Larimer County

Stormwater Design Standards

Larimer County
Committed to Excellence

2023

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CHAPTER 1.0 GENERAL PROVISIONS

1.1 Introduction

These Stormwater Design Standards (Standards) have been developed by the Larimer County Engineering Department and adopted by resolution by the Larimer County Board of County Commissioners.

1.2 Purpose

The purpose of these Standards is to establish minimum storm drainage criteria for the public safety, health, comfort, convenience, welfare and economic well-being of residents and owners of property within the County. These Standards present policies and minimum technical criteria for the planning, analysis, design and maintenance of storm drainage systems in the County. Any policies or technical criteria that are not specifically addressed in these Standards shall follow those of the most recent version of the Mile High Flood District's Urban Storm Drainage Criteria Manual (MHFD Manual), which is incorporated in these Standards by reference.

1.3 Jurisdiction

These Standards shall apply in all lands within unincorporated Larimer County including, but not limited to, to the following:

- All storm drainage systems and facilities within Larimer County rights-of-way, drainage easements (public and private) or other public-use easements.
- All privately-owned and maintained storm drainage systems and facilities.
- All new development, minor expansion, change of use, or major redevelopment, as defined in the Larimer County Land Use Code.
- The administration of drainage, floodplain and water quality provisions of the Larimer County Land Use Code and all other ordinances and regulations that require a review of drainage conditions on any property within the County.

1.4 Administration

The County Engineer is responsible for administration and enforcement of these Standards, including review of all drainage studies, plans and specifications for drainage improvements; interpretation and enforcement of the provisions of these Standards; and application of sound engineering judgement in implementing the requirements found in these Standards.

1.5 Review and Approval

The County will review all submittals for general conformance with these Standards. However, an approval by the County does not relieve the owner, engineer, or designer from responsibility for ensuring that the calculations, plans, specifications, construction and record drawings are in compliance with these Standards, as stated in the certification of the owner's engineer.

The County may also refer submittals to other local, state or federal agencies that have an interest or responsibility for drainage and/or water quality issues.

1.6 Interpretation

The County Engineer will interpret and apply the provisions of these Standards using the following governing statements:

- These Standards provide the minimum requirements to protect the public health, safety, comfort, convenience, prosperity, and welfare of the residents of Larimer County, protect property, and minimize adverse impacts to the environment.
- Whenever a provision of these Standards and any other provisions of the Larimer County Land Use Code, law, ordinance, resolution, rule or regulation of any kind, contains any requirement(s) covering any of the same subject matter, the requirements that are more restrictive or impose higher standards will govern.
- These Standards do not abrogate or annul any easements, permits, drainage reports or construction drawings accepted by the County prior to the effective date of these Standards.
- The County Engineer has final authority to resolve any conflicting interpretations of these Standards.

1.7 Variances

Variances from the provisions of these Standards are strongly discouraged but will be considered on a case-by-case basis. A formal variance request must be submitted to the County Engineer with the following information, at a minimum, included:

- Identify the specific standard (name, number, and/or applicable language) that the variance request pertains to.
- Description and discussion of the conditions and constraints that justify the variance request.
- Description, discussion, and analysis of the proposed alternative(s).
- The Variance Request Application Fee (if applicable) must be paid.
- All variance request submittals must be signed and stamped by a professional engineer licensed in Colorado.

The County Engineer may approve a variance request if the applicant can clearly and reasonably demonstrate the following:

- The applicant has established that the standard(s) cannot be achieved due to circumstances outside of their control.

- The variance will address a unique condition that is unusual for a project of similar type, extent, magnitude or location.
- The variance represents the least deviation from the standard that will provide relief and still meet the intent of the standard.
- The variance does not increase costs of public storm drainage facilities or other public facilities, including capital costs, maintenance costs, and lifecycle costs.
- The variance does not cause undue negative impact to public safety, health, welfare and environment.

The County Engineer will notify the applicant in writing of approval or denial of the variance request.

1.8 Amendments to the Standards

These Standards may be amended over time to address new regulations, updated data and information, and overall lessons learned from the past. Such amendments shall include, by reference, updates to the MHFD Manual. Minor amendments may only require approval of the County Engineer, while all major amendments will require approval of the Board of County Commissioners. Minor amendments are those that do not substantially change a policy or technical criteria such as changes to submittal requirements, clarifications, guidance and grammar.

CHAPTER 2.0 DRAINAGE REPORT SUBMITTAL REQUIREMENTS

2.1 Introduction

This chapter outlines the requirements and procedures for submittal of drainage plans and reports in the County. A general description of items to be included in the drainage report follows. Please refer to the detailed Submittal checklists in the Appendices of the Standards and on the County's website for a comprehensive list of required items. The requirements for submittal shall include a Preliminary Drainage Report, a Final Drainage Report and construction plans for drainage improvements. Under certain circumstances, an abbreviated Drainage Letter may be allowed, with approval from the County Engineer. All storm drainage plans shall be checked for conformance to the design criteria set forth in the Standards. Written approval of drainage plans must be obtained before any construction begins.

2.2 Drainage Letter

A Drainage Letter may be considered for sites that fall within a project boundary with a previously approved drainage report or for minor changes to existing properties. The Letter usually consists of an abbreviated narrative and simplified drainage plan, which the County may require to be signed and sealed by a qualified professional engineer licensed in the State of Colorado. All the following criteria must be met to substitute a Drainage Letter for a full drainage report:

- Prior approval must be obtained from the County Engineer.
- Any off-site drainage through the property must be adequately conveyed.
- The project does not alter the existing drainage pattern.
- The adjacent and downstream surface drainage system will hydraulically accommodate post-development runoff.
- No additional drainage infrastructure is required or proof of no injury to downstream properties is provided.

The following sections describe some of the submittal requirements for a drainage letter.

2.2.1 Drainage Narrative

The Letter must identify the project location, the project land use, any minor drainage changes to previously approved drainage studies and describe how it will be in general conformance with any previously approved drainage studies, if applicable.

For those sites without a previously approved drainage study, include a discussion of on- and off-site drainage patterns, list any drainage features on-site or nearby, and describe any drainage easements on the property.

Describe the approximate area of land disturbance and discuss sediment and erosion control during and after construction.

2.2.2 Drainage Features

Identify drainage features that are on-site and/or adjacent to the site such as culverts, drainages, lakes or reservoirs, rivers, irrigation ditches, low ponding areas and wetlands. Provide photos of any existing drainage features.

2.2.3 Drainage Plan

Provide a map of the site that includes property and project boundaries, contours, existing and proposed drainage patterns and facilities, and other relevant site characteristics.

2.3 Preliminary Drainage Report

A Preliminary Drainage Report (PDR) shall be submitted prior to a Final Drainage Report. The overall intent of the PDR and the County's review of the PDR is to demonstrate the proposed project is technically feasible (from a stormwater management perspective) and to identify potential drainage issues that should be addressed prior to moving to final design. The PDR shall include a complete evaluation of current drainage conditions and a preliminary, conceptual plan for handling drainage prior to actual sizing of facilities.

The following sections describe some of the submittal requirements for a PDR.

2.3.1 General Report Requirements

The report shall be typed on 8-1/2" x 11" paper and submitted electronically in pdf format or equivalent. A professional engineer's certification statement is required with stamps and signatures on reports and plans. The PDR Checklist shall be filled out by the design engineer and submitted along with the report.

2.3.2 Drainage Narrative

The drainage report must include a narrative description of the project location and any existing and proposed characteristics that influence drainage on the site. A preliminary design of the drainage facility and criteria used shall be included, as well as a discussion of how the proposed design will comply with all standards and adequately control runoff from the site.

2.3.2.1 Introduction

The introduction section of the narrative shall include a general project description and include proposed land use(s).

2.3.2.2 General Location and Description

A description of the project location should include general spatial information, such as adjacent streets; township, range, and section; and the names of any surrounding developments. A location map should accompany this section.

The property description shall include all characteristics relevant to stormwater drainage, including ground cover and soils, groundwater, any existing stormwater and irrigation facilities and easements, as well as any history of flooding on the site or the adjacent properties.

2.3.2.3 Drainage Basins and Sub-Basins

The report narrative shall include a description of the major drainage basin in which the project site is located. Any previous basin studies should be referenced and the applicable FEMA Flood Insurance Rate Map. Include a discussion of any discharge or detention requirements identified in pervious basin studies and relevant to the project. Nearby irrigation facilities, reservoirs, or emergency spillways that may affect drainage or be affected by drainage from the site should be included, as well as an identification of all outfalls to the major drainageways. A statement must be made as to the effect of the development on hazard ratings of any reservoirs in the area.

The report narrative should also include a description of the sub-basin(s) delineated for the project site. The narrative should include the sub-basin name, proposed imperviousness, major and minor peak discharge rates, and discharge location or design point. Assumptions for upstream development must take into account planned development upstream and be based on information and discussions with adjacent property owners and the Larimer County Planning Department. These assumptions should be clearly stated and justifications for the assumptions must be presented. A description of all parameters used in calculations should be included.

2.3.2.4 Drainage Design Criteria

Development must meet criteria established in previous drainage studies if any exist, and reference should be made to any drainage studies of the site or adjacent properties. Any site constraints impacting drainage should be described.

The drainage design must follow the hydrologic and hydraulic criteria as established in these Standards. All criteria used for calculations shall be described, including rainfall and design storm recurrence intervals, soil classification, and imperviousness. All methods used for calculating runoff and detention discharge and storage should be indicated, as well as any other criteria or methods used in the preliminary drainage design.

A brief description of how the drainage design meets the hydraulic criteria as established in these Standards shall be included in the PDR. Include preliminary capacity analysis of all existing and proposed drainage infrastructure. Perform floodplain analysis, if required.

Describe how the project will satisfy the requirements of the County's MS4 permit, if applicable.

2.3.2.5 Drainage Facility Design

Include a discussion of the general drainage concepts of the project site. Any upstream or downstream runoff considerations should be described, as well as anticipated and proposed drainage patterns. Discuss any tables, charts, figures, or drawings included in the report, and reference plans for bordering developments as applicable.

Provide a preliminary discussion of drainage problems on-site and possible solutions. Include design flows and storage volumes needed. Describe any existing stormwater facilities and a general description of proposed stormwater conveyance and storage facilities. Details of the relationship of proposed drainage facilities to existing or planned drainage facilities in surrounding properties or developments shall be included in the report. In cases where the point of outfall or peak flow from the property is other than historic, binding agreements from affected property owners or a letter of intent permitting such discharge shall be submitted.

