the units. Some Developers want a nice clean looking jobsite and many times the Control Measures add to the curb appeal.

One comparison example would be Silt Fence vs Straw Wattle as a perimeter surface runoff control.

Silt Fence	**Straw Wattle 8”**
More time associated with installation	Usually installed incorrectly
Difficult barrier work around	Can drive right over
Maintain typically after wind storms	Maintain after being driven over
Small – Large Sites	Small – Medium Sites
Easy to obtain	Easy to obtain
City of Fort Collins Acceptable	City of Fort Collins Acceptable on any residential and Acceptable on any commercial site with a method to prevent being driven over (typically a construction fence)
When installed correctly and maintained is highly effective	When installed and maintained is fairly effective
About $2-3/LF Might replace a few sections here or there about every half a year.	About $1-2/LF Might replace many sections every few weeks depends on construction controls
Lasts about 4-6 months without maintenance then maintenance can be intensive and technical to get right. Has been observed working for 2-3 years plus before breaking down to the elements.	Lasts about 1-2 weeks as contractors tend to drive over and busts open the straw every few days and can be easily installed with minimal technical skill. Has been observed working for a year before breaking down to the elements.
Must be removed and in some cases the dirt trench will need reseeding.	Can have the stakes remove and in some cases cut open and let the straw help as an added benefit in the reseeding or dirt areas.

As you can see, there are pros and cons to each of these Control Measures and many more that are not listed here. The silt fence might be more practical if you have larger residential or medium commercial sites that may be open for a long time, whereas a straw wattle may be more practical on an infill housing operation or a site with a quick construction schedule that would go straight to landscaping.

6.5 Stages, Sequences, and Phasing

Determine sequencing of construction: The schedule of construction will determine what areas must be disturbed at various stages throughout the development plan. The number of stages (or sequences) that should be addressed in the Erosion Control Materials depends completely on the type of Construction Activities that will result in increased pollutants being present and thereby increasing the potential of discharge.

These sequences typically include mobilization, demolition, overlot grading, import and export, utilities installation, flat work (streets, curbs, gutters, and sidewalk), vertical work (foundations, framing, interior and exterior facades), final grading, landscaping and final stabilization. Not all of these are present in every project. For projects including all of these activities, the sequences can be lumped together when it comes to their impacts.

Select Control Measures needed for each stage of the construction project. Each stage will have different demands for the controls of erosion and sedimentation. For example, overlot grading will encompass disturbed dirt and stockpiling, vehicle maintenance and traffic and particulate generation and would require one variety of controls. Whereas when the structure is being built, the focus will be on contractor traffic, chemical containments, concrete washing activities, tile cutting, painting, framing, trash control, etc. and would require an entirely different set of Control Measures because when individual homes are being built and lots are disturbed after the streets and drainage systems are in place creating new perimeters to protect.

As new pipes are installed and the inlets and outlets get tied in, those need to be protected once installed.

All perimeters where hardscape (curbs, streets, sidewalks) and soft scape (raw exposed dirt) meet is a form of perimeter protection. This shall include hardscapes that are installed as part of the project. After such hardscapes are installed perimeter protection shall be installed too and if site grades to the hardscape a Sediment barrier will need to be installed with the perimeter protection.

The simplest way to understand the sequencing needs of a particular project is once the Control Measure has been selected to address the identified pollutant, use Control Measure by Control Measure to create a reasonable timeline based upon the timeframe the pollutant will be on the construction site.
One example would be the pollutant source of concrete washing. The method of control for that activity would be a concrete wash out station.

Mobilization	Not Applicable
Demolition	Not Applicable
Over-lot Grading	Not Applicable
Import and Export	Not Applicable
Utilities Installation	Rare on occasion would be Applicable
Flat Work (Streets, Curbs, Gutters, and Sidewalk),	Applicable
Vertical Work (Foundations, Framing, Interior and Exterior Facades),	Applicable
Final Grading, Landscaping and Final Stabilization	Rare on occasion and for repair/warranty work

This would be different if we were to compare it to the pollutant source of vehicle tracking with the method of control being a Vehicle Tracking Pad.

Mobilization	Applicable
Demolition	Applicable
Over-lot Grading	Applicable
Import and Export	Applicable
Utilities Installation	Applicable
Flat Work (Streets, Curbs, Gutters, and Sidewalk),	Applicable
Vertical Work (Foundations, Framing, Interior and Exterior Facades),	Sometimes applicable if vertical is prior to flat work
Final Grading, Landscaping and Final Stabilization	Rare on occasion and usually in localized spot conditions

This would be different if we were to compare these two to the pollutant source of disturbed dirt with the method of control being an inlet protection.

Mobilization	Applicable only on Existing Inlets that would be impacted by construction
Demolition	Applicable only on Existing Inlets that would be impacted by construction
Over-lot Grading	Applicable only on Existing Inlets that would be impacted by construction
Import and Export	Applicable only on Existing Inlets that would be impacted by construction
Utilities Installation	Applicable on all new and existing inlets impacted by construction
Flat Work (Streets, Curbs, Gutters, and Sidewalk),	Applicable on all new and existing inlets impacted by construction
Vertical Work (Foundations, Framing, Interior and Exterior Facades),	Applicable on all new and existing inlets impacted by construction
Final Grading, Landscaping and Final Stabilization	Applicable on all new and existing inlets impacted by construction

Determine the Phasing of construction: Evaluate ways to maximize permanent erosion controls (existing vegetation) as much as possible to reduce the amount of exposed dirt that would be susceptible to transport materials from the site and subsequently reduce the frequency of maintenance on the sediment control. The opportunity for phasing cut-and-fill operations to minimize the period of exposure of soils needs to be assessed and then incorporated into the Erosion Control Materials. If less area is disturbed, then less area will have to be maintained, and there is less possibility of non-compliant issues or violations both by City inspections as well as State and Federal inspections.

Phasing is a key component to a successful project and once the area is disturbed, temporary erosion controls are helpful before the final site stabilization. Surface roughening, crimping and mulching, and temporary seeding have various times shown to be effective Measures where permanent erosion controls are not practical as there will be later Construction Activities that require grubbing those existing vegetation areas.

6.6 Consistency with Other Plans

Prior to selection of Control Measures for the Erosion Control Materials, it is important to cross-check other construction planning documents for consistency and/or opportunities for increased efficiencies and effectiveness.

6.6.1 Drainage Plans

The Erosion Control Materials should be prepared with due consideration of the final drainage plan for a development. As permanent drainage features are constructed, temporary Sediment Control Measures should be located and designed to both protect and complement these final drainage features. Temporary controls should be staged and removed at the appropriate time relative to the completion of permanent drainage features. Special care is necessary for permanent structures (Water Quality Structure or Low Impact Development (LIDs)) that rely on infiltration such as bio-retention, permeable pavements, sand filters, and others. These BMPs will clog if they are not adequately protected during construction (or constructed after tributary areas have been stabilized).

Coordination of temporary and post-construction Control Measures is important for several reasons. In some cases, post construction Control Measures such as extended detention basins can be modified to serve as sedimentation basins during construction. In other cases, such as in the case of rain gardens or infiltration-oriented post construction controls, it is critically important to protect the post-construction facilities from sediment loading during construction. Also, as previously noted, if an area is targeted for preservation in an uncompact, natural condition under a LID design, it is critical to keep heavy equipment and staging of materials out of these areas.

6.6.2 Air Quality Plans

Properly implemented Erosion and Sediment Control Measures are beneficial in minimizing wind erosion. For example, surface stabilization measures that help to reduce precipitation-induced erosion help to reduce windborne dust and sediment. Additional controls, such as road watering (to moisten roads but not to the extent that runoff results) and/or soil binders may be necessary to fully comply with fugitive dust regulations at a construction site.

Contact the appropriate local agency for air quality requirements during construction.
http://www.fcgov.com/airquality/fugitive-dust.php and Municipal Code §12-150

6.6.3 Landscape Plans

Add sections or notes in the Erosion Control Materials to ensure protection of trees, shrubs, and mature vegetation.

Ensure that the landscape plans include the appropriate soil amendments requirements and any temporary or permanent seed mixes.

Also verify that the seeded areas are shown in the erosion control plans so that all areas exposed in the Construction Activities are planned for a proper final stabilization. This will also create reasonable expectations as to what areas will take the longest to reach final stabilization.

6.7 Contractual Awareness

The better and more complete the prepared Erosion Control Materials are the less confusion around what can be expected on a construction site. This also leads to a better evaluation of the costs on a project and can ensure better contract bids.

When these Control Measures are included in the bid, there is less confrontation about what it takes to maintain environmental compliance, less stress by all parties because the funds will have been budgeted a head of time, and a clear understanding of the requirement are fostered in order to meet the City's criteria and prevent delays in construction schedules at the end of the job.

Recent projects have erosion control roles and responsibilities written into the contract language for who is going to install the materials, who is going to write the inspections, who is going to pull permits, who will be will be removing and disposing of the materials once the site is stabilized, which has eased the burden, blame, and confusion as to who is responsible for what.

Planning these roles and responsibilities and getting the right specialty services, or trained staff on a project, and selecting the right contractor who has a great track record for environmental compliance, these all will go a long way reducing the risks for, notices of violation, work stoppages, and fines.

6.8 Construction Dewatering

Dewatering is typically necessary during Construction Activities that involve deep excavations, instream work, pumped surface diversions, and open trench operations. In Colorado, construction dewatering frequently requires a dewatering permit from the Colorado Water Quality Control Division (WQCD) with monitoring and the completion of Discharge Monitoring Reports (DMRs), and may require dewatering permits from the Colorado Division of Water Resources.

Carefully check state permit requirements to determine when dewatering can be conducted without additional permitting.

When dewatering can be conducted without discharging surface runoff from the site, it may be possible to conduct such activities under the CDPS General Permit Stormwater Discharges Associated with Construction Activity, when no known ground contamination is present.

Some commonly used methods to handle the pumped water without surface discharge include land application to vegetated areas through a perforated discharge hose (i.e., the "sprinkler method") or dispersal from a water truck for dust control.

Construction dewatering Control Measures generally include practices to minimize turbidity in the pumped water. Representative practices that may help to reduce turbidity in various types of dewatering applications include:

- Using perimeter well points outside of the excavated area to draw down the water table rather than dewatering directly from the excavation;
- Placing a submersible pump in a perforated bucket filled with gravel for short-term pumping;
- Constructing a filtering sump pit for pumping groundwater below the excavation grade for multiple day operations;
- Using a flotation collar or other flotation device to pump from the surface of a sediment basin to avoid the silt that can accumulate on the bottom of the basin; and
- Placing the outflow end of the pump in a velocity dissipating device along with sediment containing Control Measures.

Guidance on Control Measures for construction dewatering is provided on the Dewatering Operations Fact Sheet in Appendix E.

6.9 Considerations for Unique Projects

Construction in waterways is often required for projects; this includes bridge construction, utility construction, streambank stabilization, grade control, and temporary / permanent stream crossings, which all have unique considerations that should be taken into account, see Section 7.7.1 of this Appendix.

Linear projects involving utilities, streets, highways, railways, and other transportation-related projects can pose some unique stormwater management challenges during construction. Section 7.7.3 of this Appendix identifies special considerations and approaches that may be beneficial to linear projects, and Section 7.7.2 of this Appendix provides criteria for trenching for underground utility lines.

6.9.1 Construction in Waterways

Construction in waterways requires a high standard of care in order to avoid and minimize damage to waterways, habitat and aquatic life.

In addition to the construction phase permits already discussed, this work can also require a Clean Water Act Section 404 Permit from USACE, U.S. Fish and Wildlife Service (USFWS) threatened and endangered species permitting, floodplain permitting and/or other Federal, State and Local permits. Some required permits may restrict construction to certain times of the year.

Many of the Control Measures described in Appendix E are used in waterway construction. This section provides guidance on factors to consider and plan for during construction in waterways, as well as guidance on specific Control Measures that should be evaluated for implementation based on site-specific conditions. Other Fort Collins drainage criteria and guidance that are closely related to in-stream work should also be referenced.

Control Measures commonly used when construction occurs in waterways include:

- EC-1 Surface Roughening (SR)
- EC-2 Temporary and Permanent Seeding (TS/PS)
- EC-3 Soil Binders (SB)
- EC-4 Mulching (MU)
- EC-6 Rolled Erosion Control Products (RECP)
- EC-10 Earth Dikes and Drainage Swale (ED/DS)
- EC-13 Streambank Stabilization (SS)
- SC-1 Silt Fence (SF)
- SM-1 Construction Phasing/Sequencing (CP)
- SM-8 Temporary Diversion Channel (TDC)
- SM-10 Dewatering Operations (DW)
- SM-11 Temporary Stream Crossing (TSC)

In addition to criteria specified for these BMPs, the following general principles should be followed:

- Construction vehicles should be kept out of a waterway to the maximum extent practicable.
- Where in-channel work is necessary, steps such as temporary channel diversions must be taken to stabilize the work area and control erosion during construction.
- When in-stream work has been completed, the channel must be stabilized using revegetation practices (often, including use of erosion control matting or turf reinforced mats), riprap, or other permanent stabilization measures as required by the SWMP.
- Where an actively-flowing watercourse must be crossed regularly by construction vehicles, a temporary crossing should be provided. Three primary methods are available: (1) a culvert crossing, (2) temporary bridge, and (3) a stream ford. See the Temporary Stream Crossing Fact Sheet in Appendix E.
- A permit is required for dredging and the placement of fill in the waters of the United States under Section 404 of the Clean Water Act. The local office of the USACE should be contacted concerning the requirements for obtaining a 404 permit. In addition, a permit from USFWS may be needed if threatened or endangered species are of concern in the work area. Typically, the USFWS issues are addressed in conjunction with the 404 permit if one is required. A floodplain development permit and other local permits may also be required.

404 Permit Basics

Section 404 of the Federal Clean Water Act established a program to regulate the discharge of dredged and fill material into waters of the United States, including wetlands. Responsibility for administering and enforcing Section 404 is shared by the U.S. Army Corps of Engineers (USACE) and EPA. USACE administers the day-to-day program, including individual permit decisions and jurisdictional determinations; develops policy and guidance; and enforces Section 404 provisions. EPA develops and interprets environmental criteria used in evaluating permit applications, identifies activities that are exempt from permitting, reviews/comments on individual permit applications, enforces Section 404 provisions, and has authority to veto USACE permit decisions.

A Section 404 permit is typically required when the following activities are conducted in waters of the U.S., including wetlands:

- Construction of roads or paths
- Foundations or amenities for residential, commercial, or recreational developments
- Construction of ponds, dams, dikes or weirs
- Placement of riprap and channel protection
- Laying utility pipes or lines

- When work takes place within a channel, a temporary water diversion to bypass the work area is typically required. See the Diversion Channel/Ditch Control Measure Fact Sheet in Appendix E for criteria and design details.

- To the extent practical, construction in a waterway should be sequenced to begin at the most downstream point and work progressively upstream installing required channel and grade control facilities.

- Complete work in small segments, exposing as little of the channel at a time as practical. Keep equipment operators contained in immediate work area and avoid excessive compacting of the soil surface because it inhibits revegetation.

- Where feasible, it is best to perform in-channel work between October 1 and March 31 in Colorado. This is the period when the chances of flash floods and flows higher than the 2-year flood peak flows are less likely.

- During the process of cut and fill, avoid letting side-cast or waste material enter waterways or placing it on unstable areas. Instead, efficiently move excavated material to areas needing fill or to a stockpile. For stream restoration/stabilization projects, consulting with a fluvial geomorphologist on stream stability issues may be prudent.

When selecting BMPs for in-stream construction, a variety of factors should be considered such as:

- Hydrologic factors (tributary watershed size, length of the overland flow, roughness and slope characteristics, precipitation characteristics, imperviousness, etc.)

- Base flow conditions

- Pollutants that may be delivered to the waterway from the surrounding area

- Extent of existing Erosion, head cutting or bank sloughing

- Condition/type of vegetation and percent cover

- Sources of surface runoff

- Drainage pattern

- Historical events

- Flow regulation (ditch diversions, reservoir releases)

6.9.2 Underground Utility Trenching

Minimize the length of trench open at one time to the extent practical. For most trenching projects, it should be feasible to phase construction so that no more than a few hundred feet of trench are open at any given time. Check local excavation permit criteria, which may specify a maximum length of trench that may be open.

Where consistent with safety and space considerations, place excavated material on the up-gradient side of trenches.

Trench dewatering devices must discharge in a manner that will not cause erosion or adversely affect flowing streams, wetlands, drainage systems, or offsite property. Refer to Appendix E for additional guidance on Control Measures for dewatering.

Provide storm sewer inlet protection whenever soil erosion from the excavated material has the potential to enter the storm drainage system. See Inlet Protection Control Measure Fact Sheet in Appendix E for specific guidance.

Evaluate potential for sediment contributions to inlets or receiving waters that are not in the immediate vicinity of the work area but may be impacted from runoff from the project and implement inlet protection and/or other Control Measures as necessary.

For example, if vehicles access the construction area to remove excavated material or to deliver materials, evaluate the potential for offsite sediment tracking and implement Control Measures such as street sweeping, inlet protection, stabilized access to the construction area, and other BMPs to protect inlets or receiving waters that could be affected by tracked sediment. Another example would be the perimeter controls on the up-gradient side of stockpiles and inlet protection on the opposite side of the crown of the street may be necessary if stockpile height or tracking from accessing stockpiles has the potential to contribute sediment to the opposite side of the street.

6.9.3 General Considerations

General considerations for linear construction projects include:

- Standard details for typical activities: Development of a set of standard Control Measure details for typical construction activities can promote consistent implementation of erosion and sediment Control Measures and more efficient Erosion Control Material preparation. For example, if a utility company frequently installs light poles, it may be beneficial to develop a standard detail showing the typical construction of a light pole and the associated Control Measures. Typical details for construction activities can be used by contractors showing what Control Measures must be used for specific construction activities. Control Measures should be shown on the erosion control drawings when they are installed, or in the City of Fort Collins, it is acceptable to reference the typical detail as an alternative to showing specific

Control Measures on the erosion control drawing. Control Measures must be indicated on the site map if site-specific conditions vary from the conditions assumed for development of the typical construction activity Control Measure detail.

- Construction phasing: By nature, linear construction activities are typically phased. Phasing often will be dictated by the extent of allowable traffic closures and typical requirements for closing trenches at the end of the workday in the right-of-way. For linear construction projects in the public right-of-way, stabilization often can be achieved rapidly as each segment or phase of the project is completed, often by paving or repairing and/or installing sod. For areas where revegetation is from seed, reaching final stabilization (and inactivating stormwater permit coverage) will be a lengthier process.

- Weather and climate: Linear projects such as roadwork may need to consider seasonal weather patterns when scheduling construction. Bridgework over waterbodies should be planned during traditionally low water levels (October 1 to March 31) when possible. Utility projects should attempt to close trenches prior to inclement weather, if feasible, and at the end of each day.

- Space constraints: Select BMPs that work best under the space constraints of the project. Many utility and road construction projects in urban areas have BMPs that are located in active streets.

- Durability: Particularly in active traffic areas, durability of Control Measures (i.e., ability to continue to function properly, even when run over by a vehicle) is an important consideration for Control Measure selection.

- Potential for ponding: Creation of ponded water on roadways may also be a concern. It is important to keep in mind that inlet protection can function in two different ways: filtration and/or ponding. While both of these mechanisms can play a role in sediment removal, typically, inlet protection methods that encourage filtration and limit the amount of ponding are favorable, since ponding typically does not provide enough storage for significant residence time/settling and because ponding can impede travel in streets and highways. Ponding, which occurs to at least some degree with most types of inlet protection, can typically be addressed by selection of the appropriate type of inlet protection, frequent maintenance/sediment removal, and providing an overflow path that will not cause flooding in the event that excessive ponding occurs.

- Temporary access: Unlike a typical residential or commercial development where there are access points that will be used throughout the duration of the project, for linear construction projects it is often necessary to access the work area for limited periods of time at multiple locations throughout the corridor. For utility projects where access through vegetated areas is necessary at multiple locations, but generally only for a limited amount of time at each location, consider alternatives to standard geotextile and rock-lined vehicle tracking control pads such as construction mats or turf reinforced mats for temporary access to avoid disturbance to vegetation and soil that is typically associated with traditional vehicle tracking control pads.

- Jurisdictional considerations: Linear projects are often multi-jurisdictional. In these cases, it is important to have upfront coordination with the municipalities that are involved to reduce the burden of permitting and Erosion Control Material preparation to the extent practical. For example, it may be possible to prepare Erosion Control Materials/SWMP that will satisfy the requirements of multiple municipalities rather than preparing separate SWMPs for work in only one of the municipalities.

- Permitting considerations: Check all local requirements prior to commencing work on linear construction projects.

- Wildlife considerations: How will animals interact with various materials? Will animals have an entrapment issue with one type of Control Measure vs another?

6.9.4 Special Concerns Around Seeding and Native Vegetation

Analyze the existing site vegetation, is it pristine or native?

Poor quality and substandard applications of seeding, lead to spotty, unpredictable results that may require costly re-vegetation work and over all increasing the cost of project. When seeding however, even some of the best quality and perfect applications can fail simply by the application of a wrong seed. Choosing a revegetation specialist, not just a landscaper, early in the process when determining seed species, drill depths, etc. helps reduce trouble at the end of the project when the site is having its Erosion Control Escrow retained until the seeding has been established and the contractor is wondering why the seeding has failed.

To get the project done right the first time, the designers should take many things into account when determining the types of vegetation, such as: will it control erosion as well as add aesthetic value or both? For example, forbs are generally chosen for visual appeal as they tend to have a variety of colors for each season.

Native plants have already adapted to moisture level, climate, elevation, and soil type and will after grown in, be less expensive to maintain. These native seed plants maybe more successful for permanently stabilizing a site in the long run even though these seeded areas take much longer to establish. Realistic expectations around growing seed in Colorado should be set as seeded areas have a longer than average time tables for establishment. Also, to a naked eye, native areas should not be expected to look like a bright green field at the end of a project. These areas may need an immediate, fast growing cover crop to aid in preventing erosion before the permanent vegetation will fully grow in.

Other key things to consider for a successful application:

- Will the seed selection thrive in the soil?
  - Clay, loam, sand
  - Alkaline or acidic
  - Quality of soil
- What soil amendment would function best to promote seed growth?
- Is the seed located in large amounts of sunlight or shade?
- Is the seed right for the climate zone?
- Is the seed located in transitional zones?
- Is the seed located in a micro climate?
- Is the seed able to effectively grow at this elevation?
- Is there accessibility to moisture?
- Is the seed located in harsh environmental conditions?

- Is the seed going to be planted in drought conditions?
- Is irrigation needed, and if so, how long?

A revegetation specialist takes all of these various factors into account to choose flowers, grasses, Forbes, legumes, annuals, perennials, trees, shrubs and cover crops to give the best mix for any particular application.

Some seeding requires a wide variety of ecologies and should be taken into account to reach maximum success.

When looking at seeding and native seeding applications please consult other City of Fort Collins Departments (Natural Areas, Zoning, Water Conservation, etc.) to verify they do not have conflicting criteria. If any conflict arises please present the issue to the respective Departments so clear direction can be given about what standard should govern the project.

6.10 Developer Inspections

6.10.1 Inspection Records

Requirements are found in Section 2.2.2 of Chapter 3.

Typically, these items can be incorporated into a checklist. Standard checklists may be developed and used for various types of construction projects (e.g., channel work, large-scale phased construction projects, or small urban sites). This kind of tool can help ensure the proper function of BMPs and provide a consistent approach to required documentation.

All evaluations of pollutant sources should consider the following:

- Is this a new pollutant source that will need to be included on the inspection?
- Is this existing pollutant source protected with a Control Measure?
- Is the Control Measure functioning to keep the pollutant source from being transported?
- Is there a need for additional Control Measures?

All evaluations of Control Measures should consider the following:

- Installed per design and matches the Erosion Control Materials/SWMP
- In working condition and should be monitored

- Maintenance needed and should be added to the schedule for repair
- Not effective and should have a more effective Control Measure installed
- No longer needed and should be removed as the pollutant source is no longer present

Repair or corrective measures records should include:

- What was repaired?
- When it was repaired?
- When it was identified in need of repair?
- Who corrected the repair?

As these records can very it is the Developing party's responsibility to find an inspection mechanism that works for their business practices and meets the above criteria.

6.10.2 Erosion Control Administrator

Requirements are found in Section 2.2.3 of Chapter 3.

The Erosion Control Administrator should review the accepted Erosion Control Materials for the project and become familiar with all the documents. If the approved documents were not provided by the Developer or Design Engineer, consultation with them is required.

Any supplemental documents and supporting materials should be gathered by the Erosion Control Administrator. Any additions or amendments of the Erosion Control Materials or SWMP should follow the required process to fully depict and articulate what the project will be doing.

The Erosion Control Administrator is responsible to keep materials up to date and reflect the current field conditions. This means the Control Measures should be accurately located on the map and should be installed to the exact detail specifications. Please note that either the drawing needs to be reflective of the site or the site will need to change to meet the drawings. Either way the site should look identical to the plans.

Modifying the current site map should be initialed and dated next to the modifications and preferably in a color easily identifiable and legible. The site map should be hung in a visible area that can be accessed by site personnel and the inspector if needed. These are typically found in a job trailer or placed in the SWMP mail box.

The Erosion Control Administrator should plan upcoming Construction Activities and anticipate what changes on site are going to occur that may significantly change the pollutant sources on the site and determine the proper controls to prevent of site discharge of those materials. Most discharge issues can be prevented from the beginning with some forethought.

Effective construction site stormwater management implementation involves the following:

- Consulting the accepted Erosion Control Materials
- Maintaining Control Measures in an effective condition
- Evaluating the Control Measures periodically for effectiveness
- Continual updating the Erosion Control Materials as construction progresses

6.11 Removal of Temporary Measures

Most Control Measures can be removed as soon as possible so long as the contributing drainage no longer has a pollutant discharge potential. Temporary erosion Control Measures should not be removed until all areas tributary to the temporary controls have achieved final stabilization. It may be necessary to maintain some of the Control Measures for an extended period of time, until the up-gradient areas have been fully stabilized, and vegetation has sufficiently matured to provide adequate cover. Trapped sediment and disturbed soil areas resulting from the disposal of temporary measures must be returned to final plan grades and permanently stabilized to prevent further soil erosion.

The Control Measure fact sheets in Section 6.0 of Chapter 4 provide guidance for final disposition of temporary measures. This may be as simple as removing silt fence, or more complex things such as removing accumulated sediment from a construction phase sedimentation basin that will be used as a post-construction extended detention basin. Some biodegradable Control Measures, such as erosion control blankets, are designed to remain in place and would create new areas of disturbance if removed. See the specific Control Measure fact sheets for guidance on if and how the Control Measure may be left in place as a part of final stabilization. For some Control Measures such as sediment control logs/straw wattles, some materials may be biodegradable (straw) but there may be components of the measure that biodegrade slowly (stakes) or not at all (plastic netting). Always check requirements for guidance on construction BMPs that may remain in place.

Whenever post-construction Control Measures are used for temporary Control Measures during construction, the plan should include the steps and actions needed to refurbish these facilities to a fully operational form of the post-construction Control Measure. The final site work will not be accepted by Fort Collins as complete until these permanent controls are in final and acceptable form. This includes lines and grades, volumes, outlet structures, trash racks, landscaping and other measures specified in the site development plans prepared by the Design Engineer.

6.12 Enforcement

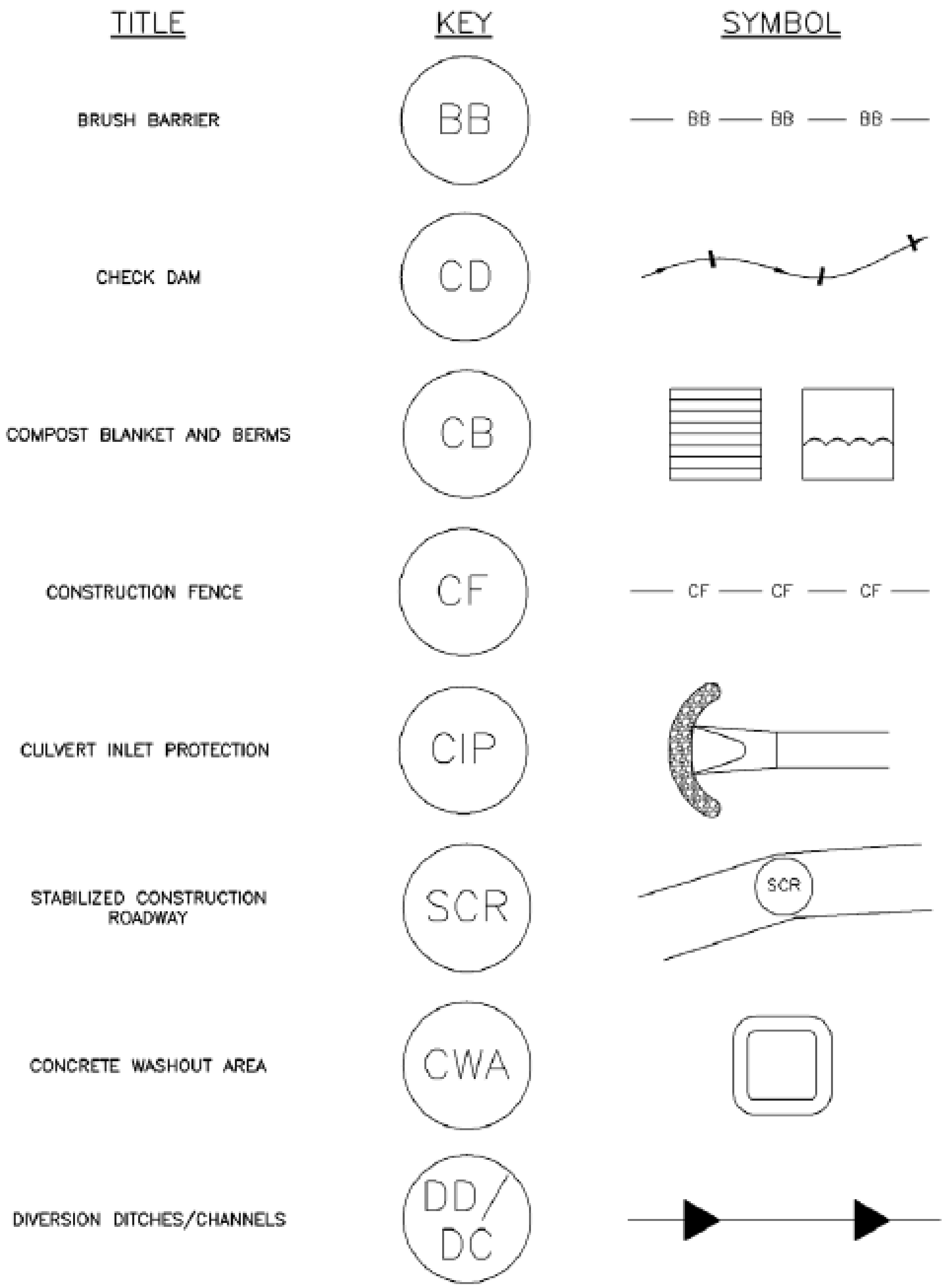
Inspection tips to avoid enforcement

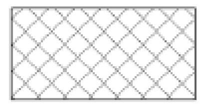
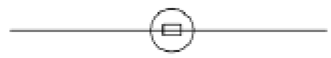
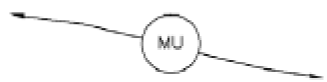
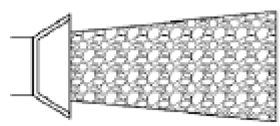
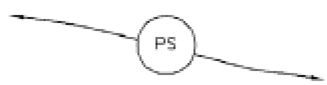
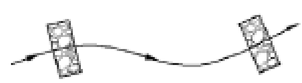
1. Have routine inspections been performed?
2. Do the SWMP and Erosion Control Plans match current site conditions?
3. Have the Control Measures been installed and followed exactly per standards and/or details?
4. Have the Control Measures been properly maintained exactly per design?
5. Are there signs of sediment leaving the site by street or pipe or other conveyance?
6. Are all sensitive areas protected?
7. Are stockpiles and hazardous materials properly contained on site and per design?
8. Is there a Spill Prevention Plan and is it being followed?
9. Are the inactive or completed areas stabilized?
10. Have the corrective actions from previous inspections been addressed?
11. Are the employees, contractors, or sub-contractors adequately trained?
12. Are personal vehicles kept off site?
13. Have all the trash and spills been cleaned up and placed in the appropriate disposal method?
14. Has all the possible chemicals been prevented from making contact with precipitation?
15. Are all the entrances cleaned?
16. All the inlet protection fixed up with no gaps or dislodged?

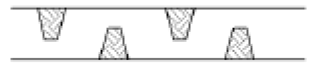
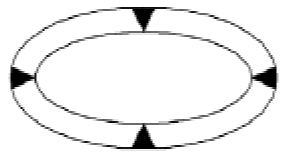
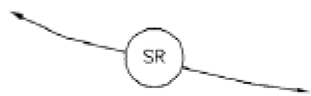
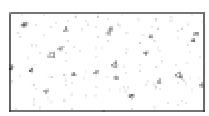
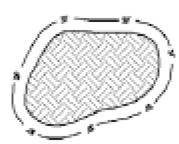
From inspection data the number one issue complained about from citizens is tracking sediment off site. Also from that same data, the number one finding of any Control Measure failures whether it is on installation, maintenance or repair is overwhelmingly inlet protection.

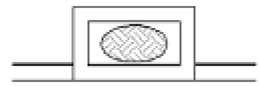
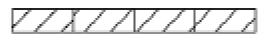
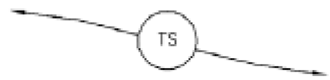
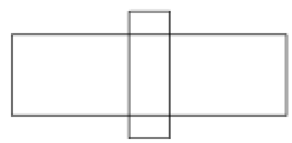
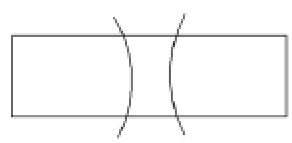
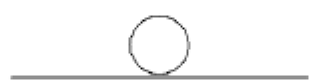
7.0 Construction Plan Symbols

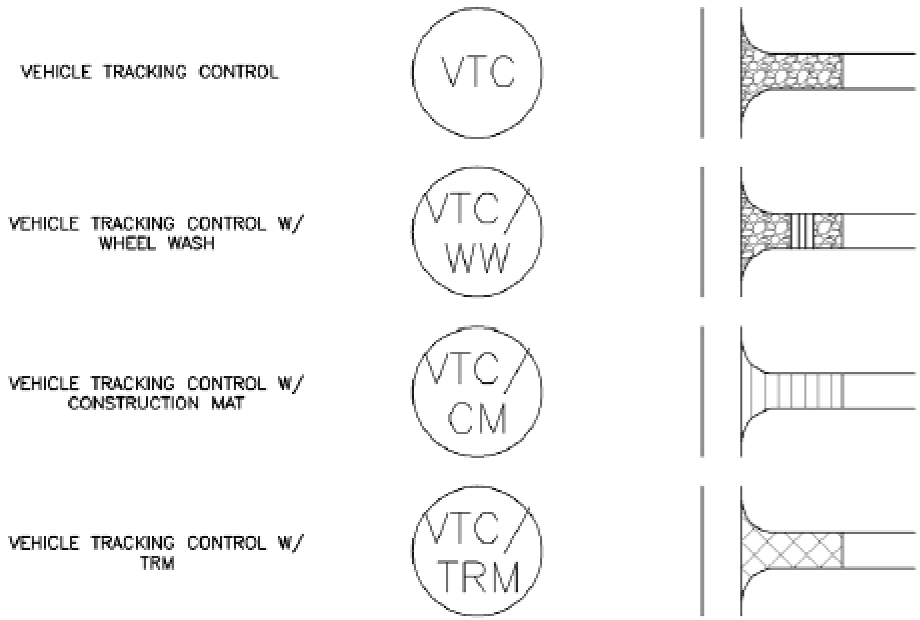
Included is a list of Control Measures with typical symbols and legend keys to clearly identify the Control Measures that are planned on a project.



TITLE	KEY	SYMBOL
DEWATERING OPERATIONS	DW	
EARTH DIKES AND DRAINAGE SWALES	ED/DS	
EROSION CONTROL BLANKET	ECB TRM	
INLET PROTECTION	IP	
MULCHING	MU	
OUTLET PROTECTION	OP	
PERMANENT SEEDING	PS	
REINFORCED CHECK DAM	RCD	

TITLE	KEY	SYMBOL
ROCK SOCKS	RS	
ROUGH CUT STREET CONTROL	RCS	
SEDIMENT BASIN	SB	
SEDIMENT CONTROL LOG	SCL	
SILT FENCE	SF	
SURFACE ROUGHENING	SR	
STABILIZED STAGING AREA	SSA	
STOCKPILE MANAGEMENT W/ PROTECTION	SP	

STOCKPILE MANAGEMENT W/ PROTECTION IN ROADWAY	SPR	
STRAW BALE BARRIER	SBB	
SEDIMENT TRAP	ST	
TEMPORARY SEEDING	TS	
TERRACING	TER	
TEMPORARY STREAM CROSSING W/CULVERT	TSCC	
TEMPORARY STREAM CROSSING W/FORD	TSCF	
TEMPORARY SLOPE DRAIN	TSD	


VEHICLE TRACKING CONTROL
VTC
VEHICLE TRACKING CONTROL W/ WHEEL WASH
VTC/ WW
VEHICLE TRACKING CONTROL W/ CONSTRUCTION MAT
VTC/ CM
VEHICLE TRACKING CONTROL W/ TRM
VTC/ TRM

Appendix E:
Construction Control Measures Fact Sheets

Description

Photograph SR-1. Surface roughening via imprinting for temporary stabilization.

Surface roughening is an erosion control practice that involves tracking, scarifying, imprinting, or tilling a disturbed area to provide temporary stabilization of disturbed areas. Surface roughening creates variations in the soil surface that help to minimize wind and water erosion. Depending on the technique used, surface roughening may also help establish conditions favorable to establishment of vegetation.

Appropriate Uses

Surface roughening can be used to provide temporary stabilization of disturbed areas, such as when revegetation cannot be immediately established due to seasonal planting limitations. Surface roughening is not a stand-alone BMP, and should be used in conjunction with other erosion and sediment controls.

Surface roughening is often implemented in conjunction with grading and is typically performed using heavy construction equipment to track the surface. Be aware that tracking with heavy equipment will also compact soils, which is not desirable in areas that will be revegetated. Scarifying, tilling, or ripping are better surface roughening techniques in locations where revegetation is planned. Roughening is not effective in very sandy soils and cannot be effectively performed in rocky soil.

Design and Installation

Typical design details for surfacing roughening on steep and mild slopes are provided in Details SR-1 and SR-2, respectively.

Surface roughening should be performed either after final grading or to temporarily stabilize an area during active construction that may be inactive for a short time period. Surface roughening should create depressions 2 to 6 inches deep and approximately 6 inches apart. The surface of exposed soil can be roughened by a number of techniques and equipment. Horizontal grooves (running parallel to the contours of the land) can be made using tracks from equipment treads, stair-step grading, ripping, or tilling.

Fill slopes can be constructed with a roughened surface. Cut slopes that have been smooth graded can be roughened as a subsequent operation. Roughening should follow along the contours of the slope. The tracks left by truck mounted equipment working perpendicular to the contour can leave acceptable horizontal depressions; however, the equipment will also compact the soil.

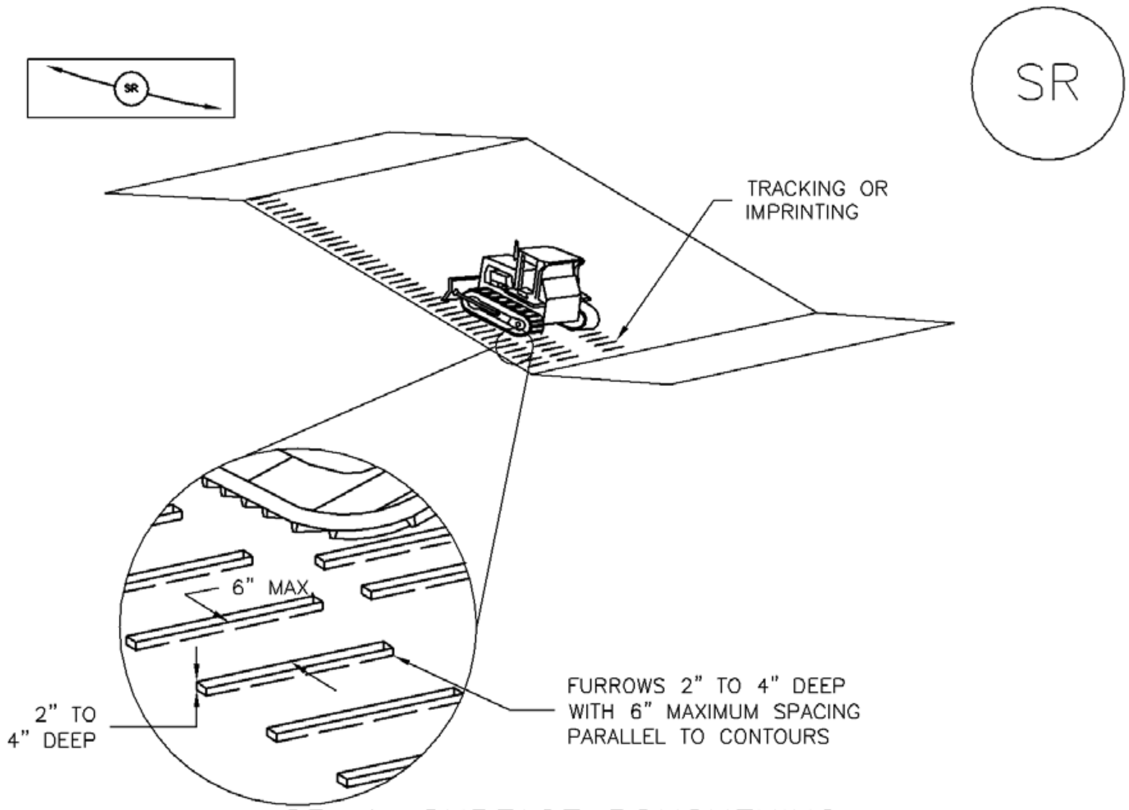
Surface Roughening	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	No

Maintenance and Removal

Care should be taken not to drive vehicles or equipment over areas that have been surface roughened. Tire tracks will smooth the roughened surface and may cause runoff to collect into rills and gullies.

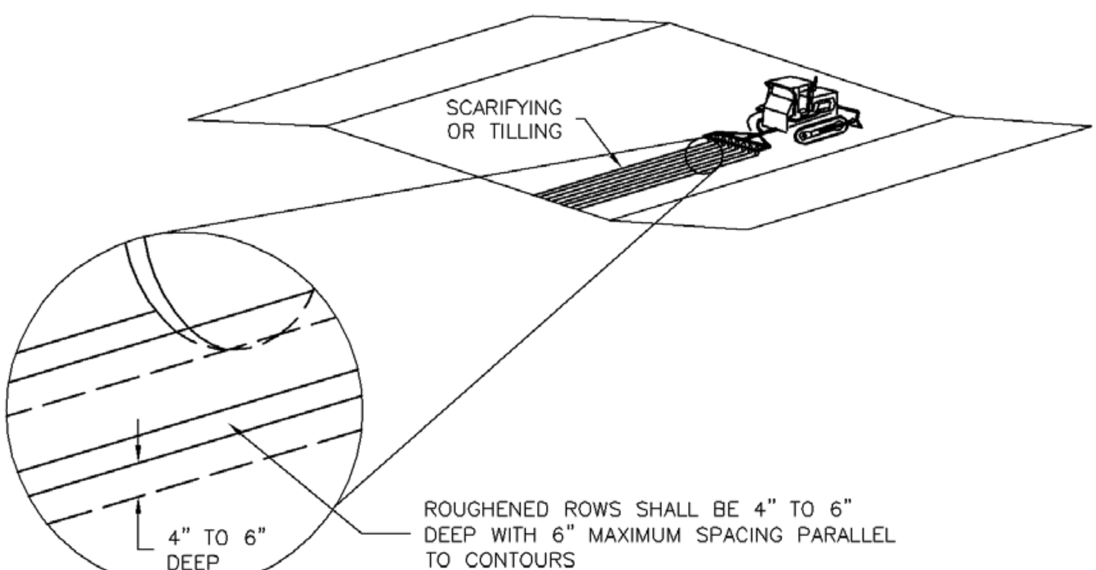
Because surface roughening is only a temporary control, additional treatments may be necessary to maintain the soil surface in a roughened condition.

Areas should be inspected for signs of erosion. Surface roughening is a temporary measure, and will not provide long-term erosion control.



SR–1. SURFACE ROUGHENING

FOR STEEP SLOPES (3:1 OR STEEPER)



SR–2. SURFACE ROUGHENING

FOR LOW SLOPES (LESS THAN 3:1)

SURFACE ROUGHENING INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   -LOCATION(S) OF SURFACE ROUGHENING.

2. SURFACE ROUGHENING SHALL BE PROVIDED PROMPTLY AFTER COMPLETION OF FINISHED GRADING (FOR AREAS NOT RECEIVING TOPSOIL) OR PRIOR TO TOPSOIL PLACEMENT OR ANY FORECASTED RAIN EVENT.

3. AREAS WHERE BUILDING FOUNDATIONS, PAVEMENT, OR SOD WILL BE PLACED WITHOUT DELAY IN THE CONSTRUCTION SEQUENCE, SURFACE ROUGHENING IS NOT REQUIRED.

4. DISTURBED SURFACES SHALL BE ROUGHENED USING RIPPING OR TILLING EQUIPMENT ON THE CONTOUR OR TRACKING UP AND DOWN A SLOPE USING EQUIPMENT TREADS.

5. A FARMING DISK SHALL NOT BE USED FOR SURFACE ROUGHENING.

SURFACE ROUGHENING MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACE UPON DISCOVERY OF THE FAILURE.

4. VEHICLES AND EQUIPMENT SHALL NOT BE DRIVEN OVER AREAS THAT HAVE BEEN SURFACE ROUGHENED.

5. IN NON-TURF GRASS FINISHED AREAS, SEEDING AND MULCHING SHALL TAKE PLACE DIRECTLY OVER SURFACE ROUGHENED AREAS WITHOUT FIRST SMOOTHING OUT THE SURFACE.

6. IN AREAS NOT SEEDED AND MULCHED AFTER SURFACE ROUGHENING, SURFACES SHALL BE RE-ROUGHENED AS NECESSARY TO MAINTAIN GROOVE DEPTH AND SMOOTH OVER RILL EROSION.

(DETAILS ADAPTED FROM TOWN OF PARKER, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

Temporary seeding can be used to stabilize disturbed areas that will be inactive for an extended period. Permanent seeding should be used to stabilize areas at final grade that will not be otherwise stabilized. Effective seeding includes preparation of a seedbed, selection of an appropriate seed mixture, proper planting techniques, and protection of the seeded area with mulch, geotextiles, or other appropriate measures.

Photograph TS/PS -1. Equipment used to drill seed. Photo courtesy of Douglas County.