Discuss any variances requested from the County and how the project will meet the intent of the criteria.

2.3.2.6 Conclusions

Discuss how the project complies with all the County's stormwater and floodplain criteria, as well as FEMA floodplain regulations, if applicable. Describe how the drainage design will control runoff from the site. Include any impacts to upstream or downstream properties. If applicable, discuss how the drainage design complies with the County's MS4 permit and which post-construction design standard will be met.

2.3.2.7 References

Include references to any criteria and technical information used in preparation of the report.

2.3.2.8 Appendices

Appendices should include the following information:

- All existing and proposed runoff calculations, as well as all assumptions and parameters used.
- Preliminary hydrologic and hydraulic calculations for water quality and flood control facilities should be included.
- A copy of the relevant Flood Insurance Rate Map (FIRM) panel and any Letters of Map Revision (LOMRs) that have changed mapping since the effective date of the FIRM.
- A map of hydrologic soil groups. The map downloaded from the Natural Resource Conservation Service (NRCS) is sufficient. Include the accompanying soils report.
- Other supporting information, calculations, mapping, etc. that the applicant relied upon to prepare the report.

2.3.3 Drainage Plan

The Drainage Plan includes supporting maps and drawings of existing and proposed site conditions and drainage facilities. The drainage plan shall include a statement such as "These plans are not to be used for construction or final record" (or similar).

2.3.3.1 Overall Drainage Map

The overall drainage map should include a map of the project that includes basin and project boundaries, flow paths and drainage patterns entering, leaving, and traversing the site, as well as any major constriction such as other development along the path of drainage. Floodplain boundaries and elevations should be shown, if applicable. Include any existing or proposed stormwater facilities.

2.3.3.2 Detailed Drainage Plan

The detailed drainage plan should be of large enough scale to show all site conditions, constraints, and the design of existing and proposed drainage facilities. The plan should include contours, flow paths, design points, property lines and easements, and locations and footprints of all facilities. The County's checklist provides additional details regarding required items to be included in the detailed drainage plan.

2.4 Final Drainage Report

The Final Drainage Report (FDR) shall be submitted for approval along with the final plat and the construction drawings. The purpose of the FDR is to update the concepts discussed in the PDR and to present design details for all proposed drainage facilities. When approved, the report will be signed by the County Engineer and shall constitute final approval of the drainage plan. The report shall include the information submitted in the PDR, with any additions, modifications, or corrections required.

The following sections describe some of the submittal requirements for an FDR.

2.4.1 Drainage Narrative

The narrative of the FDR shall include all items from the PDR, as well as the following:

2.4.1.1 Drainage Design Criteria

A detailed description of how the drainage design meets the hydraulic criteria as established in these Standards shall be included in the FDR. Provide the results of capacity analysis of existing and proposed drainage infrastructure, floodplain analyses if required, and any other drainage facility design criteria that were used.

2.4.1.2 Drainage Facility Design

The FDR shall include specific details of the drainage facility design. All final design flows and storage volumes should be included. Discuss maintenance access and aspects, as well as easements and compliance with all state, local, and federal requirements.

2.4.1.3 Appendices

In addition to the hydrologic calculations included in the PDR, the FDR shall include detailed hydraulic computations for all stormwater facilities included in the drainage design. Include capacity calculations, HGL and EGL, water surface profiles, and design details for storage and conveyance facilities.

2.4.2 Drainage Plan

The final drainage plan shall include a detailed presentation of drainage facilities. A detailed checklist including all necessary items is available in the Appendices.

2.4.3 Erosion Control Plan

This plan should indicate methods to be used during and after construction to control erosion and sediment in the development. The Erosion Control Plan shall be developed based on the guidance and criteria provided in CHAPTER 16.0 of the Standards. (As a supplement to the report, 24" x 35" drawings may be necessary to illustrate the methods and control measures to be used.)

2.4.4 Construction Plans

All storm drainage plans shall be checked for conformance with the <u>minimum</u> design criteria set forth in these Standards prior to approval. Prior to submittal of the final construction drawings, one complete set of prints shall be submitted for review and comment and will be returned if changes are required or recommended. Two complete sets of revised prints shall then be submitted for final approval along with the original review print.

A checklist detailing required items to be included on construction plans is available in the Appendices. Construction drawings should be completed in both plan and profile and show both existing and planned utilities and structures. All drawings must include the following statement, signed by the professional engineer:

> All work shall be constructed in accordance with Larimer County Standard Specifications as provided by the County Engineer, except as noted.
>
> APPROVED: ______________________ DATE: ______________________________

2.5 As-Builts and Site Certification

All new developments within the County are required to submit for review and approval an overall site certification of the constructed drainage facilities. The overall site certification must specify the proposed and the as-built conditions of the site's drainage facilities. Engineers are required to certify that as-constructed pond volumes meet or exceed the design standards for WQCV, EURV, and detention. Any variation from the approved plans must be noted and proven to function properly within standards as in the Stormwater Design Standards. Supporting calculations to justify any variation from the approved plans shall be provided including but not limited to detention volumes, pipe capacities, and swale capacities. It is the responsibility of the owner or professional engineer to prepare and submit all required information to the State Engineers Office for any water quality SCMs.

2.5.1 Lot-Grading Certification

Individual lot or building certification may be required depending on the site design, prior to the release of a certificate of occupancy by the County Building Department. Certification of drainage facilities shall be submitted to the County Engineer at least two weeks prior to release of collateral or the release of a certificate of occupancy.

2.6 Variances

Please refer to Section 1.7 of these Standards for variance request requirements.

2.7 Certification

All drainage reports and plans must be certified that they were prepared under the direct supervision of a licensed professional engineer in the State of Colorado using the following certification:

> I hereby certify that this report (plan) for the ____________________(preliminary/final) drainage design of ____ was prepared by me (or under my direct supervision) for the owners thereof and meets or exceeds the criteria in the Larimer County Stormwater Design Standards.

____
Licensed Professional Engineer
State of Colorado No. ___________
(Seal)

CHAPTER 3.0 DRAINAGE PRINCIPLES AND POLICIES

3.1 Introduction

Effective stormwater management is essential to the health and environmental and economic well-being of a community. The MHFD's guiding principles of sound drainage planning are hereby adopted by the County and inform the policies that drive the criteria of the Standards.

3.2 Principles

1. **Drainage is a regional phenomenon that does not respect the boundaries between government jurisdictions or between properties.** This makes it necessary to formulate programs that include both public and private involvement. Overall, the governmental entities most directly involved must provide coordination and master planning, but drainage planning must be integrated on a regional level if optimum results are to be achieved. The manner in which proposed drainage systems fit into existing regional systems must be quantified and discussed in the master plan.

2. **A storm drainage system is a subsystem of the total urban water resource system.** Stormwater system planning and design for any site must be compatible with comprehensive regional plans and should be coordinated with planning for land use, open space and transportation. Erosion and sediment control, flood control, site grading criteria, and water quality all closely interrelate with urban stormwater management. Any individual master plan or specific site plan should normally address all of these considerations.

3. **Every urban area has an initial (i.e., minor) and a major drainage system, whether or not they are actually planned and designed.** The initial drainage system, sometimes referred to as the "minor system," is designed to provide public convenience and to accommodate moderate, frequently occurring flows. The major system carries more water and operates when the rate or volume of runoff exceeds the capacity of the minor system. Both systems should be carefully considered.

4. **Runoff routing is primarily a space allocation problem.** The volume of water present at a given point in time in an urban region cannot be compressed or diminished. Channels and storm drains serve both conveyance and storage functions. If adequate provision is not made for drainage space demands, stormwater runoff will conflict with other land uses, result in damages, and impair or disrupt the functioning of other urban systems.

5. **Planning and design of stormwater drainage systems should not be based on the premise that problems can be transferred from one location to another.** Urbanization tends to increase downstream peak flow by increasing runoff volumes and velocities. Stormwater runoff can be stored and slowly released via detention facilities to manage peak flows, thereby reducing the drainage capacity required immediately downstream.

6. **An urban storm drainage strategy should be a multi-objective and multi-means effort.** The many competing demands placed upon space and resources within an urban region argue for a drainage management strategy that meets a number of objectives, including water quality enhancement, groundwater recharge, recreation, wildlife habitat, wetland creation, protection of landmarks/amenities, control of erosion and sediment deposition, and creation of open spaces.

7. **Design of the storm drainage system should consider the features and functions of the existing drainage system.** Every site contains natural features that may contribute to the management of stormwater without significant modifications. Existing features such as natural streams, depressions, wetlands, floodplains, permeable soils, and vegetation provide for infiltration, help control the velocity of runoff, extend the time of concentration, filter sediments and other pollutants, and recycle nutrients. Each development plan should carefully map and identify the existing natural system. Techniques that preserve or protect and enhance the natural features are encouraged. Good designs improve the effectiveness of natural systems rather than negate, replace or ignore them.

8. **In conjunction with new development and redevelopment, coordinated efforts should be made to minimize increases in, and reduce where possible, stormwater runoff volumes, flow rates, and pollutant loads to the maximum extent practicable.** Key practices include:

- The perviousness of the site and natural drainage paths should be preserved to the extent feasible. Areas conducive to infiltration of runoff should be preserved and integrated into the overall runoff management strategy for the site.
- The rate of runoff should be slowed. Preference should be given to stormwater management systems that maximize vegetative and pervious land cover. These systems will promote infiltration, filtering and slowing of the runoff. It should be noted that, due to the principle of mass conservation, it is virtually impossible to prevent increases in post-development runoff volumes for all storm events when an area urbanizes. Existing stormwater regulations typically require control of peak flows to predevelopment levels to the maximum extent practicable, and increasingly, regulatory agencies are implementing requirements focused on the control of runoff volumes for smaller, frequently occurring events. Increased flow volumes may not cause flooding problems if a watershed has a positive outfall to a stream or river; however, increases in runoff volumes may cause problems for small, enclosed watersheds (i.e. draining to a lake) or into streams of limited capacity. Increases in runoff volumes, if not appropriately managed, can also adversely affect stream stability.
- Pollution control is best accomplished by implementing a series of measures, which can include source controls, minimizing directly connected impervious area, and construction of on-site and regional facilities to control both runoff and pollution. Implementing measures that reduce the volume of runoff produced by frequently occurring events through infiltration and disconnection of impervious areas is one of the most effective means for reducing the pollutant load delivered to receiving waters.

9. **The stormwater management system should be designed beginning with the outlet or point of outflow from the project, giving full consideration to downstream effects and the effects of offsite flows entering the system.** The downstream conveyance system should be evaluated to ensure that it has sufficient capacity to accept design discharges without adverse upstream or downstream impacts such as flooding, stream bank erosion, and sediment deposition. In addition, the design of a drainage system should take into account the runoff from upstream sites, recognizing their future development runoff potential (e.g., imperviousness).

10. **The stormwater management system requires regular maintenance.** Failure to provide proper maintenance reduces both the hydraulic capacity and pollutant removal efficiency of the system. The key to effective maintenance is clear assignment of responsibilities to an established entity and a regular schedule of inspections to determine maintenance needs and to ensure that required maintenance is conducted. Local maintenance capabilities should be a consideration when selecting specific design criteria for a given site or project.

11. **Floodplains should be preserved whenever feasible and practicable.** Nature has claimed prescriptive easement for floods, via its floodplains, that cannot be denied without public and private cost. Floodplain encroachment must not be allowed unless competent engineering and planning have proven that flow capacity is maintained, risks of flooding are defined, and risks to life and property are strictly minimized. Preservation of floodplains is a policy of MHFD to manage flood hazards, preserve habitat and open space, create a more livable urban environment, and protect the public health, safety, and welfare (White 1945).

12. **Reserve sufficient right-of-way for lateral movement of incised floodplains.** Whenever an urban floodplain is contained within a narrow non-engineered channel, its lateral movement over time can cause extensive damage to public and private structures and facilities. For this reason, whenever such a condition exists, it is recommended that, at a minimum, the channel be provided with grade control structures and a right-of-way corridor be preserved of a width corresponding to normal depth calculations for the future stable channel geometry, plus maintenance access requirements.

3.3 Planning Policies

New development and redevelopment have the potential to impact drainage, both upstream and downstream. Those impacts can be analyzed, and solutions can be developed to reduce, minimize or eliminate impacts as part of the drainage planning process. The County's planning policies include the following:

1. Require drainage planning for all new development, minor expansion, change of use, or major redevelopment, as defined in the Larimer County Land Use Code. Drainage

planning may include, but is not necessarily limited to, preparation of engineering reports and development plans in accordance with requirements of these Standards.

Types of Projects in the County Requiring Drainage Planning*

New Development: Any construction activity or site alteration on a site that has not been previously developed.

Minor Expansion: Any development activity that includes the following: 1) Expansion of a mixed use-building by more than 2,000 square feet of non-residential space or the lesser of more than 10 dwelling units or 10% of the number of dwelling units; or 2) Expansion of a non-residential building by the greater of either 2,000 square feet or more than 20% of the total square footage of the building.

Change of Use: Any change of use that involves or requires on-site or off-site improvements, including but not limited to parking; landscaping, screening, or buffering; drainage facilities; outdoor uses on the lot, including sales, display, and storage.

Major Redevelopment: Any development activity on a mixed-use or non-residential site that involves change to 75 percent or more of the square footage of a primary structure. Major redevelopment shall be measured cumulatively over a rolling five-year period in the same ownership, starting with the applicant's most recent development application.

*All of these types of developments are collectively referred to as "**Projects**" throughout these Standards

2. Require implementation of solutions for potential drainage impacts so as not to transfer drainage problems from one location to another.

Comprehensive and multi-jurisdictional drainage planning is a successful approach that reduces overall drainage impacts and aims to distribute stormwater management responsibilities equitably throughout a watershed. In addition, the County encompasses many cities and towns that have developed their own drainage criteria and watershed master plans.

3. Encourage and cooperate with other local and regional agencies on the development and/or implementation of watershed-scale drainage planning and policies. This policy shall include adhering to Agreements (existing and/or future) with those agencies that have established drainage criteria and policies for their respective Growth Management Areas (e.g., City of Fort Collins, City of Loveland, etc.).

Drainage planning can present opportunities that benefit other societal needs such as transportation, recreation, open space, water quality, and others. Coordination among both private and public entities, and within various departments of the County, may be necessary to accomplish these multi-objective goals.

4. Consider stormwater runoff and drainage solutions as a potential resource for other social, environmental, and economic benefits and, where possible, encourage the development of drainage plans that incorporate those other benefits.

3.4 Technical/Design Standards Policies

The Standards presented herein establish guidelines, criteria and methods for effective stormwater management planning and design. The County's technical/design policies include the following:

1. Require drainage planning and design be conducted according to the Standards presented in this document.

The County has very diverse characteristics (e.g., land use, population density, topography, geology) that effect how stormwater may be managed in different locations. It is not always feasible or responsible to apply drainage criteria developed for highly urbanized areas to areas that are not.

2. Recognize the need for different drainage design criteria for "rural" and "urban" areas, where allowable by local, state and federal regulations.

Rural vs. Urban Areas as Defined by the Larimer County Land Use Code*

Rural areas are characterized by rural residential development with accessory agricultural and minimal infrastructure and support services.

Urban areas are characterized by a mix of residential, commercial, and industrial development.

In reality, urbanization occurs over a spectrum of imperviousness from low-density rural areas to denser suburban areas to very dense downtown areas. In general, urban areas are those within the County's Growth Management Area and rural areas are those zoned as agricultural or rural land uses.

*A zoning map is available on the Larimer County Planning Department webpage.

Drainage design requires consideration of the frequency and extent of disruptions and damage that may occur from storm events of different magnitudes. Accordingly, these Standards include design requirements for both a minor (initial) storm event and the major storm event. Minor storm event criteria are intended to minimize disruptions from more frequently occurring events. Major storm event criteria are intended to minimize damages from larger, less-frequent events.

3. Require drainage systems that are designed for both a minor (initial) storm event and a major storm event. The minor storm event shall vary based on infrastructure type and

location (generally 2-year to 10-year return period storm event). The major storm event shall be the 100-year return period storm event.

The disruptions and damages mentioned above are most often associated with streets and roadways. Drainage can be conveyed directly on streets/roadways (e.g., curb and gutter), adjacent to streets/roadways (e.g., roadside swales) or below streets/roadways (e.g., pipes and culverts). These Standards establish reasonable limits for the interactions of drainage designs on streets/roadways.

4. Recognize that streets and roadways have the primary purpose of serving traffic needs and that street/roadway drainage Criteria serve to balance traffic needs, public safety, and costs of constructing and maintaining drainage infrastructure.

Development and redevelopment generally increase the rate and volume of runoff from a site, which can lead to flooding and stream degradation downstream. Stormwater detention can be used to reduce those rates and volumes closer to predevelopment conditions.

5. Require all new development and redevelopment to provide aboveground stormwater detention following the MHFD's "full-spectrum detention" approach.

Portions of the County fall within the State of Colorado's municipal separate storm sewer system (MS4) boundaries. Development and redevelopment projects conducted within those boundaries must adhere to certain requirements of the State's MS4 permit, including implementation of post-construction stormwater control measures (aka permanent water quality treatment facilities).

6. Require all new development and redevelopment within the County's MS4 boundaries to provide permanent water quality treatment according to the Criteria presented in the Standards.

3.5 Operation and Maintenance Policies

Drainage infrastructure requires proper maintenance in order to maintain its function. Typical maintenance activities include sediment and debris removal, vegetation upkeep and erosion control. It is important that all infrastructure be accessible for maintenance. The County's operation and maintenance policies include the following:

1. Development-wide stormwater conveyance facilities shall only be situated in an outlot, common area lot, or road Right-of-Way/Easement. Drainage easements shall only be used to convey stormwater drainage from an individual lot to a dedicated development-wide stormwater facility. Approved grading and drainage plans shall not be altered unless prior approval from the County Engineer is obtained. This shall be documented and memorialized in HOA documents or as part of a recorded maintenance agreement.

2. The owners of all stormwater management facilities and infrastructure are responsible for maintenance unless it is documented that another party shall be responsible for maintenance.
3. Require maintenance access be provided to all stormwater management facilities.
4. The County reserves the right to enter a property to maintain stormwater management facilities if the owner fails to do so, and the owner shall be responsible for reimbursing the County for those costs.

3.6 Floodplain Management Policies

The County participates in the National Flood Insurance Program (NFIP). The NFIP establishes minimum criteria for development within floodplains and participation in the program allows property owners to obtain flood insurance from the federal government. The County's floodplain management policies include the following:

1. The County implements and enforces floodplain development regulations that meet or exceed the minimum standards of the NFIP, Section 44, Parts 59, 60, 65, 70 of the Federal Code of Regulations.

Further, the Colorado Water Conservation Board has issued floodplain rules and regulations for all of Colorado.

2. The County implements and enforces floodplain development regulations that meet or exceed the rules, regulations, and standards of the Colorado Water Conservation Board.

CHAPTER 4.0 FLOODPLAINS

4.1 Introduction

This chapter provides an overview of the County's Floodplain Rules and Regulations, as described in the Larimer County Floodplain Development Guide. The complete guidance document may be found on the County's website. For additional information, consult the Larimer County Land Use Code (LCLUC), Article 12: *Floodplain*.

4.2 Floodplain Regulations

In order to participate in the National Flood Insurance Program (NFIP), the County has adopted and enforces floodplain rules and regulations for development within regulatory floodplains in the County. The following floodplain regulations apply within the County:

- Article 12 of the Larimer County Land Use Code (www.larimer.org/engineering/floodplains),
- National Flood Insurance Act of 1968,
- 44 Code of Federal Regulations §65.3 (44 CFR §65.3),
- Section 2 Colorado Code of Regulations 408-1 (2 CCR 408-1), and
- Colorado Water Conservation Board (CWCB) Rules and Regulations for Regulatory Floodplains in Colorado.

4.3 Definitions

Common floodplain-related items and terms are defined below. Additional definitions may be found in the LCLUC.

100-Year Flood: A flood event having a 1-percent chance of being equaled or exceeded during any given year. The term does not imply that the flood will necessarily happen only once every 100 years.

500-Year Flood: A flood event having a 0.2-percent chance of being equaled or exceeded during any given year. The term does not imply that the flood will necessarily happen only once every 500 years.

Base Flood Elevation (BFE): The water surface elevation for the flood event associated with a 1% chance of being equaled or exceeded in any given year. Therefore, BFEs represent the 100-year flood water surface elevations.