Appropriate Uses

When the soil surface is disturbed and will remain inactive for an extended period (typically 30 days or longer), proactive stabilization measures should be implemented. If the inactive period is short-lived (on the order of two weeks), techniques such as surface roughening may be appropriate. For longer periods of inactivity, temporary seeding and mulching can provide effective erosion control. Permanent seeding should be used on finished areas that have not been otherwise stabilized.

Typically, local governments have their own seed mixes and timelines for seeding. Check jurisdictional requirements for seeding and temporary stabilization.

Design and Installation

Effective seeding requires proper seedbed preparation, selection of an appropriate seed mixture, use of appropriate seeding equipment to ensure proper coverage and density, and protection with mulch or fabric until plants are established.

The USDCM Volume 2 *Revegetation* Chapter contains detailed seed mix, soil preparations, and seeding and mulching recommendations that may be referenced to supplement this Fact Sheet.

Drill seeding is the preferred seeding method. Hydroseeding is not recommended except in areas where steep slopes prevent use of drill seeding equipment, and even in these instances it is preferable to hand seed and mulch. Some jurisdictions do not allow hydroseeding or hydromulching.

Seedbed Preparation

Prior to seeding, ensure that areas to be revegetated have soil conditions capable of supporting vegetation. Overlot grading can result in loss of topsoil, resulting in poor quality subsoils at the ground surface that have low nutrient value, little organic matter content, few soil microorganisms, rooting restrictions, and conditions less conducive to infiltration of precipitation. As a result, it is typically necessary to provide stockpiled topsoil, compost, or other

Temporary and Permanent Seeding	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	No

soil amendments and rototill them into the soil to a depth of 6 inches or more.

Topsoil should be salvaged during grading operations for use and spread on areas to be revegetated later. Topsoil should be viewed as an important resource to be utilized for vegetation establishment, due to its water-holding capacity, structure, texture, organic matter content, biological activity, and nutrient content. The rooting depth of most native grasses in the semi-arid Denver metropolitan area is 6 to 18 inches. At a minimum, the upper 6 inches of topsoil should be stripped, stockpiled, and ultimately respread across areas that will be revegetated.

Where topsoil is not available, subsoils should be amended to provide an appropriate plant-growth medium. Organic matter, such as well digested compost, can be added to improve soil characteristics conducive to plant growth. Other treatments can be used to adjust soil pH conditions when needed. Soil testing, which is typically inexpensive, should be completed to determine and optimize the types and amounts of amendments that are required.

If the disturbed ground surface is compacted, rip or rototill the surface prior to placing topsoil. If adding compost to the existing soil surface, rototilling is necessary. Surface roughening will assist in placement of a stable topsoil layer on steeper slopes, and allow infiltration and root penetration to greater depth.

Prior to seeding, the soil surface should be rough and the seedbed should be firm, but neither too loose nor compacted. The upper layer of soil should be in a condition suitable for seeding at the proper depth and conducive to plant growth. Seed-to-soil contact is the key to good germination.

Seed Mix for Temporary Vegetation

To provide temporary vegetative cover on disturbed areas which will not be paved, built upon, or fully landscaped or worked for an extended period (typically 30 days or more), plant an annual grass appropriate for the time of planting and mulch the planted areas. Annual grasses suitable for the Denver metropolitan area are listed in Table TS/PS-1. These are to be considered only as general recommendations when specific design guidance for a particular site is not available. Local governments typically specify seed mixes appropriate for their jurisdiction.

Seed Mix for Permanent Revegetation

To provide vegetative cover on disturbed areas that have reached final grade, a perennial grass mix should be established. Permanent seeding should be performed promptly (typically within 14 days) after reaching final grade. Each site will have different characteristics and a landscape professional or the local jurisdiction should be contacted to determine the most suitable seed mix for a specific site. In lieu of a specific recommendation, one of the perennial grass mixes appropriate for site conditions and growth season listed in Table TS/PS-2 can be used. The pure live seed (PLS) rates of application recommended in these tables are considered to be absolute minimum rates for seed applied using proper drill-seeding equipment.

If desired for wildlife habitat or landscape diversity, shrubs such as rubber rabbitbrush (*Chrysothamnus nauseosus*), fourwing saltbush (*Atriplex canescens*) and skunkbrush sumac (*Rhus trilobata*) could be added to the upland seedmixes at 0.25, 0.5 and 1 pound PLS/acre, respectively. In riparian zones, planting root stock of such species as American plum (*Prunus americana*), woods rose (*Rosa woodsii*), plains cottonwood (*Populus sargentii*), and willow (*Populus spp.*) may be considered. On non-topsoiled upland sites, a legume such as Ladak alfalfa at 1 pound PLS/acre can be included as a source of nitrogen for perennial grasses.

Seeding dates for the highest success probability of perennial species along the Front Range are generally in the spring from April through early May and in the fall after the first of September until the ground freezes. If the area is irrigated, seeding may occur in summer months, as well. See Table TS/PS-3 for appropriate seeding dates.

Table TS/PS-1. Minimum Drill Seeding Rates for Various Temporary Annual Grasses

Species[a] (Common name)	Growth Season[b]	Pounds of Pure Live Seed (PLS)/acre[c]	Planting Depth (inches)
1. Oats	Cool	35 - 50	1 - 2
2. Spring wheat	Cool	25 - 35	1 - 2
3. Spring barley	Cool	25 - 35	1 - 2
4. Annual ryegrass	Cool	10 - 15	½
5. Millet	Warm	3 - 15	½ - ¾
6. Sudangrass	Warm	5–10	½ - ¾
7. Sorghum	Warm	5–10	½ - ¾
8. Winter wheat	Cool	20–35	1 - 2
9. Winter barley	Cool	20–35	1 - 2
10. Winter rye	Cool	20–35	1 - 2
11. Triticale	Cool	25–40	1 - 2

[a] Successful seeding of annual grass resulting in adequate plant growth will usually produce enough dead-plant residue to provide protection from wind and water erosion for an additional year. This assumes that the cover is not disturbed or mowed closer than 8 inches.

Hydraulic seeding may be substituted for drilling only where slopes are steeper than 3:1 or where access limitations exist. When hydraulic seeding is used, hydraulic mulching should be applied as a separate operation, when practical, to prevent the seeds from being encapsulated in the mulch.

[b] See Table TS/PS-3 for seeding dates. Irrigation, if consistently applied, may extend the use of cool season species during the summer months.

[c] Seeding rates should be doubled if seed is broadcast, or increased by 50 percent if done using a Brillion Drill or by hydraulic seeding.

Table TS/PS-2. Minimum Drill Seeding Rates for Perennial Grasses

Common[a] Name	Botanical Name	Growth Season[b]	Growth Form	Seeds/ Pound	Pounds of PLS/acre
Alakali Soil Seed Mix					
Alkali sacaton	*Sporobolus airoides*	Cool	Bunch	1,750,000	0.25
Basin wildrye	*Elymus cinereus*	Cool	Bunch	165,000	2.5
Sodar streambank wheatgrass	*Agropyron riparium 'Sodar'*	Cool	Sod	170,000	2.5
Jose tall wheatgrass	*Agropyron elongatum 'Jose'*	Cool	Bunch	79,000	7.0
Arriba western wheatgrass	*Agropyron smithii 'Arriba'*	Cool	Sod	110,000	5.5
Total					**17.75**
Fertile Loamy Soil Seed Mix					
Ephriam crested wheatgrass	*Agropyron cristatum 'Ephriam'*	Cool	Sod	175,000	2.0
Dural hard fescue	*Festuca ovina 'duriuscula'*	Cool	Bunch	565,000	1.0
Lincoln smooth brome	*Bromus inermis leyss 'Lincoln'*	Cool	Sod	130,000	3.0
Sodar streambank wheatgrass	*Agropyron riparium 'Sodar'*	Cool	Sod	170,000	2.5
Arriba western wheatgrass	*Agropyron smithii 'Arriba'*	Cool	Sod	110,000	7.0
Total					**15.5**
High Water Table Soil Seed Mix					
Meadow foxtail	*Alopecurus pratensis*	Cool	Sod	900,000	0.5
Redtop	*Agrostis alba*	Warm	Open sod	5,000,000	0.25
Reed canarygrass	*Phalaris arundinacea*	Cool	Sod	68,000	0.5
Lincoln smooth brome	*Bromus inermis leyss 'Lincoln'*	Cool	Sod	130,000	3.0
Pathfinder switchgrass	*Panicum virgatum 'Pathfinder'*	Warm	Sod	389,000	1.0
Alkar tall wheatgrass	*Agropyron elongatum 'Alkar'*	Cool	Bunch	79,000	5.5
Total					**10.75**
Transition Turf Seed Mix[c]					
Ruebens Canadian bluegrass	*Poa compressa 'Ruebens'*	Cool	Sod	2,500,000	0.5
Dural hard fescue	*Festuca ovina 'duriuscula'*	Cool	Bunch	565,000	1.0
Citation perennial ryegrass	*Lolium perenne 'Citation'*	Cool	Sod	247,000	3.0
Lincoln smooth brome	*Bromus inermis leyss 'Lincoln'*	Cool	Sod	130,000	3.0
Total					**7.5**

Table TS/PS-2. Minimum Drill Seeding Rates for Perennial Grasses (cont.)

Common Name	Botanical Name	Growth Season[b]	Growth Form	Seeds/ Pound	Pounds of PLS/acre
Sandy Soil Seed Mix					
Blue grama	*Bouteloua gracilis*	Warm	Sod-forming bunchgrass	825,000	0.5
Camper little bluestem	*Schizachyrium scoparium 'Camper'*	Warm	Bunch	240,000	1.0
Prairie sandreed	*Calamovilfa longifolia*	Warm	Open sod	274,000	1.0
Sand dropseed	*Sporobolus cryptandrus*	Cool	Bunch	5,298,000	0.25
Vaughn sideoats grama	*Bouteloua curtipendula 'Vaughn'*	Warm	Sod	191,000	2.0
Arriba western wheatgrass	*Agropyron smithii 'Arriba'*	Cool	Sod	110,000	5.5
Total					**10.25**
Heavy Clay, Rocky Foothill Seed Mix					
Ephriam crested wheatgrass[d]	*Agropyron cristatum 'Ephriam'*	Cool	Sod	175,000	1.5
Oahe Intermediate wheatgrass	*Agropyron intermedium 'Oahe'*	Cool	Sod	115,000	5.5
Vaughn sideoats grama[e]	*Bouteloua curtipendula 'Vaughn'*	Warm	Sod	191,000	2.0
Lincoln smooth brome	*Bromus inermis leyss 'Lincoln'*	Cool	Sod	130,000	3.0
Arriba western wheatgrass	*Agropyron smithii 'Arriba'*	Cool	Sod	110,000	5.5
Total					**17.5**

[a] All of the above seeding mixes and rates are based on drill seeding followed by crimped hay or straw mulch. These rates should be doubled if seed is broadcast and should be increased by 50 percent if the seeding is done using a Brillion Drill or is applied through hydraulic seeding. Hydraulic seeding may be substituted for drilling only where slopes are steeper than 3:1. If hydraulic seeding is used, hydraulic mulching should be done as a separate operation.

[b] See Table TS/PS-3 for seeding dates.

[c] If site is to be irrigated, the transition turf seed rates should be doubled.

[d] Crested wheatgrass should not be used on slopes steeper than 6H to 1V.

[e] Can substitute 0.5 lbs PLS of blue grama for the 2.0 lbs PLS of Vaughn sideoats grama.

Table TS/PS-3. Seeding Dates for Annual and Perennial Grasses

	Annual Grasses (Numbers in table reference species in Table TS/PS-1)		Perennial Grasses	
Seeding Dates	**Warm**	**Cool**	**Warm**	**Cool**
January 1–March 15			✓	✓
March 16–April 30	4	1,2,3	✓	✓
May 1–May 15	4		✓	
May 16–June 30	4,5,6,7			
July 1–July 15	5,6,7			
July 16–August 31				
September 1–September 30		8,9,10,11		
October 1–December 31			✓	✓

Mulch

Cover seeded areas with mulch or an appropriate rolled erosion control product to promote establishment of vegetation. Anchor mulch by crimping, netting or use of a non-toxic tackifier. See the Mulching BMP Fact Sheet for additional guidance.

Maintenance and Removal

Monitor and observe seeded areas to identify areas of poor growth or areas that fail to germinate. Reseed and mulch these areas, as needed.

An area that has been permanently seeded should have a good stand of vegetation within one growing season if irrigated and within three growing seasons without irrigation in Colorado. Reseed portions of the site that fail to germinate or remain bare after the first growing season.

Seeded areas may require irrigation, particularly during extended dry periods. Targeted weed control may also be necessary.

Protect seeded areas from construction equipment and vehicle access.

Description

Soil binders include a broad range of treatments that can be applied to exposed soils for temporary stabilization to reduce wind and water erosion. Soil binders may be applied alone or as tackifiers in conjunction with mulching and seeding applications.

Acknowledgement: This BMP Fact Sheet has been adapted from the 2003 California Stormwater Quality Association (CASQA) Stormwater BMP Handbook: Construction (www.cabmphandbooks.com).

Photograph SB-1. Tackifier being applied to provide temporary soil stabilization. Photo courtesy of Douglas County.

Appropriate Uses

Soil binders can be used for short-term, temporary stabilization of soils on both mild and steep slopes. Soil binders are often used in areas where work has temporarily stopped, but is expected to resume before revegetation can become established. Binders are also useful on stockpiled soils or where temporary or permanent seeding has occurred.

Prior to selecting a soil binder, check with the state and local jurisdiction to ensure that the chemicals used in the soil binders are allowed. The water quality impacts of some types of soil binders are relatively unknown and may not be allowed due to concerns about potential environmental impacts. Soil binders must be environmentally benign (non-toxic to plant and animal life), easy to apply, easy to maintain, economical, and should not stain paved or painted surfaces.

Soil binders should not be used in vehicle or pedestrian high traffic areas, due to loss in effectiveness under these conditions.

Site soil type will dictate appropriate soil binders to be used. Be aware that soil binders may not function effectively on silt or clay soils or highly compacted areas. Check manufacturer's recommendations for appropriateness with regard to soil conditions. Some binders may not be suitable for areas with existing vegetation.

Design and Installation

Properties of common soil binders used for erosion control are provided in Table SB-1. Design and installation guidance below are provided for general reference. Follow the manufacturer's instructions for application rates and procedures.

Soil Binders	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	Moderate

Table SB-1. Properties of Soil Binders for Erosion Control (Source: CASQA 2003)

Evaluation Criteria	Binder Type			
	Plant Material Based (short lived)	**Plant Material Based (long lived)**	**Polymeric Emulsion Blends**	**Cementitious-Based Binders**
Resistance to Leaching	High	High	Low to Moderate	Moderate
Resistance to Abrasion	Moderate	Low	Moderate to High	Moderate to High
Longevity	Short to Medium	Medium	Medium to Long	Medium
Minimum Curing Time before Rain	9 to 18 hours	19 to 24 hours	0 to 24 hours	4 to 8 hours
Compatibility with Existing Vegetation	Good	Poor	Poor	Poor
Mode of Degradation	Biodegradable	Biodegradable	Photodegradable/ Chemically Degradable	Photodegradable/ Chemically Degradable
Specialized Application Equipment	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher
Liquid/Powder	Powder	Liquid	Liquid/Powder	Powder
Surface Crusting	Yes, but dissolves on rewetting	Yes	Yes, but dissolves on rewetting	Yes
Clean Up	Water	Water	Water	Water
Erosion Control Application Rate	Varies	Varies	Varies	4,000 to 12,000 lbs/acre Typ.

Factors to consider when selecting a soil binder generally include:

- **Suitability to situation**: Consider where the soil binder will be applied, if it needs a high resistance to leaching or abrasion, and whether it needs to be compatible with existing vegetation. Determine the length of time soil stabilization will be needed, and if the soil binder will be placed in an area where it will degrade rapidly. In general, slope steepness is not a discriminating factor.

- **Soil types and surface materials**: Fines and moisture content are key properties of surface materials. Consider a soil binder's ability to penetrate, likelihood of leaching, and ability to form a surface crust on the surface materials.

- **Frequency of application**: The frequency of application can be affected by subgrade conditions, surface type, climate, and maintenance schedule. Frequent applications could lead to high costs. Application frequency may be minimized if the soil binder has good penetration, low evaporation, and good longevity. Consider also that frequent application will require frequent equipment clean up.

An overview of major categories of soil binders, corresponding to the types included in Table SB-1 follows.

Plant-Material Based (Short Lived) Binders

- **Guar**: A non-toxic, biodegradable, natural galactomannan-based hydrocolloid treated with dispersant agents for easy field mixing. It should be mixed with water at the rate of 11 to 15 lbs per 1,000 gallons. Recommended minimum application rates are provided in Table SB-2.

Table SB-2. Application Rates for Guar Soil Stabilizer

	Slope (H:V)				
	Flat	4:1	3:1	2:1	1:1
Application Rate (lb/acre)	40	45	50	60	70

- **Psyllium**: Composed of the finely ground muciloid coating of plantago seeds that is applied as a wet slurry to the surface of the soil. It dries to form a firm but rewettable membrane that binds soil particles together but permits germination and growth of seed. Psyllium requires 12 to 18 hours drying time. Application rates should be from 80 to 200 lbs/acre, with enough water in solution to allow for a uniform slurry flow.

- **Starch**: Non-ionic, cold-water soluble (pre-gelatinized) granular cornstarch. The material is mixed with water and applied at the rate of 150 lb/acre. Approximate drying time is 9 to 12 hours.

Plant-Material Based (Long Lived) Binders

- **Pitch and Rosin Emulsion**: Generally, a non-ionic pitch and rosin emulsion has a minimum solids content of 48 percent. The rosin should be a minimum of 26 percent of the total solids content. The soil stabilizer should be a non-corrosive, water dilutable emulsion that upon application cures to a water insoluble binding and cementing agent. For soil erosion control applications, the emulsion is diluted and should be applied as follows:
  - For clayey soil: 5 parts water to 1 part emulsion

- For sandy soil: 10 parts water to 1 part emulsion

Application can be by water truck or hydraulic seeder with the emulsion and product mixture applied at the rate specified by the manufacturer.

Polymeric Emulsion Blend Binders

- **Acrylic Copolymers and Polymers**: Polymeric soil stabilizers should consist of a liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55 percent solids. The polymeric compound should be handled and mixed in a manner that will not cause foaming or should contain an anti-foaming agent. The polymeric emulsion should not exceed its shelf life or expiration date; manufacturers should provide the expiration date. Polymeric soil stabilizer should be readily miscible in water, non-injurious to seed or animal life, non-flammable, should provide surface soil stabilization for various soil types without inhibiting water infiltration, and should not re-emulsify when cured. The applied compound should air cure within a maximum of 36 to 48 hours. Liquid copolymer should be diluted at a rate of 10 parts water to 1 part polymer and the mixture applied to soil at a rate of 1,175 gallons/acre.

- **Liquid Polymers of Methacrylates and Acrylates**: This material consists of a tackifier/sealer that is a liquid polymer of methacrylates and acrylates. It is an aqueous 100 percent acrylic emulsion blend of 40 percent solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants or silicates. For soil stabilization applications, it is diluted with water in accordance with manufacturer's recommendations, and applied with a hydraulic seeder at the rate of 20 gallons/acre. Drying time is 12 to 18 hours after application.

- **Copolymers of Sodium Acrylates and Acrylamides**: These materials are non-toxic, dry powders that are copolymers of sodium acrylate and acrylamide. They are mixed with water and applied to the soil surface for erosion control at rates that are determined by slope gradient, as summarized in Table SB-3.

Table SB-3. Application Rates for Copolymers of Sodium Acrylates and Acrylamides

	Slope (H:V)		
	Flat to 5:1	5:1 to 3:1	2:2 to 1:1
Application Rate (lb/acre)	3.0-5.0	5.0-10.0	10.0-20.0

- **Polyacrylamide and Copolymer of Acrylamide**: Linear copolymer polyacrylamide is packaged as a dry flowable solid. When used as a stand-alone stabilizer, it is diluted at a rate of 11 lb/1,000 gal. of water and applied at the rate of 5.0 lb/acre.

- **Hydrocolloid Polymers**: Hydrocolloid Polymers are various combinations of dry flowable polyacrylamides, copolymers, and hydrocolloid polymers that are mixed with water and applied to the soil surface at rates of 55 to 60 lb/acre. Drying times are 0 to 4 hours.

Cementitious-Based Binders

- **Gypsum**: This formulated gypsum based product readily mixes with water and mulch to form a thin protective crust on the soil surface. It is composed of high purity gypsum that is ground, calcined and processed into calcium sulfate hemihydrate with a minimum purity of 86 percent. It is mixed in a hydraulic seeder and applied at rates 4,000 to 12,000 lb/acre. Drying time is 4 to 8 hours.

Installation

After selecting an appropriate soil binder, the untreated soil surface must be prepared before applying the soil binder. The untreated soil surface must contain sufficient moisture to assist the agent in achieving uniform distribution. In general, the following steps should be followed:

- Follow manufacturer's written recommendations for application rates, pre-wetting of application area, and cleaning of equipment after use.
- Prior to application, roughen embankment and fill areas.
- Consider the drying time for the selected soil binder and apply with sufficient time before anticipated rainfall. Soil binders should not be applied during or immediately before rainfall.
- Avoid over spray onto roads, sidewalks, drainage channels, sound walls, existing vegetation, etc.
- Soil binders should not be applied to frozen soil, areas with standing water, under freezing or rainy conditions, or when the temperature is below 40°F during the curing period.
- More than one treatment is often necessary, although the second treatment may be diluted or have a lower application rate.
- Generally, soil binders require a minimum curing time of 24 hours before they are fully effective. Refer to manufacturer's instructions for specific cure time.
- For liquid agents:
  - Crown or slope ground to avoid ponding.
  - Uniformly pre-wet ground at 0.03 to 0.3 gal/yd^2 or according to manufacturer's recommendations.
  - Apply solution under pressure. Overlap solution 6 to 12 in.
  - Allow treated area to cure for the time recommended by the manufacturer, typically at least 24 hours.
  - Apply second treatment before first treatment becomes ineffective, using 50 percent application rate.
  - In low humidity, reactivate chemicals by re-wetting with water at 0.1 to 0.2 gal/yd^2.

Maintenance and Removal

Soil binders tend to break down due to natural weathering. Weathering rates depend on a variety of site-specific and product characteristics. Consult the manufacturer for recommended reapplication rates and reapply the selected soil binder as needed to maintain effectiveness.

Soil binders can fail after heavy rainfall events and may require reapplication. In particular, soil binders will generally experience spot failures during heavy rainfall events. If runoff penetrates the soil at the top of a slope treated with a soil binder, it is likely that the runoff will undercut the stabilized soil layer and discharge at a point further down slope.

Areas where erosion is evident should be repaired and soil binder or other stabilization reapplied, as needed. Care should be exercised to minimize the damage to protected areas while making repairs.

Most binders biodegrade after exposure to sun, oxidation, heat and biological organisms; therefore, removal of the soil binder is not typically required.

Description

Photograph MU-1. An area that was recently seeded, mulched, and crimped.

Mulching consists of evenly applying straw, hay, shredded wood mulch, bark or compost to disturbed soils and securing the mulch by crimping, tackifiers, netting or other measures. Mulching helps reduce erosion by protecting bare soil from rainfall impact, increasing infiltration, and reducing runoff. Although often applied in conjunction with temporary or permanent seeding, it can also be used for temporary stabilization of areas that cannot be reseeded due to seasonal constraints.

Mulch can be applied either using standard mechanical dry application methods or using hydromulching equipment that hydraulically applies a slurry of water, wood fiber mulch, and often a tackifier.

Appropriate Uses

Use mulch in conjunction with seeding to help protect the seedbed and stabilize the soil. Mulch can also be used as a temporary cover on low to mild slopes to help temporarily stabilize disturbed areas where growing season constraints prevent effective reseeding. Disturbed areas should be properly mulched and tacked, or seeded, mulched and tacked promptly after final grade is reached (typically within no longer than 14 days) on portions of the site not otherwise permanently stabilized.

Standard dry mulching is encouraged in most jurisdictions; however, hydromulching may not be allowed in certain jurisdictions or may not be allowed near waterways.

Do not apply mulch during windy conditions.

Design and Installation

Prior to mulching, surface-roughen areas by rolling with a crimping or punching type roller or by track walking. Track walking should only be used where other methods are impractical because track walking with heavy equipment typically compacts the soil.

A variety of mulches can be used effectively at construction sites, including the following types:

Mulch	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	No

- Clean, weed- and seed-free, long-stemmed grass hay (preferred) or cereal grain straw. Hay is preferred because it is less susceptible to removal by wind. Mulch should be applied evenly at a rate of 2 tons per acre and must be tacked or fastened by an approved method suitable for the type of mulch used. At least 50 percent of the grass hay mulch, by weight, should be 10 inches or more in length.

- Grass hay mulch must be anchored and not merely placed on the surface. This can be accomplished mechanically by crimping or with the aid of tackifiers or nets. Anchoring with a crimping implement is preferred, and is the recommended method for areas flatter than 3:1. Mechanical crimpers must be capable of tucking the long mulch fibers into the soil to a depth of 3 inches without cutting them. An agricultural disk, while not an ideal substitute, may work if the disk blades are dull or blunted and set vertically; however, the frame may have to be weighted to afford proper soil penetration.

- On small areas sheltered from the wind and heavy runoff, spraying a tackifier on the mulch is satisfactory for holding it in place. For steep slopes and special situations where greater control is needed, erosion control blankets anchored with stakes should be used instead of mulch.

- Hydraulic mulching consists of wood cellulose fibers mixed with water and a tackifying agent and should be applied at a rate of no less than 1,500 pounds per acre (1,425 lbs of fibers mixed with at least 75 lbs of tackifier) with a hydraulic mulcher. For steeper slopes, up to 2000 pounds per acre may be required for effective hydroseeding. Hydromulch typically requires up to 24 hours to dry; therefore, it should not be applied immediately prior to inclement weather. Application to roads, waterways and existing vegetation should be avoided.

- Erosion control mats, blankets, or nets are recommended to help stabilize steep slopes (generally 3:1 and steeper) and waterways. Depending on the product, these may be used alone or in conjunction with grass or straw mulch. Normally, use of these products will be restricted to relatively small areas. Biodegradable mats made of straw and jute, straw-coconut, coconut fiber, or excelsior can be used instead of mulch. (See the ECM/TRM BMP for more information.)

- Some tackifiers or binders may be used to anchor mulch. Check with the local jurisdiction for allowed tackifiers. Manufacturer's recommendations should be followed at all times. (See the Soil Binder BMP for more information on general types of tackifiers.)

- Rock can also be used as mulch. It provides protection of exposed soils to wind and water erosion and allows infiltration of precipitation. An aggregate base course can be spread on disturbed areas for temporary or permanent stabilization. The rock mulch layer should be thick enough to provide full coverage of exposed soil on the area it is applied.

Maintenance and Removal

After mulching, the bare ground surface should not be more than 10 percent exposed. Reapply mulch, as needed, to cover bare areas.

Description

A compost blanket is a layer of compost uniformly applied to the soil in disturbed areas to control erosion, facilitate revegetation, and retain sediment resulting from sheet-flow runoff.

A compost filter berm is a dike of compost or a compost product that is placed perpendicular to runoff to control erosion in disturbed areas and retain sediment. Compost berms can be placed at regular intervals to help reduce the formation of rill and gully erosion when a compost blanket is stabilizing a slope.

Photograph CB-1. Application of a compost blanket to a disturbed area. Photo courtesy of Caltrans.

Appropriate Uses

Compost blankets can be used as an alternative to erosion control blankets and mulching to help stabilize disturbed areas where sheet flow conditions are present. Compost blankets should not be used in areas of concentrated flows. Compost provides an excellent source of nutrients for plant growth, and should be considered for use in areas that will be permanently vegetated.

Design and Installation

See Detail CB-1 for design details and notes.

Do not place compost in areas where it can easily be transported into drainage pathways or waterways. When using a compost blanket on a slope, berms should be installed periodically to reduce the potential for concentrated flow and rilling. Seeding should be completed before an area is composted or incorporated into the compost.

Compost quality is an important consideration when selecting compost blankets or berms. Representative compost quality factors include pH, salinity, moisture content, organic matter content, stability (maturity), and physical contaminants. The compost should meet all local, state, and federal quality requirements. Biosolids compost must meet the Standards for Class A biosolids outlined in 40 CFR Part 503. The U.S. Composting Council (USCC) certifies compost products under its Seal of Testing Assurance (STA) Program. Compost producers whose products have been certified through the STA Program provide customers with a standard product label that allows comparison between compost products. Only STA certified, Class I compost should be used.

Compost Blankets and Berms	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	No

Maintenance and Removal

When rills or gullies develop in an area that has been composted, fill and cover the area with additional compost and install berms as necessary to help reduce erosion.

Weed control can be a maintenance challenge in areas using compost blankets. A weed control strategy may be necessary, including measures such as mechanical removal and spot application of targeted herbicides by licensed applicators.

For compost berms, accumulated sediments should be removed from behind the berm when the sediments reach approximately one third the height of the berm. Areas that have been washed away should be replaced. If the berm has experienced significant or repeated washouts, a compost berm may not be the appropriate BMP for this area.

Compost blankets and berms biodegrade and do not typically require removal following site stabilization.

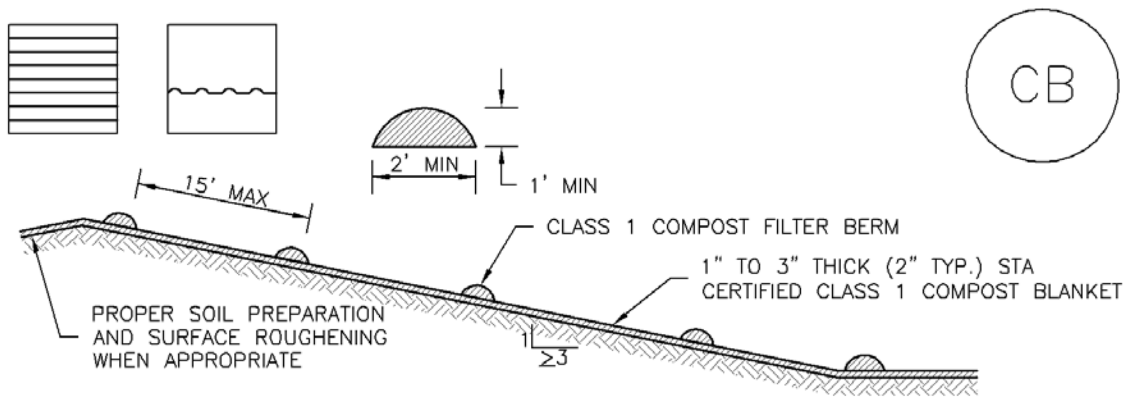


TABLE CB-1. CLASS 1 COMPOST	
PARAMETERS	CHARACTERISTIC
MINIMUM STABILITY INDICATOR	STABLE TO VERY STABLE
SOLUBLE SALTS	MAXIMUM 5 mmhos/cm
PH	6.0 – 8.0
AG INDEX	> 10
MATURITY INDICATOR EXPRESSED AS PERCENTAGE OF GERMINATION/VIGOR	80+/80+
MATURITY INDICATOR EXPRESSED AS AMMONIA N/ NITRATE N RATIO	< 4
MATURITY INDEX AS CARBON TO NITROGEN RATIO	20:1
TESTED FOR CLOPYRALID	YES/NEGATIVE RESULT
MOISTURE CONTENT	30–60%
ORGANIC MATTER CONTENT	25–45% OF DRY WEIGHT
PARTICLE SIZE DISTRIBUTION	3" (75mm) 100% PASSING
PRIMARY, SECONDARY NUTRIENTS; TRACE ELEMENTS	MUST BE REPORTED
TESTING AND TEST REPORT SUBMITTAL REQUIREMENTS	STA + CLOPYRALID
ORGANIC MATTER PER CUBIC YARD	MUST REPORT
CHEMICAL CONTAMINANTS	COMPLY WITH US EPA CLASS A STANDARD, 40 CFR 503.1 TABLES 1 & 3 LEVELS
MINIMUM MANUFACTURING/PRODUCTION REQUIREMENT	FULLY PERMITTED UNDER COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT, HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION
RISK FACTOR RELATING TO PLANT GERMINATION AND HEALTH	LOW

CB–1. COMPOST BLANKET AND COMPOST FILTER BERM

COMPOST FILTER BERM AND COMPOST BLANKET INSTALLATION NOTES

1. SEE PLAN VIEW FOR
   -LOCATION OF COMPOST FILTER BERM(S).
   -LENGTH OF COMPOST FILTER BERM(S).

2. COMPOST BERMS AND BLANKETS MAY BE USED IN PLACE OF STRAW MULCH OR GEOTEXTILE FABRIC IN AREAS WHERE ACCESS TO LANDSCAPING IS DIFFICULT DUE TO LANDSCAPING OR OTHER OBJECTS OR IN AREAS WHERE A SMOOTH TURF GRASS FINISH IS DESIRED.

3. FILTER BERMS SHALL RUN PARALLEL TO THE CONTOUR.

4. FILTER BERMS SHALL BE A MINIMUM OF 1 FEET HIGH AND 2 FEET WIDE.

5. FILTER BERMS SHALL BE APPLIED BY PNEUMATIC BLOWER OR BY HAND.

6. FILTER BERMS SHALL ONLY BE UTILIZED IN AREAS WHERE SHEET FLOW CONDITIONS PREVAIL AND NOT IN AREAS OF CONCENTRATED FLOW.

7. COMPOST BLANKETS SHALL BE APPLIED AT A DEPTH OF 1 -3 INCHES (TYPICALLY 2 INCHES). FOR AREAS WITH EXISTING VEGETATION THAT ARE TO BE SUPPLEMENTED BY COMPOST, A THIN 0.5-INCH LAYER MAY BE USED.

8. SEEDING SHALL BE PERFORMED PRIOR TO THE APPLICATION OF COMPOST. ALTERNATIVELY, SEED MAY BE COMBINED WITH COMPOST AND BLOWN WITH THE PNEUMATIC BLOWER.

9. WHEN TURF GRASS FINISH IS NOT DESIRED, SURFACE ROUGHENING ON SLOPES SHALL TAKE PLACE PRIOR TO COMPOST APPLICATION.

10. COMPOST SHALL BE A CLASS 1 COMPOST AS DEFINED BY TABLE CB-1.

COMPOST FILTER BERM MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. COMPOST BERMS AND BLANKETS SHALL BE REAPPLIED OR REGRADED AS NECESSARY IF RILLING IN THE COMPOST SURFACE OCCURS.

(DETAILS ADAPTED FROM ARAPAHOE COUNTY, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

Photograph RECP-1. Erosion control blanket protecting the slope from erosion and providing favorable conditions for revegetation.

Rolled Erosion Control Products (RECPs) include a variety of temporary or permanently installed manufactured products designed to control erosion and enhance vegetation establishment and survivability, particularly on slopes and in channels. For applications where natural vegetation alone will provide sufficient permanent erosion protection, temporary products such as netting, open weave textiles and a variety of erosion control blankets (ECBs) made of biodegradable natural materials (e.g., straw, coconut fiber) can be used. For applications where natural vegetation alone will not be sustainable under expected flow conditions, permanent rolled erosion control products such as turf reinforcement mats (TRMs) can be used. In particular, turf reinforcement mats are designed for discharges that exert velocities and sheer stresses that exceed the typical limits of mature natural vegetation.

Appropriate Uses

RECPs can be used to control erosion in conjunction with revegetation efforts, providing seedbed protection from wind and water erosion. These products are often used on disturbed areas on steep slopes, in areas with highly erosive soils, or as part of drainageway stabilization. In order to select the appropriate RECP for site conditions, it is important to have a general understanding of the general types of these products, their expected longevity, and general characteristics.

The Erosion Control Technology Council (ECTC 2005) characterizes rolled erosion control products according to these categories:

- **Mulch control netting**: A planar woven natural fiber or extruded geosynthetic mesh used as a temporary degradable rolled erosion control product to anchor loose fiber mulches.

- **Open weave textile**: A temporary degradable rolled erosion control product composed of processed natural or polymer yarns woven into a matrix, used to provide erosion control and facilitate vegetation establishment.

- **Erosion control blanket (ECB)**: A temporary degradable rolled erosion control product composed of processed natural or polymer fibers which are mechanically, structurally or chemically bound together to form a continuous matrix to provide erosion control and facilitate vegetation establishment. ECBs can be further differentiated into rapidly degrading single-net and double-net types or slowly degrading types.

Rolled Erosion Control Products	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	No

- **Turf Reinforcement Mat (TRM)**: A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh, and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.

Tables RECP-1 and RECP-2 provide guidelines for selecting rolled erosion control products appropriate to site conditions and desired longevity. Table RECP-1 is for conditions where natural vegetation alone will provide permanent erosion control, whereas Table RECP-2 is for conditions where vegetation alone will not be adequately stable to provide long-term erosion protection due to flow or other conditions.

Table RECP-1. ECTC Standard Specification for Temporary Rolled Erosion Control Products
(Adapted from Erosion Control Technology Council 2005)

Product Description	**Slope Applications***		**Channel Applications***	**Minimum Tensile Strength[1]**	**Expected Longevity**
	Maximum Gradient	C Factor[2,5]	Max. Shear Stress[3,4,6]		
Mulch Control Nets	5:1 (H:V)	≤0.10 @ 5:1	0.25 lbs/ft^2 (12 Pa)	5 lbs/ft (0.073 kN/m)	Up to 12 months
Netless Rolled Erosion Control Blankets	4:1 (H:V)	≤0.10 @ 4:1	0.5 lbs/ft^2 (24 Pa)	5 lbs/ft (0.073 kN/m)	
Single-net Erosion Control Blankets & Open Weave Textiles	3:1 (H:V)	≤0.15 @ 3:1	1.5 lbs/ft^2 (72 Pa)	50 lbs/ft (0.73 kN/m)	
Double-net Erosion Control Blankets	2:1 (H:V)	≤0.20 @ 2:1	1.75 lbs/ft^2 (84 Pa)	75 lbs/ft (1.09 kN/m)	
Mulch Control Nets	5:1 (H:V)	≤0.10 @ 5:1	0.25 lbs/ft^2 (12 Pa)	25 lbs/ft (0.36 kN/m)	24 months
Erosion Control Blankets & Open Weave Textiles (slowly degrading)	1.5:1 (H:V)	≤0.25 @ 1.5:1	2.00 lbs/ft^2 (96 Pa)	100 lbs/ft (1.45 kN/m)	24 months
Erosion Control Blankets & Open Weave Textiles	1:1 (H:V)	≤0.25 @ 1:1	2.25 lbs/ft^2 (108 Pa)	125 lbs/ft (1.82 kN/m)	36 months

* C Factor and shear stress for mulch control nettings must be obtained with netting used in conjunction with pre-applied mulch material. (*See Section 5.3 of Chapter 7 Construction BMPs for more information on the C Factor*.)

[1] Minimum Average Roll Values, Machine direction using ECTC Mod. ASTM D 5035.

[2] C Factor calculated as ratio of soil loss from RECP protected slope (tested at specified or greater gradient, H:V) to ratio of soil loss from unprotected (control) plot in large-scale testing.

[3] Required minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in) soil loss) during a 30-minute flow event in large-scale testing.

[4] The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 - 0.05.

[5] Acceptable large-scale test methods may include ASTM D 6459, or other independent testing deemed acceptable by the engineer.

[6] Per the engineer's discretion. Recommended acceptable large-scale testing protocol may include ASTM D 6460, or other independent testing deemed acceptable by the engineer.

Table RECP-2. ECTC Standard Specification for Permanent[1] Rolled Erosion Control Products
(Adapted from: Erosion Control Technology Council 2005)

Product Type	Slope Applications	Channel Applications	
	Maximum Gradient	Maximum Shear Stress[4,5]	Minimum Tensile Strength[2,3]
TRMs with a minimum thickness of 0.25 inches (6.35 mm) per ASTM D 6525 and UV stability of 80% per ASTM D 4355 (500 hours exposure).	0.5:1 (H:V)	6.0 lbs/ft^2 (288 Pa)	125 lbs/ft (1.82 kN/m)
	0.5:1 (H:V)	8.0 lbs/ft^2 (384 Pa)	150 lbs/ft (2.19 kN/m)
	0.5:1 (H:V)	10.0 lbs/ft^2 (480 Pa)	175 lbs/ft (2.55 kN/m)

[1] For TRMs containing degradable components, all property values must be obtained on the non-degradable portion of the matting alone.

[2] Minimum Average Roll Values, machine direction only for tensile strength determination using ASTM D 6818 (Supersedes Mod. ASTM D 5035 for RECPs)

[3] Field conditions with high loading and/or high survivability requirements may warrant the use of a TRM with a tensile strength of 44 kN/m (3,000 lb/ft) or greater.

[4] Required minimum shear stress TRM (fully vegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in.) soil loss) during a 30-minute flow event in large scale testing.

[5] Acceptable large-scale testing protocols may include ASTM D 6460, or other independent testing deemed acceptable by the engineer.

Design and Installation

RECPs should be installed according to manufacturer's specifications and guidelines. Regardless of the type of product used, it is important to ensure no gaps or voids exist under the material and that all corners of the material are secured using stakes and trenching. Continuous contact between the product and the soil is necessary to avoid failure. Never use metal stakes to secure temporary erosion control products. Often wooden stakes are used to anchor RECPs; however, wood stakes may present installation and maintenance challenges and generally take a long time to biodegrade. Some local jurisdictions have had favorable experiences using biodegradable stakes.

This BMP Fact Sheet provides design details for several commonly used ECB applications, including:

ECB-1 Pipe Outlet to Drainageway

ECB-2 Small Ditch or Drainageway

ECB-3 Outside of Drainageway

Staking patterns are also provided in the design details according to these factors:

- ECB type
- Slope or channel type

For other types of RECPs including TRMs, these design details are intended to serve as general guidelines for design and installation; however, engineers should adhere to manufacturer's installation recommendations.

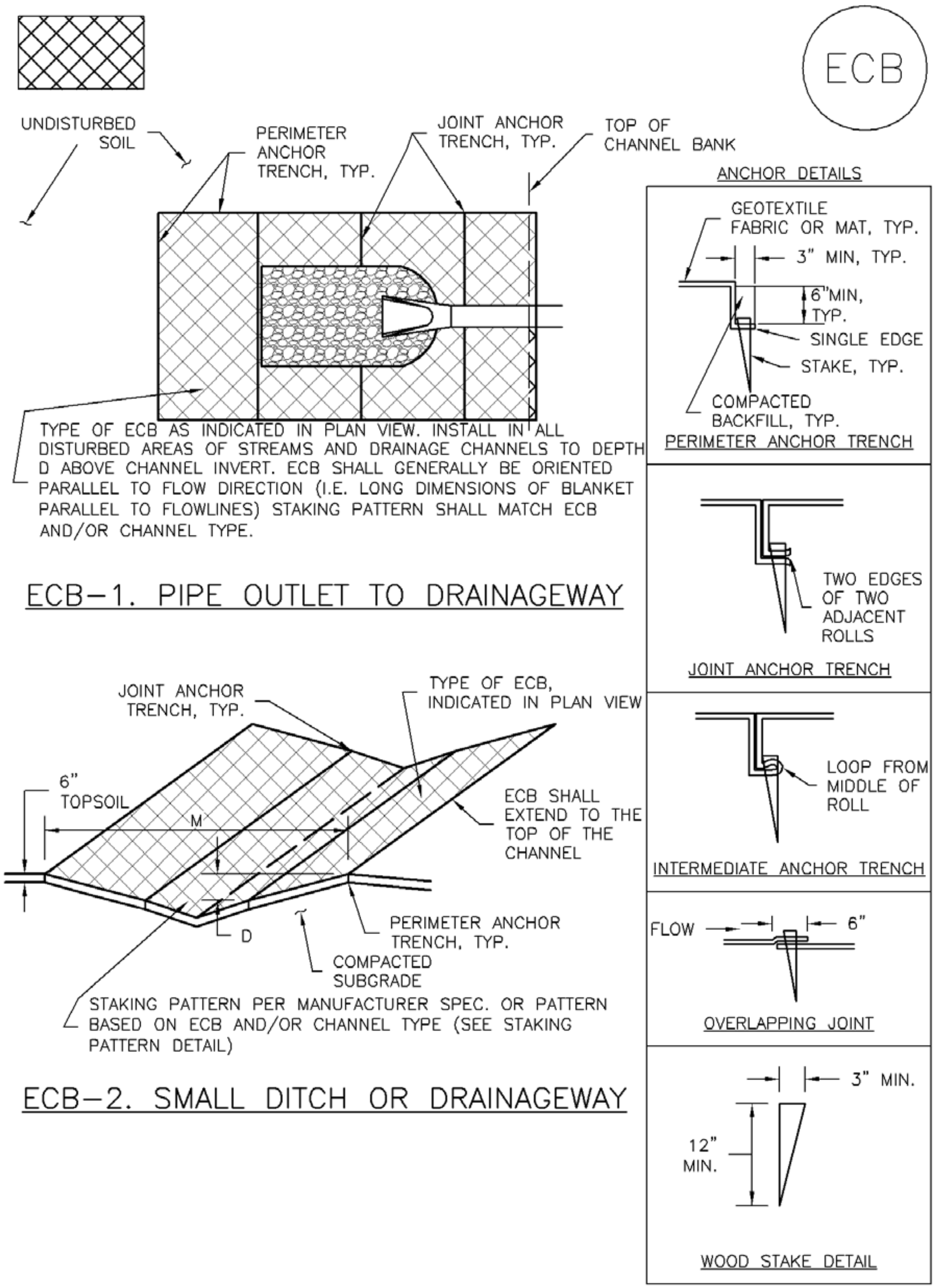
Maintenance and Removal

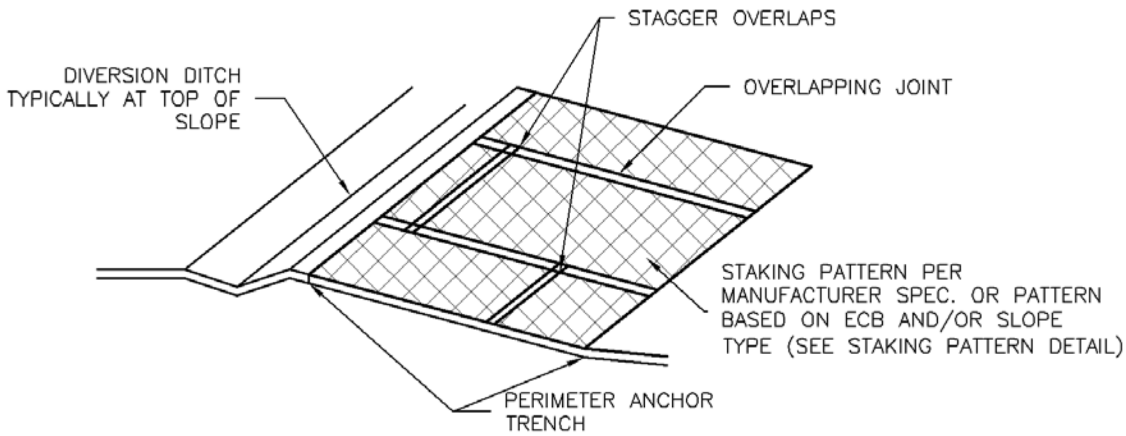
Inspection of erosion control blankets and other RECPs includes:

- Check for general signs of erosion, including voids beneath the mat. If voids are apparent, fill the void with suitable soil and replace the erosion control blanket, following the appropriate staking pattern.
- Check for damaged or loose stakes and secure loose portions of the blanket.