Certification of No-Rise: Statement by the professional engineer certifying that the proposed development activities in the floodway will not cause an increase in BFE, floodway elevations, or impact the floodway widths.

Conditional Letter of Map Revision (CLOMR): Federal Emergency Management Agency's comment on a proposed project, which does not revise an effective floodplain map, that would, upon construction, affect the hydrologic or hydraulic characteristics of a flooding source and thus result in the modification of the existing regulatory floodplain.

FEMA: Federal Emergency Management Agency, the agency responsible for administering the National Flood Insurance Program.

Flood Fringe: The portions of the Floodplain Overlay District (see Section 4.4) that are within flood zones associated with a 1% annual chance of occurrence but not located in a floodway zone.

Floodplain or Flood-Prone Areas: Any land area susceptible to being inundated as the result of a flood, including the area of land over which floodwater would flow from the spillway of a reservoir. This also includes the inundation pools for reservoirs.

Floodway: Those portions of the Floodplain Overlay District (see Section 4.4) that must be reserved from development or encroachment in order to discharge the 1% Annual Chance Flood Event without cumulatively increasing the water surface elevation more than 0.5 feet (or other height specified by the County or local community), including the channel of a river or other watercourse and any adjacent floodplain areas that must be kept free of development and other encroachments.

Letter of Map Revision (LOMR): An official amendment to the currently effective FEMA map, issued by FEMA, which changes flood zones, delineations, and elevations.

4.4 Floodplain Overlay District

For purposes of regulation, the County has established a zoning district which includes all its regulatory floodplains called the "Floodplain Overlay District," or FPO District.

The FPO District includes the FEMA Floodplain, Best Available Floodplain, Municipal Floodplain, Cache La Poudre Growth Management Area Floodplain, and Larimer County Flood-Prone Areas. Detailed descriptions of, and instructions for viewing, the FPO District boundaries can be found in the County's Floodplain Development Guide. Each floodplain contains several different flood zones, each with different regulations. Refer to the County's Floodplain Development Guide and LCLUC for detailed information regarding each zone.

The FPO District can be viewed using the online floodplain map at:

https://maps1.larimer.org/gvh/?Viewer=LIL&run=Theme&theme=Flood%20Information

If the above link does not work, search the County's floodplain website.

4.5 Floodplain Development Permits

All development within the FPO District is required to obtain a Floodplain Development Permit (FDP). Floodplain development is defined as any manmade change to improved and unimproved real estate, including, but not limited to, buildings or other structures, mining, dredging, filling, grading, paving, excavating or drilling operations.

4.5.1 Exclusions

Please refer to the County's Floodplain Development Guide or LCLUC for details regarding exclusions to the FDP requirement.

4.5.2 Standards

In addition to these Standards, all development within the FPO District must meet requirements as defined in the following documents:

- Larimer County Floodplain Development Guide,
- Larimer County Rural Area Road Standards,
- Larimer County Urban Area Street Standards,
- Larimer County Land Use Code (Article 12.0 *Floodplain*), and
- FEMA Technical Bulletins and Technical Documents (FEMA Guidance).

4.5.3 Permit Process

The process for obtaining an FDP begins with the submittal of an FDP Application and other submittal items needed to evaluate whether floodplain requirements are adequately met by the project. Floodplain development projects are categorized by structural or non-structural projects and may need to be evaluated by the County's Flood Review Board depending on the nature of the project. The process for obtaining an FDP is shown in Figure 4-1.

4.5.4 Submittals

The FDP Application may be accessed on the Larimer County Floodplains website: https://www.larimer.org/engineering/floodplains.

Submittal requirements for an FDP Application may include any/all of the following and may require certification by a licensed professional engineer:

- Construction Plans,
- Hydraulic Study,
- Certificates (No-Rise Certificate, No Adverse Impact Certificate, FEMA Elevation Certificate),
- Floodproofing Design Specifications,
- Repair of Substantial Damage or Substantial Improvement (SI/SD) Submittals,

- Ownership Documentation or Right-of-Access Agreements,
- Federal, State, and Local Permits, and
- Other Requirements.

Permit close-out submittal requirements for an FDP Application may include any/all of the following and may require certification by a licensed professional engineer:

- As-built plans
- Certificates (No-Rise Certificate, No Adverse Impact Certificate, FEMA Elevation Certificate)
- Letter of Compliance

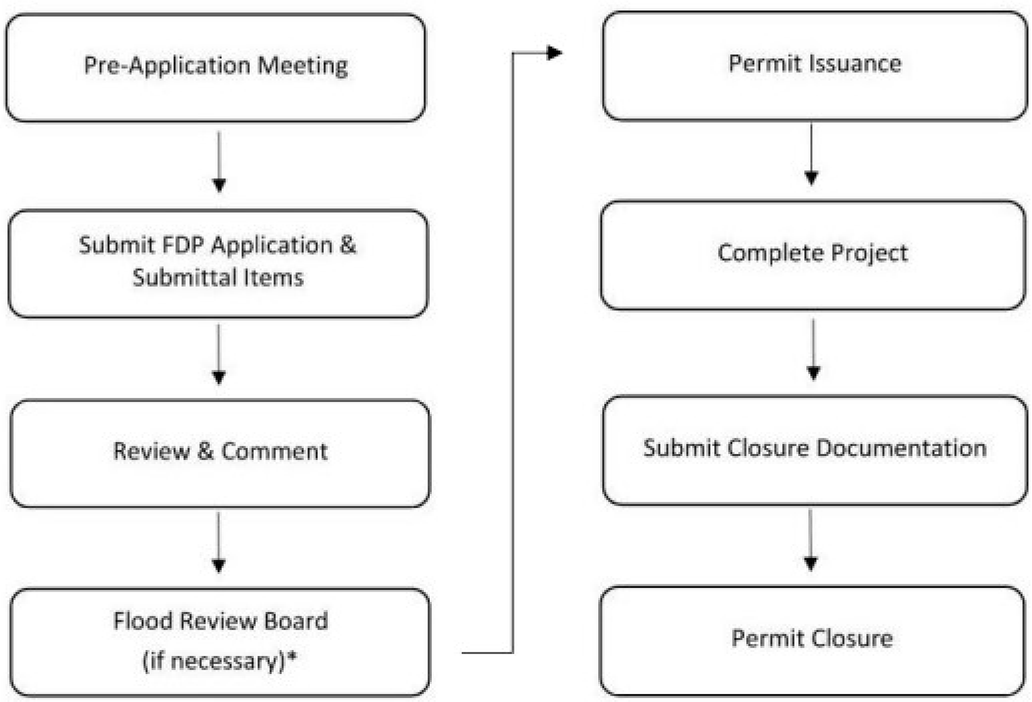

Figure 4-1. Floodplain Development Permit Flowchart (From Larimer County Floodplain Development Guide)

4.5.5 Flood Review Board

Certain floodplain permit applications require review and recommendation by the Larimer County Flood Review Board (FRB). The FRB is appointed by the Board of County Commissioners and makes recommendations to the County Engineer regarding variance requests, interpretation of the LCLUC, map amendment proposals, Floodplain Project Reviews, and provides general guidance regarding floodplain development and other flood related topics.

Projects requiring review by the FRB need to follow the processes outlined in the Floodplain Development Guide.

4.6 Additional Resources

Links to additional resources for understanding floodplains, flood risk, and development regulations may be found in the Larimer County Floodplains website and Floodplain Development Guide.

CHAPTER 5.0 RAINFALL

5.1 Introduction

This chapter provides methods for obtaining rainfall data and generating rainfall design storms to be used for hydrologic runoff analysis within the County.

Rainfall data is based on the *National Oceanic and Atmospheric Administration Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 8* (NOAA, 2013), which is referred hereinto as "NOAA Atlas 14." NOAA Atlas 14 is a precipitation frequency study released in 2013 for Colorado. It leverages over 30 years of additional precipitation data that has been recorded since the previous NOAA Atlas 2 studies were prepared in the 1970s. Approximately 15 rain gages within the County were used for NOAA Atlas 14 analysis, with various periods of record ranging from 1941 through 2011. NOAA Atlas 14 results are also readily available online using an interactive map to retrieve rainfall data at any location. MHFD and many other Colorado communities have adopted NOAA Atlas 14 since it was published.

The County Engineer may allow the use of other rainfall data if required by existing master drainage plans.

5.2 Retrieving Data from NOAA Atlas 14

Rainfall depth and intensity tables and graphs can be retrieved directly from the NOAA Atlas 14 website using the following procedures:

1. Go to the NOAA Atlas 14 website for Colorado. (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=co)
2. Select the project location by entering the latitude and longitude coordinates, address, or by using the point and click function on the interactive map.
3. Select either *Precipitation depth* (for developing design storms) or *Precipitation intensity* (for the intensity-duration-frequency curves) as the *Data type* and specify *Partial duration* as the *Time series type*. A partial duration series-based precipitation frequency estimates table appears below the map with 90% confidence intervals indicated.
4. Download the table of precipitation depth or intensity estimates, with or without 90% confidence intervals, by selecting the *Submit* button below the output table.
5. Use the *Print page* button to generate a report showing the rainfall data and location maps and provide that report with the submittals. An example of point precipitation data for an area near Red Feather Lakes is provided at the end of this chapter.

5.3 Intensity-Duration-Frequency

Rainfall intensity-duration-frequency data are needed for use in the Rational Method. NOAA Atlas 14 provides intensity values for storms of 5, 10, 15, 30, 60, and 120-minute duration (as well as longer) and return periods of 1, 2, 5, 10, 25, 50, 100, 200, 500 and 1000 years. The user should interpolate between these values to obtain intensities for a storm duration falling in between those provided.

5.4 Design Storm Distributions

Design storms to be used with the Colorado Urban Hydrograph Procedure shall be generated according to procedures outlined in the *Rainfall* chapter of the MHFD Manual. The point-rainfall depths shall be obtained from NOAA Atlas 14 according to the procedures above. Note that depth-area-reduction factors may apply for contributing areas greater than 2 square miles. Table 5-1 below shows the 2-hour design storm distribution for 5-minute increments. The Excel-based workbooks CUHP-2000 and MHFD-Detention, both provided by MHFD, will automatically generate hyetographs for multiple return periods based on drainage area and one-hour point rainfall values. These workbooks are discussed in more detail in Chapter 6 *Runoff* and Chapter 14 *Detention* of the Standards.