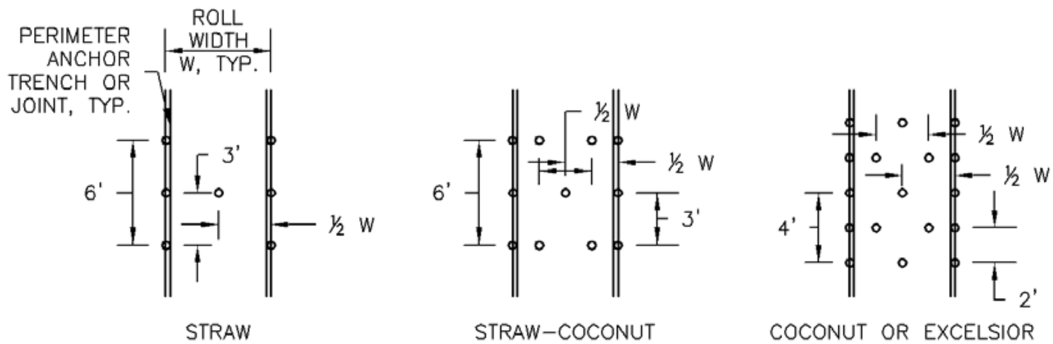
Erosion control blankets and other RECPs that are biodegradable typically do not need to be removed after construction. If they must be removed, then an alternate soil stabilization method should be installed promptly following removal.

Turf reinforcement mats, although generally resistant to biodegradation, are typically left in place as a dense vegetated cover grows in through the mat matrix. The turf reinforcement mat provides long-term stability and helps the established vegetation resist erosive forces.

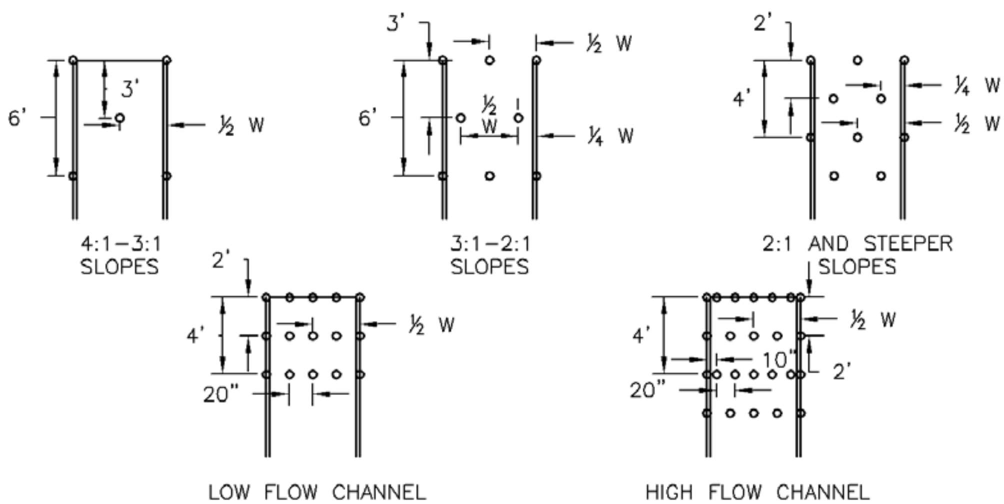

ECB
UNDISTURBED SOIL
PERIMETER ANCHOR TRENCH, TYP.
JOINT ANCHOR TRENCH, TYP.
TOP OF CHANNEL BANK
ANCHOR DETAILS
GEOTEXTILE FABRIC OR MAT, TYP.
3" MIN, TYP.
6" MIN, TYP.
SINGLE EDGE
STAKE, TYP.
COMPACTED BACKFILL, TYP.
PERIMETER ANCHOR TRENCH
TYPE OF ECB AS INDICATED IN PLAN VIEW. INSTALL IN ALL DISTURBED AREAS OF STREAMS AND DRAINAGE CHANNELS TO DEPTH D ABOVE CHANNEL INVERT. ECB SHALL GENERALLY BE ORIENTED PARALLEL TO FLOW DIRECTION (I.E. LONG DIMENSIONS OF BLANKET PARALLEL TO FLOWLINES) STAKING PATTERN SHALL MATCH ECB AND/OR CHANNEL TYPE.
ECB–1. PIPE OUTLET TO DRAINAGEWAY
TWO EDGES OF TWO ADJACENT ROLLS
JOINT ANCHOR TRENCH
JOINT ANCHOR TRENCH, TYP.
TYPE OF ECB, INDICATED IN PLAN VIEW
6" TOPSOIL
M
ECB SHALL EXTEND TO THE TOP OF THE CHANNEL
LOOP FROM MIDDLE OF ROLL
INTERMEDIATE ANCHOR TRENCH
D
PERIMETER ANCHOR TRENCH, TYP.
COMPACTED SUBGRADE
FLOW
6"
OVERLAPPING JOINT
STAKING PATTERN PER MANUFACTURER SPEC. OR PATTERN BASED ON ECB AND/OR CHANNEL TYPE (SEE STAKING PATTERN DETAIL)
ECB–2. SMALL DITCH OR DRAINAGEWAY
3" MIN.
12" MIN.
WOOD STAKE DETAIL



ECB-3. OUTSIDE OF DRAINAGEWAY



STAKING PATTERNS BY ECB TYPE



STAKING PATTERNS BY SLOPE OR CHANNEL TYPE

EROSION CONTROL BLANKET INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF ECB.
   - TYPE OF ECB (STRAW, STRAW–COCONUT, COCONUT, OR EXCELSIOR).
   - AREA, A, IN SQUARE YARDS OF EACH TYPE OF ECB.

2. 100% NATURAL AND BIODEGRADABLE MATERIALS ARE PREFERRED FOR RECPs, ALTHOUGH SOME JURISDICTIONS MAY ALLOW OTHER MATERIALS IN SOME APPLICATIONS.

3. IN AREAS WHERE ECBs ARE SHOWN ON THE PLANS, THE PERMITTEE SHALL PLACE TOPSOIL AND PERFORM FINAL GRADING, SURFACE PREPARATION, AND SEEDING AND MULCHING. SUBGRADE SHALL BE SMOOTH AND MOIST PRIOR TO ECB INSTALLATION AND THE ECB SHALL BE IN FULL CONTACT WITH SUBGRADE. NO GAPS OR VOIDS SHALL EXIST UNDER THE BLANKET.

4. PERIMETER ANCHOR TRENCH SHALL BE USED ALONG THE OUTSIDE PERIMETER OF ALL BLANKET AREAS.

5. JOINT ANCHOR TRENCH SHALL BE USED TO JOIN ROLLS OF ECBs TOGETHER (LONGITUDINALLY AND TRANSVERSELY) FOR ALL ECBs EXCEPT STRAW WHICH MAY USE AN OVERLAPPING JOINT.

6. INTERMEDIATE ANCHOR TRENCH SHALL BE USED AT SPACING OF ONE–HALF ROLL LENGTH FOR COCONUT AND EXCELSIOR ECBs.

7. OVERLAPPING JOINT DETAIL SHALL BE USED TO JOIN ROLLS OF ECBs TOGETHER FOR ECBs ON SLOPES.

8. MATERIAL SPECIFICATIONS OF ECBs SHALL CONFORM TO TABLE ECB–1.

9. ANY AREAS OF SEEDING AND MULCHING DISTURBED IN THE PROCESS OF INSTALLING ECBS SHALL BE RESEEDED AND MULCHED.

10. DETAILS ON DESIGN PLANS FOR MAJOR DRAINAGEWAY STABILIZATION WILL GOVERN IF DIFFERENT FROM THOSE SHOWN HERE.

TABLE ECB–1. ECB MATERIAL SPECIFICATIONS

TYPE	COCONUT CONTENT	STRAW CONTENT	EXCELSIOR CONTENT	RECOMMENDED NETTING**
STRAW*	–	100%	–	DOUBLE/ NATURAL
STRAW–COCONUT	30% MIN	70% MAX	–	DOUBLE/ NATURAL
COCONUT	100%	–	–	DOUBLE/ NATURAL
EXCELSIOR	–	–	100%	DOUBLE/ NATURAL

*STRAW ECBs MAY ONLY BE USED OUTSIDE OF STREAMS AND DRAINAGE CHANNEL.
**ALTERNATE NETTING MAY BE ACCEPTABLE IN SOME JURISDICTIONS

EROSION CONTROL BLANKET MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. ECBs SHALL BE LEFT IN PLACE TO EVENTUALLY BIODEGRADE, UNLESS REQUESTED TO BE REMOVED BY THE LOCAL JURISDICTION.

5. ANY ECB PULLED OUT, TORN, OR OTHERWISE DAMAGED SHALL BE REPAIRED OR REINSTALLED. ANY SUBGRADE AREAS BELOW THE GEOTEXTILE THAT HAVE ERODED TO CREATED A VOID UNDER THE BLANKET, OR THAT REMAIN DEVOID OF GRASS SHALL BE REPAIRED, RESEEDED AND MULCHED AND THE ECB REINSTALLED.

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO AND TOWN OF PARKER COLORADO, NOT AVAILABLE IN AUTOCAD)

Temporary Slope Drains (TSD) EC-7

Description

A temporary slope drain is a pipe or culvert used to convey water down a slope where there is a high potential for erosion. A drainage channel or swale at the top of the slope typically directs upgradient runoff to the pipe entrance for conveyance down the slope. The pipe outlet must be equipped with outlet protection.

Photograph TSD-1. A temporary slope drain installed to convey runoff down a slope during construction. Photo courtesy of the City of Aurora.

Appropriate Uses

Use on long, steep slopes when there is a high potential of flow concentration or rill development.

Design and Installation

Effective use of temporary slope drains involves design of an effective collection system to direct flows to the pipe, proper sizing and anchoring of the pipe, and outlet protection. Upgradient of the temporary slope drain, a temporary drainage ditch or swale should be constructed to collect surface runoff from the drainage area and convey it to the drain entrance. The temporary slope drain must be sized to safely convey the desired flow volume. At a minimum, it should be sized to convey the 2-year, 24-hour storm.

Temporary slope drains may be constructed of flexible or rigid pipe, riprap, or heavy (30 mil) plastic lining. When piping is used, it must be properly anchored by burying it with adequate cover or by using an anchor system to secure it to the ground.

The discharge from the slope drain must be directed to a stabilized outlet, temporary or permanent channel, and/or sedimentation basin.

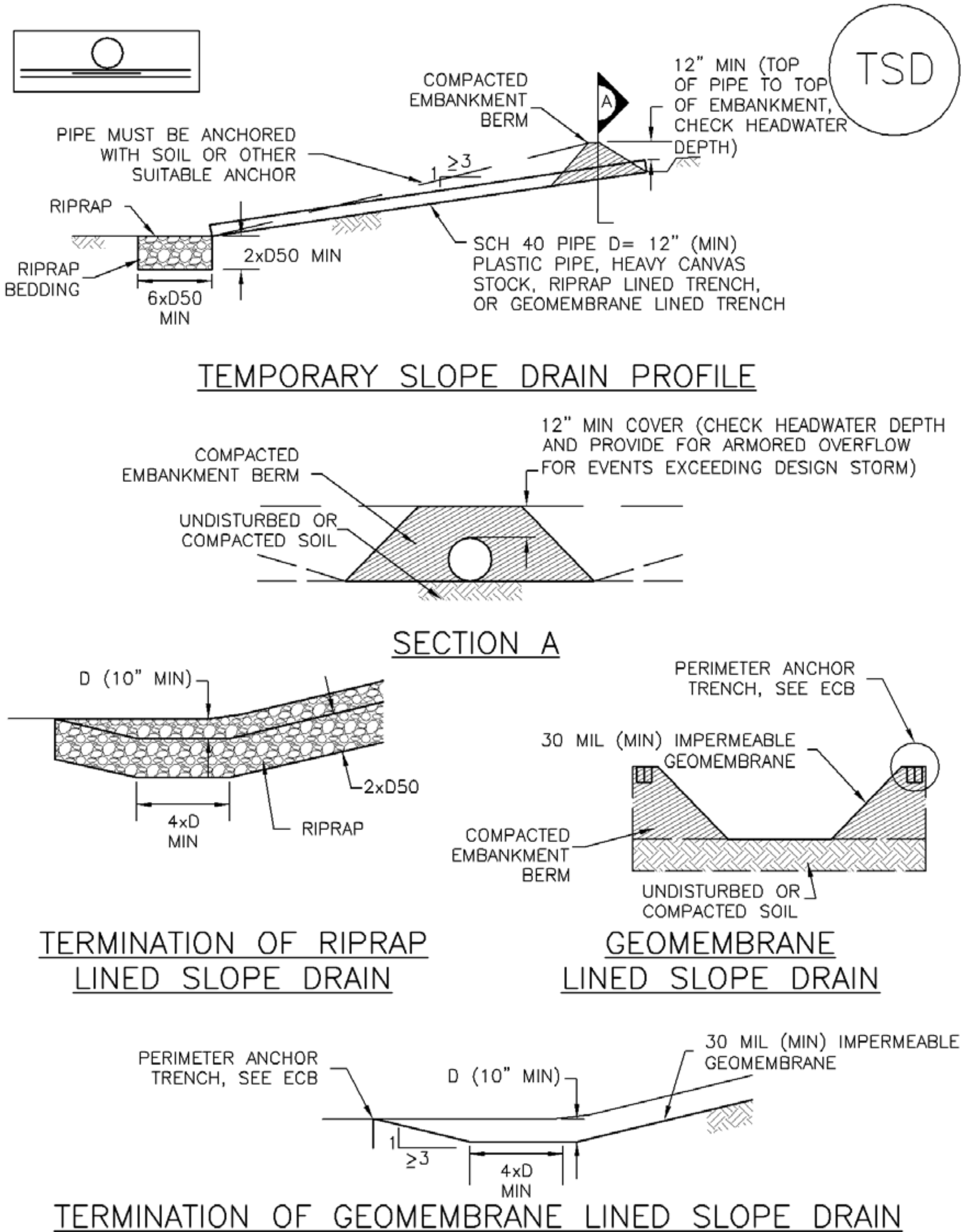
See Detail TSD-1 for additional sizing and design information.

Temporary Slope Drains	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	No

Maintenance and Removal

Inspect the entrance for sediment accumulation and remove, as needed. Clogging as a result of sediment deposition at the entrance can lead to ponding upstream causing flooding or overtopping of the slope drain. Inspect the downstream outlet for signs of erosion and stabilize, as needed. It may also be necessary to remove accumulated sediment at the outfall. Inspect pipe anchors to ensure that they are secure. If the pipe is secured by ground cover, ensure erosion has not compromised the depth of cover.

Slope drains should be removed when no longer needed or just prior to installation of permanent slope stabilization measures that cannot be installed with the slope drain in place. When slope drains are removed, the disturbed areas should be covered with topsoil, seeded, mulched or otherwise stabilized as required by the local jurisdiction.



TSD-1. TEMPORARY SLOPE DRAIN PROFILE

SLOPE DRAIN INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   -LOCATION AND LENGTH OF SLOPE DRAIN
   -PIPE DIAMETER, D, AND RIPRAP SIZE, D50.

2. SLOPE DRAIN SHALL BE DESIGNED TO CONVEY PEAK RUNOFF FOR 2-YEAR 24-HOUR STORM AT A MINIMUM. FOR LONGER DURATION PROJECTS, LARGER MAY BE APPROPRIATE.

3. SLOPE DRAIN DIMENSIONS SHALL BE CONSIDERED MINIMUM DIMENSIONS; CONTRACTOR MAY ELECT TO INSTALL LARGER FACILITIES.

4. SLOPE DRAINS INDICATED SHALL BE INSTALLED PRIOR TO UPGRADIENT LAND-DISTURBING ACTIVITIES.

5. CHECK HEADWATER DEPTHS FOR TEMPORARY AND PERMANENT SLOPE DRAINS. DETAILS SHOW MINIMUM COVER; INCREASE AS NECESSARY FOR DESIGN HEADWATER DEPTH.

6. RIPRAP PAD SHALL BE PLACED AT SLOPE DRAIN OUTFALL.

7. ANCHOR PIPE BY COVERING WITH SOIL OR AN ALTERNATE SUITABLE ANCHOR MATERIAL.

SLOPE DRAIN MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. INSPECT INLET AND OUTLET POINTS AFTER STORMS FOR CLOGGING OR EVIDENCE OF OVERTOPPING. BREACHES IN PIPE OR OTHER CONVEYANCE SHALL BE REPAIRED AS SOON AS PRACTICABLE IF OBSERVED.

5. INSPECT RIPRAP PAD AT OUTLET FOR SIGNS OF EROSION. IF SIGNS OF EROSION EXIST, ADDITIONAL ARMORING SHALL BE INSTALLED.

6. TEMPORARY SLOPE DRAINS ARE TO REMAIN IN PLACE UNTIL NO LONGER NEEDED, BUT SHALL BE REMOVED PRIOR TO THE END OF CONSTRUCTION. WHEN SLOPE DRAINS ARE REMOVED, THE DISTURBED AREA SHALL BE COVERED WITH TOP SOIL, SEEDED, MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

(DETAIL ADAPTED FROM DOUGLAS COUNTY, COLORADO AND THE CITY OF COLORADO SPRINGS, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

Photograph TOP-1. Riprap outlet protection.

Outlet protection helps to reduce erosion immediately downstream of a pipe, culvert, slope drain, rundown or other conveyance with concentrated, high-velocity flows. Typical outlet protection consists of riprap or rock aprons at the conveyance outlet.

Appropriate Uses

Outlet protection should be used when a conveyance discharges onto a disturbed area where there is potential for accelerated erosion due to concentrated flow. Outlet protection should be provided where the velocity at the culvert outlet exceeds the maximum permissible velocity of the material in the receiving channel.

Note**:** This Fact Sheet and detail are for temporary outlet protection, outlets that are intended to be used for less than 2 years. For permanent, long-term outlet protection, see the *Major Drainage* chapter of Volume 1.

Design and Installation

Design outlet protection to handle runoff from the largest drainage area that may be contributing runoff during construction (the drainage area may change as a result of grading). Key in rock, around the entire perimeter of the apron, to a minimum depth of 6 inches for stability. Extend riprap to the height of the culvert or the normal flow depth of the downstream channel, whichever is less. Additional erosion control measures such as vegetative lining, turf reinforcement mat and/or other channel lining methods may be required downstream of the outlet protection if the channel is susceptible to erosion. See Design Detail OP-1 for additional information.

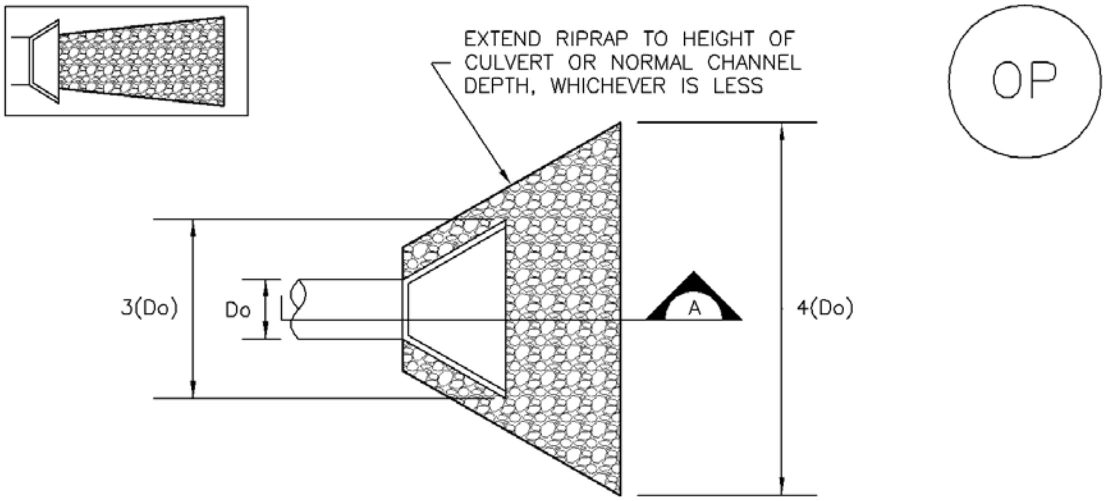
Maintenance and Removal

Inspect apron for damage and displaced rocks. If rocks are missing or significantly displaced, repair or replace as necessary. If rocks are continuously missing or displaced, consider increasing the size of the riprap or deeper keying of the perimeter.

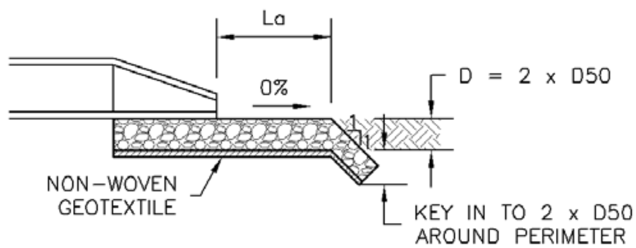
Remove sediment accumulated at the outlet before the outlet protection becomes buried and ineffective. When sediment accumulation is noted, check that upgradient BMPs, including inlet protection, are in effective operating condition.

Outlet protection may be removed once the pipe is no longer draining an upstream area, or once the downstream area has been sufficiently stabilized. If the drainage pipe is permanent, outlet protection can be left in place; however, permanent outlet protection should be designed and constructed in accordance with the requirements of the *Major Drainage* chapter of Volume 2.

Outlet Protection	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	No



TEMPORARY OUTLET PROTECTION PLAN



SECTION A

TABLE OP-1. TEMPORARY OUTLET PROTECTION SIZING TABLE

PIPE DIAMETER, Do (INCHES)	DISCHARGE, Q (CFS)	APRON LENGTH, La (FT)	RIPRAP D50 DIAMETER MIN (INCHES)
8	2.5 5	5 10	4 6
12	5 10	10 13	4 6
18	10 20 30 40	10 16 23 26	6 9 12 16
24	30 40 50 60	16 26 26 30	9 9 12 16

OP-1. TEMPORARY OUTLET PROTECTION

TEMPORARY OUTLET PROTECTION INSTALLATION NOTES

1. SEE PLAN VIEW FOR
   - –LOCATION OF OUTLET PROTECTION.
   - –DIMENSIONS OF OUTLET PROTECTION.

2. DETAIL IS INTENDED FOR PIPES WITH SLOPE $\leq$ 10%. ADDITIONAL EVALUATION OF RIPRAP SIZING AND OUTLET PROTECTION DIMENSIONS REQUIRED FOR STEEPER SLOPES.

3. TEMPORARY OUTLET PROTECTION INFORMATION IS FOR OUTLETS INTENDED TO BE UTILIZED LESS THAN 2 YEARS.

TEMPORARY OUTLET PROTECTION INSPECTION AND MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

(DETAILS ADAPTED FROM AURORA, COLORADO AND PREVIOUS VERSION OF VOLUME 3, NOT AVAILABLE IN AUTOCAD)

Photograph RCS-1. Rough cut street controls.

Description

Rough cut street controls are rock or earthen berms placed along dirt roadways that are under construction or used for construction access. These temporary berms intercept sheet flow and divert runoff from the roadway, and control erosion by minimizing concentration of flow and reducing runoff velocity.

Appropriate Uses

Appropriate uses include:

- Temporary dirt construction roadways that have not received roadbase.
- Roadways under construction that will not be paved within 14 days of final grading, and that have not yet received roadbase.

Design and Installation

Rough cut street controls are designed to redirect sheet flow off the dirt roadway to prevent water from concentrating and eroding the soil. These controls consist of runoff barriers that are constructed at intervals along the road. These barriers are installed perpendicular to the longitudinal slope from the outer edge of the roadside swale to the crown of the road. The barriers are positioned alternately from the right and left side of the road to allow construction traffic to pass in the lane not barred. If construction traffic is expected to be congested and a vehicle tracking control has been constructed, rough-cut street controls may be omitted for 400 feet from the entrance. Runoff from the controls should be directed to another stormwater BMP such as a roadside swale with check dams once removed from the roadway. See Detail RCS-1 for additional information.

Maintenance and Removal

Inspect street controls for erosion and stability. If rills are forming in the roadway or cutting through the control berms, place the street controls at shorter intervals. If earthen berms are used, periodic recompaction may be necessary. When rock berms are used, repair and/or replace as necessary when damaged. Street controls may be removed 14 days prior to road surfacing and paving.

Rough Cut Street Control	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	No

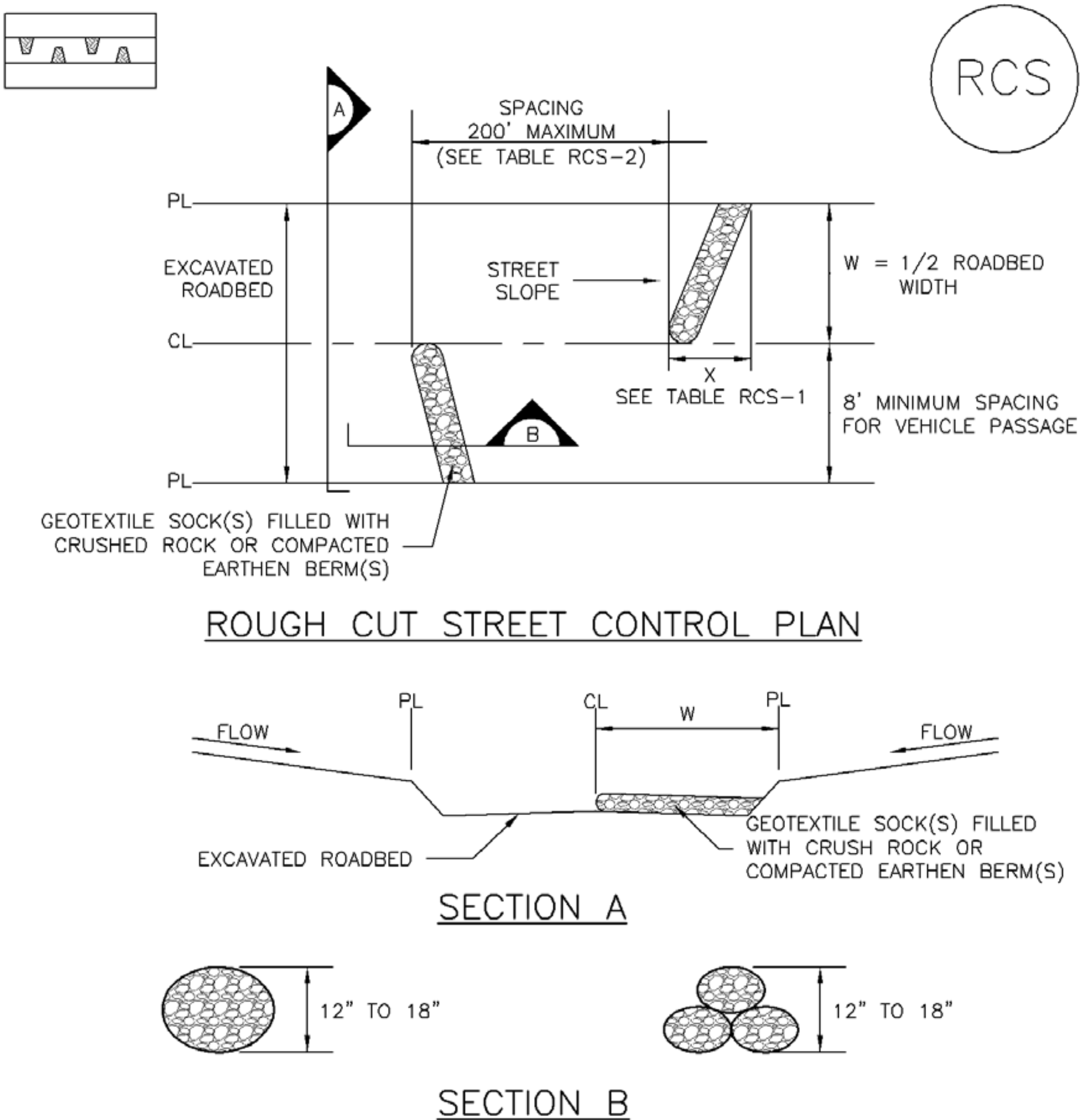


TABLE RCS-1

W (FT)	X (FT)
20–30	5
31–40	7
41–50	9
51–60	10.5
61–70	12

TABLE RCS-2

LONGITUDINAL STREET SLOPE (%)	SPACING (FT)
<2 2	NOT TYPICALLY NEEDED 200
3 4	200 150
5 6	100 50
7 8	25 25

RCS–1. ROUGH CUT STREET CONTROL

<u>ROUGH CUT STREET CONTROL INSTALLATION NOTES</u>

1. SEE PLAN VIEW FOR
   -LOCATION OF ROUGH CUT STREET CONTROL MEASURES.

2. ROUGH CUT STREET CONTROL SHALL BE INSTALLED AFTER A ROAD HAS BEEN CUT IN, AND WILL NOT BE PAVED FOR MORE THAN 14 DAYS OR FOR TEMPORARY CONSTRUCTION ROADS THAT HAVE NOT RECEIVED ROAD BASE.

<u>ROUGH CUT STREET CONTROL INSPECTION AND MAINTENANCE NOTES</u>

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

(DETAILS ADAPTED FROM AURORA, COLORADO, NOT AVAILABLE IN AUTOCAD)

<u>NOTE:</u> MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

Earth dikes and drainage swales are temporary storm conveyance channels constructed either to divert runoff around slopes or to convey runoff to additional sediment control BMPs prior to discharge of runoff from a site. Drainage swales may be lined or unlined, but if an unlined swale is used, it must be well compacted and capable of resisting erosive velocities.

Photograph ED/DS-1. Example of an earth dike used to divert flows at a construction site. Photo courtesy of CDOT.

Appropriate Uses

Earth dikes and drainage swales are typically used to control the flow path of runoff at a construction site by diverting runoff around areas prone to erosion, such as steep slopes. Earth dikes and drainage swales may also be constructed as temporary conveyance features. This will direct runoff to additional sediment control treatment BMPs, such as sediment traps or basins.

Design and Installation

When earth dikes are used to divert water for slope protection, the earth dike typically consists of a horizontal ridge of soil placed perpendicular to the slope and angled slightly to provide drainage along the contour. The dike is used in conjunction with a swale or a small channel upslope of the berm to convey the diverted water. Temporary diversion dikes can be constructed by excavation of a V-shaped trench or ditch and placement of the fill on the downslope side of the cut. There are two types of placement for temporary slope diversion dikes:

- A dike located at the top of a slope to divert upland runoff away from the disturbed area and convey it in a temporary or permanent channel.
- A diversion dike located at the base or mid-slope of a disturbed area to intercept runoff and reduce the effective slope length.

Depending on the project, either an earth dike or drainage swale may be more appropriate. If there is a need for cut on the project, then an excavated drainage swale may be better suited. When the project is primarily fill, then a conveyance constructed using a berm may be the better option.

All dikes or swales receiving runoff from a disturbed area should direct stormwater to a sediment control BMP such as a sediment trap or basin.

Earth Dikes and Drainage Swales	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	No

Unlined dikes or swales should only be used for intercepting sheet flow runoff and are not intended for diversion of concentrated flows.

Details with notes are provided for several design variations, including:

ED-1. Unlined Earth Dike formed by Berm

DS-1. Unlined Excavated Swale

DS-2. Unlined Swale Formed by Cut and Fill

DS-3. ECB-lined Swale

DS-4. Synthetic-lined Swale

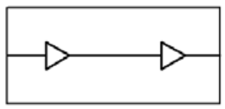
DS-5. Riprap-lined Swale

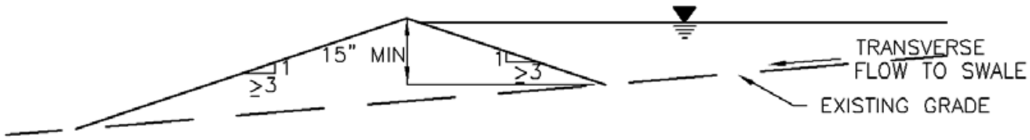
The details also include guidance on permissible velocities for cohesive channels if unlined approaches will be used.

Maintenance and Removal

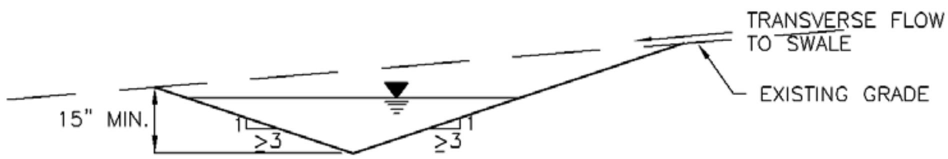
Inspect earth dikes for stability, compaction, and signs of erosion and repair. Inspect side slopes for erosion and damage to erosion control fabric. Stabilize slopes and repair fabric as necessary. If there is reoccurring extensive damage, consider installing rock check dams or lining the channel with riprap.

If drainage swales are not permanent, remove dikes and fill channels when the upstream area is stabilized. Stabilize the fill or disturbed area immediately following removal by revegetation or other permanent stabilization method approved by the local jurisdiction.

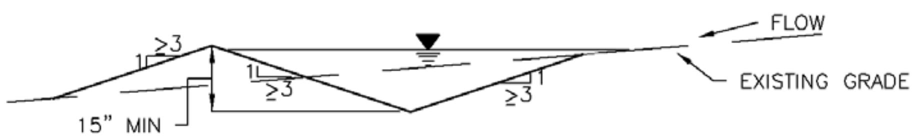




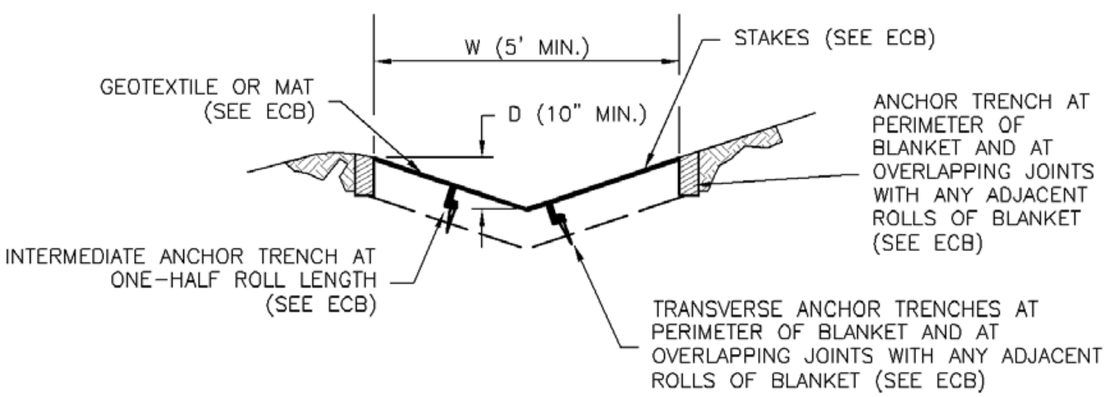
ED-1. COMPACTED UNLINED EARTH DIKE FORMED BY BERM



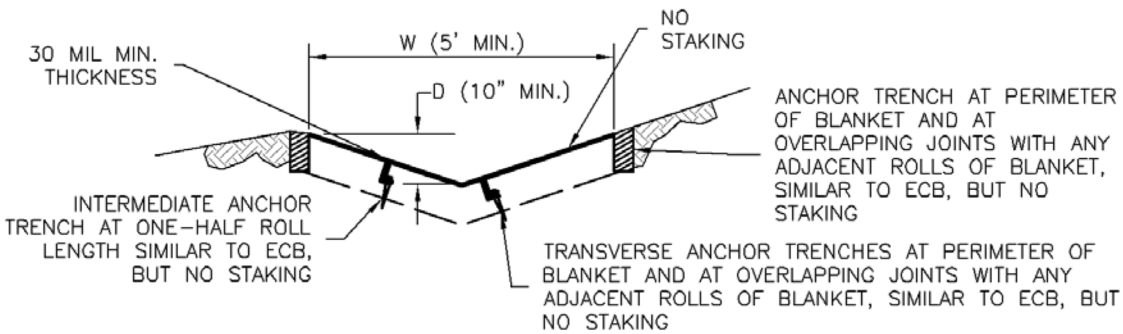
DS-1. COMPACTED UNLINED EXCAVATED SWALE



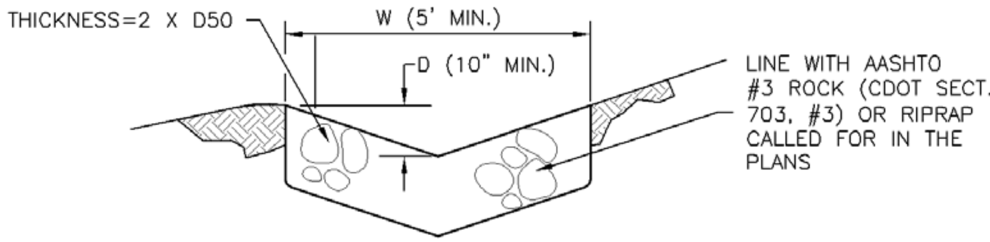
DS-2. COMPACTED UNLINED SWALE FORMED BY CUT AND FILL



DS-3. ECB LINED SWALE (CUT AND FILL OR BERM)



DS-4. SYNTHETIC LINED SWALE



DS-5. RIPRAP LINED SWALE

EARTH DIKE AND DRAINAGE SWALE INSTALLATION NOTES

1. SEE SITE PLAN FOR:
   - LOCATION OF DIVERSION SWALE
   - TYPE OF SWALE (UNLINED, COMPACTED AND/OR LINED).
   - LENGTH OF EACH SWALE.
   - DEPTH, D, AND WIDTH, W DIMENSIONS.
   - FOR ECB/TRM LINED DITCH, SEE ECB DETAIL.
   - FOR RIPRAP LINED DITCH, SIZE OF RIPRAP, D50.

2. SEE DRAINAGE PLANS FOR DETAILS OF PERMANENT CONVEYANCE FACILITIES AND/OR DIVERSION SWALES EXCEEDING 2-YEAR FLOW RATE OR 10 CFS.

3. EARTH DIKES AND SWALES INDICATED ON SWMP PLAN SHALL BE INSTALLED PRIOR TO LAND-DISTURBING ACTIVITIES IN PROXIMITY.

4. EMBANKMENT IS TO BE COMPACTED TO 90% OF MAXIMUM DENSITY AND WITHIN 2% OF OPTIMUM MOISTURE CONTENT ACCORDING TO ASTM D698.

5. SWALES ARE TO DRAIN TO A SEDIMENT CONTROL BMP.

6. FOR LINED DITCHES, INSTALLATION OF ECB/TRM SHALL CONFORM TO THE REQUIREMENTS OF THE ECB DETAIL.

7. WHEN CONSTRUCTION TRAFFIC MUST CROSS A DIVERSION SWALE, INSTALL A TEMPORARY CULVERT WITH A MINIMUM DIAMETER OF 12 INCHES.

EARTH DIKE AND DRAINAGE SWALE MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. SWALES SHALL REMAIN IN PLACE UNTIL THE END OF CONSTRUCTION; IF APPROVED BY LOCAL JURISDICTION, SWALES MAY BE LEFT IN PLACE.

5. WHEN A SWALE IS REMOVED, THE DISTURBED AREA SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY LOCAL JURISDICTION.

(DETAIL ADAPTED FROM DOUGLAS COUNTY, COLORADO AND THE CITY OF COLORADO SPRINGS, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

Photograph TER-1. Use of a terrace to reduce erosion by controlling slope length on a long, steep slope. Photo courtesy of Douglas County.

Terracing involves grading steep slopes into a series of relatively flat sections, or terraces, separated at intervals by steep slope segments. Terraces shorten the uninterrupted flow lengths on steep slopes, helping to reduce the development of rills and gullies. Retaining walls, gabions, cribbing, deadman anchors, rock-filled slope mattresses, and other types of soil retention systems can be used in terracing.

Appropriate Uses

Terracing techniques are most typically used to control erosion on slopes that are steeper than 4:1.

Design and Installation

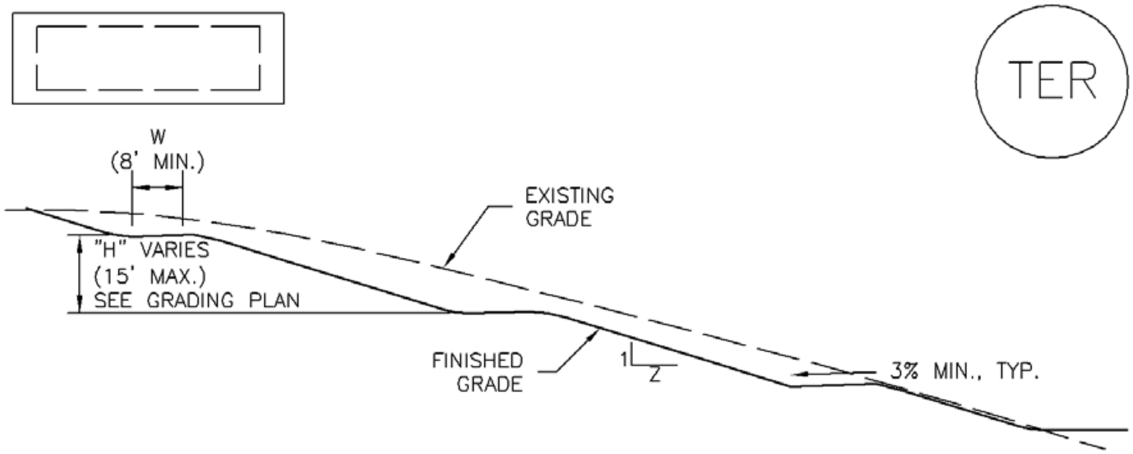
Design details with notes are provided in Detail TER-1.

The type, number, and spacing of terraces will depend on the slope, slope length, and other factors. The Revised Universal Soil Loss Equation (RUSLE) may be helpful in determining spacing of terraces on slopes. Terracing should be used in combination with other stabilization measures that provide cover for exposed soils such as mulching, seeding, surface roughening, or other measures.

Maintenance and Removal

Repair rill erosion on slopes and remove accumulated sediment, as needed. Terracing may be temporary or permanent. If terracing is temporary, the slope should be topsoiled, seeded, and mulched when the slope is graded to its final configuration and terraces are removed. Due to the steepness of the slope, once terraces are graded, erosion control blankets or other stabilization measures are typically required. If terraces are permanent, vegetation should be established on slopes and terraces as soon as practical.

Terracing	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	No



TER–1. TERRACING

TERRACING INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   –LOCATION OF TERRACING
   –WIDTH (W), AND SLOPE (Z).

2. TERRACING IS TYPICALLY NOT REQUIRED FOR SLOPES OF 4:1 OR FLATTER.

3. GRADE TERRACES TO DRAIN BACK TO SLOPE AT A MINIMUM OF 3% GRADE.

TERRACING MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. RILL EROSION OCCURRING ON TERRACED SLOPES SHALL BE REPAIRED, RESEEDED, MULCHED OR STABILIZED IN A MANNER APPROVED BY LOCAL JURISDICTION.

5. TERRACING MAY NEED TO BE RE–GRADED TO RETURN THE SLOPE TO THE FINAL DESIGN GRADE. THE SLOPE SHALL THEN BE COVERED WITH TOPSOIL, SEEDED AND MULCHED, OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

(DETAIL ADAPTED FROM DOUGLAS COUNTY, COLORADO AND TOWN OF PARKER, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

Photograph CD-1. Rock check dams in a roadside ditch. Photo courtesy of WWE.

Check dams are temporary grade control structures placed in drainage channels to limit the erosivity of stormwater by reducing flow velocity. Check dams are typically constructed from rock, gravel bags, sand bags, or sometimes, proprietary devices. Reinforced check dams are typically constructed from rock and wire gabion. Although the primary function of check dams is to reduce the velocity of concentrated flows, a secondary benefit is sediment trapping upstream of the structure.

Appropriate Uses

Use as a grade control for temporary drainage ditches or swales until final soil stabilization measures are established upstream and downstream. Check dams can be used on mild or moderately steep slopes. Check dams may be used under the following conditions:

- As temporary grade control facilities along waterways until final stabilization is established.
- Along permanent swales that need protection prior to installation of a non-erodible lining.
- Along temporary channels, ditches or swales that need protection where construction of a non-erodible lining is not practicable.
- Reinforced check dams should be used in areas subject to high flow velocities.

Design and Installation

Place check dams at regularly spaced intervals along the drainage swale or ditch. Check dams heights should allow for pools to develop upstream of each check dam, extending to the downstream toe of the check dam immediately upstream.

When rock is used for the check dam, place rock mechanically or by hand. Do not dump rocks into the drainage channel. Where multiple check dams are used, the top of the lower dam should be at the same elevation as the toe of the upper dam.

When reinforced check dams are used, install erosion control fabric under and around the check dam to prevent erosion on the upstream and downstream sides. Each section of the dam should be keyed in to reduce the potential for washout or undermining. A rock apron upstream and downstream of the dam may be necessary to further control erosion.

Check Dams	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	No

Design details with notes are provided for the following types of check dams:

- Rock Check Dams (CD-1)
- Reinforced Check Dams (CD-2)

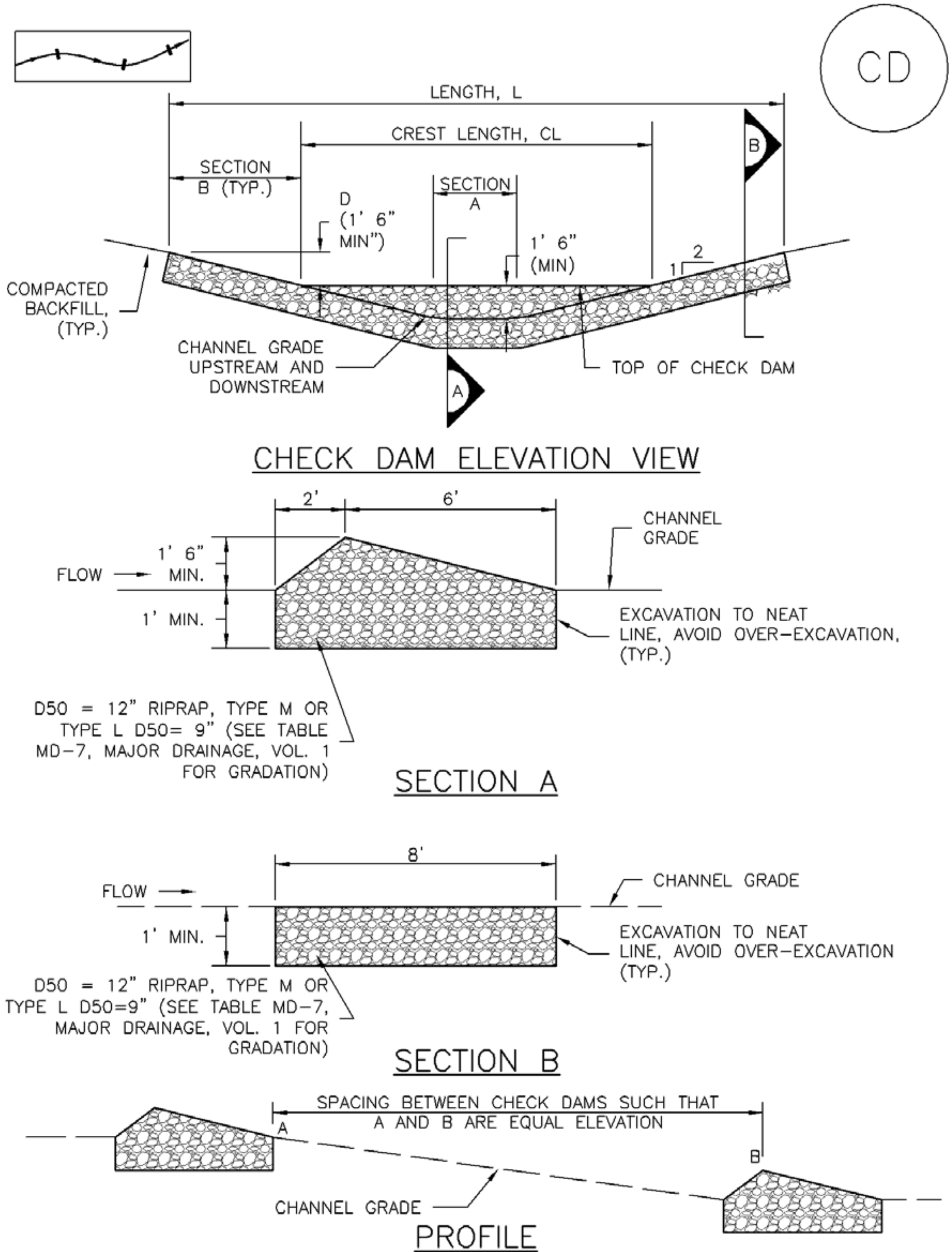
Sediment control logs may also be used as check dams; however, silt fence is not appropriate for use as a check dam. Many jurisdictions also prohibit or discourage use of straw bales for this purpose.

Maintenance and Removal

Replace missing rocks causing voids in the check dam. If gravel bags or sandbags are used, replace or repair torn or displaced bags.

Remove accumulated sediment, as needed to maintain BMP effectiveness, typically before the sediment depth upstream of the check dam is within ½ of the crest height. Remove accumulated sediment prior to mulching, seeding, or chemical soil stabilization. Removed sediment can be incorporated into the earthwork with approval from the Project Engineer, or disposed of at an alternate location in accordance with the standard specifications.

Check dams constructed in permanent swales should be removed when perennial grasses have become established, or immediately prior to installation of a non-erodible lining. All of the rock and accumulated sediment should be removed, and the area seeded and mulched, or otherwise stabilized.



CD-1. CHECK DAM

CHECK DAM INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF CHECK DAMS.
   - CHECK DAM TYPE (CHECK DAM OR REINFORCED CHECK DAM).
   - LENGTH (L), CREST LENGTH (CL), AND DEPTH (D).

2. CHECK DAMS INDICATED ON INITIAL SWMP SHALL BE INSTALLED AFTER CONSTRUCTION FENCE, BUT PRIOR TO ANY UPSTREAM LAND DISTURBING ACTIVITIES.

3. RIPRAP UTILIZED FOR CHECK DAMS SHOULD BE OF APPROPRIATE SIZE FOR THE APPLICATION. TYPICAL TYPES OF RIPRAP USED FOR CHECK DAMS ARE TYPE M (D50 12") OR TYPE L (D50 9").

4. RIPRAP PAD SHALL BE TRENCHED INTO THE GROUND A MINIMUM OF 1'.

5. THE ENDS OF THE CHECK DAM SHALL BE A MINIMUM OF 1' 6" HIGHER THAN THE CENTER OF THE CHECK DAM.

CHECK DAM MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

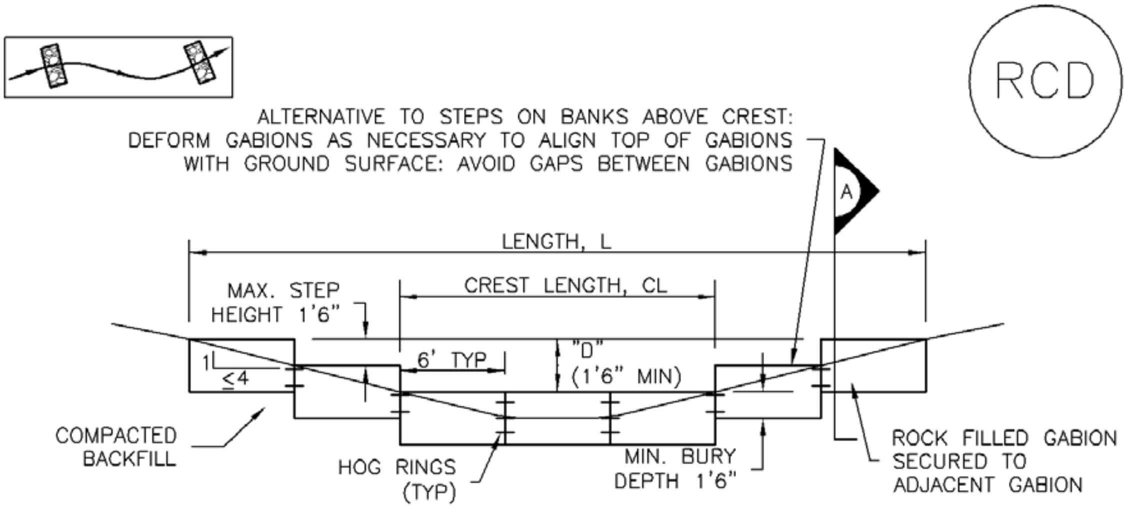
4. SEDIMENT ACCUMULATED UPSTREAM OF THE CHECK DAMS SHALL BE REMOVED WHEN THE SEDIMENT DEPTH IS WITHIN ½ OF THE HEIGHT OF THE CREST.

5. CHECK DAMS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND APPROVED BY THE LOCAL JURISDICTION.

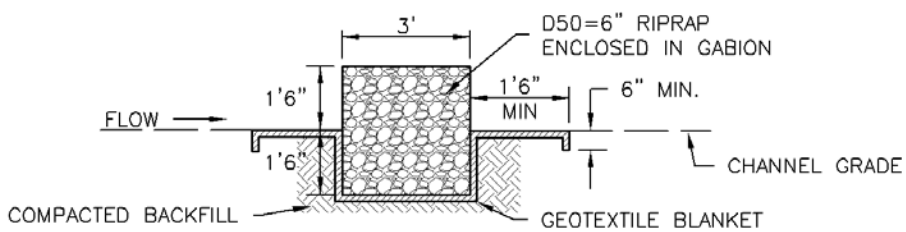
6. WHEN CHECK DAMS ARE REMOVED, EXCAVATIONS SHALL BE FILLED WITH SUITABLE COMPACTED BACKFILL. DISTURBED AREA SHALL BE SEEDED AND MULCHED AND COVERED WITH GEOTEXTILE OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.



REINFORCED CHECK DAM ELEVATION VIEW



SECTION A

REINFORCED CHECK DAM INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATIONS OF CHECK DAMS.
   - CHECK DAM TYPE (CHECK DAM OR REINFORCED CHECK DAM).
   - LENGTH (L), CREST LENGTH (CL), AND DEPTH (D).

2. CHECK DAMS INDICATED ON THE SWMP SHALL BE INSTALLED PRIOR TO AN UPSTREAM LAND-DISTURBING ACTIVITIES.

3. REINFORCED CHECK DAMS, GABIONS SHALL HAVE GALVANIZED TWISTED WIRE NETTING WITH A MAXIMUM OPENING DIMENSION OF 4½" AND A MINIMUM WIRE THICKNESS OF 0.10". WIRE "HOG RINGS" AT 4" SPACING OR OTHER APPROVED MEANS SHALL BE USED AT ALL GABION SEAMS AND TO SECURE THE GABION TO THE ADJACENT SECTION.

4. THE CHECK DAM SHALL BE TRENCHED INTO THE GROUND A MINIMUM OF 1' 6".

5. GEOTEXTILE BLANKET SHALL BE PLACED IN THE REINFORCED CHECK DAM TRENCH EXTENDING A MINIMUM OF 1' 6" ON BOTH THE UPSTREAM AND DOWNSTREAM SIDES OF THE REINFORCED CHECK DAM.

CD-2. REINFORCED CHECK DAM

REINFORCED CHECK DAM MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. SEDIMENT ACCUMULATED UPSTREAM OF REINFORCED CHECK DAMS SHALL BE REMOVED AS NEEDED TO MAINTAIN THE EFFECTIVENESS OF BMP, TYPICALLY WHEN THE UPSTREAM SEDIMENT DEPTH IS WITHIN ½ THE HEIGHT OF THE CREST.

5. REPAIR OR REPLACE REINFORCED CHECK DAMS WHEN THERE ARE SIGNS OF DAMAGE SUCH AS HOLES IN THE GABION OR UNDERCUTTING.

6. REINFORCED CHECK DAMS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND APPROVED BY THE LOCAL JURISDICTION.

7. WHEN REINFORCED CHECK DAMS ARE REMOVED, ALL DISTURBED AREAS SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED, AND COVERED WITH A GEOTEXTILE BLANKET, OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

(DETAIL ADAPTED FROM DOUGLAS COUNTY, COLORADO AND CITY OF AURORA, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

Streambank stabilization involves a combination of erosion and sediment control practices to protect streams, banks, and in-stream habitat from accelerated erosion. BMPs associated with streambank stabilization may include protection of existing vegetation, check dams/grade control, temporary and permanent seeding, outlet protection, rolled erosion control products, temporary diversions, dewatering operations and bioengineering practices such as brush layering, live staking and fascines.

Photograph SS-1. Streambank stabilization using geotextiles following installation of a permanent in-stream grade control structure.

Appropriate Uses

Streambank stabilization may be a construction activity in and of itself, or it may be in conjunction with a broader construction project that discharges to a waterway that is susceptible to accelerated erosion due to increases in the rate and volume of stormwater runoff. Depending on the health of the stream, water quality sampling and testing may be advisable prior to and/or during construction to evaluate health and stability of the stream and potential effects from adjacent construction activities.

Design and Installation

Streambank stabilization consists of protecting the stream in a variety of ways to minimize negative effects to the stream environment. The following lists the minimum requirements necessary for construction streambank stabilization:

- Protect existing vegetation along the stream bank in accordance with the Vegetated Buffers and Protection of Existing Vegetation Fact Sheets. Preserving a riparian buffer along the streambank will help to remove sediment and decrease runoff rates from the disturbed area.
- Outside the riparian buffer, provide sediment control in the form of a silt fence or equivalent sediment control practice along the entire length of the stream that will receive runoff from the area of disturbance. In some cases, a double-layered perimeter control may be justified adjacent to sensitive receiving waters and wetlands to provide additional protection.
- Stabilize all areas that will be draining to the stream. Use rolled erosion control products, temporary or permanent seeding, or other appropriate measures.
- Ensure all point discharges entering the stream are adequately armored with a velocity dissipation device and appropriate outlet protection.

Streambank Stabilization	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	No

See individual design details and notes for the various BMPs referenced in this practice. Additional information on bioengineering techniques for stream stabilization can be found in the *Major Drainage* chapter of Volume 1 and additional guidance on BMPs for working in waterways can be found in UDFCD's *Best Management Practices for Construction in Waterways Training Manual*.

Maintenance and Removal

Inspect BMPs protecting the stream for damage on a daily basis. Maintain, repair, or replace damaged BMPs following the guidance provided in individual BMP Fact Sheets for practices that are implemented. Some streambank stabilization BMPs are intended to remain in place as vegetation matures (e.g. erosion control blankets protecting seeded stream banks and turf reinforcement mats).

For BMPs that are not to remain in place as a part of final stabilization such as silt fence and other temporary measures, BMPs should be removed when all land disturbing activities have ceased and areas have been permanently stabilized.

Description

Photograph DC-1. Water truck used for dust suppression. Photo courtesy of Douglas County.

Wind erosion and dust control BMPs help to keep soil particles from entering the air as a result of land disturbing construction activities. These BMPs include a variety of practices generally focused on either graded disturbed areas or construction roadways. For graded areas, practices such as seeding and mulching, use of soil binders, site watering, or other practices that provide prompt surface cover should be used. For construction roadways, road watering and stabilized surfaces should be considered.

Appropriate Uses

Dust control measures should be used on any site where dust poses a problem to air quality. Dust control is important to control for the health of construction workers and surrounding waterbodies.

Design and Installation

The following construction BMPs can be used for dust control:

- An irrigation/sprinkler system can be used to wet the top layer of disturbed soil to help keep dry soil particles from becoming airborne.
- Seeding and mulching can be used to stabilize disturbed surfaces and reduce dust emissions.
- Protecting existing vegetation can help to slow wind velocities across the ground surface, thereby limiting the likelihood of soil particles to become airborne.
- Spray-on soil binders form a bond between soil particles keeping them grounded. Chemical treatments may require additional permitting requirements. Potential impacts to surrounding waterways and habitat must be considered prior to use.
- Placing rock on construction roadways and entrances will help keep dust to a minimum across the construction site.
- Wind fences can be installed on site to reduce wind speeds. Install fences perpendicular to the prevailing wind direction for maximum effectiveness.

Wind Erosion Control/ Dust Control	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	Moderate

Maintenance and Removal

When using an irrigation/sprinkler control system to aid in dust control, be careful not to overwater. Overwatering will cause construction vehicles to track mud off-site.

Description

Photograph CWA-1. Example of concrete washout area. Note gravel tracking pad for access and sign.

Concrete waste management involves designating and properly managing a specific area of the construction site as a concrete washout area. A concrete washout area can be created using one of several approaches designed to receive wash water from washing of tools and concrete mixer chutes, liquid concrete waste from dump trucks, mobile batch mixers, or pump trucks. Three basic approaches are available: excavation of a pit in the ground, use of an above ground storage area, or use of prefabricated haul-away concrete washout containers. Surface discharges of concrete washout water from construction sites are prohibited.

Appropriate Uses

Concrete washout areas must be designated on all sites that will generate concrete wash water or liquid concrete waste from onsite concrete mixing or concrete delivery.

Because pH is a pollutant of concern for washout activities, when unlined pits are used for concrete washout, the soil must have adequate buffering capacity to result in protection of state groundwater standards; otherwise, a liner/containment must be used. The following management practices are recommended to prevent an impact from unlined pits to groundwater:

- The use of the washout site should be temporary (less than 1 year), and
- The washout site should be not be located in an area where shallow groundwater may be present, such as near natural drainages, springs, or wetlands.

Design and Installation

Concrete washout activities must be conducted in a manner that does not contribute pollutants to surface waters or stormwater runoff. Concrete washout areas may be lined or unlined excavated pits in the ground, commercially manufactured prefabricated washout containers, or aboveground holding areas constructed of berms, sandbags or straw bales with a plastic liner.

Although unlined washout areas may be used, lined pits may be required to protect groundwater under certain conditions.

Concrete Washout Area	
Functions	
Erosion Control	No
Sediment Control	No
Site/Material Management	Yes

Do not locate an unlined washout area within 400 feet of any natural drainage pathway or waterbody or within 1,000 feet of any wells or drinking water sources. Even for lined concrete washouts, it is advisable to locate the facility away from waterbodies and drainage paths. If site constraints make these setbacks infeasible or if highly permeable soils exist in the area, then the pit must be installed with an impermeable liner (16 mil minimum thickness) or surface storage alternatives using prefabricated concrete washout devices or a lined aboveground storage area should be used.

Design details with notes are provided in Detail CWA-1 for pits and CWA-2 for aboveground storage areas. Pre-fabricated concrete washout container information can be obtained from vendors.

Maintenance and Removal

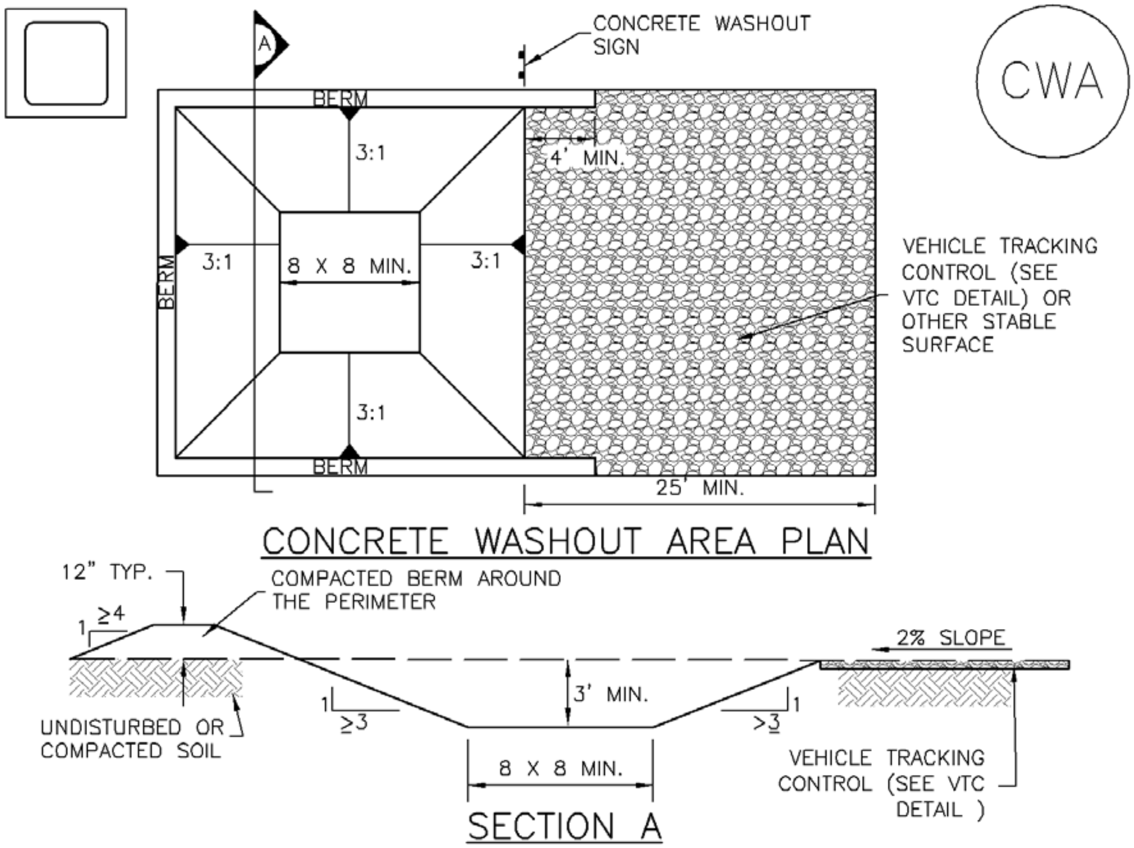
A key consideration for concrete washout areas is to ensure that adequate signage is in place identifying the location of the washout area. Part of inspecting and maintaining washout areas is ensuring that adequate signage is provided and in good repair and that the washout area is being used, as opposed to washout in non-designated areas of the site.

Remove concrete waste in the washout area, as needed to maintain BMP function (typically when filled to about two-thirds of its capacity). Collect concrete waste and deliver offsite to a designated disposal location.

Upon termination of use of the washout site, accumulated solid waste, including concrete waste and any contaminated soils, must be removed from the site to prevent on-site disposal of solid waste. If the wash water is allowed to evaporate and the concrete hardens, it may be recycled.

Photograph CWA-2. Prefabricated concrete washout. Photo courtesy of CDOT**.**

Photograph CWA-3. Earthen concrete washout. Photo courtesy of CDOT**.**



CWA–1. CONCRETE WASHOUT AREA

CWA INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   –CWA INSTALLATION LOCATION.

2. DO NOT LOCATE AN UNLINED CWA WITHIN 400' OF ANY NATURAL DRAINAGE PATHWAY OR WATERBODY. DO NOT LOCATE WITHIN 1,000' OF ANY WELLS OR DRINKING WATER SOURCES. IF SITE CONSTRAINTS MAKE THIS INFEASIBLE, OR IF HIGHLY PERMEABLE SOILS EXIST ON SITE, THE CWA MUST BE INSTALLED WITH AN IMPERMEABLE LINER (16 MIL MIN. THICKNESS) OR SURFACE STORAGE ALTERNATIVES USING PREFABRICATED CONCRETE WASHOUT DEVICES OR A LINED ABOVE GROUND STORAGE ARE SHOULD BE USED.

3. THE CWA SHALL BE INSTALLED PRIOR TO CONCRETE PLACEMENT ON SITE.

4. CWA SHALL INCLUDE A FLAT SUBSURFACE PIT THAT IS AT LEAST 8' BY 8' SLOPES LEADING OUT OF THE SUBSURFACE PIT SHALL BE 3:1 OR FLATTER. THE PIT SHALL BE AT LEAST 3' DEEP.

5. BERM SURROUNDING SIDES AND BACK OF THE CWA SHALL HAVE MINIMUM HEIGHT OF 1'.

6. VEHICLE TRACKING PAD SHALL BE SLOPED 2% TOWARDS THE CWA.

7. SIGNS SHALL BE PLACED AT THE CONSTRUCTION ENTRANCE, AT THE CWA, AND ELSEWHERE AS NECESSARY TO CLEARLY INDICATE THE LOCATION OF THE CWA TO OPERATORS OF CONCRETE TRUCKS AND PUMP RIGS.

8. USE EXCAVATED MATERIAL FOR PERIMETER BERM CONSTRUCTION.

CWA MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. THE CWA SHALL BE REPAIRED, CLEANED, OR ENLARGED AS NECESSARY TO MAINTAIN CAPACITY FOR CONCRETE WASTE. CONCRETE MATERIALS, ACCUMULATED IN PIT, SHALL BE REMOVED ONCE THE MATERIALS HAVE REACHED A DEPTH OF 2'.

5. CONCRETE WASHOUT WATER, WASTED PIECES OF CONCRETE AND ALL OTHER DEBRIS IN THE SUBSURFACE PIT SHALL BE TRANSPORTED FROM THE JOB SITE IN A WATER-TIGHT CONTAINER AND DISPOSED OF PROPERLY.

6. THE CWA SHALL REMAIN IN PLACE UNTIL ALL CONCRETE FOR THE PROJECT IS PLACED.

7. WHEN THE CWA IS REMOVED, COVER THE DISTURBED AREA WITH TOP SOIL, SEED AND MULCH OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

(DETAIL ADAPTED FROM DOUGLAS COUNTY, COLORADO AND THE CITY OF PARKER, COLORADO, NOT AVAILABLE IN AUTOCAD).

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Photograph SP-1. A topsoil stockpile that has been partially revegetated and is protected by silt fence perimeter control.

Description

Stockpile management includes measures to minimize erosion and sediment transport from soil stockpiles.

Appropriate Uses

Stockpile management should be used when soils or other erodible materials are stored at the construction site. Special attention should be given to stockpiles in close proximity to natural or manmade storm systems.

Design and Installation

Locate stockpiles away from all drainage system components including storm sewer inlets. Where practical, choose stockpile locations that that will remain undisturbed for the longest period of time as the phases of construction progress. Place sediment control BMPs around the perimeter of the stockpile, such as sediment control logs, rock socks, silt fence, straw bales and sand bags. See Detail SP-1 for guidance on proper establishment of perimeter controls around a stockpile. For stockpiles in active use, provide a stabilized designated access point on the upgradient side of the stockpile.

Stabilize the stockpile surface with surface roughening, temporary seeding and mulching, erosion control blankets, or soil binders. Soils stockpiled for an extended period (typically for more than 60 days) should be seeded and mulched with a temporary grass cover once the stockpile is placed (typically within 14 days). Use of mulch only or a soil binder is acceptable if the stockpile will be in place for a more limited time period (typically 30-60 days). Timeframes for stabilization of stockpiles noted in this fact sheet are "typical" guidelines. Check permit requirements for specific federal, state, and/or local requirements that may be more prescriptive.

Stockpiles should not be placed in streets or paved areas unless no other practical alternative exists. See the Stabilized Staging Area Fact Sheet for guidance when staging in roadways is unavoidable due to space or right-of-way constraints. For paved areas, rock socks must be used for perimeter control and all inlets with the potential to receive sediment from the stockpile (even from vehicle tracking) must be protected.

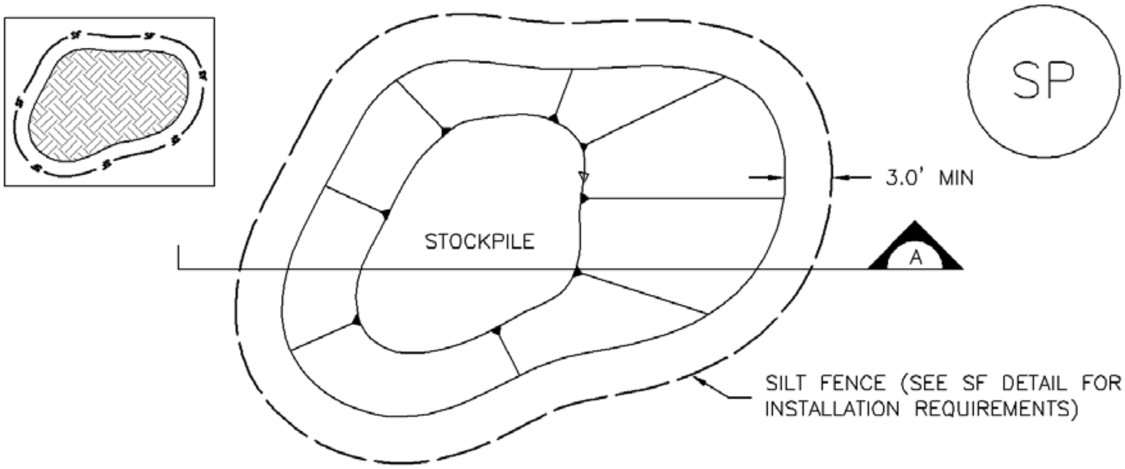
Maintenance and Removal

Inspect perimeter controls and inlet protection in accordance with their respective BMP Fact Sheets. Where seeding, mulch and/or soil binders are used, reseeding or reapplication of soil binder may be necessary.

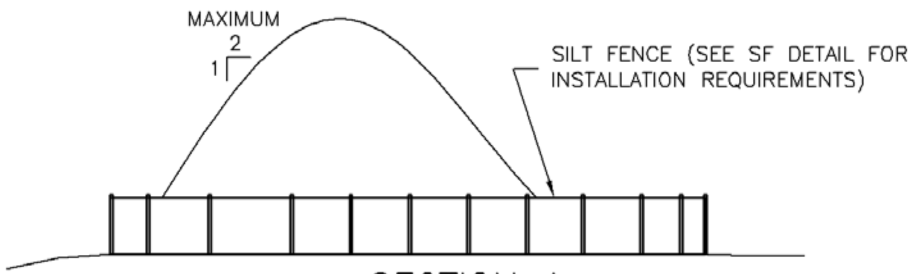
When temporary removal of a perimeter BMP is necessary to access a stockpile, ensure BMPs are reinstalled in accordance with their respective design detail section.

Stockpile Management	
Functions	
Erosion Control	Yes
Sediment Control	Yes
Site/Material Management	Yes

When the stockpile is no longer needed, properly dispose of excess materials and revegetate or otherwise stabilize the ground surface where the stockpile was located.



STOCKPILE PROTECTION PLAN



SECTION A

SP-1. STOCKPILE PROTECTION

STOCKPILE PROTECTION INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   -LOCATION OF STOCKPILES.
   -TYPE OF STOCKPILE PROTECTION.

2. INSTALL PERIMETER CONTROLS IN ACCORDANCE WITH THEIR RESPECTIVE DESIGN DETAILS. SILT FENCE IS SHOWN IN THE STOCKPILE PROTECTION DETAILS; HOWEVER, OTHER TYPES OF PERIMETER CONTROLS INCLUDING SEDIMENT CONTROL LOGS OR ROCK SOCKS MAY BE SUITABLE IN SOME CIRCUMSTANCES. CONSIDERATIONS FOR DETERMINING THE APPROPRIATE TYPE OF PERIMETER CONTROL FOR A STOCKPILE INCLUDE WHETHER THE STOCKPILE IS LOCATED ON A PERVIOUS OR IMPERVIOUS SURFACE, THE RELATIVE HEIGHTS OF THE PERIMETER CONTROL AND STOCKPILE, THE ABILITY OF THE PERIMETER CONTROL TO CONTAIN THE STOCKPILE WITHOUT FAILING IN THE EVENT THAT MATERIAL FROM THE STOCKPILE SHIFTS OR SLUMPS AGAINST THE PERIMETER, AND OTHER FACTORS.

3. STABILIZE THE STOCKPILE SURFACE WITH SURFACE ROUGHENING, TEMPORARY SEEDING AND MULCHING, EROSION CONTROL BLANKETS, OR SOIL BINDERS. SOILS STOCKPILED FOR AN EXTENDED PERIOD (TYPICALLY FOR MORE THAN 60 DAYS) SHOULD BE SEEDED AND MULCHED WITH A TEMPORARY GRASS COVER ONCE THE STOCKPILE IS PLACED (TYPICALLY WITHIN 14 DAYS). USE OF MULCH ONLY OR A SOIL BINDER IS ACCEPTABLE IF THE STOCKPILE WILL BE IN PLACE FOR A MORE LIMITED TIME PERIOD (TYPICALLY 30-60 DAYS).

4. FOR TEMPORARY STOCKPILES ON THE INTERIOR PORTION OF A CONSTRUCTION SITE, WHERE OTHER DOWNGRADIENT CONTROLS, INCLUDING PERIMETER CONTROL, ARE IN PLACE, STOCKPILE PERIMETER CONTROLS MAY NOT BE REQUIRED.

STOCKPILE PROTECTION MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

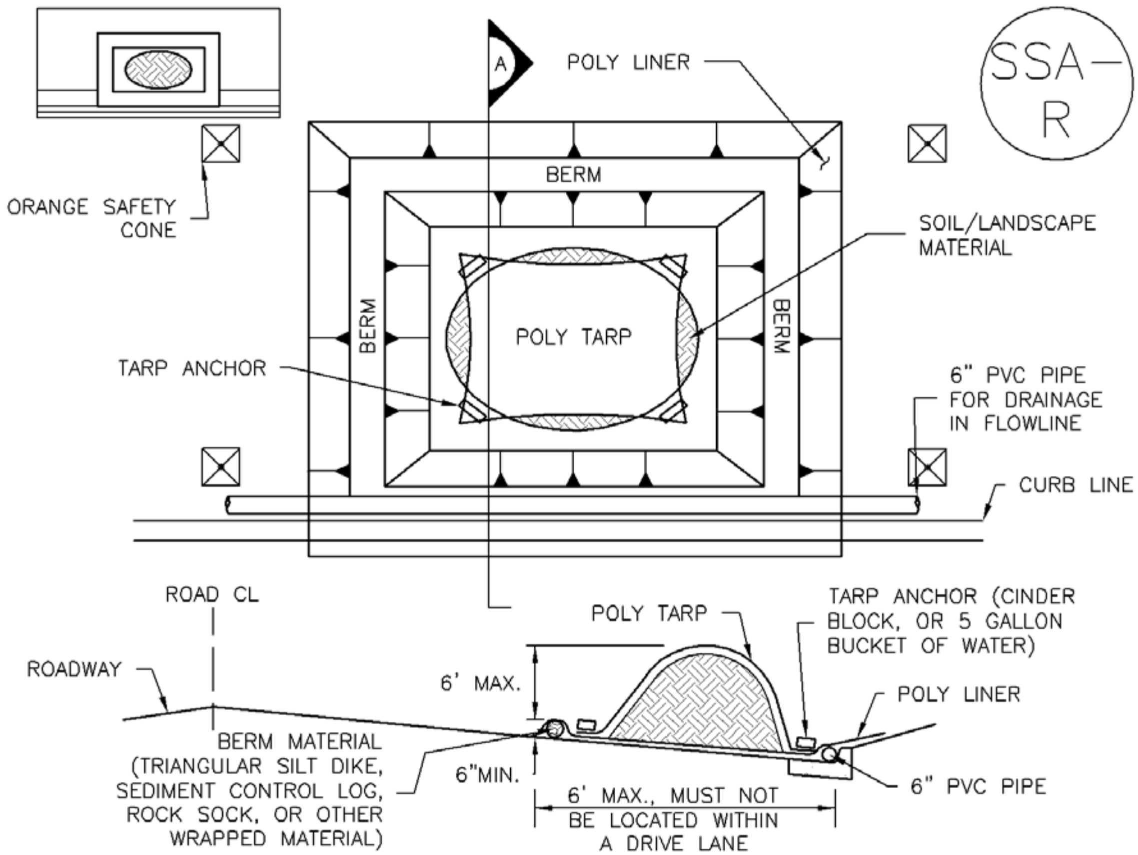
STOCKPILE PROTECTION MAINTENANCE NOTES

4. IF PERIMETER PROTECTION MUST BE MOVED TO ACCESS SOIL STOCKPILE, REPLACE PERIMETER CONTROLS BY THE END OF THE WORKDAY.

5. STOCKPILE PERIMETER CONTROLS CAN BE REMOVED ONCE ALL THE MATERIAL FROM THE STOCKPILE HAS BEEN USED.

(DETAILS ADAPTED FROM PARKER, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.



SP-2. MATERIALS STAGING IN ROADWAY

MATERIALS STAGING IN ROADWAYS INSTALLATION NOTES

1. SEE PLAN VIEW FOR
   - LOCATION OF MATERIAL STAGING AREA(S).
   - CONTRACTOR MAY ADJUST LOCATION AND SIZE OF STAGING AREA WITH APPROVAL FROM THE LOCAL JURISDICTION.

2. FEATURE MUST BE INSTALLED PRIOR TO EXCAVATION, EARTHWORK OR DELIVERY OF MATERIALS.

3. MATERIALS MUST BE STATIONED ON THE POLY LINER. ANY INCIDENTAL MATERIALS DEPOSITED ON PAVED SECTION OR ALONG CURB LINE MUST BE CLEANED UP PROMPTLY.

4. POLY LINER AND TARP COVER SHOULD BE OF SIGNIFICANT THICKNESS TO PREVENT DAMAGE OR LOSS OF INTEGRITY.

5. SAND BAGS MAY BE SUBSTITUTED TO ANCHOR THE COVER TARP OR PROVIDE BERMING UNDER THE BASE LINER.

6. FEATURE IS NOT INTENDED FOR USE WITH WET MATERIAL THAT WILL BE DRAINING AND/OR SPREADING OUT ON THE POLY LINER OR FOR DEMOLITION MATERIALS.

7. THIS FEATURE CAN BE USED FOR:
   - UTILITY REPAIRS.
   - WHEN OTHER STAGING LOCATIONS AND OPTIONS ARE LIMITED.
   - OTHER LIMITED APPLICATION AND SHORT DURATION STAGING.

MATERIALS STAGING IN ROADWAY MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. INSPECT PVC PIPE ALONG CURB LINE FOR CLOGGING AND DEBRIS. REMOVE OBSTRUCTIONS PROMPTLY.

5. CLEAN MATERIAL FROM PAVED SURFACES BY SWEEPING OR VACUUMING.

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

(DETAILS ADAPTED FROM AURORA, COLORADO)

Description

Implement construction site good housekeeping practices to prevent pollution associated with solid, liquid and hazardous construction-related materials and wastes. Stormwater Management Plans (SWMPs) should clearly specify BMPs including these good housekeeping practices:

- Provide for waste management.
- Establish proper building material staging areas.
- Designate paint and concrete washout areas.
- Establish proper equipment/vehicle fueling and maintenance practices.
- Control equipment/vehicle washing and allowable non-stormwater discharges.
- Develop a spill prevention and response plan.

Acknowledgement: This Fact Sheet is based directly on EPA guidance provided in *Developing Your Stormwater Pollution Prevent Plan* (EPA 2007).

Photographs GH-1 and GH-2. Proper materials storage and secondary containment for fuel tanks are important good housekeeping practices. Photos courtesy of CDOT and City of Aurora.

Appropriate Uses

Good housekeeping practices are necessary at all construction sites.

Design and Installation

The following principles and actions should be addressed in SWMPs:

- **Provide for Waste Management.** Implement management procedures and practices to prevent or reduce the exposure and transport of pollutants in stormwater from solid, liquid and sanitary wastes that will be generated at the site. Practices such as trash disposal, recycling, proper material handling, and cleanup measures can reduce the potential for stormwater runoff to pick up construction site wastes and discharge them to surface waters. Implement a comprehensive set of waste-management practices for hazardous or toxic materials, such as paints, solvents, petroleum products, pesticides, wood preservatives, acids, roofing tar, and other materials. Practices should include storage, handling, inventory, and cleanup procedures, in case of spills. Specific practices that should be considered include:

Solid or Construction Waste

- o Designate trash and bulk waste-collection areas on-site.

Good Housekeeping	
Functions	
Erosion Control	No
Sediment Control	No
Site/Material Management	Yes

- Recycle materials whenever possible (e.g., paper, wood, concrete, oil).
- Segregate and provide proper disposal options for hazardous material wastes.
- Clean up litter and debris from the construction site daily.
- Locate waste-collection areas away from streets, gutters, watercourses, and storm drains. Waste-collection areas (dumpsters, and such) are often best located near construction site entrances to minimize traffic on disturbed soils. Consider secondary containment around waste collection areas to minimize the likelihood of contaminated discharges.
- Empty waste containers before they are full and overflowing.

Sanitary and Septic Waste

- Provide convenient, well-maintained, and properly located toilet facilities on-site.
- Locate toilet facilities away from storm drain inlets and waterways to prevent accidental spills and contamination of stormwater.
- Maintain clean restroom facilities and empty portable toilets regularly.
- Where possible, provide secondary containment pans under portable toilets.
- Provide tie-downs or stake-downs for portable toilets.
- Educate employees, subcontractors, and suppliers on locations of facilities.
- Treat or dispose of sanitary and septic waste in accordance with state or local regulations. Do not discharge or bury wastewater at the construction site.
- Inspect facilities for leaks. If found, repair or replace immediately.
- Special care is necessary during maintenance (pump out) to ensure that waste and/or biocide are not spilled on the ground.

Hazardous Materials and Wastes

- Develop and implement employee and subcontractor education, as needed, on hazardous and toxic waste handling, storage, disposal, and cleanup.
- Designate hazardous waste-collection areas on-site.
- Place all hazardous and toxic material wastes in secondary containment.

Photograph GH-3. Locate portable toilet facilities on level surfaces away from waterways and storm drains. Photo courtesy of WWE.

- Hazardous waste containers should be inspected to ensure that all containers are labeled properly and that no leaks are present.

- **Establish Proper Building Material Handling and Staging Areas**. The SWMP should include comprehensive handling and management procedures for building materials, especially those that are hazardous or toxic. Paints, solvents, pesticides, fuels and oils, other hazardous materials or building materials that have the potential to contaminate stormwater should be stored indoors or under cover whenever possible or in areas with secondary containment. Secondary containment measures prevent a spill from spreading across the site and may include dikes, berms, curbing, or other containment methods. Secondary containment techniques should also ensure the protection of groundwater. Designate staging areas for activities such as fueling vehicles, mixing paints, plaster, mortar, and other potential pollutants. Designated staging areas enable easier monitoring of the use of materials and clean up of spills. Training employees and subcontractors is essential to the success of this pollution prevention principle. Consider the following specific materials handling and staging practices:

  - Train employees and subcontractors in proper handling and storage practices.

  - Clearly designate site areas for staging and storage with signs and on construction drawings. Staging areas should be located in areas central to the construction site. Segment the staging area into sub-areas designated for vehicles, equipment, or stockpiles. Construction entrances and exits should be clearly marked so that delivery vehicles enter/exit through stabilized areas with vehicle tracking controls (See Vehicle Tracking Control Fact Sheet).

  - Provide storage in accordance with Spill Protection, Control and Countermeasures (SPCC) requirements and plans and provide cover and impermeable perimeter control, as necessary, for hazardous materials and contaminated soils that must be stored on site.

  - Ensure that storage containers are regularly inspected for leaks, corrosion, support or foundation failure, or other signs of deterioration and tested for soundness.

  - Reuse and recycle construction materials when possible.

- **Designate Concrete Washout Areas**. Concrete contractors should be encouraged to use the washout facilities at their own plants or dispatch facilities when feasible; however, concrete washout commonly occurs on construction sites. If it is necessary to provide for concrete washout areas on-site, designate specific washout areas and design facilities to handle anticipated washout water. Washout areas should also be provided for paint and stucco operations. Because washout areas can be a source of pollutants from leaks or spills, care must be taken with regard to their placement and proper use. See the Concrete Washout Area Fact Sheet for detailed guidance.

  Both self-constructed and prefabricated washout containers can fill up quickly when concrete, paint, and stucco work are occurring on large portions of the site. Be sure to check for evidence that contractors are using the washout areas and not dumping materials onto the ground or into drainage facilities. If the washout areas are not being used regularly, consider posting additional signage, relocating the facilities to more convenient locations, or providing training to workers and contractors.

  When concrete, paint, or stucco is part of the construction process, consider these practices which will help prevent contamination of stormwater. Include the locations of these areas and the maintenance and inspection procedures in the SWMP.

- o Do not washout concrete trucks or equipment into storm drains, streets, gutters, uncontained areas, or streams. Only use designated washout areas.

- o Establish washout areas and advertise their locations with signs. Ensure that signage remains in good repair.

- o Provide adequate containment for the amount of wash water that will be used.

- o Inspect washout structures daily to detect leaks or tears and to identify when materials need to be removed.

- o Dispose of materials properly. The preferred method is to allow the water to evaporate and to recycle the hardened concrete. Full service companies may provide dewatering services and should dispose of wastewater properly. Concrete wash water can be highly polluted. It should not be discharged to any surface water, storm sewer system, or allowed to infiltrate into the ground in the vicinity of waterbodies. Washwater should not be discharged to a sanitary sewer system without first receiving written permission from the system operator.

- **Establish Proper Equipment/Vehicle Fueling and Maintenance Practices**. Create a clearly designated on-site fueling and maintenance area that is clean and dry. The on-site fueling area should have a spill kit, and staff should know how to use it. If possible, conduct vehicle fueling and maintenance activities in a covered area. Consider the following practices to help prevent the discharge of pollutants to stormwater from equipment/vehicle fueling and maintenance. Include the locations of designated fueling and maintenance areas and inspection and maintenance procedures in the SWMP.

  - o Train employees and subcontractors in proper fueling procedures (stay with vehicles during fueling, proper use of pumps, emergency shutoff valves, etc.).

  - o Inspect on-site vehicles and equipment regularly for leaks, equipment damage, and other service problems.

  - o Clearly designate vehicle/equipment service areas away from drainage facilities and watercourses to prevent stormwater run-on and runoff.

  - o Use drip pans, drip cloths, or absorbent pads when replacing spent fluids.

  - o Collect all spent fluids, store in appropriate labeled containers in the proper storage areas, and recycle fluids whenever possible.

- **Control Equipment/Vehicle Washing and Allowable Non-Stormwater Discharges.** Implement practices to prevent contamination of surface and groundwater from equipment and vehicle wash water. Representative practices include:

  - o Educate employees and subcontractors on proper washing procedures.

  - o Use off-site washing facilities, when available.

  - o Clearly mark the washing areas and inform workers that all washing must occur in this area.

  - o Contain wash water and treat it using BMPs. Infiltrate washwater when possible, but maintain separation from drainage paths and waterbodies.

- Use high-pressure water spray at vehicle washing facilities without detergents. Water alone can remove most dirt adequately.
- Do not conduct other activities, such as vehicle repairs, in the wash area.
- Include the location of the washing facilities and the inspection and maintenance procedures in the SWMP.

- **Develop a Spill Prevention and Response Plan.** Spill prevention and response procedures must be identified in the SWMP. Representative procedures include identifying ways to reduce the chance of spills, stop the source of spills, contain and clean up spills, dispose of materials contaminated by spills, and train personnel responsible for spill prevention and response. The plan should also specify material handling procedures and storage requirements and ensure that clear and concise spill cleanup procedures are provided and posted for areas in which spills may potentially occur. When developing a spill prevention plan, include the following:
  - Note the locations of chemical storage areas, storm drains, tributary drainage areas, surface waterbodies on or near the site, and measures to stop spills from leaving the site.
  - Provide proper handling and safety procedures for each type of waste. Keep Material Safety Data Sheets (MSDSs) for chemical used on site with the SWMP.
  - Establish an education program for employees and subcontractors on the potential hazards to humans and the environment from spills and leaks.
  - Specify how to notify appropriate authorities, such as police and fire departments, hospitals, or municipal sewage treatment facilities to request assistance. Emergency procedures and contact numbers should be provided in the SWMP and posted at storage locations.
  - Describe the procedures, equipment and materials for immediate cleanup of spills and proper disposal.
  - Identify personnel responsible for implementing the plan in the event of a spill. Update the spill prevention plan and clean up materials as changes occur to the types of chemicals stored and used at the facility.

Spill Prevention, Control, and Countermeasure (SPCC) Plan

Construction sites may be subject to 40 CFR Part 112 regulations that require the preparation and implementation of a SPCC Plan to prevent oil spills from aboveground and underground storage tanks. The facility is subject to this rule if it is a non-transportation-related facility that:

- Has a total storage capacity greater than 1,320 gallons or a completely buried storage capacity greater than 42,000 gallons.
- Could reasonably be expected to discharge oil in quantities that may be harmful to navigable waters of the United States and adjoining shorelines.

Furthermore, if the facility is subject to 40 CFR Part 112, the SWMP should reference the SPCC Plan. To find out more about SPCC Plans, see EPA's website on SPPC at www.epa.gov/oilspill/spcc.htm.

Reporting Oil Spills

In the event of an oil spill, contact the National Response Center toll free at 1-800-424- 8802 for assistance, or for more details, visit their website: www.nrc.uscg.mil.

Maintenance and Removal

Effective implementation of good housekeeping practices is dependent on clear designation of personnel responsible for supervising and implementing good housekeeping programs, such as site cleanup and disposal of trash and debris, hazardous material management and disposal, vehicle and equipment maintenance, and other practices. Emergency response "drills" may aid in emergency preparedness.

Checklists may be helpful in good housekeeping efforts.

Staging and storage areas require permanent stabilization when the areas are no longer being used for construction-related activities.

Construction-related materials, debris and waste must be removed from the construction site once construction is complete.

Design Details

See the following Fact Sheets for related Design Details:

MM-1 Concrete Washout Area

MM-2 Stockpile Management

SM-4 Vehicle Tracking Control

Design details are not necessary for other good housekeeping practices; however, be sure to designate where specific practices will occur on the appropriate construction drawings.

Description

A silt fence is a woven geotextile fabric attached to wooden posts and trenched into the ground. It is designed as a sediment barrier to intercept sheet flow runoff from disturbed areas.

Photograph SF-1. Silt fence creates a sediment barrier, forcing sheet flow runoff to evaporate or infiltrate.

Appropriate Uses

A silt fence can be used where runoff is conveyed from a disturbed area as sheet flow. Silt fence is not designed to receive concentrated flow or to be used as a filter fabric. Typical uses include:

- Down slope of a disturbed area to accept sheet flow.
- Along the perimeter of a receiving water such as a stream, pond or wetland.
- At the perimeter of a construction site.