Table 5-1. from MHFD Manual showing 2-hour design storm distributions based on 1-hour precipitation depths

Time Minutes	Percent of 1 Hour Precipitation Depth (%)				
	2-Year	5-Year	10-Year	25- and 50-Year	100- and 500-Year
5	2.0	2.0	2.0	1.3	1.0
10	4.0	3.7	3.7	3.5	3.0
15	8.4	8.7	8.2	5.0	4.6
20	16.0	15.3	15.0	8.0	8.0
25	25.0	25.0	25.0	15.0	14.0
30	14.0	13.0	12.0	25.0	25.0
35	6.3	5.8	5.6	12.0	14.0
40	5.0	4.4	4.3	8.0	8.0
45	3.0	3.6	3.8	5.0	6.2
50	3.0	3.6	3.2	5.0	5.0
55	3.0	3.0	3.2	3.2	4.0
60	3.0	3.0	3.2	3.2	4.0
65	3.0	3.0	3.2	3.2	4.0
70	2.0	3.0	3.2	2.4	2.0
75	2.0	2.5	3.2	2.4	2.0
80	2.0	2.2	2.5	1.8	1.2
85	2.0	2.2	1.9	1.8	1.2
90	2.0	2.2	1.9	1.4	1.2
95	2.0	2.2	1.9	1.4	1.2
100	2.0	1.5	1.9	1.4	1.2
105	2.0	1.5	1.9	1.4	1.2
110	2.0	1.5	1.9	1.4	1.2
115	1.0	1.5	1.7	1.4	1.2
120	1.0	1.3	1.3	1.4	1.2
Totals	115.7%	115.7%	115.7%	115.6%	115.6%

5.5 Example

Obtain the 5-year rainfall intensity value to use in the Rational Method for a 45-acre watershed in the Red Feather Lakes area. T_c = 17 minutes.

1. Go to the NOAA Atlas 14 website and select the location on the interactive map (Figure 5-1).

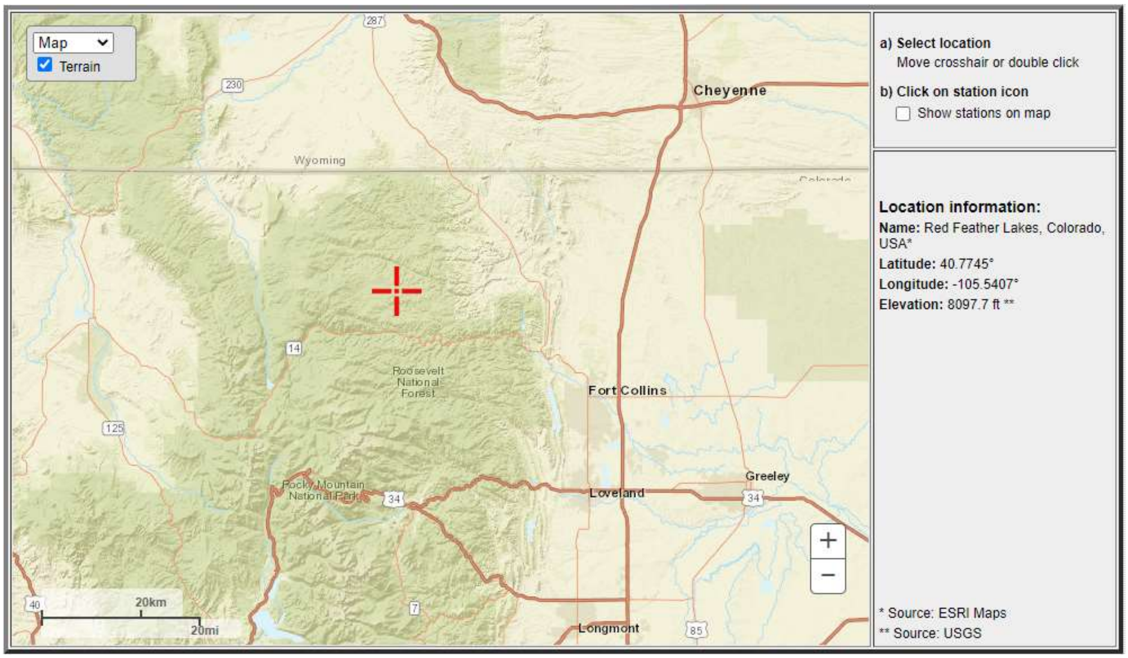

Figure 5-1. Location near Red Feather Lakes selected for point precipitation estimates using NOAA Atlas 14

2. Select Precipitation intensity, English units, and Partial duration time series.
3. Download the table of precipitation frequency estimates (Figure 5-2).
4. Create a graph of intensity-duration-frequency values (Figure 5-3).
5. Interpolate to find 5-year, 17-minute intensity.
    a. Find 5-year, 15-minute intensity and 5-year, 30-minute intensity from precipitation table downloaded from NOAA

Duration (minutes)	5-year Intensity (in/hr)
15	2.51
30	1.62

    b. Use Equation 1 for linear interpolation:

$$y = y_1 + (x - x_1)(y_2 - y_1)/(x_2 - x_1) \qquad (1)$$

Where:

y = 5-year, 17-minute intensity
x = 17 minutes
x_1 = Duration 1
x_2 = Duration 2
y_1 = Intensity 1
y_2 = Intensity 2

c. I = 2.4 in/hr

PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**2.64** (2.03-3.43)	**3.22** (2.47-4.19)	**4.22** (3.23-5.51)	**5.10** (3.89-6.71)	**6.40** (4.75-8.87)	**7.46** (5.41-10.5)	**8.58** (6.02-12.5)	**9.77** (6.60-14.7)	**11.4** (7.44-17.8)	**12.8** (8.08-20.1)
10-min	**1.94** (1.49-2.51)	**2.36** (1.81-3.07)	**3.09** (2.36-4.04)	**3.74** (2.85-4.91)	**4.69** (3.48-6.49)	**5.47** (3.96-7.69)	**6.28** (4.41-9.13)	**7.15** (4.83-10.8)	**8.37** (5.44-13.0)	**9.34** (5.91-14.7)
15-min	**1.57** (1.21-2.05)	**1.92** (1.47-2.50)	**2.51** (1.92-3.28)	**3.04** (2.32-3.99)	**3.81** (2.83-5.28)	**4.44** (3.22-6.26)	**5.11** (3.58-7.42)	**5.82** (3.93-8.74)	**6.80** (4.43-10.6)	**7.59** (4.80-12.0)
30-min	**1.02** (0.782-1.32)	**1.24** (0.950-1.61)	**1.62** (1.24-2.12)	**1.96** (1.49-2.57)	**2.46** (1.83-3.41)	**2.87** (2.08-4.04)	**3.30** (2.32-4.80)	**3.76** (2.54-5.66)	**4.41** (2.87-6.86)	**4.92** (3.11-7.77)
60-min	**0.629** (0.483-0.817)	**0.752** (0.578-0.979)	**0.976** (0.748-1.27)	**1.18** (0.900-1.55)	**1.49** (1.12-2.09)	**1.76** (1.28-2.49)	**2.04** (1.44-2.98)	**2.35** (1.59-3.55)	**2.79** (1.82-4.36)	**3.15** (2.00-4.97)
2-hr	**0.374** (0.290-0.482)	**0.443** (0.344-0.572)	**0.571** (0.441-0.740)	**0.692** (0.532-0.900)	**0.879** (0.665-1.22)	**1.04** (0.766-1.46)	**1.22** (0.867-1.77)	**1.41** (0.966-2.12)	**1.69** (1.12-2.62)	**1.92** (1.23-3.00)
3-hr	**0.278** (0.217-0.357)	**0.324** (0.252-0.416)	**0.413** (0.321-0.532)	**0.500** (0.386-0.647)	**0.638** (0.488-0.887)	**0.761** (0.564-1.07)	**0.896** (0.643-1.30)	**1.05** (0.723-1.57)	**1.27** (0.843-1.96)	**1.45** (0.934-2.25)
6-hr	**0.171** (0.134-0.217)	**0.194** (0.152-0.247)	**0.242** (0.190-0.309)	**0.291** (0.227-0.374)	**0.373** (0.289-0.516)	**0.446** (0.335-0.624)	**0.529** (0.384-0.761)	**0.623** (0.435-0.925)	**0.761** (0.512-1.17)	**0.877** (0.570-1.35)
12-hr	**0.104** (0.083-0.131)	**0.117** (0.093-0.148)	**0.144** (0.114-0.183)	**0.172** (0.135-0.219)	**0.219** (0.171-0.300)	**0.261** (0.198-0.361)	**0.308** (0.226-0.439)	**0.362** (0.255-0.532)	**0.442** (0.300-0.669)	**0.508** (0.334-0.773)
24-hr	**0.062** (0.050-0.078)	**0.071** (0.057-0.089)	**0.088** (0.070-0.110)	**0.105** (0.083-0.132)	**0.132** (0.104-0.178)	**0.156** (0.119-0.213)	**0.183** (0.135-0.257)	**0.213** (0.152-0.309)	**0.257** (0.176-0.385)	**0.294** (0.195-0.442)
2-day	**0.036** (0.029-0.044)	**0.042** (0.034-0.051)	**0.052** (0.042-0.065)	**0.062** (0.050-0.078)	**0.078** (0.062-0.104)	**0.092** (0.071-0.124)	**0.107** (0.080-0.148)	**0.124** (0.089-0.177)	**0.148** (0.102-0.218)	**0.167** (0.112-0.249)
3-day	**0.026** (0.021-0.032)	**0.030** (0.024-0.037)	**0.037** (0.030-0.046)	**0.044** (0.036-0.055)	**0.055** (0.044-0.073)	**0.065** (0.050-0.087)	**0.075** (0.056-0.104)	**0.087** (0.063-0.124)	**0.104** (0.072-0.152)	**0.118** (0.079-0.174)
4-day	**0.021** (0.017-0.025)	**0.024** (0.019-0.029)	**0.029** (0.024-0.036)	**0.035** (0.028-0.043)	**0.043** (0.034-0.057)	**0.050** (0.039-0.067)	**0.058** (0.044-0.080)	**0.067** (0.049-0.095)	**0.080** (0.056-0.117)	**0.091** (0.062-0.133)
7-day	**0.014** (0.011-0.017)	**0.016** (0.013-0.019)	**0.019** (0.016-0.023)	**0.022** (0.018-0.027)	**0.027** (0.022-0.035)	**0.031** (0.025-0.041)	**0.036** (0.027-0.049)	**0.041** (0.030-0.058)	**0.048** (0.034-0.070)	**0.054** (0.037-0.079)
10-day	**0.011** (0.009-0.013)	**0.012** (0.010-0.015)	**0.015** (0.012-0.018)	**0.017** (0.014-0.021)	**0.021** (0.017-0.027)	**0.024** (0.019-0.031)	**0.027** (0.021-0.036)	**0.031** (0.022-0.043)	**0.036** (0.025-0.051)	**0.040** (0.027-0.058)
20-day	**0.007** (0.006-0.009)	**0.008** (0.007-0.010)	**0.010** (0.008-0.012)	**0.011** (0.009-0.013)	**0.013** (0.011-0.017)	**0.015** (0.012-0.019)	**0.016** (0.012-0.022)	**0.018** (0.013-0.025)	**0.020** (0.015-0.029)	**0.022** (0.016-0.032)
30-day	**0.006** (0.005-0.007)	**0.007** (0.005-0.008)	**0.008** (0.006-0.009)	**0.009** (0.007-0.011)	**0.010** (0.008-0.013)	**0.011** (0.009-0.014)	**0.013** (0.010-0.016)	**0.014** (0.010-0.019)	**0.015** (0.011-0.021)	**0.017** (0.012-0.024)
45-day	**0.005** (0.004-0.006)	**0.005** (0.004-0.006)	**0.006** (0.005-0.008)	**0.007** (0.006-0.009)	**0.008** (0.007-0.010)	**0.009** (0.007-0.011)	**0.010** (0.008-0.013)	**0.011** (0.008-0.014)	**0.012** (0.008-0.016)	**0.013** (0.009-0.018)
60-day	**0.004** (0.003-0.005)	**0.005** (0.004-0.005)	**0.005** (0.005-0.006)	**0.006** (0.005-0.007)	**0.007** (0.006-0.009)	**0.008** (0.006-0.010)	**0.008** (0.006-0.011)	**0.009** (0.007-0.012)	**0.010** (0.007-0.014)	**0.010** (0.007-0.015)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format: All | Submit