Design and Installation

Silt fence should be installed along the contour of slopes so that it intercepts sheet flow. The maximum recommended tributary drainage area per 100 lineal feet of silt fence, installed along the contour, is approximately 0.25 acres with a disturbed slope length of up to 150 feet and a tributary slope gradient no steeper than 3:1. Longer and steeper slopes require additional measures. This recommendation only applies to silt fence installed along the contour. Silt fence installed for other uses, such as perimeter control, should be installed in a way that will not produce concentrated flows. For example, a "J-hook" installation may be appropriate to force runoff to pond and evaporate or infiltrate in multiple areas rather than concentrate and cause erosive conditions parallel to the silt fence.

See Detail SF-1 for proper silt fence installation, which involves proper trenching, staking, securing the fabric to the stakes, and backfilling the silt fence. Properly installed silt fence should not be easily pulled out by hand and there should be no gaps between the ground and the fabric.

Silt fence must meet the minimum allowable strength requirements, depth of installation requirement, and other specifications in the design details. Improper installation of silt fence is a common reason for silt fence failure; however, when properly installed and used for the appropriate purposes, it can be highly effective.

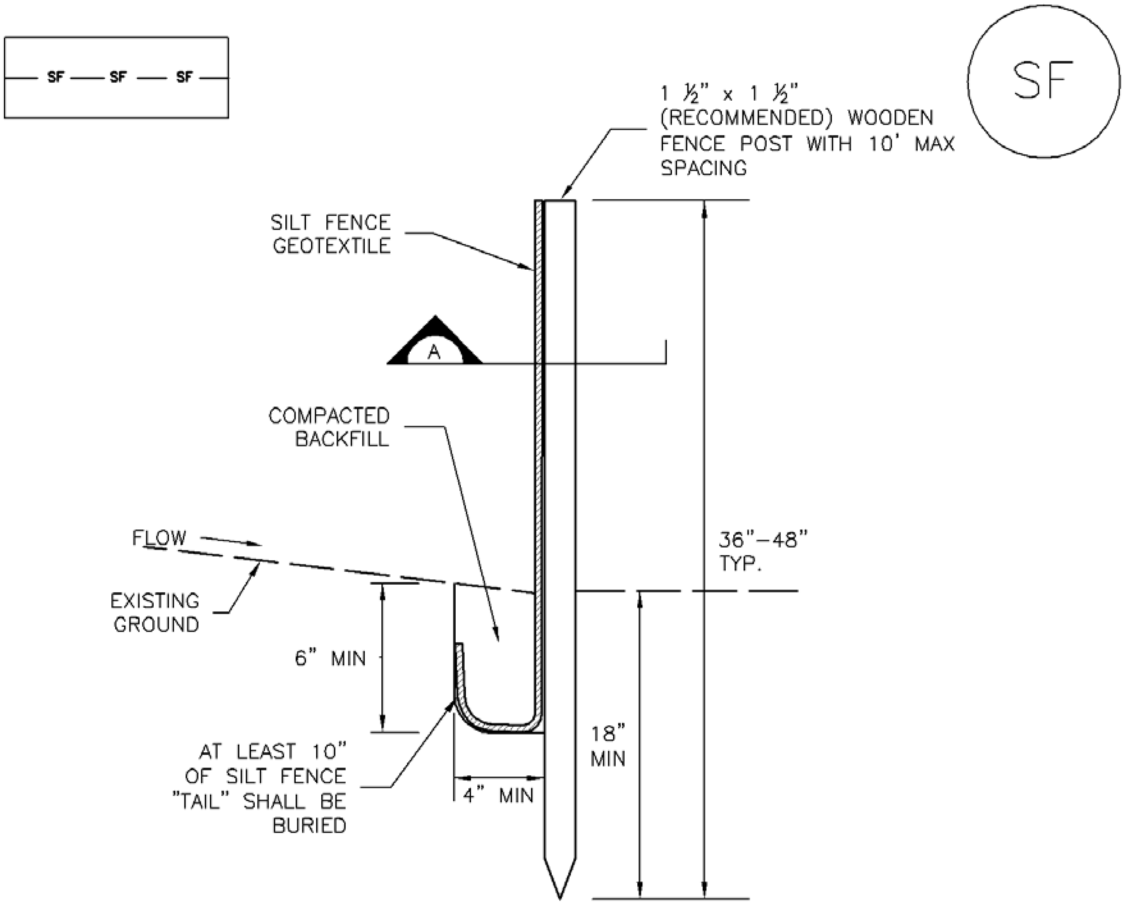
Silt Fence	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No

Maintenance and Removal

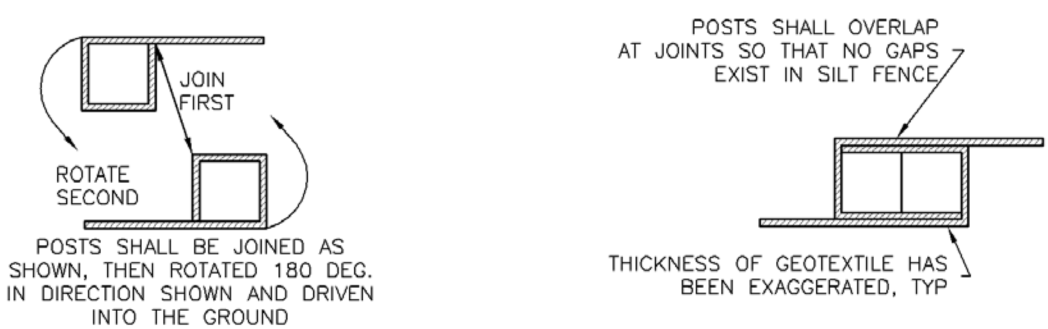
Inspection of silt fence includes observing the material for tears or holes and checking for slumping fence and undercut areas bypassing flows. Repair of silt fence typically involves replacing the damaged section with a new section. Sediment accumulated behind silt fence should be removed, as needed to maintain BMP effectiveness, typically before it reaches a depth of 6 inches.

Silt fence may be removed when the upstream area has reached final stabilization.

Photograph SF-2. When silt fence is not installed along the contour, a "J-hook" installation may be appropriate to ensure that the BMP does not create concentrated flow parallel to the silt fence. Photo courtesy of Tom Gore.



SILT FENCE



SECTION A

SF–1. SILT FENCE

SILT FENCE INSTALLATION NOTES

1. SILT FENCE MUST BE PLACED AWAY FROM THE TOE OF THE SLOPE TO ALLOW FOR WATER PONDING. SILT FENCE AT THE TOE OF A SLOPE SHOULD BE INSTALLED IN A FLAT LOCATION AT LEAST SEVERAL FEET (2–5 FT) FROM THE TOE OF THE SLOPE TO ALLOW ROOM FOR PONDING AND DEPOSITION.

2. A UNIFORM 6" X 4" ANCHOR TRENCH SHALL BE EXCAVATED USING TRENCHER OR SILT FENCE INSTALLATION DEVICE. NO ROAD GRADERS, BACKHOES, OR SIMILAR EQUIPMENT SHALL BE USED.

3. COMPACT ANCHOR TRENCH BY HAND WITH A "JUMPING JACK" OR BY WHEEL ROLLING. COMPACTION SHALL BE SUCH THAT SILT FENCE RESISTS BEING PULLED OUT OF ANCHOR TRENCH BY HAND.

4. SILT FENCE SHALL BE PULLED TIGHT AS IT IS ANCHORED TO THE STAKES. THERE SHOULD BE NO NOTICEABLE SAG BETWEEN STAKES AFTER IT HAS BEEN ANCHORED TO THE STAKES.

5. SILT FENCE FABRIC SHALL BE ANCHORED TO THE STAKES USING 1" HEAVY DUTY STAPLES OR NAILS WITH 1" HEADS. STAPLES AND NAILS SHOULD BE PLACED 3" ALONG THE FABRIC DOWN THE STAKE.

6. AT THE END OF A RUN OF SILT FENCE ALONG A CONTOUR, THE SILT FENCE SHOULD BE TURNED PERPENDICULAR TO THE CONTOUR TO CREATE A "J–HOOK." THE "J–HOOK" EXTENDING PERPENDICULAR TO THE CONTOUR SHOULD BE OF SUFFICIENT LENGTH TO KEEP RUNOFF FROM FLOWING AROUND THE END OF THE SILT FENCE (TYPICALLY 10' – 20').

7. SILT FENCE SHALL BE INSTALLED PRIOR TO ANY LAND DISTURBING ACTIVITIES.

SILT FENCE MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. SEDIMENT ACCUMULATED UPSTREAM OF THE SILT FENCE SHALL BE REMOVED AS NEEDED TO MAINTAIN THE FUNCTIONALITY OF THE BMP, TYPICALLY WHEN DEPTH OF ACCUMULATED SEDIMENTS IS APPROXIMATELY 6".

5. REPAIR OR REPLACE SILT FENCE WHEN THERE ARE SIGNS OF WEAR, SUCH AS SAGGING, TEARING, OR COLLAPSE.

6. SILT FENCE IS TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND APPROVED BY THE LOCAL JURISDICTION, OR IS REPLACED BY AN EQUIVALENT PERIMETER SEDIMENT CONTROL BMP.

7. WHEN SILT FENCE IS REMOVED, ALL DISTURBED AREAS SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

(DETAIL ADAPTED FROM TOWN OF PARKER, COLORADO AND CITY OF AURORA, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Sediment Control Log (SCL) SC-2

Description

A sediment control log is a linear roll made of natural materials such as straw, coconut fiber, or other fibrous material trenched into the ground and held with a wooden stake. Sediment control logs are also often referred to as "straw wattles." They are used as a sediment barrier to intercept sheet flow runoff from disturbed areas.

Photographs SCL-1 and SCL-2. Sediment control logs used as 1) a perimeter control around a soil stockpile; and, 2) as a "J-hook" perimeter control at the corner of a construction site.

Appropriate Uses

Sediment control logs can be used in the following applications to trap sediment:

- As perimeter control for stockpiles and the site.
- As part of inlet protection designs.
- As check dams in small drainage ditches. (Sediment control logs are not intended for use in channels with high flow velocities.)
- On disturbed slopes to shorten flow lengths (as an erosion control).
- As part of multi-layered perimeter control along a receiving water such as a stream, pond or wetland.

Sediment control logs work well in combination with other layers of erosion and sediment controls.

Design and Installation

Sediment control logs should be installed along the contour to avoid concentrating flows. The maximum allowable tributary drainage area per 100 lineal feet of sediment control log, installed along the contour, is approximately 0.25 acres with a disturbed slope length of up to 150 feet and a tributary slope gradient no steeper than 3:1. Longer and steeper slopes require additional measures. This recommendation only applies to sediment control logs installed along the contour. When installed for other uses, such as perimeter control, it should be installed in a way that will not produce concentrated flows. For example, a "J-hook" installation may be appropriate to force runoff to pond and evaporate or infiltrate in multiple areas rather than concentrate and cause erosive conditions parallel to the BMP.

Sediment Control Log	
Functions	
Erosion Control	Moderate
Sediment Control	Yes
Site/Material Management	No

Although sediment control logs initially allow runoff to flow through the BMP, they can quickly become a barrier and should be installed is if they are impermeable.

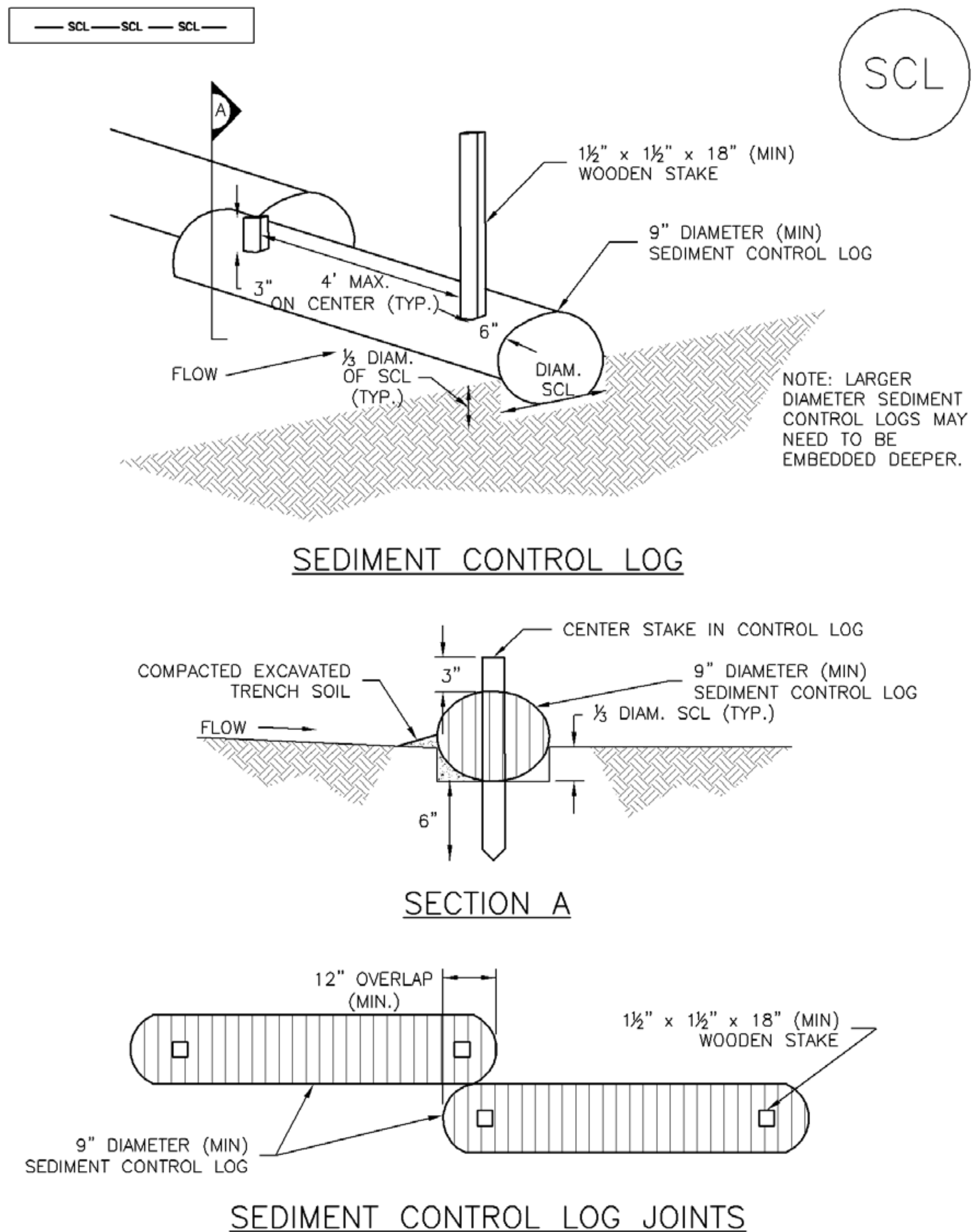
Design details and notes for sediment control logs are provided in Detail SCL-1. Sediment logs must be properly trenched and staked into the ground to prevent undercutting, bypassing and displacement. When installed on slopes, sediment control logs should be installed along the contours (i.e., perpendicular to flow).

Improper installation can lead to poor performance. Be sure that sediment control logs are properly trenched, anchored and tightly jointed.

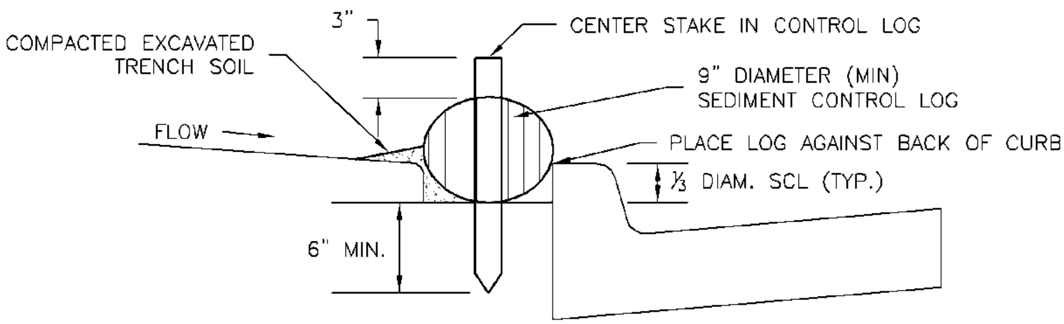
Maintenance and Removal

Be aware that sediment control logs will eventually degrade. Remove accumulated sediment before the depth is one-half the height of the sediment log and repair damage to the sediment log, typically by replacing the damaged section.

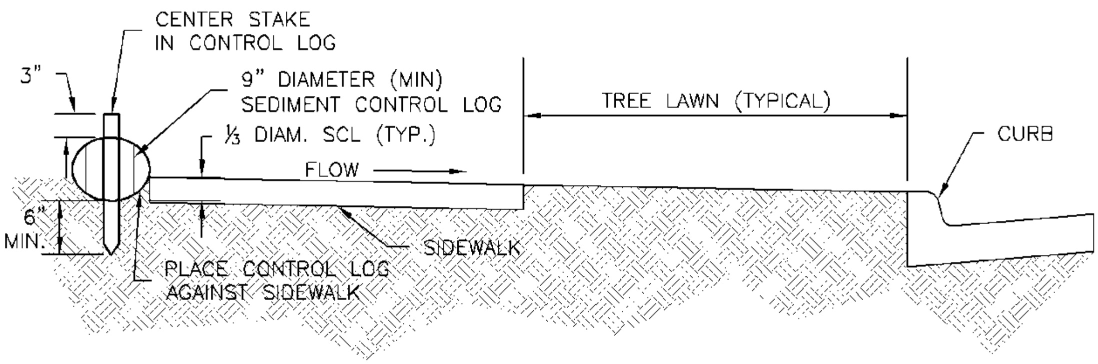
Once the upstream area is stabilized, remove and properly dispose of the logs. Areas disturbed beneath the logs may need to be seeded and mulched. Sediment control logs that are biodegradable may occasionally be left in place (e.g., when logs are used in conjunction with erosion control blankets as permanent slope breaks). However, removal of sediment control logs after final stabilization is typically recommended when used in perimeter control, inlet protection and check dam applications.



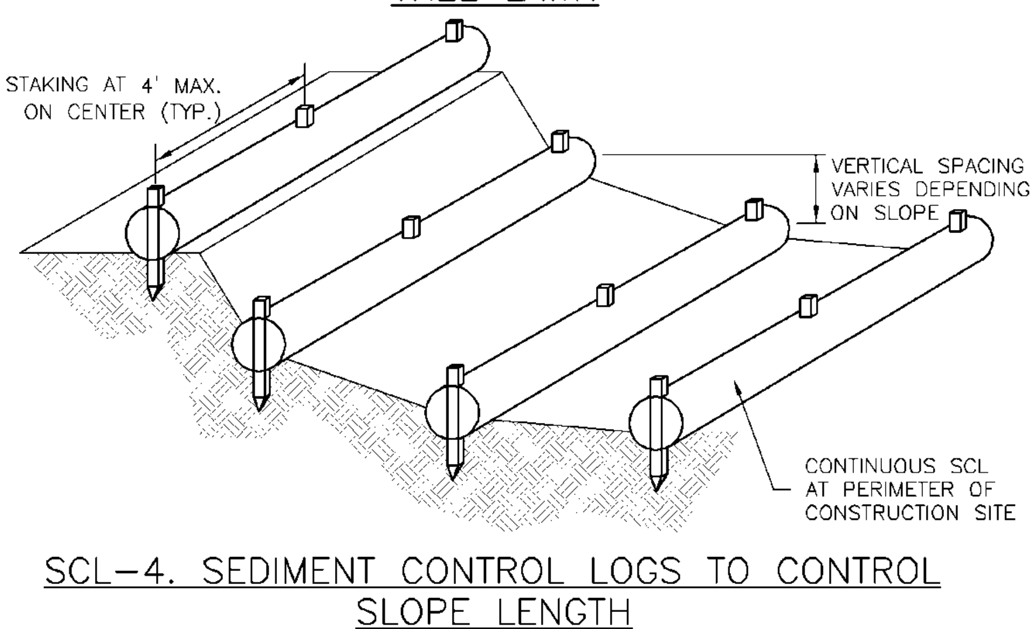
SCL-1. SEDIMENT CONTROL LOG



SCL-2. SEDIMENT CONTROL LOG AT BACK OF CURB



SCL-3. SEDIMENT CONTROL LOG AT SIDEWALK WITH TREE LAWN



SCL-4. SEDIMENT CONTROL LOGS TO CONTROL SLOPE LENGTH

SEDIMENT CONTROL LOG INSTALLATION NOTES

1. SEE PLAN VIEW FOR LOCATION AND LENGTH OF SEDIMENT CONTROL LOGS.

2. SEDIMENT CONTROL LOGS THAT ACT AS A PERIMETER CONTROL SHALL BE INSTALLED PRIOR TO ANY UPGRADIENT LAND-DISTURBING ACTIVITIES.

3. SEDIMENT CONTROL LOGS SHALL CONSIST OF STRAW, COMPOST, EXCELSIOR OR COCONUT FIBER, AND SHALL BE FREE OF ANY NOXIOUS WEED SEEDS OR DEFECTS INCLUDING RIPS, HOLES AND OBVIOUS WEAR.

4. SEDIMENT CONTROL LOGS MAY BE USED AS SMALL CHECK DAMS IN DITCHES AND SWALES. HOWEVER, THEY SHOULD NOT BE USED IN PERENNIAL STREAMS OR HIGH VELOCITY DRAINAGE WAYS.

5. IT IS RECOMMENDED THAT SEDIMENT CONTROL LOGS BE TRENCHED INTO THE GROUND TO A DEPTH OF APPROXIMATELY ⅓ OF THE DIAMETER OF THE LOG. IF TRENCHING TO THIS DEPTH IS NOT FEASIBLE AND/OR DESIRABLE (SHORT TERM INSTALLATION WITH DESIRE NOT TO DAMAGE LANDSCAPE) A LESSER TRENCHING DEPTH MAY BE ACCEPTABLE WITH MORE ROBUST STAKING

6. THE UPHILL SIDE OF THE SEDIMENT CONTROL LOG SHALL BE BACKFILLED WITH SOIL THAT IS FREE OF ROCKS AND DEBRIS. THE SOIL SHALL BE TIGHTLY COMPACTED INTO THE SHAPE OF A RIGHT TRIANGLE USING A SHOVEL OR WEIGHTED LAWN ROLLER.

7. FOLLOW MANUFACTURERS' GUIDANCE FOR STAKING. IF MANUFACTURERS' INSTRUCTIONS DO NOT SPECIFY SPACING, STAKES SHALL BE PLACED ON 4' CENTERS AND EMBEDDED A MINIMUM OF 6" INTO THE GROUND. 3" OF THE STAKE SHALL PROTRUDE FROM THE TOP OF THE LOG. STAKES THAT ARE BROKEN PRIOR TO INSTALLATION SHALL BE REPLACED.

SEDIMENT CONTROL LOG MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. SEDIMENT ACCUMULATED UPSTREAM OF SEDIMENT CONTROL LOG SHALL BE REMOVED AS NEEDED TO MAINTAIN FUNCTIONALITY OF THE BMP, TYPICALLY WHEN DEPTH OF ACCUMULATED SEDIMENTS IS APPROXIMATELY ½ OF THE HEIGHT OF THE SEDIMENT CONTROL LOG.

5. SEDIMENT CONTROL LOG SHALL BE REMOVED AT THE END OF CONSTRUCTION. IF DISTURBED AREAS EXIST AFTER REMOVAL, THEY SHALL BE COVERED WITH TOP SOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

(DETAILS ADAPTED FROM TOWN OF PARKER, COLORADO, JEFFERSON COUNTY, COLORADO, DOUGLAS COUNTY, COLORADO, AND CITY OF AURORA, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

A brush barrier is a perimeter sediment control constructed with stacked shrubs, tree limbs, and bushy vegetation that has been cleared from a construction area. Brush barriers reduce sediment loads by intercepting and slowing sheet flow from disturbed areas.

Photograph BB-1. Brush barrier constructed with chipped wood. Photo courtesy of EPA.

Appropriate Uses

A brush barrier is an appropriate BMP at sites where there is adequate brush from the clearing and grubbing of the construction site to construct an effective brush barrier. Brush barriers are typically used at the toe of slopes and should be implemented in combination with other BMPs such as surface roughening and reseeding. Brush barriers should be considered short-term, supplemental BMPs because they are constructed of materials that naturally decompose. Brush barriers are not acceptable as a sole means of perimeter control, but they may be used internally within a site to reduce slope length or at the site perimeter in combination with other perimeter control BMPs for multi-layered protection.

Brush barriers are not appropriate for high-velocity flow areas. A large amount of material is needed to construct a useful brush barrier; therefore, alternative perimeter controls such as a fabric silt fence may be more appropriate for sites with little material from clearing.

Design and Installation

The drainage area for brush barriers should be no greater than 0.25 acre per 100 feet of barrier length. Additionally, the drainage slope leading down to a brush barrier must be no greater than 3:1 and no longer than 150 feet.

To construct an effective brush barrier, use only small shrubs and limbs with diameters of 6 inches or less. Larger materials (such as a tree stump) can create void spaces in the barrier, making it ineffective. The brush barrier mound should be at least 3 feet high and 5 feet wide at its base.

In order to avoid significant movement of the brush and improve effectiveness, a filter fabric can be placed over the top of the brush pile, keyed in on the upstream side, and anchored on the downstream side. On the upgradient side, the filter fabric cover should be buried in a trench 4 inches deep and 6 inches wide.

Brush Barrier	
Functions	
Erosion Control	Moderate
Sediment Control	Moderate
Site/Material	No

Maintenance and Removal

Inspect the brush barrier for voids where concentrated flow or erosion is occurring. Voids in the brush barrier should be filled with additional brush. Accumulated sediment should be removed from the uphill side of the barrier when sediment height reaches one-third of the height of the barrier.

If filter fabric is used, inspect the filter fabric for damage; replace and properly secure it, as needed.

Once the upstream area has been vegetated or stabilized, the brush barrier should be removed and the underlying area revegetated.

Description

Photograph RS-1. Rock socks placed at regular intervals in a curb line can help reduce sediment loading to storm sewer inlets. Rock socks can also be used as perimeter controls.

A rock sock is constructed of gravel that has been wrapped by wire mesh or a geotextile to form an elongated cylindrical filter. Rock socks are typically used either as a perimeter control or as part of inlet protection. When placed at angles in the curb line, rock socks are typically referred to as curb socks. Rock socks are intended to trap sediment from stormwater runoff that flows onto roadways as a result of construction activities.

Appropriate Uses

Rock socks can be used at the perimeter of a disturbed area to control localized sediment loading. A benefit of rock socks as opposed to other perimeter controls is that they do not have to be trenched or staked into the ground; therefore, they are often used on roadway construction projects where paved surfaces are present.

Use rock socks in inlet protection applications when the construction of a roadway is substantially complete and the roadway has been directly connected to a receiving storm system.

Design and Installation

When rock socks are used as perimeter controls, the maximum recommended tributary drainage area per 100 lineal feet of rock socks is approximately 0.25 acres with disturbed slope length of up to 150 feet and a tributary slope gradient no steeper than 3:1. A rock sock design detail and notes are provided in Detail RS-1. Also see the Inlet Protection Fact Sheet for design and installation guidance when rock socks are used for inlet protection and in the curb line.

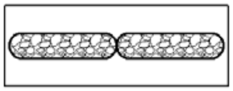
When placed in the gutter adjacent to a curb, rock socks should protrude no more than two feet from the curb in order for traffic to pass safely. If located in a high traffic area, place construction markers to alert drivers and street maintenance workers of their presence.

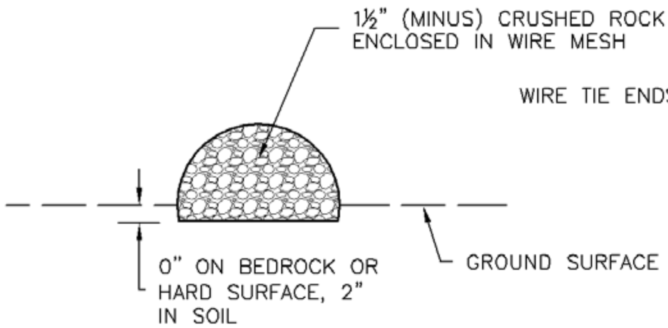
Maintenance and Removal

Rock socks are susceptible to displacement and breaking due to vehicle traffic. Inspect rock socks for damage and repair or replace as necessary. Remove sediment by sweeping or vacuuming as needed to maintain the functionality of the BMP, typically when sediment has accumulated behind the rock sock to one-half of the sock's height.

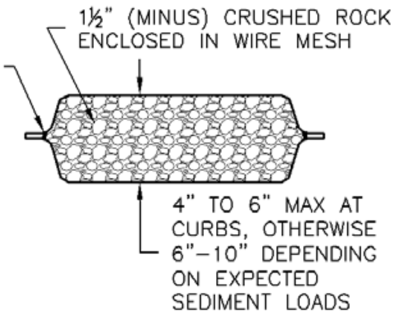
Once upstream stabilization is complete, rock socks and accumulated sediment should be removed and properly disposed.

Rock Sock	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No

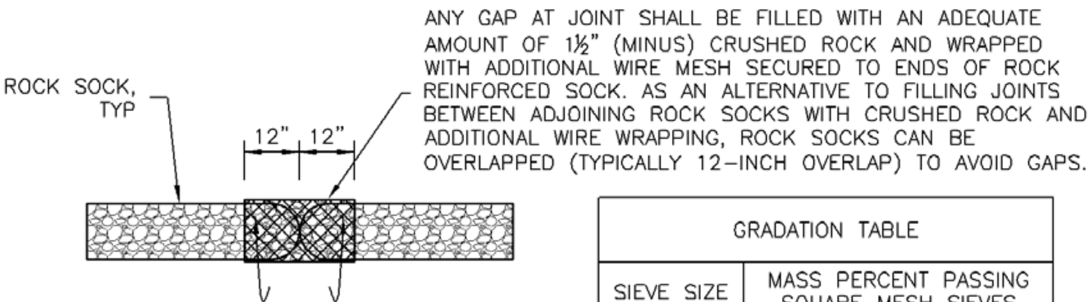




ROCK SOCK SECTION



ROCK SOCK PLAN



ROCK SOCK JOINTING

GRADATION TABLE	
SIEVE SIZE	MASS PERCENT PASSING SQUARE MESH SIEVES
	NO. 4
2"	100
1½"	90 – 100
1"	20 – 55
¾"	0 – 15
⅜"	0 – 5
MATCHES SPECIFICATIONS FOR NO. 4 COARSE AGGREGATE FOR CONCRETE PER AASHTO M43. ALL ROCK SHALL BE FRACTURED FACE, ALL SIDES.	

ROCK SOCK INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   -LOCATION(S) OF ROCK SOCKS.

2. CRUSHED ROCK SHALL BE 1½" (MINUS) IN SIZE WITH A FRACTURED FACE (ALL SIDES) AND SHALL COMPLY WITH GRADATION SHOWN ON THIS SHEET (1½" MINUS).

3. WIRE MESH SHALL BE FABRICATED OF 10 GAGE POULTRY MESH, OR EQUIVALENT, WITH A MAXIMUM OPENING OF ½", RECOMMENDED MINIMUM ROLL WIDTH OF 48"

4. WIRE MESH SHALL BE SECURED USING "HOG RINGS" OR WIRE TIES AT 6" CENTERS ALONG ALL JOINTS AND AT 2" CENTERS ON ENDS OF SOCKS.

5. SOME MUNICIPALITIES MAY ALLOW THE USE OF FILTER FABRIC AS AN ALTERNATIVE TO WIRE MESH FOR THE ROCK ENCLOSURE.

RS-1. ROCK SOCK PERIMETER CONTROL

ROCK SOCK MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. ROCK SOCKS SHALL BE REPLACED IF THEY BECOME HEAVILY SOILED, OR DAMAGED BEYOND REPAIR.

5. SEDIMENT ACCUMULATED UPSTREAM OF ROCK SOCKS SHALL BE REMOVED AS NEEDED TO MAINTAIN FUNCTIONALITY OF THE BMP, TYPICALLY WHEN DEPTH OF ACCUMULATED SEDIMENTS IS APPROXIMATELY ½ OF THE HEIGHT OF THE ROCK SOCK.

6. ROCK SOCKS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND APPROVED BY THE LOCAL JURISDICTION.

7. WHEN ROCK SOCKS ARE REMOVED, ALL DISTURBED AREAS SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

(DETAIL ADAPTED FROM TOWN OF PARKER, COLORADO AND CITY OF AURORA, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

NOTE: THE DETAILS INCLUDED WITH THIS FACT SHEET SHOW COMMONLY USED, CONVENTIONAL METHODS OF ROCK SOCK INSTALLATION IN THE DENVER METROPOLITAN AREA. THERE ARE MANY OTHER SIMILAR PROPRIETARY PRODUCTS ON THE MARKET. UDFCD NEITHER NDORSES NOR DISCOURAGES USE OF PROPRIETARY PROTECTION PRODUCTS; HOWEVER, IN THE EVENT PROPRIETARY METHODS ARE USED, THE APPROPRIATE DETAIL FROM THE MANUFACTURER MUST BE INCLUDED IN THE SWMP AND THE BMP MUST BE INSTALLED AND MAINTAINED AS SHOWN IN THE MANUFACTURER'S DETAILS.

Description

Photograph IP-1. Inlet protection for a curb opening inlet.

Inlet protection consists of permeable barriers installed around an inlet to filter runoff and remove sediment prior to entering a storm drain inlet. Inlet protection can be constructed from rock socks, sediment control logs, silt fence, block and rock socks, or other materials approved by the local jurisdiction. Area inlets can also be protected by over-excavating around the inlet to form a sediment trap.

Appropriate Uses

Install protection at storm sewer inlets that are operable during construction. Consider the potential for tracked-out sediment or temporary stockpile areas to contribute sediment to inlets when determining which inlets must be protected. This may include inlets in the general proximity of the construction area, not limited to downgradient inlets. Inlet protection is <u>not</u> a stand-alone BMP and should be used in conjunction with other upgradient BMPs.

Design and Installation

To function effectively, inlet protection measures must be installed to ensure that flows do not bypass the inlet protection and enter the storm drain without treatment. However, designs must also enable the inlet to function without completely blocking flows into the inlet in a manner that causes localized flooding. When selecting the type of inlet protection, consider factors such as type of inlet (e.g., curb or area, sump or on-grade conditions), traffic, anticipated flows, ability to secure the BMP properly, safety and other site-specific conditions. For example, block and rock socks will be better suited to a curb and gutter along a roadway, as opposed to silt fence or sediment control logs, which cannot be properly secured in a curb and gutter setting, but are effective area inlet protection measures.

Several inlet protection designs are provided in the Design Details. Additionally, a variety of proprietary products are available for inlet protection that may be approved for use by local governments. If proprietary products are used, design details and installation procedures from the manufacturer must be followed. Regardless of the type of inlet protection selected, inlet protection is most effective when combined with other BMPs such as curb socks and check dams. Inlet protection is often the last barrier before runoff enters the storm sewer or receiving water.

Design details with notes are provided for these forms of inlet protection:

IP-1. Block and Rock Sock Inlet Protection for Sump or On-grade Inlets

IP-2. Curb (Rock) Socks Upstream of Inlet Protection, On-grade Inlets

Inlet Protection (various forms)	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No

IP-3. Rock Sock Inlet Protection for Sump/Area Inlet

IP-4. Silt Fence Inlet Protection for Sump/Area Inlet

IP-5. Over-excavation Inlet Protection

IP-6. Straw Bale Inlet Protection for Sump/Area Inlet

CIP-1. Culvert Inlet Protection

Propriety inlet protection devices should be installed in accordance with manufacturer specifications.

More information is provided below on selecting inlet protection for sump and on-grade locations.

Inlets Located in a Sump

When applying inlet protection in sump conditions, it is important that the inlet continue to function during larger runoff events. For curb inlets, the maximum height of the protective barrier should be lower than the top of the curb opening to allow overflow into the inlet during larger storms without excessive localized flooding. If the inlet protection height is greater than the curb elevation, particularly if the filter becomes clogged with sediment, runoff will not enter the inlet and may bypass it, possibly causing localized flooding, public safety issues, and downstream erosion and damage from bypassed flows.

Area inlets located in a sump setting can be protected through the use of silt fence, concrete block and rock socks (on paved surfaces), sediment control logs/straw wattles embedded in the adjacent soil and stacked around the area inlet (on pervious surfaces), over-excavation around the inlet, and proprietary products providing equivalent functions.

Inlets Located on a Slope

For curb and gutter inlets on paved sloping streets, block and rock sock inlet protection is recommended in conjunction with curb socks in the gutter leading to the inlet. For inlets located along unpaved roads, also see the Check Dam Fact Sheet.

Maintenance and Removal

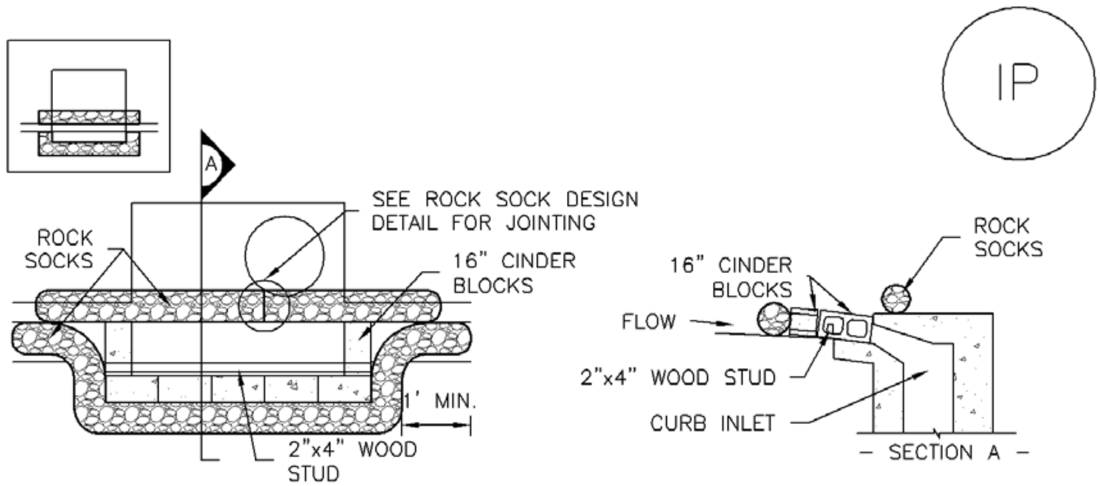
Inspect inlet protection frequently. Inspection and maintenance guidance includes:

- Inspect for tears that can result in sediment directly entering the inlet, as well as result in the contents of the BMP (e.g., gravel) washing into the inlet.
- Check for improper installation resulting in untreated flows bypassing the BMP and directly entering the inlet or bypassing to an unprotected downstream inlet. For example, silt fence that has not been properly trenched around the inlet can result in flows under the silt fence and directly into the inlet.
- Look for displaced BMPs that are no longer protecting the inlet. Displacement may occur following larger storm events that wash away or reposition the inlet protection. Traffic or equipment may also crush or displace the BMP.
- Monitor sediment accumulation upgradient of the inlet protection.

- Remove sediment accumulation from the area upstream of the inlet protection, as needed to maintain BMP effectiveness, typically when it reaches no more than half the storage capacity of the inlet protection. For silt fence, remove sediment when it accumulates to a depth of no more than 6 inches. Remove sediment accumulation from the area upstream of the inlet protection as needed to maintain the functionality of the BMP.

- Propriety inlet protection devices should be inspected and maintained in accordance with manufacturer specifications. If proprietary inlet insert devices are used, sediment should be removed in a timely manner to prevent devices from breaking and spilling sediment into the storm drain.

Inlet protection must be removed and properly disposed of when the drainage area for the inlet has reached final stabilization.



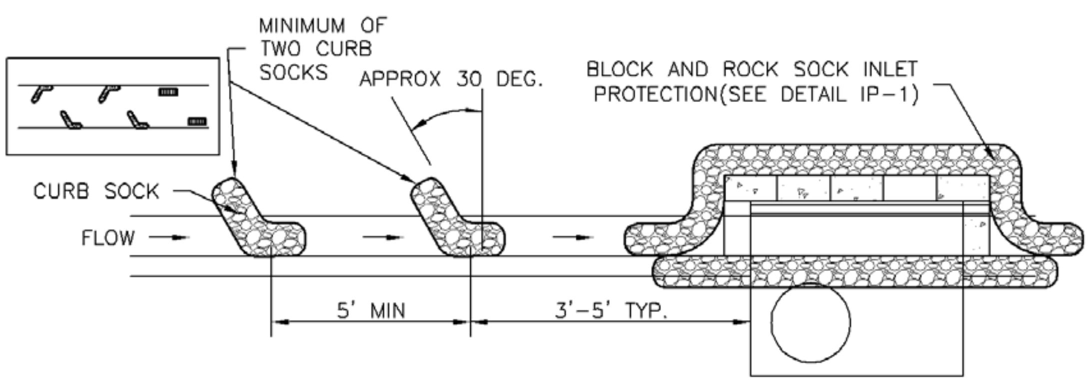
IP–1. BLOCK AND ROCK SOCK SUMP OR ON GRADE INLET PROTECTION

BLOCK AND CURB SOCK INLET PROTECTION INSTALLATION NOTES

1. SEE ROCK SOCK DESIGN DETAIL FOR INSTALLATION REQUIREMENTS.

2. CONCRETE "CINDER" BLOCKS SHALL BE LAID ON THEIR SIDES AROUND THE INLET IN A SINGLE ROW, ABUTTING ONE ANOTHER WITH THE OPEN END FACING AWAY FROM THE CURB.

3. GRAVEL BAGS SHALL BE PLACED AROUND CONCRETE BLOCKS, CLOSELY ABUTTING ONE ANOTHER AND JOINTED TOGETHER IN ACCORDANCE WITH ROCK SOCK DESIGN DETAIL.



IP–2. CURB ROCK SOCKS UPSTREAM OF INLET PROTECTION

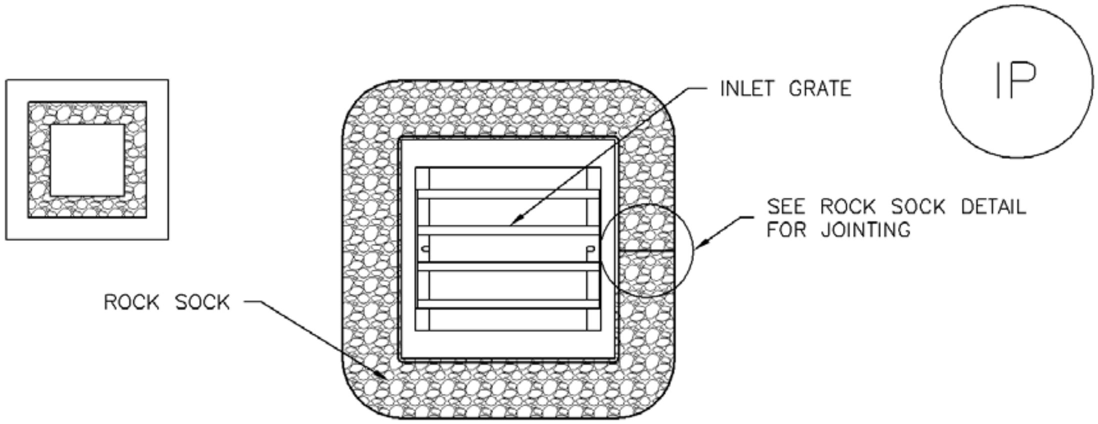
CURB ROCK SOCK INLET PROTECTION INSTALLATION NOTES

1. SEE ROCK SOCK DESIGN DETAIL INSTALLATION REQUIREMENTS.

2. PLACEMENT OF THE SOCK SHALL BE APPROXIMATELY 30 DEGREES FROM PERPENDICULAR IN THE OPPOSITE DIRECTION OF FLOW.

3. SOCKS ARE TO BE FLUSH WITH THE CURB AND SPACED A MINIMUM OF 5 FEET APART.

4. AT LEAST TWO CURB SOCKS IN SERIES ARE REQUIRED UPSTREAM OF ON–GRADE INLETS.

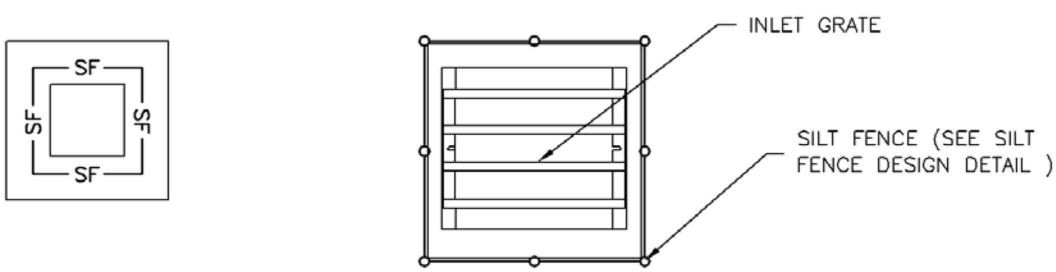


IP–3. ROCK SOCK SUMP/AREA INLET PROTECTION

ROCK SOCK SUMP/AREA INLET PROTECTION INSTALLATION NOTES

1. SEE ROCK SOCK DESIGN DETAIL FOR INSTALLATION REQUIREMENTS.

2. STRAW WATTLES/SEDIMENT CONTROL LOGS MAY BE USED IN PLACE OF ROCK SOCKS FOR INLETS IN PERVIOUS AREAS. INSTALL PER SEDIMENT CONTROL LOG DETAIL.



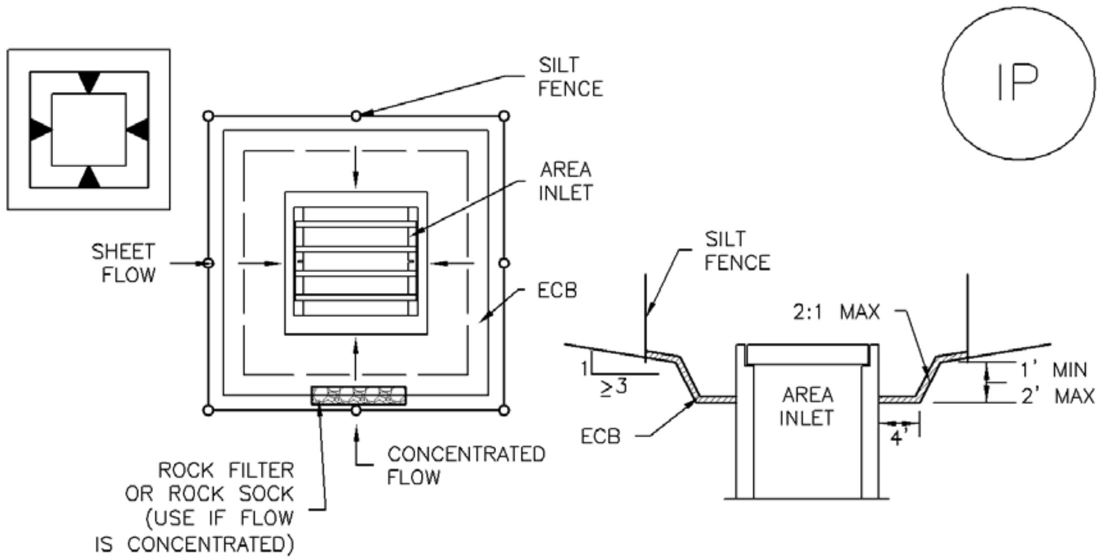
IP–4. SILT FENCE FOR SUMP INLET PROTECTION

SILT FENCE INLET PROTECTION INSTALLATION NOTES

1. SEE SILT FENCE DESIGN DETAIL FOR INSTALLATION REQUIREMENTS.

2. POSTS SHALL BE PLACED AT EACH CORNER OF THE INLET AND AROUND THE EDGES AT A MAXIMUM SPACING OF 3 FEET.

3. STRAW WATTLES/SEDIMENT CONTROL LOGS MAY BE USED IN PLACE OF SILT FENCE FOR INLETS IN PERVIOUS AREAS. INSTALL PER SEDIMENT CONTROL LOG DETAIL.