Figure 5-2. Output table of precipitation intensity estimates including 90% confidence intervals produced for a point near Red Feather Lakes using NOAA Atlas 14

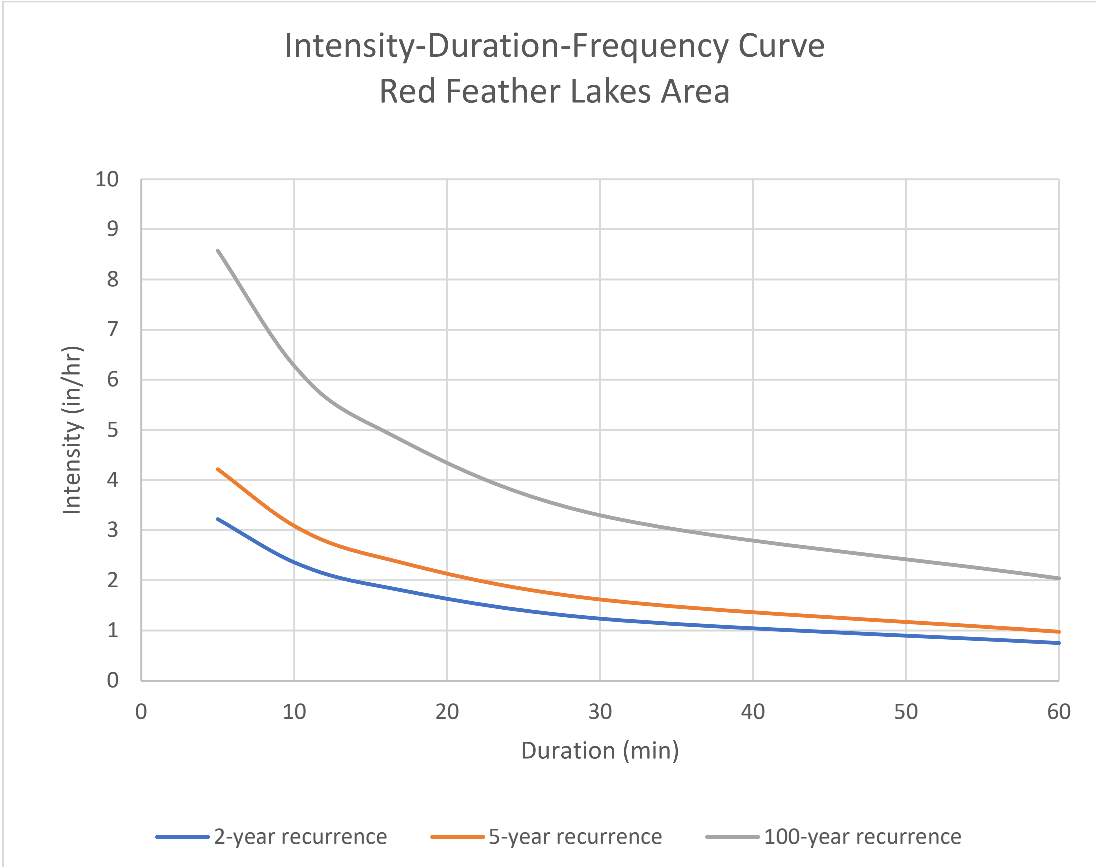

Figure 5-3. Intensity-duration-frequency curve generated from NOAA Atlas 14 data for a point outside Red Feather Lakes

5.6 Submittal Requirements

Drainage reports shall include the following information related to rainfall:

- Map showing NOAA Atlas 14 rainfall location,
- Summary table and/or figures of relevant precipitation values and return intervals, and
- Summary table and/or figures of design storms.

5.7 References

National Oceanic and Atmospheric Administration (NOAA), 2013. NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 8, Version 2.0.

CHAPTER 6.0 RUNOFF

6.1 Introduction

This chapter provides design criteria and procedures to be used for determining runoff peaks and volumes for the design of stormwater drainage infrastructure in the County.

The selection of the appropriate criteria and procedures will be based on the project size, location and/or type. Many small projects can be completed using the Rational Method where only peak discharges are computed. Larger projects with complex routing and those that require detention design will need to use one of the methods that generate runoff hydrographs. The Colorado Urban Hydrograph Procedure (CUHP) and EPA Stormwater Management Model (SWMM) are most applicable for hydrologic modeling in urban areas. The Hydraulic Engineering Center – Hydrologic Modeling System (HEC-HMS) includes other methods that can be applied in both urban and rural watersheds. In some situations, it may be possible to use streamflow measurements or estimates from other sources. Table 6-1 is a summary of the methods discussed in this chapter and general guidelines for when each method can be used. The following sections discuss each method in more detail and provide additional criteria.

Table 6-1. Accepted Hydrologic Runoff Methods in Larimer County

Runoff Calculation Method	Application Criteria
Rational Method	● May be used in simple drainage basins of less than 90 acres. ● Should not be used when routing is required or parameters other than peak flow are warranted.
CUHP	● Urban areas only ● Required for basins greater than 90 acres, may be used for smaller basins ● Should be used in conjunction with SWMM when routing of the hydrograph is required.
SWMM	● Used for routing of runoff hydrographs generated from CUHP or HEC-HMS ● May be used for generating runoff hydrographs in Fort Collins Growth Management Area
HEC-HMS	● May be used for rural areas ● Includes multiple runoff hydrograph methods (including Soil Conservation Service Curve Number) ● Also includes routing methods
Streamflow Statistical Analysis	● Used for bridge/culvert design on streams with existing gages ● At least 30 years of annual maximum peak discharge data required
StreamStats	● Limited application for small, private projects such as culverts/bridges. Must be approved for use by County Engineer.

The percent impervious values that shall be used for different land uses and surfaces are provided in Table 6-2. If an appropriate land use or surface is not provided in Table 6-2, the engineer shall use values from the MHFD Manual or another relevant source (subject to acceptance by the County Engineer).

Table 6-2: Percent imperviousness values to be used in hydrologic modeling

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential Lots (lot area only):	
Single-family	
2.5 acres or larger	12
0.75-2.49 acres	20
0.25-0.74 acres	30
0.24 acres or less	45
Apartments/Multi-Family	75
Industrial:	
Light Areas	80
Heavy Areas	90
Parks, cemeteries:	10
Schools:	55
Railroad yard areas:	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Offsite flow analysis (when land use not defined)	45
Streets/Roadways:	
Paved	100
Recycled Asphalt	100
Gravel (packed)	40
Driveways/Sidewalks:	90
Roofs:	90
Lawns:	2

6.2 Rational Method

The Rational Method may be used to compute peak flows for projects with a contributing area less than 90 acres and which do not have complex drainage systems (e.g., different flow paths for different flow rates). The overall contributing area should be subdivided into smaller subbasins so that hydrologic losses are homogeneous and uniform within each subbasin and to provide adequate resolution for design of drainage infrastructure. The user should read and understand the general applications, limitations and assumptions of the Rational Method as discussed in the *Runoff* chapter of the MHFD Manual.

Application of the Rational Method shall follow the design procedures provided in the *Runoff* chapter of the MHFD Manual. Use of the MHFD's UD-Rational software program is preferred, however, the use of other spreadsheet programs and/or well-organized written calculations are also acceptable.

6.3 Colorado Urban Hydrograph Procedure (CUHP)

The Colorado Urban Hydrograph Procedure (CUHP) is a unit hydrograph method developed for application in urban watersheds along the Front Range of Colorado. It generates a full runoff hydrograph from each subcatchment using design storm rainfall distributions and various watershed parameters. Routing of the subcatchment runoff hydrographs is performed using the EPA Stormwater Management Model (SWMM) discussed in the following section.

CUHP is available from the MHFD as a Microsoft Excel-based program. Application of CUHP, including selection of parameter values, shall follow the procedures provided in the *Runoff* chapter of the MHFD Manual and the CUHP User's Manual.

6.4 EPA Stormwater Management Model (SWMM)

SWMM is a computer program that simulates stormwater runoff and flow routing through urban watersheds. Runoff hydrographs are generated by a non-linear reservoir routing algorithm using design storm rainfall distributions and various watershed parameters. The County prefers that CUHP is used for generating runoff hydrographs for urban watersheds; however, exceptions may be necessary if the project is within the City of Fort Collins Growth Management Area.