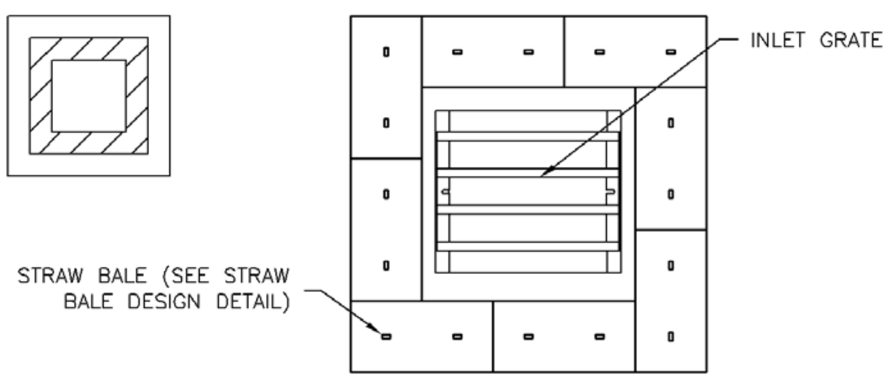
IP-5. OVEREXCAVATION INLET PROTECTION

OVEREXCAVATION INLET PROTECTION INSTALLATION NOTES

1. THIS FORM OF INLET PROTECTION IS PRIMARILY APPLICABLE FOR SITES THAT HAVE NOT YET REACHED FINAL GRADE AND SHOULD BE USED ONLY FOR INLETS WITH A RELATIVELY SMALL CONTRIBUTING DRAINAGE AREA.

2. WHEN USING FOR CONCENTRATED FLOWS, SHAPE BASIN IN 2:1 RATIO WITH LENGTH ORIENTED TOWARDS DIRECTION OF FLOW.

3. SEDIMENT MUST BE PERIODICALLY REMOVED FROM THE OVEREXCAVATED AREA.



IP-6. STRAW BALE FOR SUMP INLET PROTECTION

STRAW BALE BARRIER INLET PROTECTION INSTALLATION NOTES

1. SEE STRAW BALE DESIGN DETAIL FOR INSTALLATION REQUIREMENTS.

2. BALES SHALL BE PLACED IN A SINGLE ROW AROUND THE INLET WITH ENDS OF BALES TIGHTLY ABUTTING ONE ANOTHER.

GENERAL INLET PROTECTION INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF INLET PROTECTION.
   - TYPE OF INLET PROTECTION (IP.1, IP.2, IP.3, IP.4, IP.5, IP.6)

2. INLET PROTECTION SHALL BE INSTALLED PROMPTLY AFTER INLET CONSTRUCTION OR PAVING IS COMPLETE (TYPICALLY WITHIN 48 HOURS). IF A RAINFALL/RUNOFF EVENT IS FORECAST, INSTALL INLET PROTECTION PRIOR TO ONSET OF EVENT.

3. MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

INLET PROTECTION MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. SEDIMENT ACCUMULATED UPSTREAM OF INLET PROTECTION SHALL BE REMOVED AS NECESSARY TO MAINTAIN BMP EFFECTIVENESS, TYPICALLY WHEN STORAGE VOLUME REACHES 50% OF CAPACITY, A DEPTH OF 6" WHEN SILT FENCE IS USED, OR ¼ OF THE HEIGHT FOR STRAW BALES.

5. INLET PROTECTION IS TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS PERMANENTLY STABILIZED, UNLESS THE LOCAL JURISDICTION APPROVES EARLIER REMOVAL OF INLET PROTECTION IN STREETS.

6. WHEN INLET PROTECTION AT AREA INLETS IS REMOVED, THE DISTURBED AREA SHALL BE COVERED WITH TOP SOIL, SEEDED AND MULCHED, OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

(DETAIL ADAPTED FROM TOWN OF PARKER, COLORADO AND CITY OF AURORA, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

NOTE: THE DETAILS INCLUDED WITH THIS FACT SHEET SHOW COMMONLY USED, CONVENTIONAL METHODS OF INLET PROTECTION IN THE DENVER METROPOLITAN AREA. THERE ARE MANY PROPRIETARY INLET PROTECTION METHODS ON THE MARKET. UDFCD NEITHER ENDORSES NOR DISCOURAGES USE OF PROPRIETARY INLET PROTECTION; HOWEVER, IN THE EVENT PROPRIETARY METHODS ARE USED, THE APPROPRIATE DETAIL FROM THE MANUFACTURER MUST BE INCLUDED IN THE SWMP AND THE BMP MUST BE INSTALLED AND MAINTAINED AS SHOWN IN THE MANUFACTURER'S DETAILS.

NOTE: SOME MUNICIPALITIES DISCOURAGE OR PROHIBIT THE USE OF STRAW BALES FOR INLET PROTECTION. CHECK WITH LOCAL JURISDICTION TO DETERMINE IF STRAW BALE INLET PROTECTION IS ACCEPTABLE.

Description

A sediment basin is a temporary pond built on a construction site to capture eroded or disturbed soil transported in storm runoff prior to discharge from the site. Sediment basins are designed to capture site runoff and slowly release it to allow time for settling of sediment prior to discharge. Sediment basins are often constructed in locations that will later be modified to serve as post-construction stormwater basins.

Photograph SB-1. Sediment basin at the toe of a slope. Photo courtesy of WWE.

Appropriate Uses

Most large construction sites (typically greater than 2 acres) will require one or more sediment basins for effective management of construction site runoff. On linear construction projects, sediment basins may be impractical; instead, sediment traps or other combinations of BMPs may be more appropriate.

Sediment basins should not be used as stand-alone sediment controls. Erosion and other sediment controls should also be implemented upstream.

When feasible, the sediment basin should be installed in the same location where a permanent post-construction detention pond will be located.

Design and Installation

The design procedure for a sediment basin includes these steps:

- **Basin Storage Volume**: Provide a storage volume of at least 3,600 cubic feet per acre of drainage area. To the extent practical, undisturbed and/or off-site areas should be diverted around sediment basins to prevent "clean" runoff from mixing with runoff from disturbed areas. For undisturbed areas (both on-site and off-site) that cannot be diverted around the sediment basin, provide a minimum of 500 ft^3/acre of storage for undeveloped (but stable) off-site areas in addition to the 3,600 ft^3/acre for disturbed areas. For stable, developed areas that cannot be diverted around the sediment basin, storage volume requirements are summarized in Table SB-1.

- **Basin Geometry:** Design basin with a minimum length-to-width ratio of 2:1 (L:W). If this cannot be achieved because of site space constraints, baffling may be required to extend the effective distance between the inflow point(s) and the outlet to minimize short-circuiting.

- **Dam Embankment**: It is recommended that embankment slopes be 4:1 (H:V) or flatter and no steeper than 3:1 (H:V) in any location.

Sediment Basins	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No

- **Inflow Structure**: For concentrated flow entering the basin, provide energy dissipation at the point of inflow.

Table SB-1. Additional Volume Requirements for Undisturbed and Developed TributaryAreas Draining through Sediment Basins

Imperviousness (%)	Additional Storage Volume (ft^3) Per Acre of Tributary Area
Undeveloped	500
10	800
20	1230
30	1600
40	2030
50	2470
60	2980
70	3560
80	4360
90	5300
100	6460

- **Outlet Works**: The outlet pipe shall extend through the embankment at a minimum slope of 0.5 percent. Outlet works can be designed using one of the following approaches:
  - **Perforated Riser/Plate**: Follow the design criteria for Full Spectrum Detention outlets in the EDB BMP Fact Sheet provided in Chapter 4 of this manual for sizing of outlet perforations with an emptying time of approximately 72 hours. In lieu of the well-screen trash rack, pack uniformly sized 1½ - to 2-inch gravel in front of the plate. This gravel will need to be cleaned out frequently during the construction period as sediment accumulates within it. The gravel pack will need to be removed and disposed of following construction to reclaim the basin for use as a permanent detention facility. If the basin will be used as a permanent extended detention basin for the site, a well-screen trash rack will need to be installed once contributing drainage areas have been stabilized and the gravel pack and accumulated sediment have been removed.
  - **Floating Skimmer**: If a floating skimmer is used, install it using manufacturer's recommendations. Illustration SB-1 provides an illustration of a Faircloth Skimmer Floating Outlet™, one of the more commonly used floating skimmer outlets. A skimmer should be designed to release the design volume in no less than 48 hours. The use of a floating skimmer outlet can increase the sediment capture efficiency of a basin significantly. A floating outlet continually decants cleanest water off the surface of the pond and releases cleaner water than would discharge from a perforated riser pipe or plate.

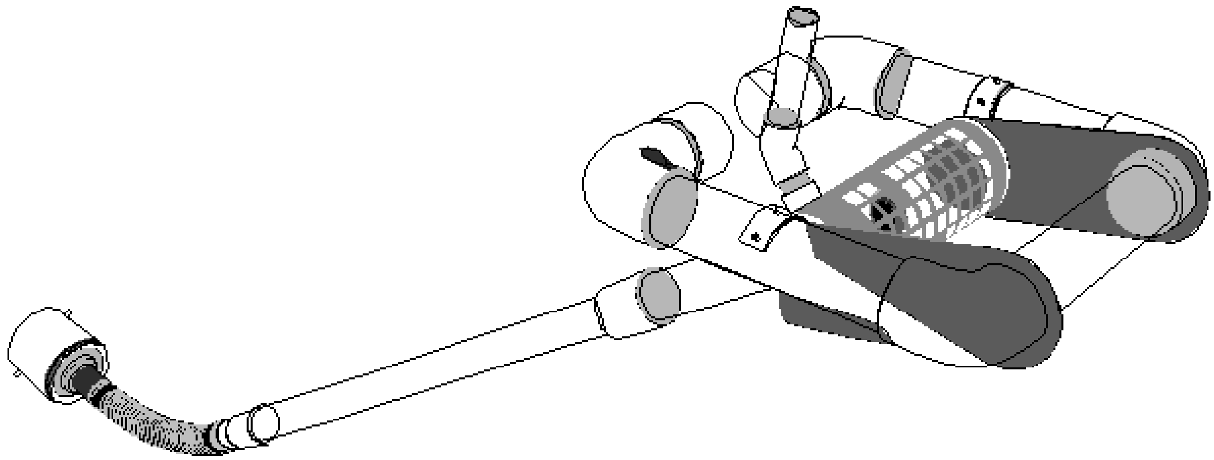


Illustration SB-1. Outlet structure for a temporary sediment basin - Faircloth Skimmer Floating Outlet. Illustration courtesy of J. W. Faircloth & Sons, Inc., FairclothSkimmer.com.

- **Outlet Protection**: Outlet protection should be provided where the velocity of flow will exceed the maximum permissible velocity of the material of the waterway into which discharge occurs. This may require the use of a riprap apron at the outlet location and/or other measures to keep the waterway from eroding.

- **Emergency Spillway**: Provide a stabilized emergency overflow spillway for rainstorms that exceed the capacity of the sediment basin volume and its outlet. Protect basin embankments from erosion and overtopping. If the sediment basin will be converted to a permanent detention basin, design and construct the emergency spillway(s) as required for the permanent facility. If the sediment basin will not become a permanent detention basin, it may be possible to substitute a heavy polyvinyl membrane or properly bedded rock cover to line the spillway and downstream embankment, depending on the height, slope, and width of the embankments.

Maintenance and Removal

Maintenance activities include the following:

- Dredge sediment from the basin, as needed to maintain BMP effectiveness, typically when the design storage volume is no more than one-third filled with sediment.

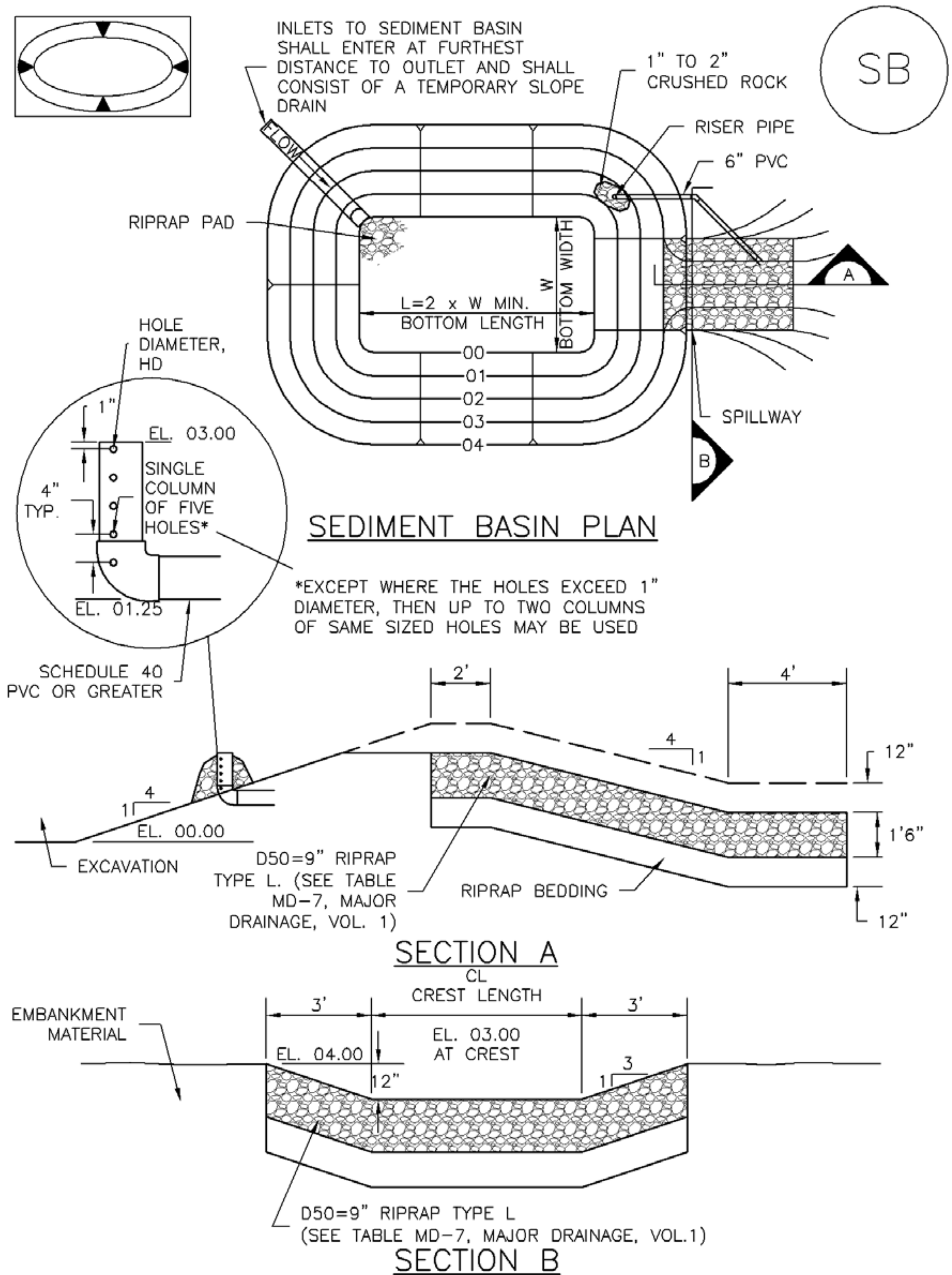
- Inspect the sediment basin embankments for stability and seepage.

- Inspect the inlet and outlet of the basin, repair damage, and remove debris. Remove, clean and replace the gravel around the outlet on a regular basis to remove the accumulated sediment within it and keep the outlet functioning.

- Be aware that removal of a sediment basin may require dewatering and associated permit requirements.

- Do not remove a sediment basin until the upstream area has been stabilized with vegetation.

Final disposition of the sediment basin depends on whether the basin will be converted to a permanent post-construction stormwater basin or whether the basin area will be returned to grade. For basins being converted to permanent detention basins, remove accumulated sediment and reconfigure the basin and outlet to meet the requirements of the final design for the detention facility. If the sediment basin is not to be used as a permanent detention facility, fill the excavated area with soil and stabilize with vegetation.



SB-1. SEDIMENT BASIN

TABLE SB-1. SIZING INFORMATION FOR STANDARD SEDIMENT BASIN			
Upstream Drainage Area (rounded to nearest acre), (ac)	Basin Bottom Width (W), (ft)	Spillway Crest Length (CL), (ft)	Hole Diameter (HD), (in)
1	12 ½	2	9/32
2	21	3	13/16
3	28	5	½
4	33 ½	6	9/16
5	38 ½	8	21/32
6	43	9	21/32
7	47 ¼	11	25/32
8	51	12	27/32
9	55	13	⅞
10	58 ¼	15	15/16
11	61	16	31/32
12	64	18	1
13	67 ½	19	1 1/16
14	70 ½	21	1 ⅛
15	73 ¼	22	1 3/16

SEDIMENT BASIN INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF SEDIMENT BASIN.
   - TYPE OF BASIN (STANDARD BASIN OR NONSTANDARD BASIN).
   - FOR STANDARD BASIN, BOTTOM WIDTH W, CREST LENGTH CL, AND HOLE DIAMETER, HD.
   - FOR NONSTANDARD BASIN, SEE CONSTRUCTION DRAWINGS FOR DESIGN OF BASIN INCLUDING RISER HEIGHT H, NUMBER OF COLUMNS N, HOLE DIAMETER HD AND PIPE DIAMETER D.

2. FOR STANDARD BASIN, BOTTOM DIMENSION MAY BE MODIFIED AS LONG AS BOTTOM AREA IS NOT REDUCED.

3. SEDIMENT BASINS SHALL BE INSTALLED PRIOR TO ANY OTHER LAND-DISTURBING ACTIVITY THAT RELIES ON ON BASINS AS AS A STORMWATER CONTROL.

4. EMBANKMENT MATERIAL SHALL CONSIST OF SOIL FREE OF DEBRIS, ORGANIC MATERIAL, AND ROCKS OR CONCRETE GREATER THAN 3 INCHES AND SHALL HAVE A MINIMUM OF 15 PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE.

5. EMBANKMENT MATERIAL SHALL BE COMPACTED TO AT LEAST 95 PERCENT OF MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D698.

6. PIPE SCH 40 OR GREATER SHALL BE USED.

7. THE DETAILS SHOWN ON THESE SHEETS PERTAIN TO STANDARD SEDIMENT BASIN(S) FOR DRAINAGE AREAS LESS THAN 15 ACRES. SEE CONSTRUCTION DRAWINGS FOR EMBANKMENT, STORAGE VOLUME, SPILLWAY, OUTLET, AND OUTLET PROTECTION DETAILS FOR ANY SEDIMENT BASIN(S) THAT HAVE BEEN INDIVIDUALLY DESIGNED FOR DRAINAGE AREAS LARGER THAN 15 ACRES.

SEDIMENT BASIN MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. SEDIMENT ACCUMULATED IN BASIN SHALL BE REMOVED AS NEEDED TO MAINTAIN BMP EFFECTIVENESS, TYPICALLY WHEN SEDIMENT DEPTH REACHES ONE FOOT (I.E., TWO FEET BELOW THE SPILLWAY CREST).

5. SEDIMENT BASINS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS ACCEPTED BY THE LOCAL JURISDICTION.

6. WHEN SEDIMENT BASINS ARE REMOVED, ALL DISTURBED AREAS SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

Sediment traps are formed by excavating an area or by placing an earthen embankment across a low area or drainage swale. Sediment traps are designed to capture drainage from disturbed areas less than one acre and allow settling of sediment.

Photograph ST-1. Sediment traps are used to collect sediment-laden runoff from disturbed area. Photo courtesy of EPA Menu of BMPs.

Appropriate Uses

Sediment traps can be used in combination with other layers of erosion and sediment controls to trap sediment from small drainage areas (less than one acre) or areas with localized high sediment loading. For example, sediment traps are often provided in conjunction with vehicle tracking controls and wheel wash facilities.

Design and Installation

A sediment trap consists of a small excavated basin with an earthen berm and a riprap outlet. The berm of the sediment trap may be constructed from the excavated material and must be compacted to 95 percent of the maximum density in accordance with ASTM D698. An overflow outlet must be provided at an elevation at least 6 inches below the top of the berm. See Detail ST-1 for additional design and installation information.

Maintenance and Removal

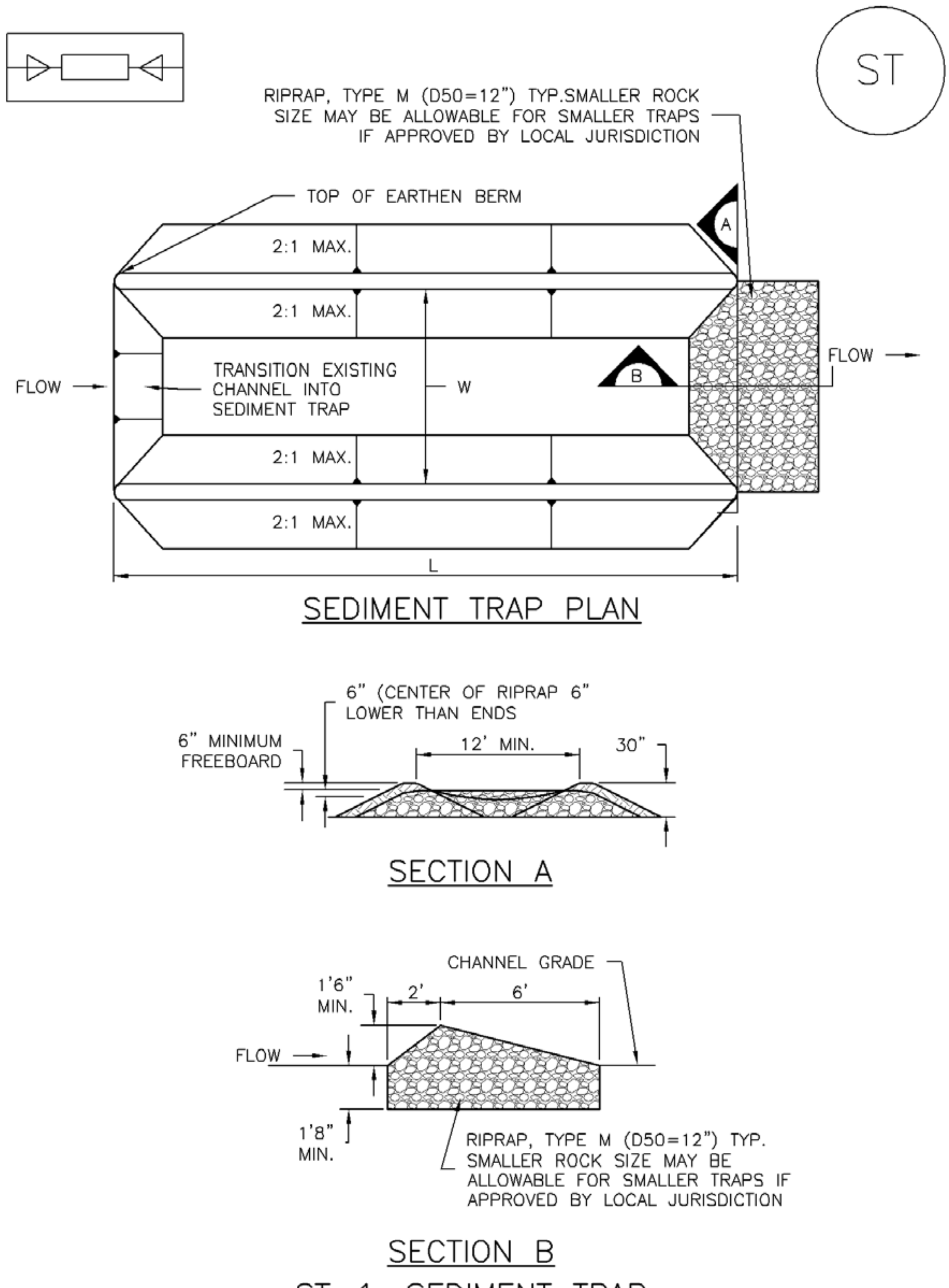
Inspect the sediment trap embankments for stability and seepage.

Remove accumulated sediment as needed to maintain the effectiveness of the sediment trap, typically when the sediment depth is approximately one-half the height of the outflow embankment.

Inspect the outlet for debris and damage. Repair damage to the outlet, and remove all obstructions.

A sediment trap should not be removed until the upstream area is sufficiently stabilized. Upon removal of the trap, the disturbed area should be covered with topsoil and stabilized.

Sediment Trap	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No



ST–1. SEDIMENT TRAP

SEDIMENT TRAP INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   -LOCATION, LENGTH AND WIDTH OF SEDIMENT TRAP.

2. ONLY USE FOR DRAINAGE AREAS LESS THAN 1 ACRE.

3. SEDIMENT TRAPS SHALL BE INSTALLED PRIOR TO ANY UPGRADIENT LAND-DISTURBING ACTIVITIES.

4. SEDIMENT TRAP BERM SHALL BE CONSTRUCTED FROM MATERIAL FROM EXCAVATION. THE BERM SHALL BE COMPACTED TO 95% OF THE MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D698.

5. SEDIMENT TRAP OUTLET TO BE CONSTRUCTED OF RIPRAP, TYPE M (D50=12") TYP.SMALLER ROCK SIZE MAY BE ALLOWABLE FOR SMALLER TRAPS IF APPROVED BY LOCAL JURISDICTION.

6. THE TOP OF THE EARTHEN BERM SHALL BE A MINIMUM OF 6" HIGHER THAN THE TOP OF THE RIPRAP OUTLET STRUCTURE.

7. THE ENDS OF THE RIPRAP OUTLET STRUCTURE SHALL BE A MINIMUM OF 6" HIGHER THAN THE CENTER OF THE OUTLET STRUCTURE.

SEDIMENT TRAP MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. REMOVE SEDIMENT ACCUMULATED IN TRAP AS NEEDED TO MAINTAIN THE FUNCTIONALITY OF THE BMP, TYPICALLY WHEN THE SEDIMENT DEPTH REACHES ½ THE HEIGHT OF THE RIPRAP OUTLET.

5. SEDIMENT TRAPS SHALL REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND APPROVED BY THE LOCAL JURISDICTION.

6. WHEN SEDIMENT TRAPS ARE REMOVED, THE DISTURBED AREA SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO, NOT AVAILABLE IN AUTOCAD)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Photograph VB-1. A vegetated buffer is maintained between the area of active construction and the drainage swale. Photo courtesy of WWE.

Description

Buffer strips of preserved natural vegetation or grass help protect waterways and wetlands from land disturbing activities. Vegetated buffers improve stormwater runoff quality by straining sediment, promoting infiltration, and slowing runoff velocities.

Appropriate Uses

Vegetated buffers can be used to separate land disturbing activities and natural surface waters or conveyances. In many jurisdictions, local governments require some type of setback from natural waterways. Concentrated flow should not be directed through a buffer; instead, runoff should be in the form of sheet flow. Vegetated buffers are typically used in combination with other perimeter control BMPs such as sediment control logs or silt fence for multi-layered protection.

Design and Installation

Minimum buffer widths may vary based on local regulations. Clearly delineate the boundary of the natural buffer area using construction fencing, silt fence, or a comparable technique. In areas that have been cleared and graded, vegetated buffers such as sod can also be installed to create or restore a vegetated buffer around the perimeter of the site.

Maintenance and Removal

Inspect buffer areas for signs of erosion such as gullies or rills. Stabilize eroding areas, as needed. If erosion is due to concentrated flow conditions, it may be necessary to install a level spreader or other technique to restore sheet flow conditions. Inspect perimeter controls delineating the vegetative buffer and repair or replace as needed.

Vegetated Buffers	
Functions	
Erosion Control	Moderate
Sediment Control	Yes
Site/Material Management	Yes

Description

Photograph CT-1. Proprietary chemical treatment system being used on a construction site with sensitive receiving waters. Photo courtesy of WWE.

Chemical treatment for erosion and sediment control can take several forms:

1. Applying chemicals to disturbed surfaces to reduce erosion (these uses are discussed in the Soil Binders Fact Sheet).
2. Adding flocculants to sedimentation ponds or tanks to enhance sediment removal prior.
3. Using proprietary barriers or flow-through devices containing flocculants (e.g., "floc logs").

The use of flocculants as described in No. 2 and No. 3 above will likely require special permitting. Check with the state permitting agency. See the Soil Binder BMP Fact Sheet for information on surface application of chemical treatments, as described in No. 1.

Appropriate Uses

At sites with fine-grained materials such as clays, chemical addition to sedimentation ponds or tanks can enhance settling of suspended materials through flocculation.

Prior to selecting and using chemical treatments, it is important to check state and local permit requirements related to their use.

Design and Installation

Due to variations among proprietary chemical treatment methods, design details are not provided for this BMP. Chemical feed systems for sedimentation ponds, settling tanks and dewatering bags should be installed and operated in accordance with manufacturer's recommendations and applicable regulations. Alum and chitosan are two common chemicals used as flocculants. Because the potential long-term impact of these chemicals to natural drainageways is not yet fully understood, the state does not currently allow chemical addition under the CDPS General Stormwater Construction Discharge Permit. Additional permitting may be necessary, which may include sampling requirements and numeric discharge limits.

Any devices or barriers containing chemicals should be installed following manufacturer's guidelines. Check for state and local jurisdiction usage restrictions and requirements before including these practices in the SWMP and implementing them onsite.

Chemical Treatment	
Functions	
Erosion Control	Moderate
Sediment Control	Yes
Site/Material Management	No

Maintenance and Removal

Chemical feed systems for sedimentation ponds or tanks should be maintained in accordance with manufacturer's recommendations and removed when the systems are no longer being used. Accumulated sediment should be dried and disposed of either at a landfill or in accordance with applicable regulations.

Barriers and devices containing chemicals should be removed and replaced when tears or other damage to the devices are observed. These barriers should be removed and properly disposed of when the site has been stabilized.

Description

Photograph CP-1. Construction phasing to avoid disturbing the entire area at one time. Photo courtesy of WWE.

Effective construction site management to minimize erosion and sediment transport includes attention to construction phasing, scheduling, and sequencing of land disturbing activities. On most construction projects, erosion and sediment controls will need to be adjusted as the project progresses and should be documented in the SWMP.

Construction phasing refers to disturbing only part of a site at a time to limit the potential for erosion from dormant parts of a site. Grading activities and construction are completed and soils are effectively stabilized on one part of a site before grading and construction begins on another portion of the site.

Construction sequencing or scheduling refers to a specified work schedule that coordinates the timing of land disturbing activities and the installation of erosion and sediment control practices.

Appropriate Uses

All construction projects can benefit from upfront planning to phase and sequence construction activities to minimize the extent and duration of disturbance. Larger projects and linear construction projects may benefit most from construction sequencing or phasing, but even small projects can benefit from construction sequencing that minimizes the duration of disturbance.

Typically, erosion and sediment controls needed at a site will change as a site progresses through the major phases of construction. Erosion and sediment control practices corresponding to each phase of construction must be documented in the SWMP.

Design and Installation

BMPs appropriate to the major phases of development should be identified on construction drawings. In some cases, it will be necessary to provide several drawings showing construction-phase BMPs placed according to stages of development (e.g., clearing and grading, utility installation, active construction, final stabilization). Some municipalities in the Denver area set maximum sizes for disturbed area associated with phases of a construction project. Additionally, requirements for phased construction drawings vary among local governments within the UDFCD boundary. Some local governments require separate erosion and sediment control drawings for initial BMPs, interim conditions (in active construction), and final stabilization.

Construction Scheduling	
Functions	
Erosion Control	Moderate
Sediment Control	Moderate
Site/Material Management	Yes

Typical construction phasing BMPs include:

- Limit the amount of disturbed area at any given time on a site to the extent practical. For example, a 100-acre subdivision might be constructed in five phases of 20 acres each.

- If there is carryover of stockpiled material from one phase to the next, position carryover material in a location easily accessible for the pending phase that will not require disturbance of stabilized areas to access the stockpile. Particularly with regard to efforts to balance cut and fill at a site, careful planning for location of stockpiles is important.

Typical construction sequencing BMPs include:

- Sequence construction activities to minimize duration of soil disturbance and exposure. For example, when multiple utilities will occupy the same trench, schedule installation so that the trench does not have to be closed and opened multiple times.

- Schedule site stabilization activities (e.g., landscaping, seeding and mulching, installation of erosion control blankets) as soon as feasible following grading.

- Install initial erosion and sediment control practices before construction begins. Promptly install additional BMPs for inlet protection, stabilization, etc., as construction activities are completed.

Table CP-1 provides typical sequencing of construction activities and associated BMPs.

Maintenance and Removal

When the construction schedule is altered, erosion and sediment control measures in the SWMP and construction drawings should be appropriately adjusted to reflect actual "on the ground" conditions at the construction site. Be aware that changes in construction schedules can have significant implications for site stabilization, particularly with regard to establishment of vegetative cover.

Table CP-1. Typical Phased BMP Installation for Construction Projects

Project Phase	**BMPs**
Pre-disturbance, Site Access	▪ Install sediment controls downgradient of access point (on paved streets this may consist of inlet protection). ▪ Establish vehicle tracking control at entrances to paved streets. Fence as needed. ▪ Use construction fencing to define the boundaries of the project and limit access to areas of the site that are not to be disturbed. **Note: it may be necessary to protect inlets in the general vicinity of the site, even if not downgradient, if there is a possibility that sediment tracked from the site could contribute to the inlets.**
Site Clearing and Grubbing	▪ Install perimeter controls as needed on downgradient perimeter of site (silt fence, wattles, etc). ▪ Limit disturbance to those areas planned for disturbance and protect undisturbed areas within the site (construction fence, flagging, etc). ▪ Preserve vegetative buffer at site perimeter. ▪ Create stabilized staging area. ▪ Locate portable toilets on flat surfaces away from drainage paths. Stake in areas susceptible to high winds. ▪ Construct concrete washout area and provide signage. ▪ Establish waste disposal areas. ▪ Install sediment basins. ▪ Create dirt perimeter berms and/or brush barriers during grubbing and clearing. ▪ Separate and stockpile topsoil, leave roughened and/or cover. ▪ Protect stockpiles with perimeter control BMPs. Stockpiles should be located away from drainage paths and should be accessed from the upgradient side so that perimeter controls can remain in place on the downgradient side. Use erosion control blankets, temporary seeding, and/or mulch for stockpiles that will be inactive for an extended period. ▪ Leave disturbed area of site in a roughened condition to limit erosion. Consider temporary revegetation for areas of the site that have been disturbed but that will be inactive for an extended period. ▪ Water to minimize dust but not to the point that watering creates runoff.

Project Phase	BMPs
Utility And Infrastructure Installation	**In Addition to the Above BMPs:** ▪ Close trench as soon as possible (generally at the end of the day). ▪ Use rough-cut street control or apply road base for streets that will not be promptly paved. ▪ Provide inlet protection as streets are paved and inlets are constructed. ▪ Protect and repair BMPs, as necessary. ▪ Perform street sweeping as needed.
Building Construction	**In Addition to the Above BMPs:** ▪ Implement materials management and good housekeeping practices for home building activities. ▪ Use perimeter controls for temporary stockpiles from foundation excavations. ▪ For lots adjacent to streets, lot-line perimeter controls may be necessary at the back of curb.
Final Grading	**In Addition to the Above BMPs:** ▪ Remove excess or waste materials. ▪ Remove stored materials.
Final Stabilization	**In Addition to the Above BMPs:** ▪ Seed and mulch/tackify. ▪ Seed and install blankets on steep slopes. ▪ Remove all temporary BMPs when site has reached final stabilization.

Description

Protection of existing vegetation on a construction site can be accomplished through installation of a construction fence around the area requiring protection. In cases where upgradient areas are disturbed, it may also be necessary to install perimeter controls to minimize sediment loading to sensitive areas such as wetlands. Existing vegetation may be designated for protection to maintain a stable surface cover as part of construction phasing, or vegetation may be protected in areas designated to remain in natural condition under post-development conditions (e.g., wetlands, mature trees, riparian areas, open space).

Photograph PV-1. Protection of existing vegetation and a sensitive area. Photo courtesy of CDOT.

Appropriate Uses

Existing vegetation should be preserved for the maximum practical duration on a construction site through the use of effective construction phasing. Preserving vegetation helps to minimize erosion and can reduce revegetation costs following construction.

Protection of wetland areas is required under the Clean Water Act, unless a permit has been obtained from the U.S. Army Corps of Engineers (USACE) allowing impacts in limited areas.

If trees are to be protected as part of post-development landscaping, care must be taken to avoid several types of damage, some of which may not be apparent at the time of injury. Potential sources of injury include soil compaction during grading or due to construction traffic, direct equipment-related injury such as bark removal, branch breakage, surface grading and trenching, and soil cut and fill. In order to minimize injuries that may lead to immediate or later death of the tree, tree protection zones should be developed during site design, implemented at the beginning of a construction project, as well as continued during active construction.

Design and Installation

General

Once an area has been designated as a preservation area, there should be no construction activity allowed within a set distance of the area. Clearly mark the area with construction fencing. Do not allow stockpiles, equipment, trailers or parking within the protected area. Guidelines to protect various types of existing vegetation follow.

Protection of Existing Vegetation	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	Yes

Surface Cover During Phased Construction

Install construction fencing or other perimeter controls around areas to be protected from clearing and grading as part of construction phasing.

Maintaining surface cover on steep slopes for the maximum practical duration during construction is recommended.

Open Space Preservation

Where natural open space areas will be preserved as part of a development, it is important to install construction fencing around these areas to protect them from compaction. This is particularly important when areas with soils with high infiltration rates are preserved as part of LID designs. Preserved open space areas should not be used for staging and equipment storage.

Wetlands and Riparian Areas

Install a construction fence around the perimeter of the wetland or riparian (streamside vegetation) area to prevent access by equipment. In areas downgradient of disturbed areas, install a perimeter control such as silt fence, sediment control logs, or similar measure to minimize sediment loading to the wetland.

Tree Protection[1]

- Before beginning construction operations, establish a tree protection zone around trees to be preserved by installing construction fences. Allow enough space from the trunk to protect the root zone from soil compaction and mechanical damage, and the branches from mechanical damage (see Table PV-1). If low branches will be kept, place the fence outside of the drip line. Where this is not possible, place fencing as far away from the trunk as possible. In order to maintain a healthy tree, be aware that about 60 percent of the tree's root zone extends beyond the drip line.

Table PV-1
Guidelines for Determining the Tree Protection Zone
(Source: Matheny and Clark, 1998; as cited in GreenCO and WWE 2008)

	Distance from Trunk (ft) per inch of DBH		
Species Tolerance to Damage	*Young*	*Mature*	*Over mature*
Good	0.5'	0.75'	1.0'
Moderate	0.75'	1.0'	1.25'
Poor	1.0'	1.25'	1.5'
Notes: DBH = diameter at breast height (4.5 ft above grade); Young = <20% of life expectancy; Mature = 20%-80% of life expectancy; Over mature =>80% of life expectancy			

- Most tree roots grow within the top 12 to 18 inches of soil. Grade changes within the tree protection zone should be avoided where possible because seemingly minor grade changes can either smother

[1] Tree Protection guidelines adapted from GreenCO and WWE (2008). *Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability, Third Release.* See www.greenco.org for more detailed guidance on tree preservation.

roots (in fill situations) or damage roots (in cut situations). Consider small walls where needed to avoid grade changes in the tree protection zone.

- Place and maintain a layer of mulch 4 to 6-inch thick from the tree trunk to the fencing, keeping a 6-inch space between the mulch and the trunk. Mulch helps to preserve moisture and decrease soil compaction if construction traffic is unavoidable. When planting operations are completed, the mulch may be reused throughout planting areas.

- Limit access, if needed at all, and appoint one route as the main entrance and exit to the tree protection zone. Within the tree protection zone, do not allow any equipment to be stored, chemicals to be dumped, or construction activities to take place except fine grading, irrigation system installation, and planting operations. These activities should be conducted in consultation with a landscaping professional, following Green Industry BMPs.

- Be aware that soil compaction can cause extreme damage to tree health that may appear gradually over a period of years. Soil compaction is easier to prevent than repair.

Maintenance and Removal

Repair or replace damaged or displaced fencing or other protective barriers around the vegetated area.

If damage occurs to a tree, consult an arborist for guidance on how to care for the tree. If a tree in a designated preservation area is damaged beyond repair, remove and replace with a 2-inch diameter tree of the same or similar species.

Construction equipment must not enter a wetland area, except as permitted by the U.S. Army Corps of Engineers (USACE). Inadvertent placement of fill in a wetland is a 404 permit violation and will require notification of the USACE.

If damage to vegetation occurs in a protected area, reseed the area with the same or similar species, following the recommendations in the USDCM *Revegetation* chapter.

Photograph CF-1. A construction fence helps delineate areas where existing vegetation is being protected. Photo courtesy of Douglas County.

Description

A construction fence restricts site access to designated entrances and exits, delineates construction site boundaries, and keeps construction out of sensitive areas such as natural areas to be preserved as open space, wetlands and riparian areas.

Appropriate Uses

A construction fence can be used to delineate the site perimeter and locations within the site where access is restricted to protect natural resources such as wetlands, waterbodies, trees, and other natural areas of the site that should not be disturbed.

If natural resource protection is an objective, then the construction fencing should be used in combination with other perimeter control BMPs such as silt fence, sediment control logs or similar measures.

Design and Installation

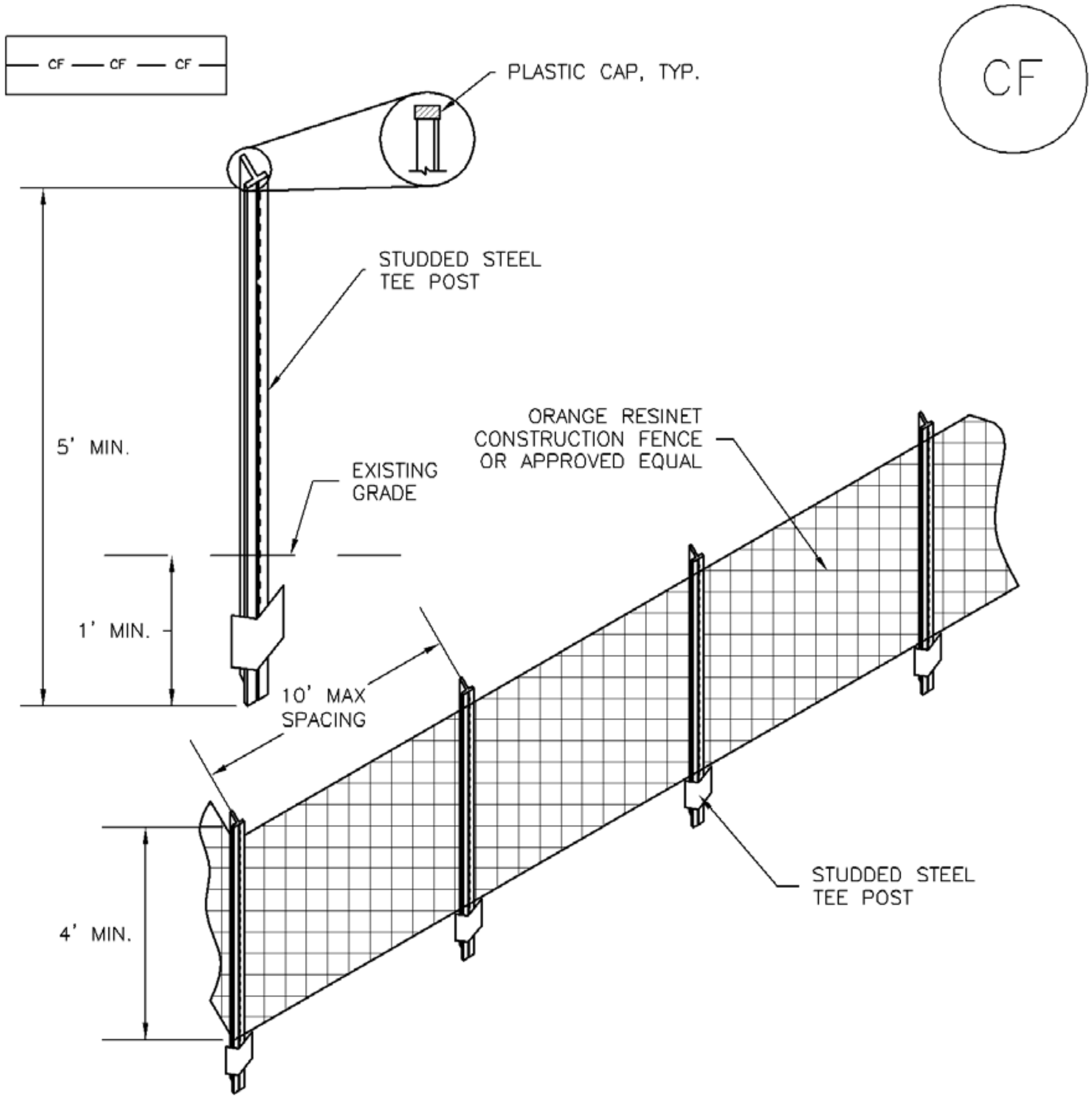
Construction fencing may be chain link or plastic mesh and should be installed following manufacturer's recommendations. See Detail CF-1 for typical installations.

Do not place construction fencing in areas within work limits of machinery.

Maintenance and Removal

- Inspect fences for damage; repair or replace as necessary.
- Fencing should be tight and any areas with slumping or fallen posts should be reinstalled.
- Fencing should be removed once construction is complete.

Construction Fence	
Functions	
Erosion Control	No
Sediment Control	No
Site/Material Management	Yes



CF–1. PLASTIC MESH CONSTRUCTION FENCE

CONSTRUCTION FENCE INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   –LOCATION OF CONSTRUCTION FENCE.

2. CONSTRUCTION FENCE SHOWN SHALL BE INSTALLED PRIOR TO ANY LAND DISTURBING ACTIVITIES.

3. CONSTRUCTION FENCE SHALL BE COMPOSED OF ORANGE, CONTRACTOR–GRADE MATERIAL THAT IS AT LEAST 4' HIGH. METAL POSTS SHOULD HAVE A PLASTIC CAP FOR SAFETY.

4. STUDDED STEEL TEE POSTS SHALL BE UTILIZED TO SUPPORT THE CONSTRUCTION FENCE. MAXIMUM SPACING FOR STEEL TEE POSTS SHALL BE 10'.

5. CONSTRUCTION FENCE SHALL BE SECURELY FASTENED TO THE TOP, MIDDLE, AND BOTTOM OF EACH POST.

CONSTRUCTION FENCE MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. CONSTRUCTION FENCE SHALL BE REPAIRED OR REPLACED WHEN THERE ARE SIGNS OF DAMAGE SUCH AS RIPS OR SAGS. CONSTRUCTION FENCE IS TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND APPROVED BY THE LOCAL JURISDICTION.

5. WHEN CONSTRUCTION FENCES ARE REMOVED, ALL DISTURBED AREAS ASSOCIATED WITH THE INSTALLATION, MAINTENANCE, AND/OR REMOVAL OF THE FENCE SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED, OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

(DETAIL ADAPTED FROM TOWN OF PARKER, COLORADO, NOT AVAILABLE IN AUTOCAD)

Description

Photograph VTC-1. A vehicle tracking control pad constructed with properly sized rock reduces off-site sediment tracking.

Vehicle tracking controls provide stabilized construction site access where vehicles exit the site onto paved public roads. An effective vehicle tracking control helps remove sediment (mud or dirt) from vehicles, reducing tracking onto the paved surface.

Appropriate Uses

Implement a stabilized construction entrance or vehicle tracking control where frequent heavy vehicle traffic exits the construction site onto a paved roadway. An effective vehicle tracking control is particularly important during the following conditions:

- Wet weather periods when mud is easily tracked off site.
- During dry weather periods where dust is a concern.
- When poorly drained, clayey soils are present on site.

Although wheel washes are not required in designs of vehicle tracking controls, they may be needed at particularly muddy sites.

Design and Installation

Construct the vehicle tracking control on a level surface. Where feasible, grade the tracking control towards the construction site to reduce off-site runoff. Place signage, as needed, to direct construction vehicles to the designated exit through the vehicle tracking control. There are several different types of stabilized construction entrances including:

VTC-1. Aggregate Vehicle Tracking Control. This is a coarse-aggregate surfaced pad underlain by a geotextile. This is the most common vehicle tracking control, and when properly maintained can be effective at removing sediment from vehicle tires.

VTC-2. Vehicle Tracking Control with Construction Mat or Turf Reinforcement Mat. This type of control may be appropriate for site access at very small construction sites with low traffic volume over vegetated areas. Although this application does not typically remove sediment from vehicles, it helps protect existing vegetation and provides a stabilized entrance.

Vehicle Tracking Control	
Functions	
Erosion Control	Moderate
Sediment Control	Yes
Site/Material Management	Yes

VTC-3. Stabilized Construction Entrance/Exit with Wheel Wash. This is an aggregate pad, similar to VTC-1, but includes equipment for tire washing. The wheel wash equipment may be as simple as hand-held power washing equipment to more advance proprietary systems. When a wheel wash is provided, it is important to direct wash water to a sediment trap prior to discharge from the site.

Vehicle tracking controls are sometimes installed in combination with a sediment trap to treat runoff.

Maintenance and Removal

Inspect the area for degradation and replace aggregate or material used for a stabilized entrance/exit as needed. If the area becomes clogged and ponds water, remove and dispose of excess sediment or replace material with a fresh layer of aggregate as necessary.

With aggregate vehicle tracking controls, ensure rock and debris from this area do not enter the public right-of-way.

Remove sediment that is tracked onto the public right of way daily or more frequently as needed. Excess sediment in the roadway indicates that the stabilized construction entrance needs maintenance.

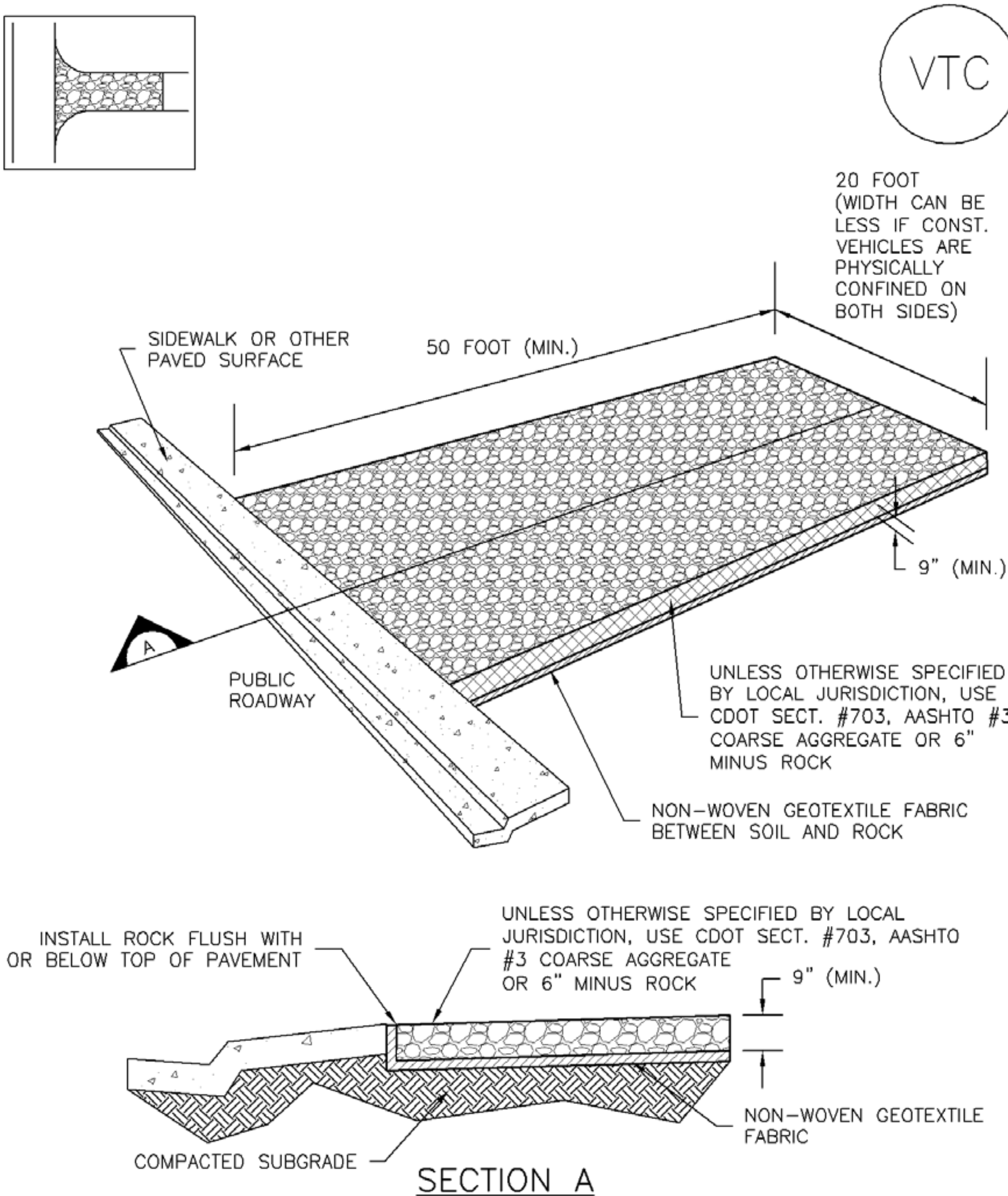
Ensure that drainage ditches at the entrance/exit area remain clear.

Photograph VTC-2. A vehicle tracking control pad with wheel wash facility. Photo courtesy of Tom Gore.

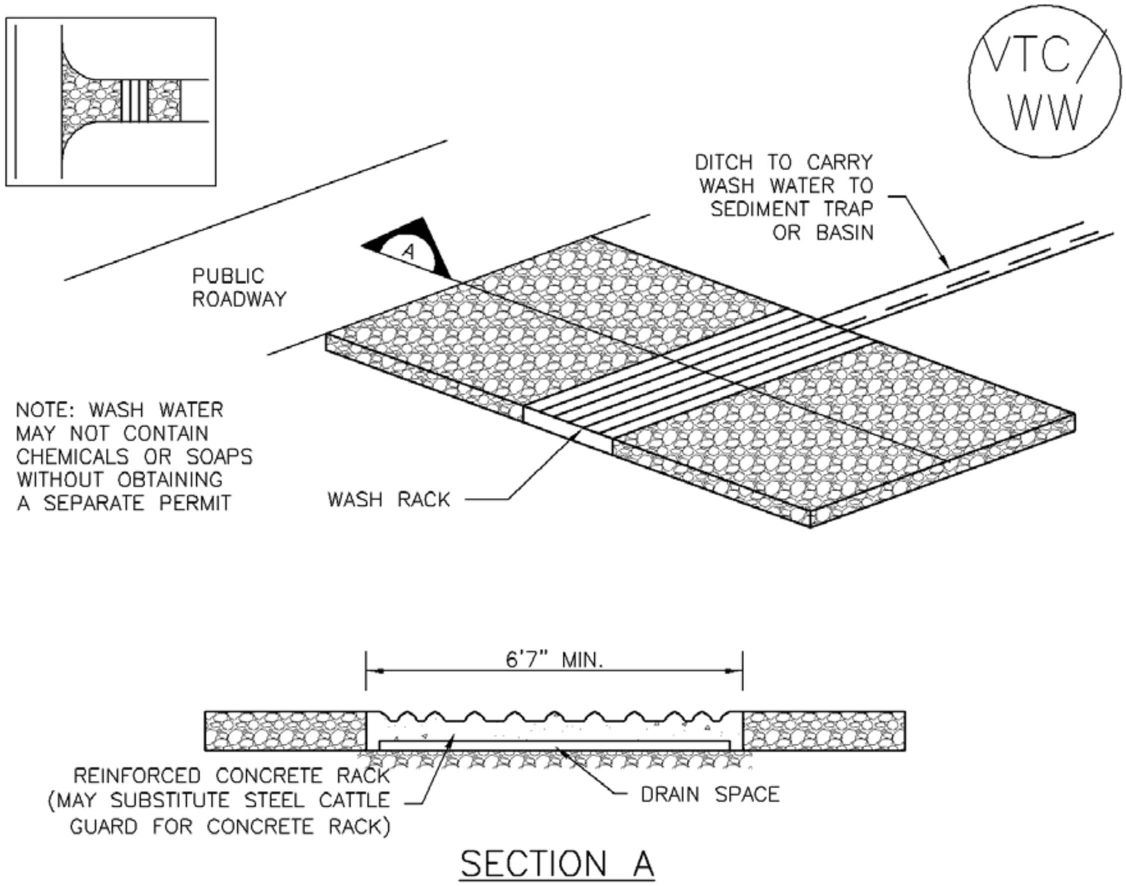
A stabilized entrance should be removed only when there is no longer the potential for vehicle tracking to occur. This is typically after the site has been stabilized.

When wheel wash equipment is used, be sure that the wash water is discharged to a sediment trap prior to discharge. Also inspect channels conveying the water from the wash area to the sediment trap and stabilize areas that may be eroding.

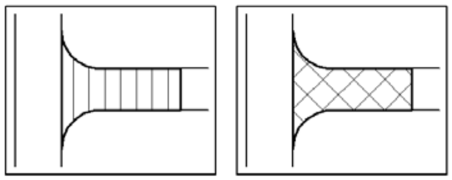
When a construction entrance/exit is removed, excess sediment from the aggregate should be removed and disposed of appropriately. The entrance should be promptly stabilized with a permanent surface following removal, typically by paving.

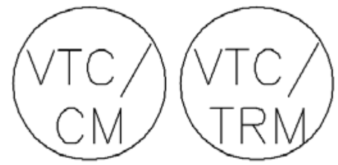


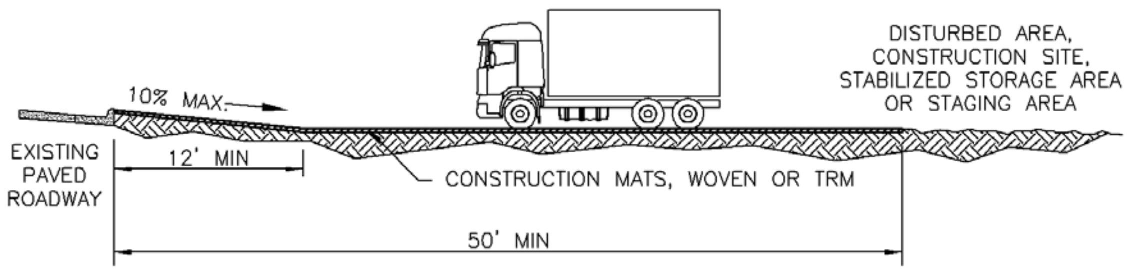
VTC-1. AGGREGATE VEHICLE TRACKING CONTROL

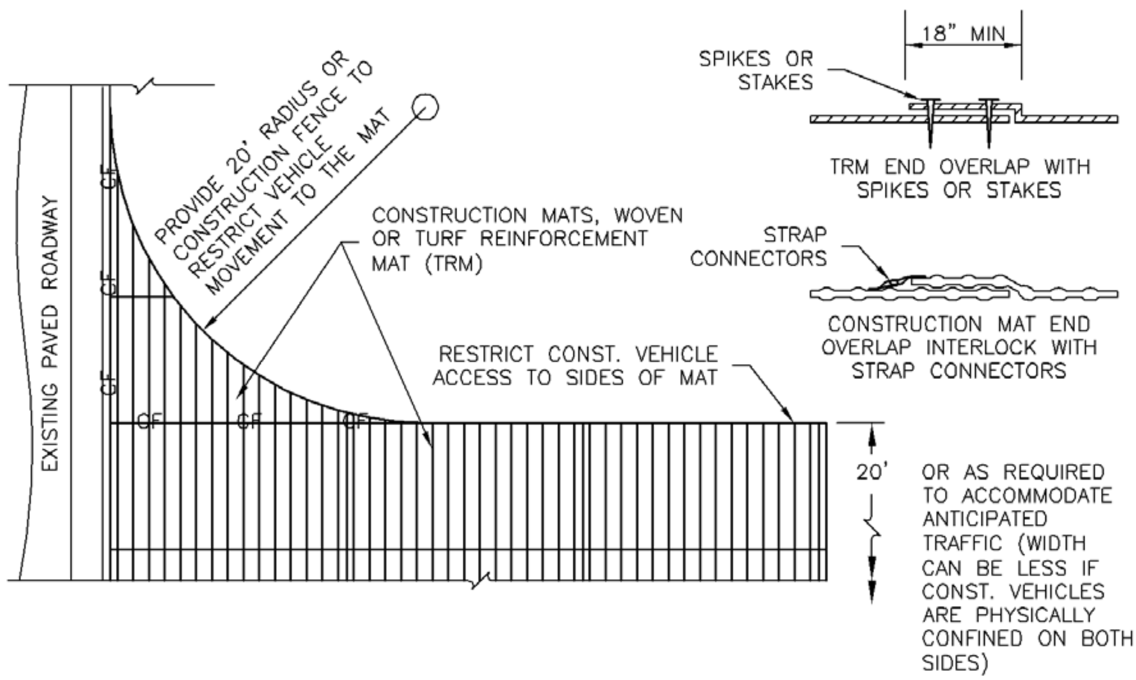


VTC-2. AGGREGATE VEHICLE TRACKING CONTROL WITH WASH RACK









VTC–3. VEHICLE TRACKING CONTROL W/ CONSTRUCTION MAT OR TURF REINFORCEMENT MAT (TRM)

STABILIZED CONSTRUCTION ENTRANCE/EXIT INSTALLATION NOTES

1. SEE PLAN VIEW FOR
   -LOCATION OF CONSTRUCTION ENTRANCE(S)/EXIT(S).
   -TYPE OF CONSTRUCTION ENTRANCE(S)/EXITS(S) (WITH/WITHOUT WHEEL WASH, CONSTRUCTION MAT OR TRM).

2. CONSTRUCTION MAT OR TRM STABILIZED CONSTRUCTION ENTRANCES ARE ONLY TO BE USED ON SHORT DURATION PROJECTS (TYPICALLY RANGING FROM A WEEK TO A MONTH) WHERE THERE WILL BE LIMITED VEHICULAR ACCESS.

3. A STABILIZED CONSTRUCTION ENTRANCE/EXIT SHALL BE LOCATED AT ALL ACCESS POINTS WHERE VEHICLES ACCESS THE CONSTRUCTION SITE FROM PAVED RIGHT-OF-WAYS.

4. STABILIZED CONSTRUCTION ENTRANCE/EXIT SHALL BE INSTALLED PRIOR TO ANY LAND DISTURBING ACTIVITIES.

5. A NON-WOVEN GEOTEXTILE FABRIC SHALL BE PLACED UNDER THE STABILIZED CONSTRUCTION ENTRANCE/EXIT PRIOR TO THE PLACEMENT OF ROCK.

6. UNLESS OTHERWISE SPECIFIED BY LOCAL JURISDICTION, ROCK SHALL CONSIST OF DOT SECT. #703, AASHTO #3 COARSE AGGREGATE OR 6" (MINUS) ROCK.

STABILIZED CONSTRUCTION ENTRANCE/EXIT MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. ROCK SHALL BE REAPPLIED OR REGRADED AS NECESSARY TO THE STABILIZED ENTRANCE/EXIT TO MAINTAIN A CONSISTENT DEPTH.

5. SEDIMENT TRACKED ONTO PAVED ROADS IS TO BE REMOVED THROUGHOUT THE DAY AND AT THE END OF THE DAY BY SHOVELING OR SWEEPING. SEDIMENT MAY NOT BE WASHED DOWN STORM SEWER DRAINS.

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

(DETAILS ADAPTED FROM CITY OF BROOMFIELD, COLORADO, NOT AVAILABLE IN AUTOCAD)

Description

A stabilized construction roadway is a temporary method to control sediment runoff, vehicle tracking, and dust from roads during construction activities.

Photograph SCR-1. Stabilized construction roadway.

Appropriate Uses

Use on high traffic construction roads to minimize dust and erosion.

Stabilized construction roadways are used instead of rough-cut street controls on roadways with frequent construction traffic.

Design and Installation

Stabilized construction roadways typically involve two key components: 1) stabilizing the road surface with an aggregate base course of 3-inch-diameter granular material and 2) stabilizing roadside ditches, if applicable. Early application of road base is generally suitable where a layer of coarse aggregate is specified for final road construction.

Maintenance and Removal

Apply additional gravel as necessary to ensure roadway integrity.

Inspect drainage ditches along the roadway for erosion and stabilize, as needed, through the use of check dams or rolled erosion control products.

Gravel may be removed once the road is ready to be paved. Prior to paving, the road should be inspected for grade changes and damage. Regrade and repair as necessary.

Stabilized Construction Roadway	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material Management	Yes

Description

Photograph SSA-1. Example of a staging area with a gravel surface to prevent mud tracking and reduce runoff. Photo courtesy of Douglas County.

A stabilized staging area is a clearly designated area where construction equipment and vehicles, stockpiles, waste bins, and other construction-related materials are stored. The contractor office trailer may also be located in this area. Depending on the size of the construction site, more than one staging area may be necessary.

Appropriate Uses

Most construction sites will require a staging area, which should be clearly designated in SWMP drawings. The layout of the staging area may vary depending on the type of construction activity. Staging areas located in roadways due to space constraints require special measures to avoid materials being washed into storm inlets.

Design and Installation

Stabilized staging areas should be completed prior to other construction activities beginning on the site. Major components of a stabilized staging area include:

- Appropriate space to contain storage and provide for loading/unloading operations, as well as parking if necessary.
- A stabilized surface, either paved or covered, with 3-inch diameter aggregate or larger.
- Perimeter controls such as silt fence, sediment control logs, or other measures.
- Construction fencing to prevent unauthorized access to construction materials.
- Provisions for Good Housekeeping practices related to materials storage and disposal, as described in the Good Housekeeping BMP Fact Sheet.
- A stabilized construction entrance/exit, as described in the Vehicle Tracking Control BMP Fact Sheet, to accommodate traffic associated with material delivery and waste disposal vehicles.

Over-sizing the stabilized staging area may result in disturbance of existing vegetation in excess of that required for the project. This increases costs, as well as requirements for long-term stabilization following the construction period. When designing the stabilized staging area, minimize the area of disturbance to the extent practical.

Stabilized Staging Area	
Functions	
Erosion Control	Yes
Sediment Control	Moderate
Site/Material	Yes

Minimizing Long-Term Stabilization Requirements

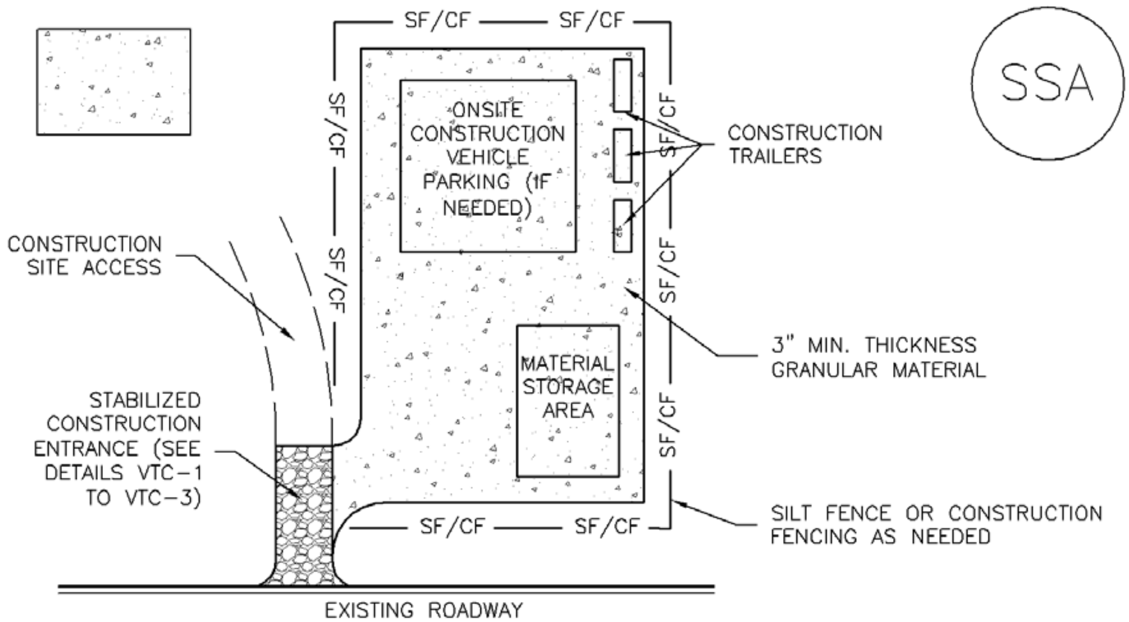
- Utilize off-site parking and restrict vehicle access to the site.
- Use construction mats in lieu of rock when staging is provided in an area that will not be disturbed otherwise.
- Consider use of a bermed contained area for materials and equipment that do not require a stabilized surface.
- Consider phasing of staging areas to avoid disturbance in an area that will not be otherwise disturbed.

See Detail SSA-1 for a typical stabilized staging area and SSA-2 for a stabilized staging area when materials staging in roadways is required.

Maintenance and Removal

Maintenance of stabilized staging areas includes maintaining a stable surface cover of gravel, repairing perimeter controls, and following good housekeeping practices.

When construction is complete, debris, unused stockpiles and materials should be recycled or properly disposed. In some cases, this will require disposal of contaminated soil from equipment leaks in an appropriate landfill. Staging areas should then be permanently stabilized with vegetation or other surface cover planned for the development.



SSA-1. STABILIZED STAGING AREA

STABILIZED STAGING AREA INSTALLATION NOTES

1. SEE PLAN VIEW FOR
   - LOCATION OF STAGING AREA(S).
   - CONTRACTOR MAY ADJUST LOCATION AND SIZE OF STAGING AREA WITH APPROVAL FROM THE LOCAL JURISDICTION.

2. STABILIZED STAGING AREA SHOULD BE APPROPRIATE FOR THE NEEDS OF THE SITE. OVERSIZING RESULTS IN A LARGER AREA TO STABILIZE FOLLOWING CONSTRUCTION.

3. STAGING AREA SHALL BE STABILIZED PRIOR TO OTHER OPERATIONS ON THE SITE.

4. THE STABILIZED STAGING AREA SHALL CONSIST OF A MINIMUM 3" THICK GRANULAR MATERIAL.

5. UNLESS OTHERWISE SPECIFIED BY LOCAL JURISDICTION, ROCK SHALL CONSIST OF DOT SECT. #703, AASHTO #3 COARSE AGGREGATE OR 6" (MINUS) ROCK.

6. ADDITIONAL PERIMETER BMPs MAY BE REQUIRED INCLUDING BUT NOT LIMITED TO SILT FENCE AND CONSTRUCTION FENCING.

STABILIZED STAGING AREA MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. ROCK SHALL BE REAPPLIED OR REGRADED AS NECESSARY IF RUTTING OCCURS OR UNDERLYING SUBGRADE BECOMES EXPOSED.

STABILIZED STAGING AREA MAINTENANCE NOTES

5. STABILIZED STAGING AREA SHALL BE ENLARGED IF NECESSARY TO CONTAIN PARKING, STORAGE, AND UNLOADING/LOADING OPERATIONS.

6. THE STABILIZED STAGING AREA SHALL BE REMOVED AT THE END OF CONSTRUCTION. THE GRANULAR MATERIAL SHALL BE REMOVED OR, IF APPROVED BY THE LOCAL JURISDICTION, USED ON SITE, AND THE AREA COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY LOCAL JURISDICTION.

NOTE: MANY MUNICIPALITIES PROHIBIT THE USE OF RECYCLED CONCRETE AS GRANULAR MATERIAL FOR STABILIZED STAGING AREAS DUE TO DIFFICULTIES WITH RE–ESTABLISHMENT OF VEGETATION IN AREAS WHERE RECYCLED CONCRETE WAS PLACED.

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO, NOT AVAILABLE IN AUTOCAD)

Street Sweeping and Vacuuming (SS) SM-7

Photograph SS-1. A street sweeper removes sediment and potential pollutants along the curb line at a construction site. Photo courtesy of Tom Gore.

Description

Street sweeping and vacuuming remove sediment that has been tracked onto roadways to reduce sediment transport into storm drain systems or a surface waterway.

Appropriate Uses

Use this practice at construction sites where vehicles may track sediment offsite onto paved roadways.

Design and Installation

Street sweeping or vacuuming should be conducted when there is noticeable sediment accumulation on roadways adjacent to the construction site. Typically, this will be concentrated at the entrance/exit to the construction site. Well-maintained stabilized construction entrances, vehicle tracking controls and tire wash facilities can help reduce the necessary frequency of street sweeping and vacuuming.

On smaller construction sites, street sweeping can be conducted manually using a shovel and broom. Never wash accumulated sediment on roadways into storm drains.

Maintenance and Removal

- Inspect paved roads around the perimeter of the construction site on a daily basis and more frequently, as needed. Remove accumulated sediment, as needed.
- Following street sweeping, check inlet protection that may have been displaced during street sweeping.
- Inspect area to be swept for materials that may be hazardous prior to beginning sweeping operations.

Street Sweeping/ Vacuuming	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	Yes

Description

A temporary diversion channel diverts water from a stream to allow for construction activities to take place underneath or in the stream. Diversion channels are often required during the construction of detention ponds, dams, in-stream grade control structures, utility installation and other activities that require working in waterways.

Photograph TDC-1. Use of a temporary diversion channel (right side) to enable installation of a grade control structure (left side). Photo courtesy of WWE.

Appropriate Uses

Temporary diversion channels vary with the size of the waterway that is being diverted. For large streams, a temporary diversion may consist of berms or coffer dams constructed in the stream to confine flow to one side of the stream while work progresses on the dry side of the berm. For smaller streams and often for construction of dams and detention basins, a temporary diversion channel may divert the entire waterway, as illustrated in Figure TDC-1. For very short duration projects (typically less than 4 weeks) during dry periods with low base flows, a pump and bypass pipe may serve as a temporary diversion. Whenever a temporary diversion is used, construction should be scheduled during drier times of the year if possible, and construction in the waterway should progress as quickly as possible to reduce the risk of exceeding the temporary diversion channel capacity.

Some construction activities within a waterway are very short lived, namely a few hours or days in duration, and are minor in nature. These are typically associated with maintenance of utilities and stream crossings and minor repairs to outfalls and eroded banks. In these cases, construction of temporary diversion channels can often cause more soil disturbance and sediment movement than the maintenance activity itself. If it can be reasonably determined based on area and duration of disturbance that channel work will result in less disturbance and movement of sediment than would be done through installation of a temporary diversion channel, it is reasonable to exempt these activities from the requirement to construct a temporary diversion.

Design and Installation

Temporary Diversion Channel sizing procedures typically include the following steps:

- Using the tributary area, A (in acres), determine the design peak flow rate according to Figure DC-2. Note: For long duration projects, or where the consequences of diversion failure warrant, a larger design flow may be necessary.

- Determine depth of flow, 1-foot maximum for flows less than 20 cfs and 3 feet maximum for flows less than 100 cfs. (Flows in excess of 100 cfs should be designed in accordance with the *Major Drainage* chapter in Volume 1).

Temporary Diversion Channel	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	No

- Determine channel slope based on existing and proposed site conditions.
- Perform initial channel sizing calculations using Manning's Equation. Determine maximum permissible velocities based on lining material.
- Determine the channel geometry and check the capacity using Manning's Equation and the "n" value given in Table TDC-1. The steepest side slope allowable for a temporary channel is two horizontal to one vertical (2:1), unless vertical walls are installed using sheet piling, concrete or stacked stone. Temporary diversion channels should have a minimum freeboard of 0.5 feet above the design water surface elevation.

Figure DC-2 may be used to estimate the **minimum** design discharge for the sizing of temporary diversion channels and pipes. The curves in this figure were developed using annual peak flow data collected from 17 watersheds within the UDFCD boundary. These data were collected over extended periods of time (up to eleven years) and, as a result, provide a sound statistical basis for the figure. The data supporting Figure TDC-2 were taken during the high flood potential period of April through September. The values from Figure TDC-2 represent approximately the 95th percentile event that can occur, on the average, any given year, which means that it is likely that about 95 percent of runoff peaks during an average year will be less than values from this chart. This may not be the case in wetter-than-average seasons. Figure TDC-2 provides estimated 2-year peak flow rates based on watershed imperviousness for small waterways (< 12 square miles). Because Figure TDC-2 was developed using data from small watersheds, it is not appropriate to extrapolate from this figure for larger, more complex watersheds. For larger waterways (e.g., South Platte River, Sand Creek, Bear Creek, etc.), including ones controlled by flood control reservoirs (e.g. Chatfield Dam, Cherry Creek Dam, etc.), site specific risk assessment may be necessary to evaluate the appropriate level of protection to be provided by the temporary diversion. It is also important to recognize that larger floods can and do occur. It is the responsibility of the designer and the contractor to assess their risk of having the temporary diversion being exceeded and to evaluate the damages such an event may cause to the project, adjacent properties and others. Consider larger capacity diversions to protect a project if it will require a temporary diversion for more than one year.

Because temporary diversion channels typically are not in service long enough to establish adequate vegetative lining, they must be designed to be stable for the design flow with the channel shear stress less than the critical tractive shear stress for the channel lining material. This stability criterion applies not only to diversion channels, but also to the stream-side of berms when berms are used to isolate a work area within a stream. Unlined channels should not be used. Table TDC-1 gives Manning's "n" values for lining materials. Design procedures for temporary channels are described in detail in the Hydraulic Engineering Circular No. 15 published by the Federal Highway Administration. The methods presented in this Fact Sheet are greatly simplified and are based on information developed using the most commonly used erosion control materials.

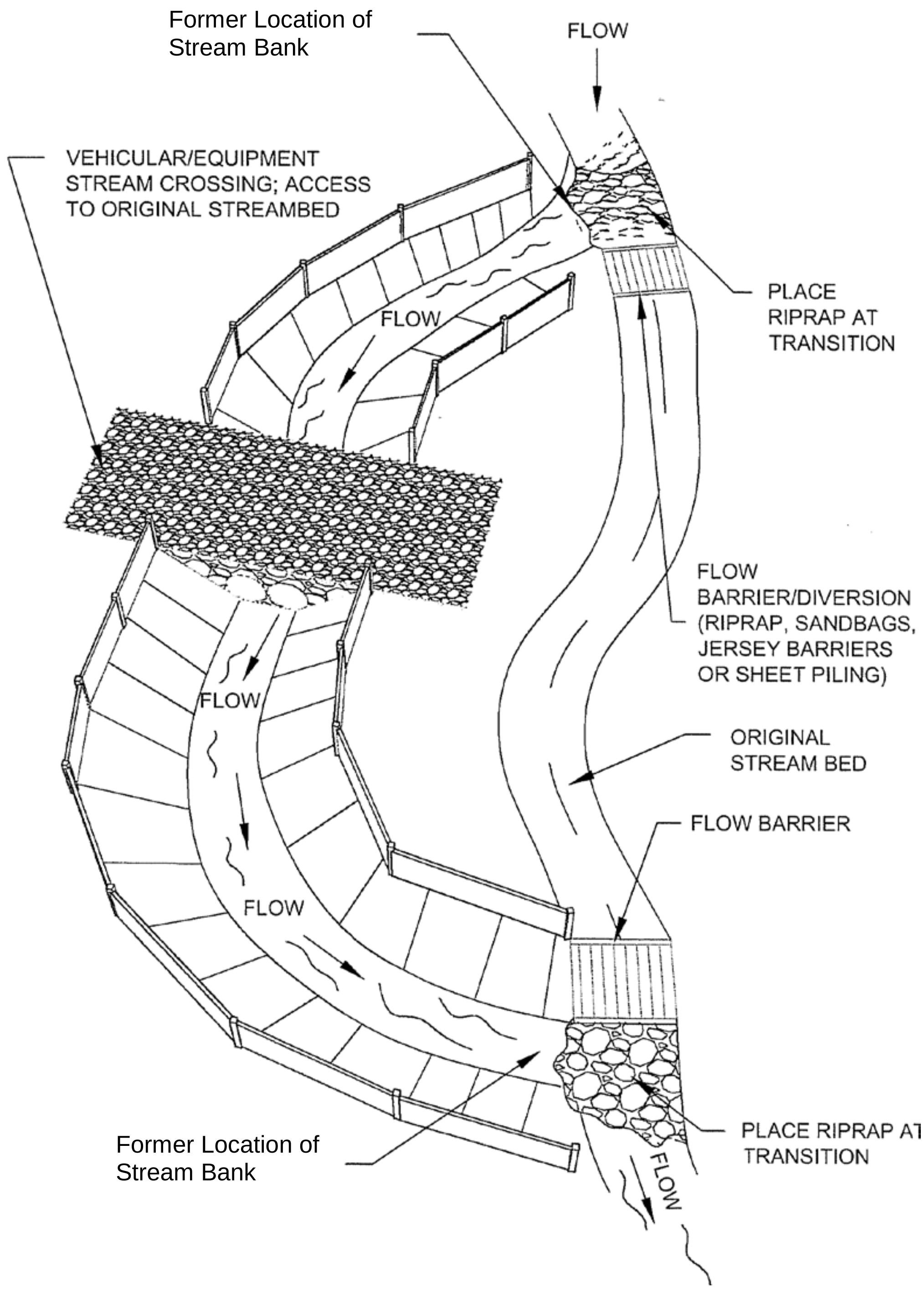


Figure DC-1. Typical Temporary Diversion Channel

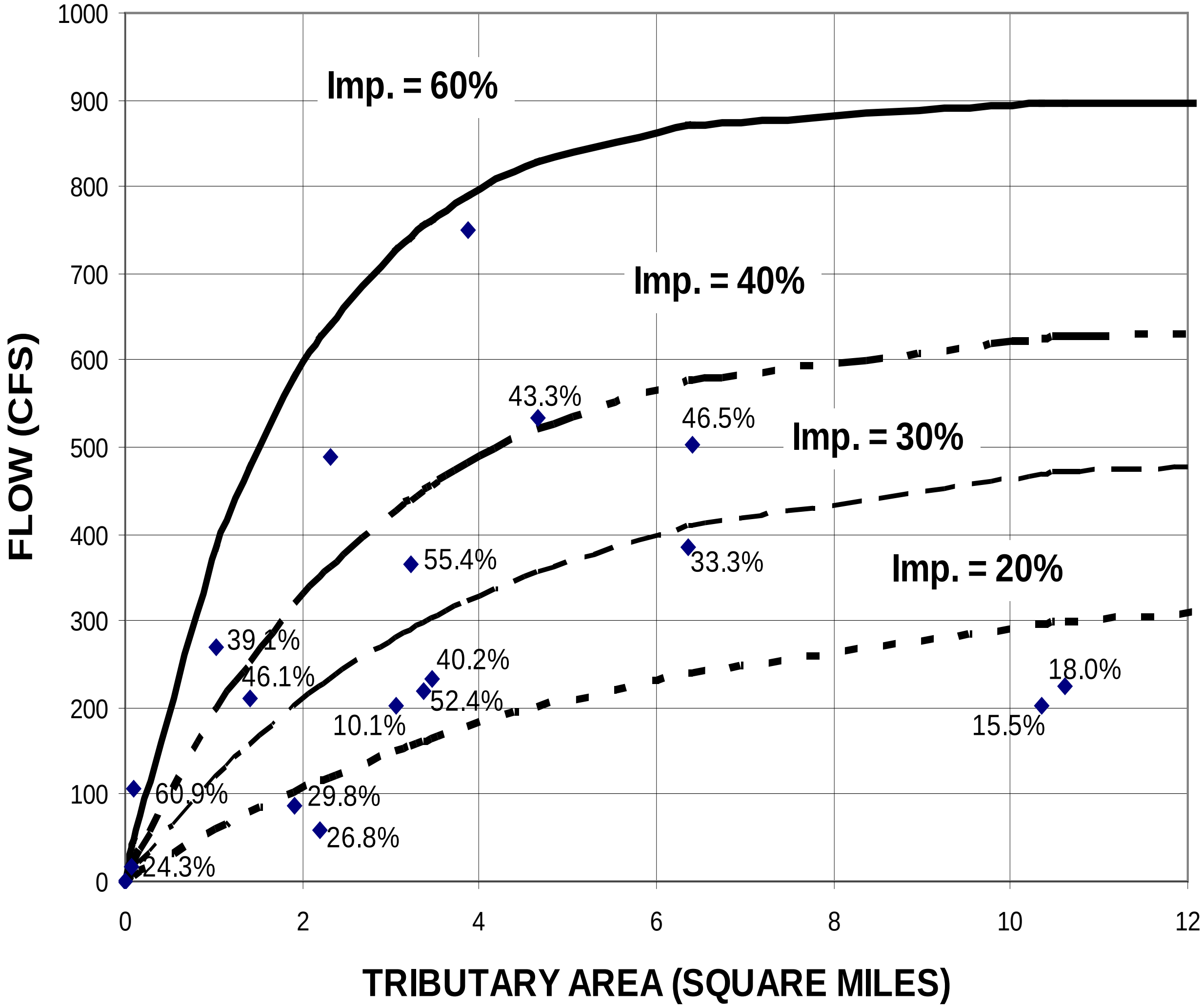


Figure TDC-2. Temporary Diversion Facility Sizing Nomograph Based on 2-year Peak Flows - Denver Metropolitan and Adjacent Areas

Table TDC-1. Temporary Diversion Channel Design Criteria

Lining Material	Manning's n for Flow Depth 0 ft to 1.0 ft	Manning's n for Flow Depth 1.0 ft to 3.0 ft	Manning's n for Flow Depth 3.0 ft to 5.0 ft
Plastic Membrane	0.011	0.010	0.009
Straw or Curled Wood Mats	0.035	0.025	0.020
Riprap, Type VL	0.070	0.045	0.035
Riprap, Type L	0.100	0.070	0.040
Riprap, Type M	0.125	0.075	0.045

Notes: Use manufacturer's Manning's n when available.

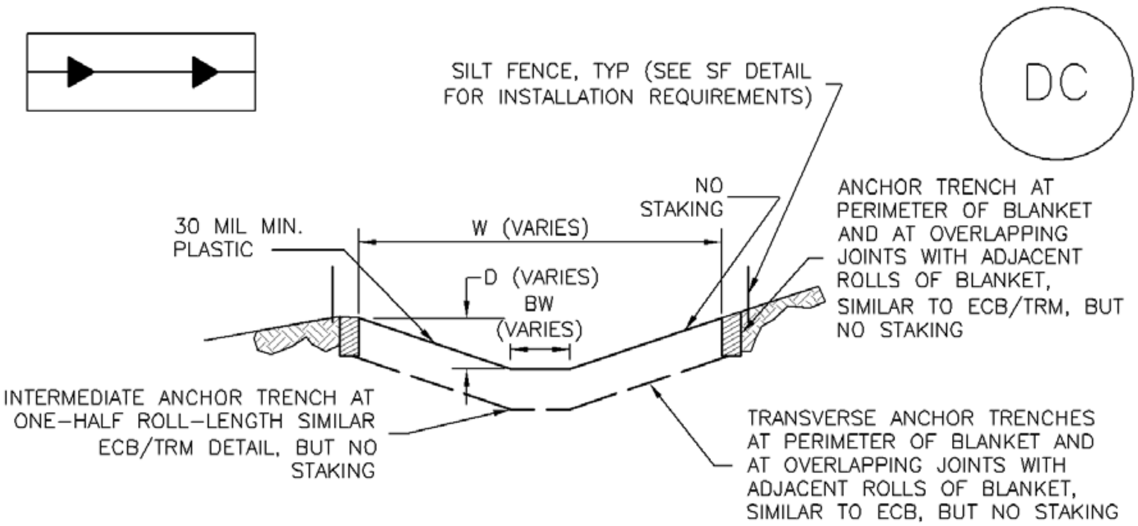
See the *Major Drainage* chapter of Volume 1 for riprap gradation.

Erosion protection should extend a minimum of 0.5 feet above the design water depth.

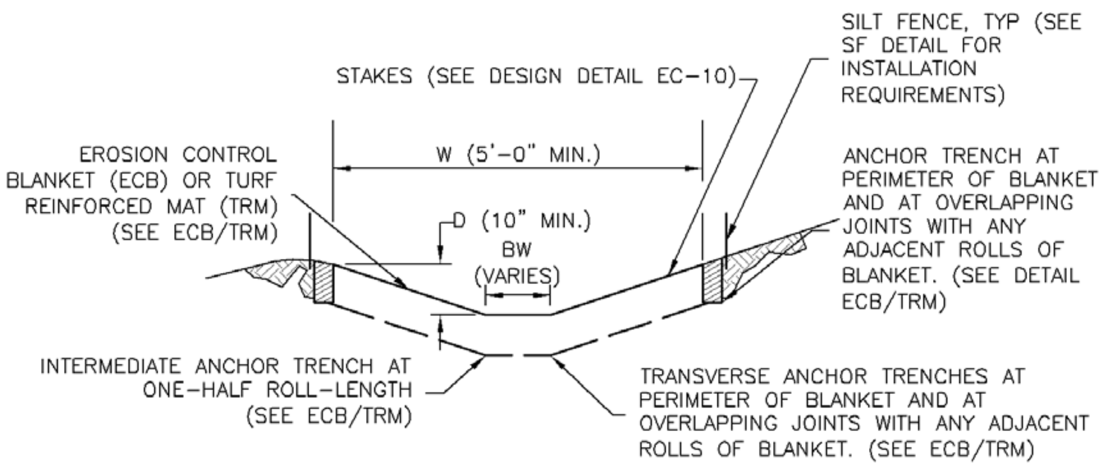
Maintenance and Removal

Because temporary diversion channels are one of the most critical BMPs for work in waterways, they must be inspected and maintained frequently to remain in effective operating condition. Flow barriers should be inspected at the start and end of each workday and at any time that excess water is noted in dry work areas. The diversion channel itself should be inspected for signs of erosion, and the lining should be repaired or replaced if there are signs of failure. Check armoring at the diversion return point to the waterway, and add additional armoring if erosion is noted.

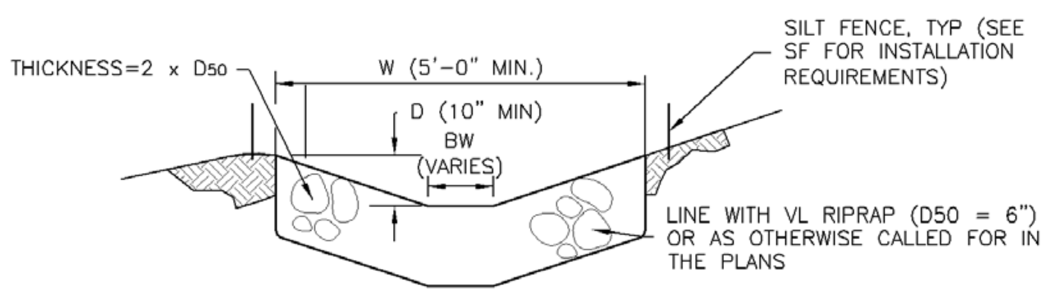
Water should not be allowed to flow back through the natural stream until all construction is completed. After redirecting the flow through the natural channel, lining materials should be removed from the temporary diversion channel. The diversion channel should then be backfilled and stabilized. Points of tie-in to the natural channel should be protected with riprap sized in accordance with the *Major Drainage* chapter in Volume 1.



DC–1. PLASTIC LINED DIVERSION CHANNEL



DC–2. GEOTEXTILE OR MAT LINED DIVERSION CHANNEL



DC–3. RIPRAP LINED DIVERSION CHANNEL

CHANNEL DIVERSION INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF DIVERSION CHANNEL
   - TYPE OF CHANNEL (UNLINED, GEOTEXTILE OR MAT LINED, PLASTIC LINE, OR RIPRAP LINED).
   - LENGTH OF EACH TYPE OF CHANNEL.
   - DEPTH, D, WIDTH, W, AND BOTTOM WIDTH, BW.
   - FOR RIPRAP LINED CHANNEL, SIZE OF RIPRAP, D50, SHALL BE SHOWN ON PLANS.

2. SEE DRAINAGE PLANS FOR DETAILS OF PERMANENT CONVEYANCE FACILITIES.

3. DIVERSION CHANNELS INDICATED ON THE SWMP PLAN SHALL BE INSTALLED PRIOR TO WORK IN DOWNGRADIENT AREAS OR NATURAL CHANNELS.

4. FOR GEOTEXTILE OR MAT LINED CHANNELS, INSTALLATION OF GEOTEXTILE OR MAT SHALL CONFORM TO THE REQUIREMENTS OF DETAIL ECB, FOR PLASTIC LINED CHANNELS, INSTALLATION OF ANCHOR TRENCHES SHALL CONFORM TO THE REQUIREMENTS OF DETAIL ECB.

5. WHERE CONSTRUCTION TRAFFIC MUST CROSS A DIVERSION CHANNEL, THE PERMITTEE SHALL INSTALL A TEMPORARY STREAM CROSSING CONFORMING TO THE REQUIREMENTS OF DETAIL TSC.

DIVERSION CHANNEL MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. DIVERSION CHANNELS ARE TO REMAIN IN PLACE UNTIL WORK IN THE DOWNGRADIENT AREA OR NATURAL CHANNEL IS NO LONGER REQUIRED. IF APPROVED BY LOCAL JURISDICTION DIVERSION CHANNEL MAY BE LEFT IN PLACE.