SWMM's hydraulic routing features include open channels, storm pipes, culverts, and detention basins. When used in conjunction with CUHP, SWMM imports runoff hydrographs directly from the CUHP/SWMM interface file and applies them to the corresponding SWMM routing node. SWMM models should be run using the kinematic wave routing method. Use of the dynamic wave routing method may be approved by the County Engineer if the applicant can demonstrate the need for doing so. The steady-state routing method is not allowed under any circumstances. The SWMM model can be downloaded from the EPA Stormwater Management Model website.

https://www.epa.gov/water-research/storm-water-management-model-swmm

6.5 Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS)

The HEC-Hydrologic Modeling System (HMS) is a computer program with several different methods for generating runoff hydrographs and routing hydrographs through various conveyance elements. Although the County will accept any of the rainfall-runoff methods included in HEC-HMS, the Soil Conservation Service (SCS) Curve Number Loss Method and SCS Unit Hydrograph Method are commonly used and familiar to most engineers. The appropriate routing method must be selected by the user based on conditions being modeled. It is recommended that the user discuss which methods to use with the County Engineer prior to proceeding with the modeling work.

https://www.hec.usace.army.mil/software/hec-hms/

6.6 Streamflow Statistical Analysis

If a project is located on a gaged stream, it may be appropriate to use the recorded stream flow data to determine peak flow estimates for various return intervals. The period of record for the stream gage should extend at least 30 years if the 100-year return interval is to be estimated. The user is responsible for determining the reasonableness of the gage data considering the location of the project compared to the gage and changes in land use or other watershed characteristics that have occurred over time or are projected to occur. The USGS Guidelines for Determining Flood Flow Frequency Bulletin 17C (USGS, 2019) includes a variety of methods that may be applicable for this type of analysis.

https://pubs.usgs.gov/tm/04/b05/tm4b5.pdf

6.7 StreamStats

StreamStats is an online tool provided by the United States Geological Survey (USGS) to estimate peak flows for various return intervals at a given design point. While relatively easy to use, the estimates provided by StreamStats can have large margins of error that exceed those of more detailed hydrologic analyses. When using StreamStats results, the user should review the reported margin of error and consider applying a safety factor (i.e., increasing the design flow) to provide a level of conservativeness. The County Engineer will generally only approve StreamStats estimates for relatively small, low-risk projects on private property and must be approved by the County Engineer prior to submittal.

https://streamstats.usgs.gov/ss/

6.8 Offsite Flows (Upstream)

Hydrologic analysis is required to quantify upstream, offsite flows that drain through a proposed project area. Offsite flows shall be based on fully developed conditions as defined by existing drainage master plans or other planning documents. If such plans do not exist, then existing conditions may be used. Additionally, the County may require that a drainage easement be acquired for the areas where offsite flows are conveyed. The engineer shall consult with the County Engineer to determine the project-specific requirements of the hydrologic analysis and easement.

6.9 Post-Fire Runoff Considerations

The hydrologic response of watersheds impacted by wildfire can be significantly greater than natural conditions. Burned vegetation and soil result in a reduction of interception/infiltration losses and shorter overland flow paths that ultimately increase runoff volumes and peak flows. Experience in Colorado has shown that a 2-year rainfall event can produce post-fire runoff peaks and volumes exceeding the pre-fire 10/25-year peaks and volumes. These conditions are typically most significant in the first 5 years after a wildfire and can last for over 10 years depending on various factors.

The design engineer should make appropriate considerations for these changes when working on any project in/near recent wildfire-impacted watersheds. For example, various hydrologic modeling parameters may have to be modified from their typical values to appropriately account for the increased hydrologic response. Several publications are available online that provide guidance for post-fire hydrologic modeling, including the Natural Resource Conservation Service (NRCS) publication, *Hydrologic Analyses of Post-Wildfire Conditions, Hydrology Technical Note No. 4* (NRCS, 2016). The design engineer is encouraged to discuss appropriate modeling methods with the County Engineer prior to developing submittals.

6.10 Submittal Requirements

Drainage Reports shall include the following information (at a minimum) to document runoff calculations:

- Discussion of hydrologic method(s) used, including assumptions and references used for parameter selection,
- Plans showing delineation, area and runoff coefficients/imperviousness of subbasins,
- Spreadsheets showing all Rational Method calculations, including references for equations used for different spreadsheet columns and calculations, and
- Print outs of modeling input files and summary tables/figures of model outputs at critical design points.

6.11 References

Natural Resource Conservation Service (NRCS), 2016. Hydrologic Analysis of Post-Wildfire Conditions – Hydrology Technical Note No. 4. August 2016.

United States Geological Survey (USGS), 2019. Guidelines for Determining Flood Flow Frequency – Bulletin 17C, Version 1.1. May 2019.

CHAPTER 7.0 STREETS

7.1 Introduction

This chapter provides criteria for allowable drainage encroachment in streets and roadways in the County and procedures for determining encroachment.

The primary function of streets and roadways is to provide safe traffic movement, therefore stormwater drainage and conveyance in streets must be designed to prevent or minimize interference with that objective. Encroachment criteria are based on the classification of the street/roadway being evaluated and are different for the minor and major events. Minor event criteria are more stringent because those events occur more frequently and would otherwise impede traffic movement more frequently. Similarly, criteria are generally more stringent for higher traffic streets/roadways (e.g., arterials) compared to those with lower traffic (e.g., local roadways). To meet encroachment criteria, the engineer must generally design a storm drain system or open channel system (e.g., roadside swales) along with adequate placement of inlets to convey excess flows off the streets/roadways.

7.2 Street Classifications

Streets shall be classified as Local, Minor Collector, Major Collector, or Arterial depending upon their functionality and Urban or Rural depending on their location. The link below is the County's most recent (2018) functional classification map, however these classifications are updated periodically so it is recommended to check the County's website for the most up-to-date version.

https://www.larimer.gov/sites/default/files/uploads/2018/functional_classification_36x48.pdf

For more detailed information regarding street classifications within the County, please refer to the Larimer County Urban Area Street Standards and Larimer County Rural Area Road Standards.

7.3 Minor and Major Events

Table 7-1 presents the minor and major storm events to be used for encroachment analysis. The minor storms are different for rural and urban streets/roadways.

Table 7-1 Minor and major storm design events for rural and urban streets and roadways

Roadway Location	Minor Storm	Major Storm
Rural	10-year	100-year
Urban	2-year	100-year

7.4 Encroachment and Cross-Street Flow Criteria

Encroachment criteria for the minor storm event (Table 7-2) and major storm event (Table 7-3) are presented below.

Table 7-2 Encroachment criteria for minor storm event

Street Classification	Maximum Depth and Inundation Area
Local	No curb overtopping allowed. Where there is no curb, flows may not encroach beyond the edge of ROW. Flow may spread to crown.
Minor Collector	No curb overtopping allowed. Where there is no curb, flows may not encroach beyond the edge of ROW. One lane must be kept free of water.
Major Collector & Arterial	No curb overtopping allowed. Where there is no curb, flows may not encroach beyond the edge of ROW. One lane must be kept free of water in each direction.

Table 7-3 Encroachment criteria for major storm event

Street Classification	Maximum Depth and Inundation Area
Local	Maximum depth of water is 6" over the crown or 12" at the edge of pavement (whichever is more restrictive). Buildings shall have at least 18" of freeboard*.
Minor Collector	Maximum depth of water is 6" over the crown or 12" at the edge of pavement (whichever is more restrictive). Buildings shall have at least 18" of freeboard*.
Major Collector & Arterial	No inundation over the crown. Maximum depth of water at edge of pavement is 12". Buildings shall have at least 18" of freeboard*.
*Freeboard requirements are based on the water surface elevation in the street/roadway. Where freeboard requirements cannot be met, buildings shall be floodproofed according to the County floodplain regulations.	

Cross-street flow can occur under several conditions; 1) where runoff spreads across the crown of a roadway, 2) where runoff is conveyed across an intersection in a cross-pan and 3) where a roadway is overtopped due to culvert or bridge capacity constraints. Cross-flow depths that are not within a cross-pan must meet the requirements in Table 7-2 and Table 7-3 above. Allowable cross-street flow depths using cross-pans are provided in Table 7-4.

Table 7-4 Allowable cross-street flow depths using cross-pans

Street Classification	Minor Storm Flow	Major Storm Flow
Local & Minor Collector	6” depth in cross-pan	12” depth in cross-pan
Major Collector & Arterial	No cross flow allowed	No cross flow allowed

7.5 Design Procedures

Hydraulic calculations must be completed to determine the capacity of street cross sections and the resulting encroachment. These calculations are often performed in conjunction with inlet calculations and/or roadside swale calculations. The engineer shall perform these calculations according to the procedures outlined in the *Streets, Inlets and Storm Drains* chapter of the MHFD Manual. The MHFD-Inlet design spreadsheet incorporates many of these design procedures and is recommended to be used within the County.

7.6 Submittal Requirements

Drainage Reports shall include the following information (at a minimum) to document street capacity calculations:

- Drawing plans shall identify the classification of all roadways,
- Drawing plans shall include cross-sections showing maximum extents of encroachment, flow depths and water surface elevations, and
- All cross pans shall be labeled on drawing plans.

CHAPTER 8.0 INLETS

8.1 Introduction

This chapter provides the criteria and methodology for design and evaluation of storm drain inlets located in the County. The primary purpose of storm drain inlets is to intercept excess surface runoff and convey it into a storm drainage system, thereby reducing or eliminating surface flooding.

8.2 Inlet Types and Application

Most inlets fall within one of four types: grate, curb-opening, combination, and slotted. Table 8-1 provides a description of the most applicable setting for each type. Inlets are further classified as being on a “continuous grade” or in a “sump.” Roadway geometry often dictates the location of street inlets located along the curb and gutter. In general, inlets are placed at all low points (sumps), along continuous grade curb and gutter, median breaks, intersections, and crosswalks. The spacing of inlets along a continuous grade segment of roadway is governed by the allowable spread of flow and flow depth. See further details of allowable spread of flow in CHAPTER 7.0, Streets.

Inlets on ***continuous grade*** are placed in a section of curb and gutter on a continuous slope such that ponding does not occur when the inlet capacity is exceeded.

Inlets are also placed in ***sump*** conditions. Sump conditions exist wherever ponding occurs, such as at low points.