5. IF DIVERSION CHANNELS ARE REMOVED, THE DISTURBED AREA SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY LOCAL JURISDICTION.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

Description

The BMPs selected for construction dewatering vary depending on site-specific features such as soils, topography, anticipated discharge quantities, and discharge location. Dewatering typically involves pumping water from an inundated area to a BMP, and then downstream to a receiving waterway, sediment basin, or well-vegetated area. Dewatering typically involves use of several BMPs in sequence.

Photograph DW-1. A relatively small dewatering operation using straw bales and a dewatering bag.

Appropriate Uses

Dewatering operations are used when an area of the construction site needs to be dewatered as the result of a large storm event, groundwater, or existing ponding conditions. This can occur during deep excavation, utility trenching, and wetland or pond excavation.

Photograph DW-2. Dewatering bags used for a relatively large dewatering operation.

Design and Installation

Dewatering techniques will vary depending on site conditions. However, all dewatering discharges must be treated to remove sediment before discharging from the construction site. Discharging water into a sediment trap or basin is an acceptable treatment option. Water may also be treated using a dewatering filter bag, and a series of straw bales or sediment logs. If these previous options are not feasible due to space or the ability to passively treat the discharge to remove sediment, then a settling tank or an active treatment system may need to be utilized. Settling tanks are manufactured tanks with a series of baffles to promote settling. Flocculants can also be added to the tank to induce more rapid settling. This is an approach sometimes used on highly urbanized construction sites. Contact the state agency for special requirements prior to using flocculents and land application techniques.

Some commonly used methods to handle the pumped water without surface discharge include land application to vegetated areas through a perforated discharge hose (i.e., the "sprinkler method") or dispersal from a water truck for dust control.

Dewatering Operations	
Functions	
Erosion Control	Moderate
Sediment Control	Yes
Site/Material Management	Yes

Dewatering discharges to non-paved areas must minimize the potential for scour at the discharge point either using a velocity dissipation device or dewatering filter bag.

Design Details are provided for these types of dewatering situations:

DW-1. Dewatering for Pond Already Filled with Water

DW-2 Dewatering Sump for Submersed Pump

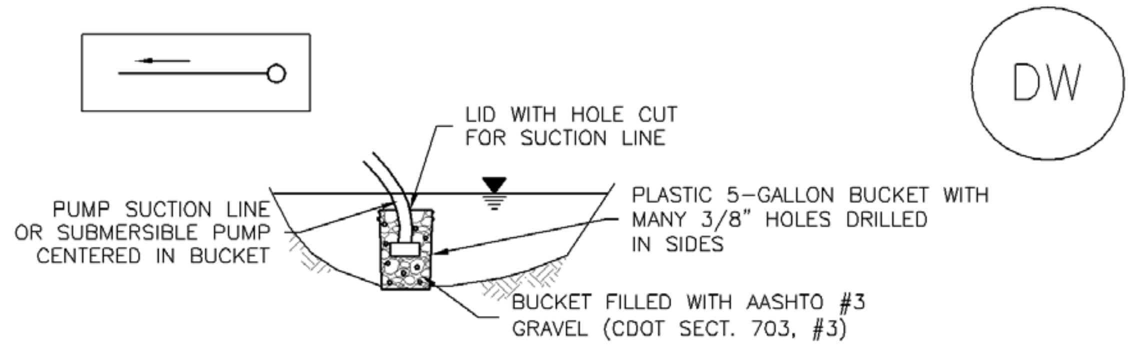
DW-3 Sump Discharge Settling Basin

DW-4 Dewatering Filter Bag

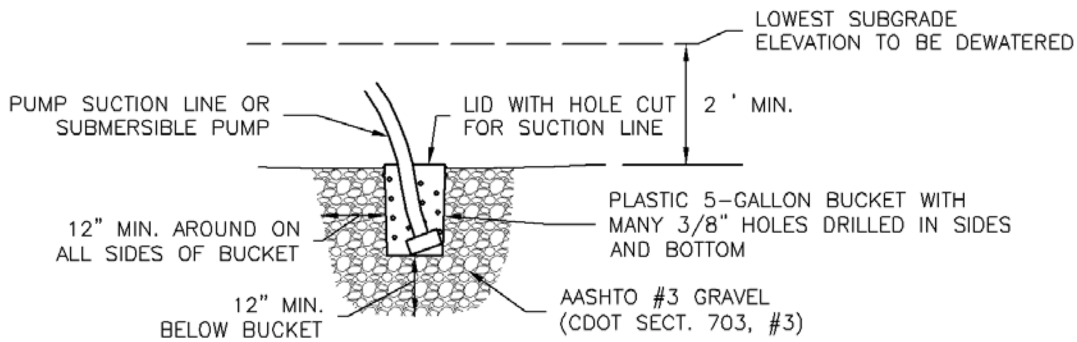
Maintenance and Removal

When a sediment basin or trap is used to enable settling of sediment from construction dewatering discharges, inspect the basin for sediment accumulation. Remove sediment prior to the basin or trap reaching half full. Inspect treatment facilities prior to any dewatering activity. If using a sediment control practice such as a sediment trap or basin, complete all maintenance requirements as described in the fact sheets prior to dewatering.

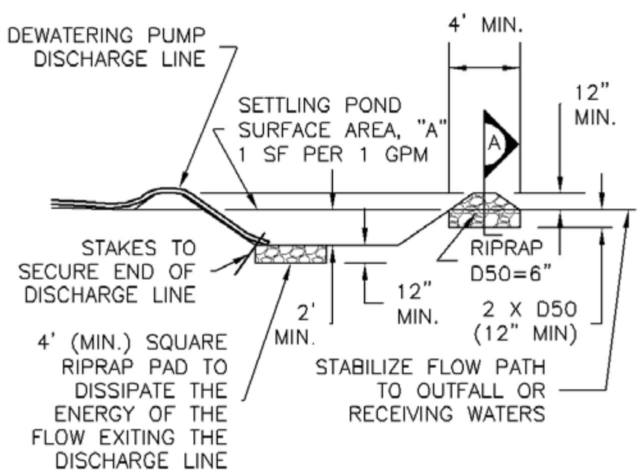
Properly dispose of used dewatering bags, as well as sediment removed from the dewatering BMPs. Depending on the size of the dewatering operation, it may also be necessary to revegetate or otherwise stabilize the area where the dewatering operation was occurring.

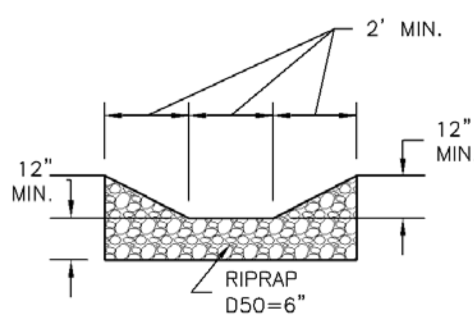


DW-1. DEWATERING POND ALREADY FILLED WITH WATER



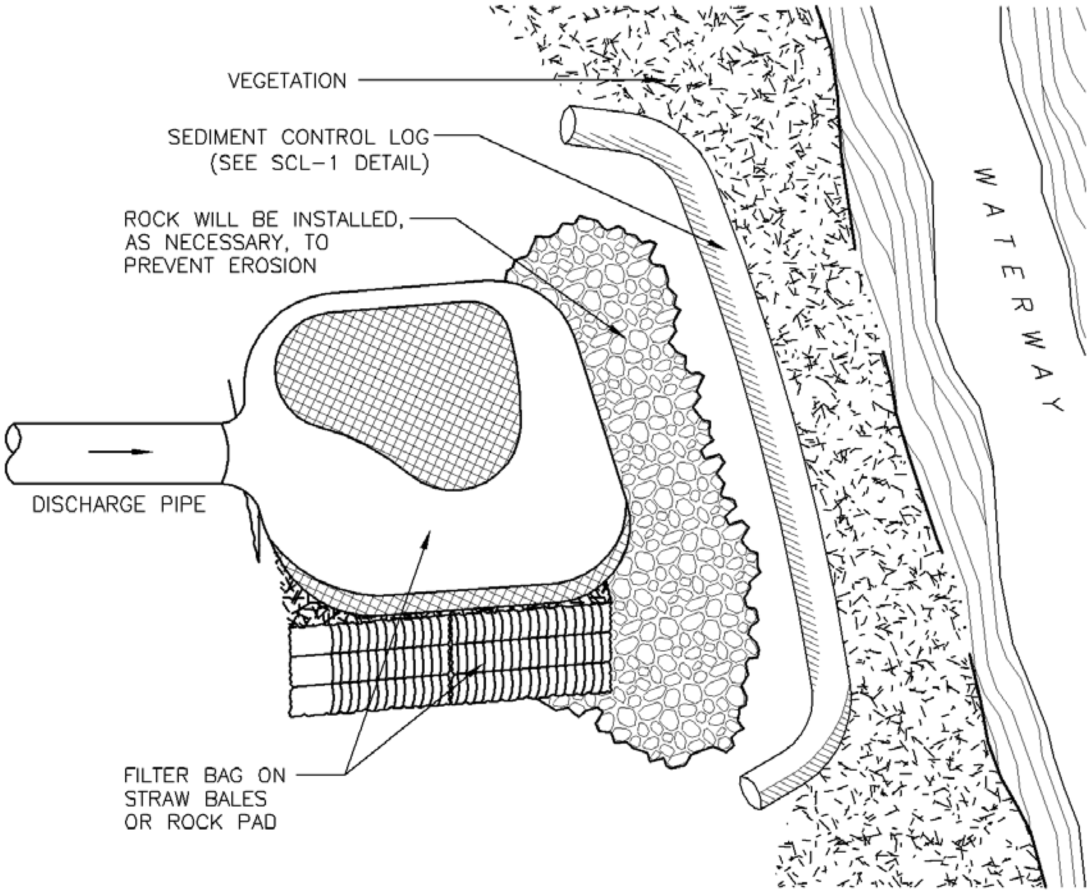
DW-2. DEWATERING SUMP FOR SUBMERSED PUMP





DW-3. SUMP DISCHARGE SETTLING BASIN

SETTLING BASIN SECTION A



DW-4. DEWATERING FILTER BAG

DEWATERING INSTALLATION NOTES

1. SEE PLAN VIEW FOR;
   - LOCATION OF DEWATERING EQUIPMENT.
   - TYPE OF DEWATERING OPERATION (DW-1 TO DW-4).

2. THE OWNER OR CONTRACTOR SHALL OBTAIN A CONSTRUCTION DISCHARGE (DEWATERING) PERMIT FROM THE STATE PRIOR TO ANY DEWATERING OPERATIONS DISCHARGING FROM THE SITE. ALL DEWATERING SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE PERMIT.

3. THE OWNER OR OPERATOR SHALL PROVIDE, OPERATE, AND MAINTAIN DEWATERING SYSTEMS OF SUFFICIENT SIZE AND CAPACITY TO PERMIT EXCAVATION AND SUBSEQUENT CONSTRUCTION IN DRY CONDITIONS AND TO LOWER AND MAINTAIN THE GROUNDWATER LEVEL A MINIMUM OF 2-FEET BELOW THE LOWEST POINT OF EXCAVATION AND CONTINUOUSLY MAINTAIN EXCAVATIONS FREE OF WATER UNTIL BACK-FILLED TO FINAL GRADE.

DEWATERING INSTALLATION NOTES

4. DEWATERING OPERATIONS SHALL USE ONE OR MORE OF THE DEWATERING SUMPS SHOWN ABOVE, WELL POINTS, OR OTHER MEANS APPROVED BY THE LOCAL JURISDICTION TO REDUCE THE PUMPING OF SEDIMENT, AND SHALL PROVIDE A TEMPORARY SEDIMENT BASIN OR FILTRATION BMP TO REDUCE SEDIMENT TO ALLOWABLE LEVELS PRIOR TO RELEASE OFF SITE OR TO A RECEIVING WATER. A SEDIMENT BASIN MAY BE USED IN LIEU OF SUMP DISCHARGE SETTLING BASIN SHOWN ABOVE IF A 4-FOOT-SQUARE RIPRAP PAD IS PLACED AT THE DISCHARGE POINT AND THE DISCHARGE END OF THE LINE IS STAKED IN PLACE TO PREVENT MOVEMENT OF THE LINE.

DEWATERING MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. DEWATERING BMPs ARE REQUIRED IN ADDITION TO ALL OTHER PERMIT REQUIREMENTS.

5. TEMPORARY SETTLING BASINS SHALL BE REMOVED WHEN NO LONGER NEEDED FOR DEWATERING OPERATIONS. ANY DISTURBED AREA SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO, NOT AVAILABLE IN AUTOCAD)

Description

Where an actively flowing watercourse must be crossed regularly by construction vehicles, a temporary crossing should be provided. Three primary methods are available:

- Culvert crossing
- Stream ford
- Temporary bridge

Culvert crossings and fords are the most commonly used methods. Due to the expense associated with a temporary bridge, these are used primarily on long-term projects.

Photograph TSC-1. A temporary stream crossing using culverts. Photo courtesy of Tom Gore.

Appropriate Uses

Construction vehicles shall be kept out of waterways to the maximum extent practicable. Use a temporary stream crossing when it is absolutely necessary to cross a stream on a construction site. Construct a temporary crossing even if the stream or drainageway is typically dry. Multiple stream crossings should be avoided to minimize environmental impacts.

A permit is required for placement of fill in a waterway under Section 404 of the Clean Water Act. The local office of the U.S. Army Corps of Engineers (USACE) should be contacted concerning the requirements for obtaining a 404 permit. In addition, a permit from the U.S. Fish and Wildlife Service (USFWS) may be needed if endangered species are of concern in the work area. Typically, the USFWS issues are addressed by a 404 permit, if one is required. The municipality of jurisdiction should also be consulted, and can provide assistance. Other permits to be obtained may include a floodplain development permit from the local jurisdiction.

Design and Installation

Design details are provided for these types of stream crossings:

TSC-1. Culvert Crossing

TSC-2. Ford Crossing

TSC-3. Flume Crossing

Temporary Stream Crossing	
Functions	
Erosion Control	Yes
Sediment Control	Yes
Site/Material Management	No

A culvert crossing should be designed to pass at least the 2-year design flow. Use Figure DC-2 from the Temporary Channel Diversion Fact Sheet to determine the 2-year peak flow rate. Culvert sizing must account for the headwater and tailwater controls to properly size the culvert. For additional discussion on design of box culverts and pipes, see the *Major Drainage* chapter in Volume 1. The designer also needs to confirm that the riprap selected is appropriate for the conditions in the channel being crossed.

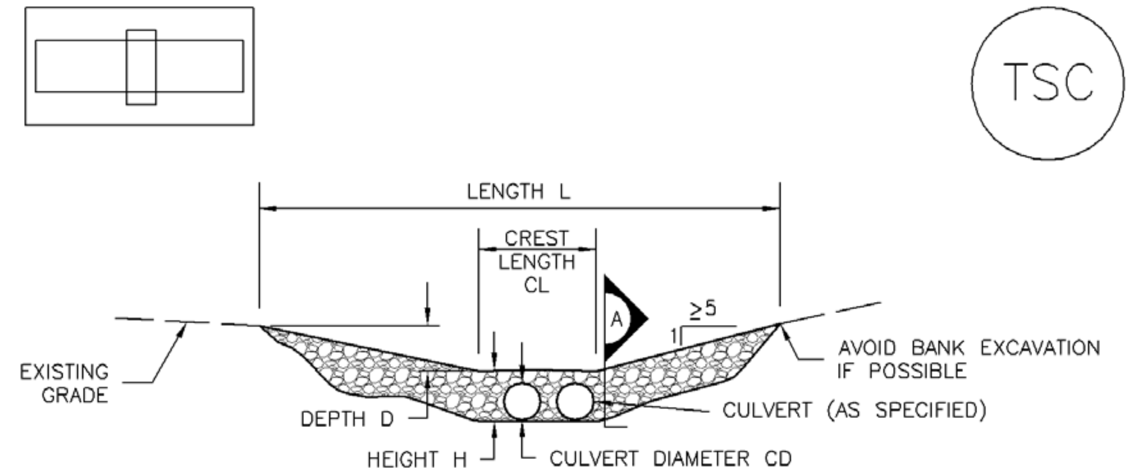
When a ford must be used, namely when a culvert is not practical or the best solution, the ford should be lined with at least a 12-inch thick layer of Type VL (D_{50} = 6 inches) or Type L (D_{50} = 9 inches) riprap with void spaces filed with 1-1/2 inch diameter rock. Ford crossings are recommended primarily for crossings of ephemeral (i.e. intermittently, briefly flowing) streams.

For a temporary bridge crossing, consult with a structural and/or geotechnical engineer for temporary bridge design or consider pre-fabricated alternatives.

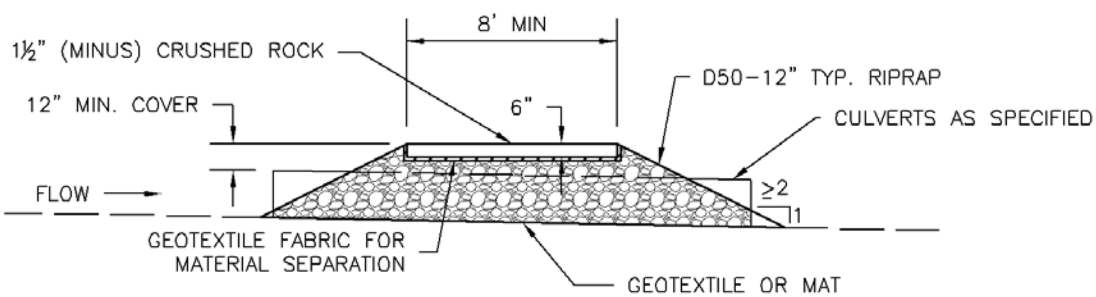
Maintenance and Removal

Inspect stream for bank erosion and in-stream degradation. If bank erosion is occurring, stabilize banks using erosion control practices such as erosion control blankets. If in-stream degradation is occurring, armor the culvert outlet(s) with riprap to dissipate energy (see Outlet Protection Fact Sheet). If sediment is accumulating upstream of the crossing, remove excess sediment as needed to maintain the functionality of the crossing.

Remove the temporary crossing when it is no longer needed for construction. Take care to minimize the amount of sediment lost into the stream upon removal. Once the crossing has been removed, stabilize the stream banks with seed and erosion control blankets.

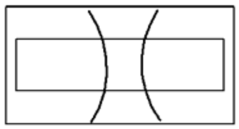


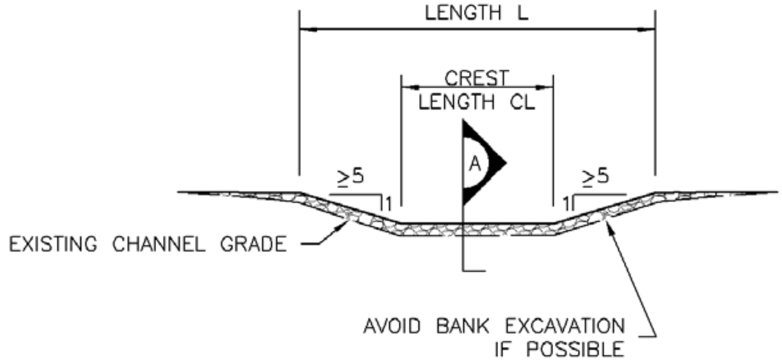
CULVERT CROSSING SECTION



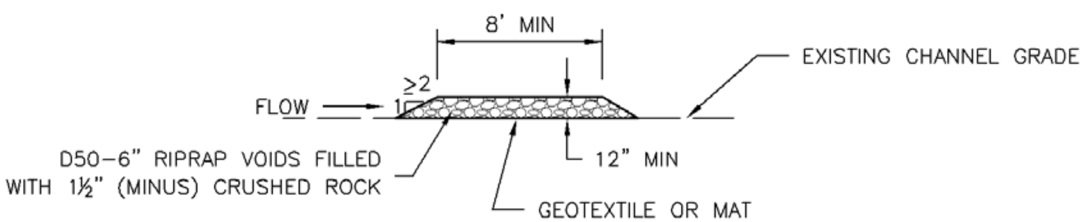
SECTION A

TSC–1. CULVERT CROSSING



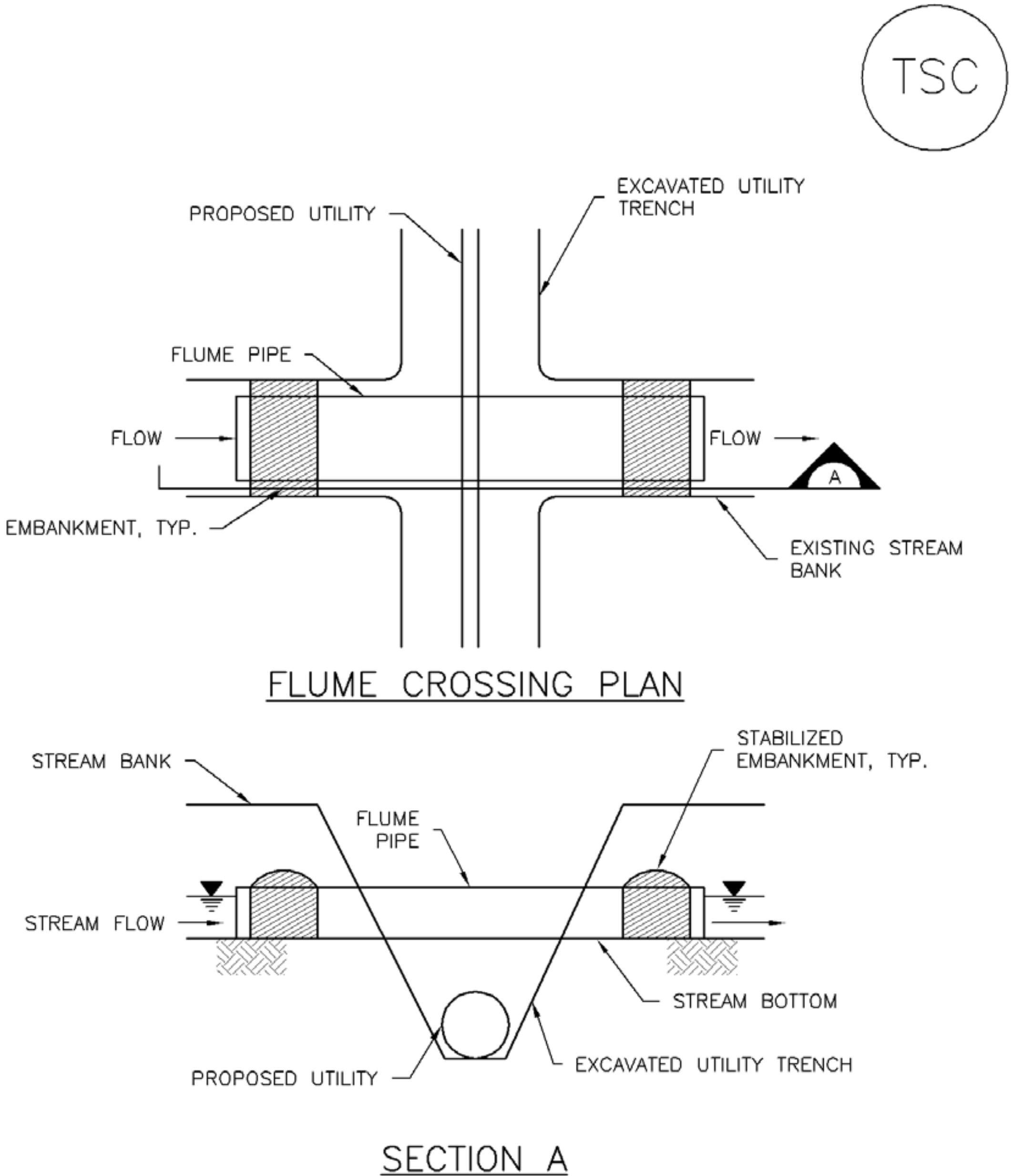


FORD CROSSING SECTION



SECTION A

TSC-2. FORD CROSSING



TSC–3. FLUME CROSSING

TEMPORARY STREAM CROSSING INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATIONS OF TEMPORARY STREAM CROSSINGS.
   - STREAM CROSSING TYPE (FORD, CULVERT, OR FLUME).
   - FOR FORD CROSSING: LENGTH (L), CREST LENGTH (CL), AND DEPTH (D).
   - FOR CULVERT CROSSING: LENGTH (L), CREST LENGTH (CL), CROSSING HEIGHT (H), DEPTH (D), CULVERT DIAMETER (CD), AND NUMBER, TYPE AND CLASS OR GAUGE OF CULVERTS.

2. TEMPORARY STREAM CROSSING DIMENSIONS, D50, AND NUMBER OF CULVERTS INDICATED (FOR CULVERT CROSSING) SHALL BE CONSIDERED MINIMUM DIMENSIONS; ENGINEER MAY ELECT TO INSTALL LARGER FACILITIES. ANY DAMAGE TO STREAM CROSSING OR EXISTING STREAM CHANNEL DURING BASEFLOW OR FLOOD EVENTS SHALL BE PROMPTLY REPAIRED.

3. SEE MAJOR DRAINAGE CHAPTER FOR RIPRAP GRADATIONS.

4. WHERE FAILURE OF A STREAM CROSSING CAN RESULT IN SIGNIFICANT DAMAGE OR HARM IT MUST BE DESIGNED BY A STRUCTURAL ENGINEER.

TEMPORARY STREAM CROSSING MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. REMOVE SEDIMENT ACCUMULATED UPSTREAM OF CROSSING AS NEEDED TO MAINTAIN THE FUNCTIONALITY OF THE CROSSING.

5. STREAM CROSSINGS ARE TO REMAIN IN PLACE UNTIL NO LONGER NEEDED AND SHALL BE REMOVED PRIOR TO THE END OF CONSTRUCTION.

6. WHEN STREAM CROSSINGS ARE REMOVED, THE DISTURBED AREA SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED AND COVERED WITH GEOTEXTILE OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

(DETAIL ADAPTED FROM DOUGLAS COUNTY, COLORADO AND CITY OF AURORA, COLORADO (Va. DSWC), NOT AVAILABLE IN AUTOCAD)

Description

Photograph TBP-1. Effective stormwater management at temporary batch plants requires implementation of multiple BMPs. Photo courtesy of California Stormwater BMP Handbook.

Temporary batch plant management includes implementing multiple BMPs such as perimeter controls, concrete washout area, stabilized construction access, good housekeeping, and other practices designed to reduce polluted runoff from the batch plant area.

Appropriate Uses

Implement this BMP at temporary batch plants and identify the location of the batch plant in the SWMP.

Additional permitting may be required for the operation of batch plants depending on their duration and location.

Design and Installation

The following lists temporary management strategies to mitigate runoff from batch plant operations:

- When stockpiling materials, follow the Stockpile Management BMP.
- Locate batch plants away from storm drains and natural surface waters.
- A perimeter control should be installed around the temporary batch plant.
- Install run-on controls where feasible.
- A designated concrete washout should be located within the perimeter of the site following the procedures in the Concrete Washout Area BMP.
- Follow the Good Housekeeping BMP, including proper spill containment measures, materials storage, and waste storage practices.
- A stabilized construction entrance or vehicle tracking control pad should be installed at the plant entrance, in accordance with the Vehicle Tracking Control BMP.

Maintenance and Removal

Inspect the batch plant for proper functioning of the BMPs, with attention to material and waste storage areas, integrity of perimeter BMPs, and an effective stabilized construction entrance.

Temporary Batch Plants	
Functions	
Erosion Control	No
Sediment Control	No
Site/Material Management	Yes

After the temporary batch plant is no longer needed, remove stockpiled materials and equipment, regrade the site as needed, and revegetate or otherwise stabilize the area.

Description

Manage runoff from paving and grinding operations to reduce pollutants entering storm drainage systems and natural drainageways.

Photograph PGO-1. Paving operations on a Colorado highway. Photo courtesy of CDOT.

Appropriate Uses

Use runoff management practices during all paving and grinding operations such as surfacing, resurfacing, and saw cutting.

Design and Installation

There are a variety of management strategies that can be used to manage runoff from paving and grinding operations:

- Establish inlet protection for all inlets that could potentially receive runoff.
- Schedule paving operations when dry weather is forecasted.
- Keep spill kits onsite for equipment spills and keep drip pans onsite for stored equipment.
- Install perimeter controls when asphalt material is used on embankments or shoulders near waterways, drainages, or inlets.
- Do not wash any paved surface into receiving storm drain inlets or natural drainageways. Instead, loose material should be swept or vacuumed following paving and grinding operations.
- Store materials away from drainages or waterways.
- Recycle asphalt and pavement material when feasible. Material that cannot be recycled must be disposed of in accordance with applicable regulations.

See BMP Fact Sheets for Inlet Protection, Silt Fence and other perimeter controls selected for use during paving and grinding operations.

Maintenance and Removal

Perform maintenance and removal of inlet protection and perimeter controls in accordance with their respective fact sheets.

Promptly respond to spills in accordance with the spill prevention and control plan.

Paving and Grinding Operations	
Functions	
Erosion Control	No
Sediment Control	No
Site/Material Management	Yes

Appendix F:
Construction Control Measures Standard Notes

Standard Erosion Control Notes

General Erosion Control Requirements

These notes are a summary for the legal requirements, that are set forth in the Fort Collins Stormwater Criteria Manual (FCSCM), and that any conflict is resolved by the more stringent requirement controlling.

1) The Property Owner, Owner's Representative, Developer, Design Engineer, General Contractor, Sub-contractors, or similar title for the developing entity (here after referred to as the Developer) has provided these Erosion Control Materials in accordance with Erosion Control Criteria set forth in the Manual as an attempt to identify erosion, sediment, and other potential pollutant sources associated with these Construction Activities and preventing those pollutants from leaving the project site as an illicit discharge. Full City requirements and are outlined and clarified in the Manual under Chapter 4: Construction Control Measures and should be used to identify and define what is needed on a project.

2) The Developer shall make themselves thoroughly familiar with the provisions and the content of the specifications laid out in the Manual, the Development Agreement, the Erosion Control Materials compiled for this project, and the following notes as all these materials are applicable to this project.

3) The Developer shall implement and maintain Control Measures for all potential pollutants from the start of land disturbing activities until final stabilization of the construction site.

4) The City Erosion Control Inspector shall be **notified at least twenty-four (24) hours prior** to the desired start of any construction activities on this site to allow adequate time for on-site confirmation (initial inspection which can take up to two business days after receiving the request) that the site is in fact protected from sediment and pollutants discharges off site. Please contact erosion@fcgov.com early to schedule those Initial Erosion Control Inspections well in advance so that demolition, clearing, grubbing, tree removal, and scraping may begin without delay. Failure to receive an on-site confirmation before construction activities commence is an automatic "Notice of Violation" and can result in further enforcement actions.

5) The Developer shall proactively provide all appropriate Control Measures to prevent damage to adjacent downstream and leeward properties. This includes but is not limited to: trees, shrubs, lawns, walks, pavements, roadways, structures, creeks, wetlands, streams, rivers, and utilities that are not designed for removal, relocation, or replacement in the course of construction.

6) At all times the Developer shall be responsible to ensure adequate Control Measures are designed, selected, installed, maintain, repaired, replaced, and ultimately removed in order

to prevent and control erosion suspension, sediment transportation, and pollutant discharge as a result of construction activities associated with this project.

7) All applicable Control Measures based upon the sequencing and/or phasing of the project shall be installed prior to those construction activities commencing.

8) As dynamic conditions (due to the nature, timing, sequence, and phasing of construction) in the field may warrant Control Measures in addition, or different, to what is shown on these plans, the Developer shall at all times be responsible to implement the Control Measures that are most effective with the current state and progress of construction. The Developer shall implement whatever measures are determined necessary, and/or as directed by the City Erosion Control Inspector. The Developer shall insure that all Erosion Control Plans (Maps) or SWMP documents are updated to reflect the current site conditions, with updates being initialed and dated. These site inspections and site condition updates shall be made available upon request by the City.

9) All listings, provisions, materials, procedures, activities, site work and the like articulated in this or other written site-specific documents (Including but not limited to the erosion control reports, development agreements, landscape, and drainage materials) shall meet or exceed the most restrictive language for City, County, State, and Federal regulations with regards to erosion, sediment, pollutant, and other pollution source Control Measures. The Developer shall be responsible to comply with all of these aforementioned laws and regulations.

10) The Developer shall ensure that all appropriate permits (CDPS General Permit Stormwater Discharges Associated with Construction Activity, Dewatering, Clean Water Act, Army Corps of Engineers' 404 Wetlands Mitigation Permit, etc.) have been attained prior to the relevant activity has begun. These permits or copies shall be made available upon request by the City.

11) The Developer shall furnish all conveniences and assistances to aid the Erosion Control Inspectors of materials, workmanship, records, and self-inspections, etc. of the Control Measures involved in the construction activities.

12) The Developer shall request clarification of all apparent site construction issues that may arise due to inconsistencies in construction plans for the site or site conditions around the selected Control Measures by contacting the Erosion Control Inspector. The Erosion Control Inspector will not be responsible for any explanations, interpretations, or supplementary data provided by others.

13) All Control Measures shall be installed in accordance with the Manual.

14) The City reserves the right to require additional Control Measures as site conditions warrant, to the extent authorized by relevant legal authority.

15) As with any construction standards, occasions may arise where the minimum erosion control standards are either inappropriate or cannot be justified. In these cases, a variance to these

standards **may** be applied for pursuant to the terms, conditions, and procedures of the Manual.

16) Inspection. The contractor shall inspect site pollutant sources and implement Control Measures at a minimum of once every two weeks during construction and within 24 hours following a precipitation event. Documentation of each inspection shall be recorded and retained by the contractor.

17) All temporary Control Measures shall be cleaned, repaired, or reconstructed as necessary in order to assure continual performance of their intended function. All retained sediments, particularly those on paved roadway surfaces, shall be removed and disposed of in a manner and location so as not to cause their release into any drainage way.

18) Any Control Measure may be substituted for another standard Control Measure so long as that Control Measure is equal to, or of greater protection than the original Control Measure that was to be used in that location. (ex. silt fence, for wattles, or for compact berms) Wattle alone on commercial construction sites have shown to be an ineffective substitute for silt fence or compact berms unless it is accompanied by a construction fence to prevent vehicle traffic.

19) Any implementation or replacement of existing Control Measures for a non-standard control, or alternative Control Measure, shall require the review and acceptance by the City erosion control staff before the measure will be allowed to be used on this project. These Control Measures' details shall be submitted, reviewed and accepted to be in accordance with the Erosion Control Criteria based upon the functionality and effectiveness in accordance with sound engineering and hydrological practices

Land disturbance, Stockpiles, and Storage of Soils

20) There shall be no earth-disturbing activity outside the limits designated on the accepted plans. Off road staging areas or stockpiles must be preapproved by the City. Disturbances beyond these limits will be restored to original condition.

21) Pre-disturbance vegetation shall be identified, protected, and retained wherever possible. Removal or disturbance of existing vegetation shall be limited to the area required for immediate construction operations, and for the shortest practical period of time. This should include sequencing and phasing construction activities in a way so that the soil is not exposed for long periods of time by schedule or limit grading to small areas. This should also include when practical advancing the schedule on stabilization activities such that landscaping takes place shortly if not immediately after grading has occurred. Vegetation efforts shall start as soon as possible to return the site to a stabilized condition. Sensitive areas should avoid clearing and grading activities as much possible.

22) All exposed soils or disturbed areas are considered a potential pollutant and shall have Control Measures implemented on the site to prevent materials from leaving the site.

23) All soils exposed during land disturbing activity (stripping, grading, utility installations, stockpiling, filling, etc.) shall be kept in a roughened condition at all times by equipment tracking, scarifying or disking the surface on a contour with a 2 to 4 inch minimum variation in soil surface until mulch, vegetation, and/or other permanent erosion control is installed.

24) No soil stockpile shall exceed ten (10) feet in height. All soil stockpiles shall be protected from sediment transport through the use of surface roughening, watering, and down gradient perimeter controls. All soil stockpiles shall be protected from sediment transport by wind in accordance with Municipal Code §12-150. All stockpiles shall be flattened to meet grade or removed from site as soon as practical, and no later than the completion of construction activities or abandonment of the project. All off-site stockpile storage locations in City limits shall have a stockpile permit from the City Engineering Department prior to using the area to store material. If frequent access from hardscape to the stockpile is needed a structural tracking Control Measure shall be implemented.

25) All required Control Measures shall be installed **prior** to any land disturbing activity (stockpiling, stripping, grading, etc.). All of the required erosion Control Measures must be installed at the appropriate time in the construction sequence as indicated in the approved project schedule, construction plans, and erosion control report.

26) All inlets, curb-cuts, culverts, and other storm sewer infrastructure which could be potentially impacted by construction activities shall be protected with Control Measures. Material accumulated from this Control Measure shall be promptly removed and in cases where the protection has failed, the pipes shall be thoroughly cleaned out.

27) All streams, stream corridors, buffers, woodlands, wetlands, or other sensitive areas shall be protected from impact by any construction activity through the use of Control Measures.

28) All exposed dirt shall have perimeter control. Any perimeter controls that drain off or has the ability to be tracked onto the nearby hardscape shall have some form of effective sediment control as the, or as part of the, perimeter control.

29) All exposed slopes should be protected. All exposed steep slopes (Steeper than 3:1 H:V) shall be protected from erosion and sediment transport through use of Control Measures.

30) No soils shall remain exposed by land disturbing activity for more than thirty (30) days after activity has ceased before required temporary seeding or permanent erosion control (e.g. seed/mulch, landscaping, etc.) is installed. This is not just limited to projects that are abandoned; this includes any project that is temporarily halted and no immediate activity is to resume within the next thirty (30) days, unless otherwise approved by the City Erosion Control Inspector. During a season when seeding does not produce vegetative cover, another

temporary erosion control shall be implemented with or until temporary seeding or permanent erosion control can be performed.

31) All individual lots shall have effective sediment controls located on the street side and any down gradient side. Typically most lots drain to the front yet on those cases where houses are along a pond or drainage swale have the lot drain in a different direction than the street, those individual lots will need protection on that down gradient side to prevent sediment from leaving the lot. See the Individual Lot Details for further clarification.

Vehicle Tracking

32) At all points where vehicles exit or leave the exposed dirt area on to a hardscape or semi hardscape (concrete, asphalt, road base, etc.) shall have installed at least one structural tracking Control Measure to prevent vehicle tracking. All areas not protected by an adequate perimeter control shall be considered a point where vehicles exit the site. Access points should be limited to as few entrances as possible (All perimeter areas shall be protected from tracking activities).

33) In all areas that the structural tracking Control Measures fail to prevent vehicle tracking, collection and proper disposal of that material is required. All inlets located near access points and affected by tracking activities shall be prevented from the introduction of sediment into the drainage system.

34) City Municipal Code §20-62, among other things, prohibits the tracking, dropping, or depositing of soils or any other material onto city streets by or from any source. City Municipal Code, §26-498, among other things, prohibits the discharge of pollutants on public or private property if there is a significant potential for migration of such pollutant. Therefore, all tracked or deposited materials (intentional or inadvertent) are not permitted to remain on the street or gutter and shall be removed and legally disposed of by the Developer in a timely and immediate manner. Dirt ramps installed in the curb-lines are not exempt to these sections of code and shall not be permitted in the street right of way (public or private).

35) If repeated deposit of material occurs on a site, additional structural tracking controls may be required of the Developer by the City Erosion Control Inspector.

Loading and Unloading Operations

36) The Developer shall apply Control Measure to limit traffic (site worker or public) impacts and proactively locate material delivered to the site in close proximity to the work area or immediately incorporated in the construction to limit operational impacts to disturbed areas, vehicle tracking, and sediment deposition that could impact water quality.

Outdoor Storage or Construction Site Materials, Building Materials, Fertilizers, and Chemicals

37) Any materials of a non-polluting nature (steel, rock, brick, lumber, etc.) shall be inspected for any residue coming off the material during routine inspection and will generally be located where practical at least fifty (50) feet from any permanent or interim drainage ways.

38) Any high environmental impact pollutant materials that have a high likelihood to result in discharge when in contact with stormwater (lubricants, fuels, paints, solvents, detergents, fertilizers, chemical sprays, bags of cement mix, etc.) should not be kept on site where practical. When not practical, they should be stored inside (vehicle, trailer, connex, building, etc.) and out of contact with stormwater or stormwater runoff. Where not available, they shall be stored outside in a raised (high spots or on pallets), covered (plastic or tarped), and sealed (leak proof container) in secondary containment location. The secondary containment or other Control Measure shall be adequately sized, located, where practical, at least fifty (50) feet from any permanent or interim stormwater structures or drainage ways and shall be monitored as part of the routine inspections.

Vehicle and equipment maintenance and fueling

39) Parking, refueling, and maintenance of vehicles and equipment should be limited in one area of the site to minimize possible spills and fuel storage areas. This area shall be located, where practical, at least fifty (50) feet from any permanent or interim stormwater structures or drainage ways and shall be monitored as part of the routine inspections. All areas shall keep spill kits and supplies close.

Significant Dust or Particulate generating Process

40) The property must be actively preventing the emission of fugitive dust at all times during construction and vegetation activities. All land disturbing activities that result in fugitive dust shall be in accordance with Municipal Code §12-150 to reduce the impacts to adjacent properties and community health. All required practices shall be implemented and additional ones shall be followed. These practices include watering the sites and discontinuing construction activities until the wind subsides as determined by any City Inspectors.

Concrete truck / equipment washing, including the concrete truck chute and associated fixtures and equipment

41) All concrete and equipment washing shall use structural Control Measures appropriate to the volume of wash and frequency of use. These Control Measures shall be located, where practical, at least fifty (50) feet from any permanent or interim stormwater structures or drainage ways and shall be monitored as part of the routine inspections. These areas shall be clearly identified and protected from any wash from leaving the Control Measure. If frequent

access from hardscape to the Control Measure is to occur, a structural tracking Control Measure shall be implemented. These Control Measures shall be frequently cleaned out.

42) The Developer is responsible for ensuring washing activity is taking place at the appropriate Control Measure and site workers are not washing or dumping wash water on to the dirt or other uncontrolled locations.

Dedicated Asphalt and concrete batch plants

43) Dedicated asphalt and concrete batch plants are not acceptable on construction sites within the City of Fort Collins without an expressed written request and plan to reduce pollutants associated with that type of activity and approval by the City of Fort Collins specifically the Erosion Control Inspector. The Developer shall inform the erosion control inspection staff of any dedicated asphalt, or concrete batch plants that is to be used on site.

Concrete Saw Cutting Materials

44) Saw cutting material shall be in accordance with Municipal Code §12-150 for air emissions and all water applications to the saw cutting shall prevent material from leaving the immediate site and collected. These cutting locations, once dried, shall be swept and scraped of all material and shall have proper and legal disposal.

Waste Materials Storage and Sanitary Facilities

45) Trash, debris, material salvage, and/or recycling areas shall be, where practical, at least fifty (50) feet from any permanent or interim stormwater structures or drainage ways and shall be monitored as part of the routine inspections. These facilities should be located out of the wind and covered as able. Where not able to cover, locating said areas on the side of other structures to reduce exposure to winds, and follow maximum loading guidelines as marked on the container. The Developer is required to practice good housekeeping to keep the construction site free of litter, construction debris, and leaking containers.

46) Sanitary facilities shall be prevented from tipping through the use of anchoring to the ground or lashing to a stabilized structure. These facilities shall also be located as far as practical from an inlet, curb cut, drainage swale or other drainage conveyances to prevent material transport from leaving the local area. This consists of the facility being located, where practical, at least fifty (50) feet from any permanent or interim drainage ways.

Other Site Operations and Potential Spill Areas

47) Spills: For those minor spills that; are less than the State's reportable quantity for spills, stay within the permitted area, and in no way threaten any stormwater conveyance, notify the

City of Fort Collins Utilities by email at erosion@fcgov.com or phone (970) 817-4770. For any significant, major, or hazardous spills, notify the City of Fort Collins Utilities by phone only after Emergency Response (911) has been notified and is on route, County Health Department (LCDHE) has been notified through Larimer County Sheriff Dispatch (970) 416-1985, and the State Spill Hotline Incident Reporting have been contacted 1-877-518-5608. Written documentation shall be provided to the City within 5 days of the event. All spills shall be cleaned up immediately.

48) Selection of “plastic welded” erosion control blankets shall not be used in areas that wildlife, such as snakes, are likely to be located as these have proven to cause entrapment issues.

Final stabilization and project completion

49) Any stormwater facilities used as a temporary Control Measure will be restored and storm sewer lines will be cleaned upon completion of the project and before turning the maintenance over to the Owner, Homeowners Association (HOA), or other party responsible for long term maintenance of those facility.

50) All final stabilization specifications shall be done in accordance with the Manual, Chapter 4: Construction Control Measures.

51) All disturbed areas designed to be vegetated shall be amended, seeded & mulched, or landscaped as specified in the landscape plans within 14 working days of final grading.

52) Soil in all vegetated (landscaped or seeded) areas, including parkways and medians shall comply with all requirements set forth in Sections 12-130 through 12-132 of the City Municipal Code, as well as Section 3.8.21 for the City Land Use Code.

53) All seeding shall refer to landscaping plans for species mixture and application rates and depths requirements.

54) All seed shall be drilled where practical to a depth based upon the seed type. Broadcast seeding shall be applied at double the rate as prescribed for drill seeding and shall be lightly hand raked after application. Hydroseeding may be substituted for drill seeding on slopes steeper than 3(H):1(V) or on other areas not practical to drill seed and crimp and mulch. All hydroseeding must be conducted as two separate processes of seeding and tackification.

55) All seeded areas must be mulched within twenty-four (24) after planting. All mulch shall be mechanically crimped and or adequately applied tackifier. The use of crimped mulch or tackifier may require multiple re-applications if not properly installed or have weathered or degraded before vegetation has been established. Areas of embankments having slopes greater than or equal to 3H:1V shall be stabilized with an erosion mat or approved equal to ensure seed will be able to germinate on the steep slopes. During a season when seeding does

not produce vegetative cover, another temporary erosion control shall be implemented along with, or until, temporary seeding or permanent erosion control can be performed.

56) The Developer shall warranty and maintain all vegetative measures for two growing seasons after installation or until seventy percent (70%) vegetative cover has been established, whichever is longer and meets all the Criteria outlined in the Fort Collins Stormwater Criteria Manual Chapter 4: Construction Control Measures.

57) The Developer shall maintain, monitor, repair, and replace any and all applicable Control Measures until final stabilization has been obtained. All Control Measures must remain until such time as all upstream contributing pollutant sources have been vegetated or removed from the site. When any Control Measure is removed, the Developer shall be responsible for the cleanup and removal of all sediment and debris from that Control Measure. At the point at which the site has been deemed stabilized and verified by City Erosion Control Inspector, all temporary Control Measures can then be fully removed. All measures shall be removed within 30 days after final stabilization is achieved.

58) The responsible party shall maintain and keep current all payments or related forms of security for the Erosion Control Escrow until 1) stabilization has been reached and 2) all Control Measures and/or BMPs have sediment materials collected and the Control Measure removed from the site. At that time the site will be considered completed and any remaining Erosion Control Escrow shall be returned to the appropriate parties.