Table 8-1 Inlet type and application

Inlet Type	Applicable Setting	Advantages	Disadvantages
Grate	Sumps and continuous grades (should be made bicycle safe)	Perform well over wide range of grades	Can become clogged and lose some capacity with increasing grade
Curb-opening	Sumps and continuous grades (but not steep grades)	Do not clog easily	Lose capacity with increasing grade
Combination	Sumps and continuous grades (should be made bicycle safe)	High capacity and do not clog easily	More expensive than grate and curb-openings alone
Slotted	Locations where sheet flow must be intercepted	Intercept flow over wide section	Susceptible to clogging

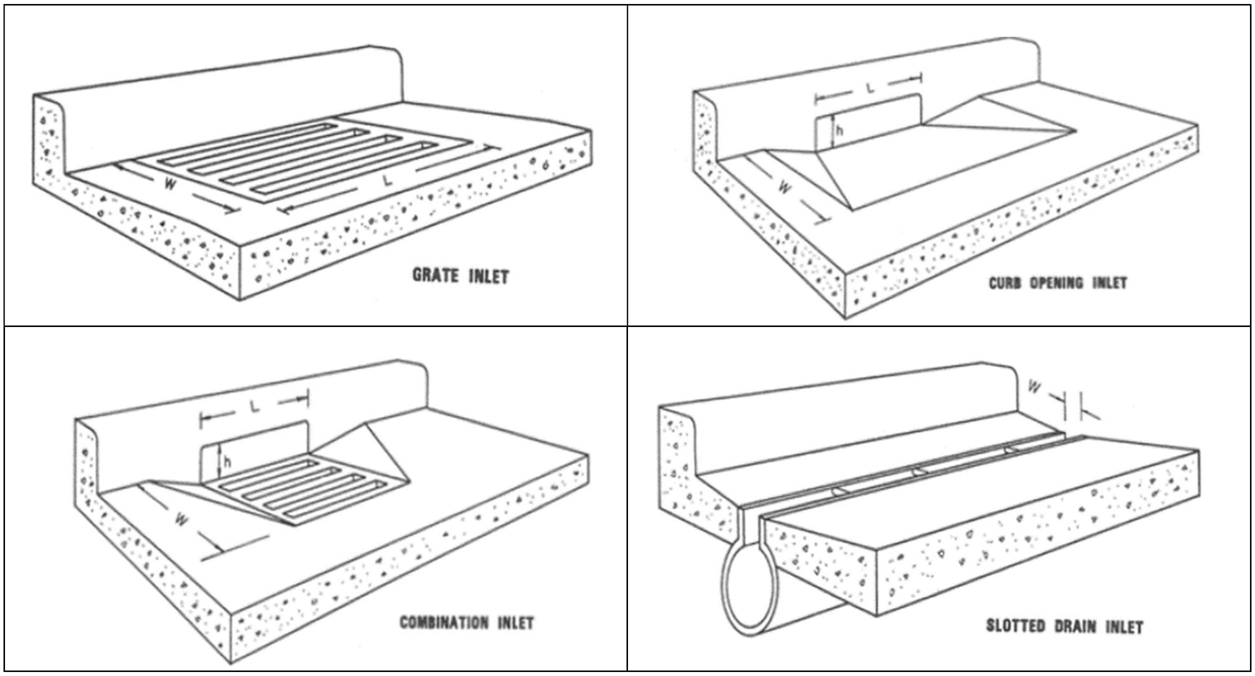

Figure 8-1: Perspective view of different inlet types

8.3 Design Procedures and Considerations

Inlet design includes both determining hydraulic capacity and appropriate inlet placement. The engineer shall follow the inlet design procedures and considerations outlined in the *Inlets* chapter of the MHFD Manual to determine appropriate inlet types, sizes, and locations. The County recommends the UD-Inlet software, downloadable from the MHFD website, be used for all inlet calculations.

8.4 Submittal Requirements

Drainage Reports shall include the following information (at a minimum) to document inlet design and application:

- Spreadsheet tables showing street capacity, runoff and inlet calculations. The use of MHFD-Inlet workbook is preferred, but not required. If the MHFD-Inlet workbook is not used, all equations used to calculations must be documented.
- Plans shall show the locations and type of inlets.
- For sump inlets, plans shall show the emergency overflow path and maximum ponding elevation for the major event, assuming the inlets become clogged.

CHAPTER 9.0 STORM DRAINS

9.1 Introduction

This chapter provides design criteria and procedures for all storm drains within the County public right-of-way or easements. Storm drains provide subsurface conveyance of runoff where surface drainage is not adequate or possible. Storm drains must be sized to carry the portion of runoff that cannot be conveyed on the surface, as dictated by the available capacity in streets and roadside swales during minor and major storm events.

Rural Areas

Storm drains are not preferred in rural areas due to higher construction and maintenance costs compared to open swales. Swales also provide additional benefits such as runoff reduction and pollutant removal. Projects that propose to include storm drains in rural areas should be discussed with the County Engineer prior to development of submittal documents.

Note: culverts are not considered storm drains in this context

9.2 Pipe Sizes and Materials

All storm drains within the County public right-of-way or easements shall be a minimum of 15 inches diameter (or the hydraulic equivalent if other than circular) and reinforced concrete pipe (RCP) of Class 3 or greater.

9.3 Manholes

Manholes are required at all pipe junctions (including laterals servicing inlets), as well as changes in pipe size, alignment, elevation, or slope. A minimum diameter of 4 feet is required for all manholes. Larger diameters may be required for larger pipes, when pipe alignment is not straight, or when multiple pipes share a manhole. Maximum spacing between manholes shall be no more than 400 feet, and the County may require manholes at spacing as close as 200 feet for pipes larger than 24” diameter depending on maintenance requirements and access. The design engineer should consult with the County Engineer on manhole spacing prior to developing submittal documents.

9.4 Storm Drain Outlets

Storm drain outlets shall have a headwall/wingwall or flared end section and appropriate erosion protection such as riprap aprons or low tailwater basins. Refer to the *Hydraulic Structures* chapter of the MHFD Manual for design criteria and considerations.

9.5 Storm Drain Cover

Cover depth and material shall be based on pipe manufacturer recommendations or, when traffic loadings are present, the American Association of State Highway and Transportation Officials (AASHTO) HS-20 loadings, whichever is more stringent. The minimum cover for any storm drain shall be 12 inches above the pipe crown.

9.6 Hydraulic Design

Storm drains shall be designed to convey the minor storm at 80% or less of full pipe capacity (without surcharging). A minimum velocity of 2 ft/sec for the minor storm is required to limit the accumulation of debris and sediment and the maximum velocity in the storm drain shall not exceed 20 ft/sec. The Manning's *n* values used for hydraulic calculations should be 0.013 or per manufacturer's recommendations. The energy grade line (EGL) shall be calculated as part of the hydraulic design and must account for pipe friction losses and pipe form losses. Total hydraulic losses must include friction, expansion, contraction, bend, and junction losses following the methods outlined in the *Streets, Inlets and Storm Drains* chapter of the MHFD Manual. The EGL shall be 6 inches or more below the manhole lid elevation or flowline elevation at the inlet for the major storm event.

Table 9-1. Allowable values for storm drain design parameters

Design Parameter	Allowable Value
Pipe size	Minimum 15 inches diameter (in public ROW or easement)
Pipe material	RCP Class 3 or greater (in public ROW or easement)
Manhole diameter	Minimum 4 feet
Manhole spacing	Maximum 400 feet
Storm drain cover	Minimum 12 inches above pipe crown
Flow depth	≤ 80% of pipe full-flow capacity for minor storm
Velocity	Minimum 2 ft/sec; maximum 20 ft/sec
Manning's *n*	0.013, or manufacturer's recommendation
EGL	≥ 6 inches below manhole lid elevation or flowline elevation at the inlet for major storm event

9.7 Design Procedures

The design of storm drain systems shall be performed in accordance with procedures outlined in the *Streets, Inlets and Storm Drains* chapter of the MHFD Manual. These procedures can be implemented using spreadsheets and/or other software (e.g., StormCAD, AutoDesk SSA, etc.) specifically designed for pipe hydraulic calculations.

The MHFD's UD-Sewer program is no longer supported by MHFD, however the County may still accept UD-Sewer results as long as the program is still operable with a current version of Microsoft Excel.

9.8 Submittal Requirements

Drainage Reports shall include the following information (at a minimum) to document storm drain design:

- Plans shall show location, size and ownership of all storm drains,
- Summary tables including pipe size, pipe capacity, flowrates, velocities, and HGL and EGL elevations,
- Profiles showing ground, HGL and EGL elevations,
- Schematics showing pipe network used in modeling software (if applicable), and
- Print outs of modeling software inputs and outputs.

CHAPTER 10.0 CULVERTS

10.1 Introduction

This chapter provides design criteria and procedures to be used for culverts within the County. Culverts are conduits that provide conveyance of surface water underneath roadways, driveways, and other types of embankments that cross surface water drainageways.

10.2 Design Criteria and Considerations

10.2.1 Additional Requirements, References and Guidelines

In addition to the criteria and considerations outlined in this chapter, culvert design may be dictated by:

- FEMA floodplains: Culverts constructed in a regulatory floodway must demonstrate no rise in water surface elevation, or a Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR) is required.
- Drainage Areas of Interest: Culverts constructed within a Drainage Area of Interest may be required to meet more stringent requirements than other areas in the County. The County's *Bridges and Culverts* guidance document provides additional information regarding regulations for construction of crossings in Larimer County Drainage Areas of Interest. This document may be accessed on the County's website, and all technical requirements shall be met as prescribed therein.
- Master Plans: Culverts must be designed in compliance with any existing Master Plans in effect for the watershed.

No Adverse Impact

These criteria are the minimum requirements for culvert design. *All crossings, public or private, must show no adverse impact on adjacent property for the 100-year storm event.* In some cases, more stringent criteria may be required to achieve this overarching requirement.

10.2.2 Culvert Classification, Design Event, Headwater Depths

Culverts must be sized to convey the discharge from a design event based on the type of crossing that the culvert is serving (

Table 10-1), referred to as the “Culvert Classification.” Figure 10-1 shows different culvert classifications. The headwater depth criteria dictate the maximum ratio of upstream headwater to the vertical dimension of the culvert. The overtopping depth represents the maximum allowable depth measured at the crown of the roadway for the 100-year event. If a crossing does not meet one of the classifications, consult with the County Engineer for appropriate design criteria.

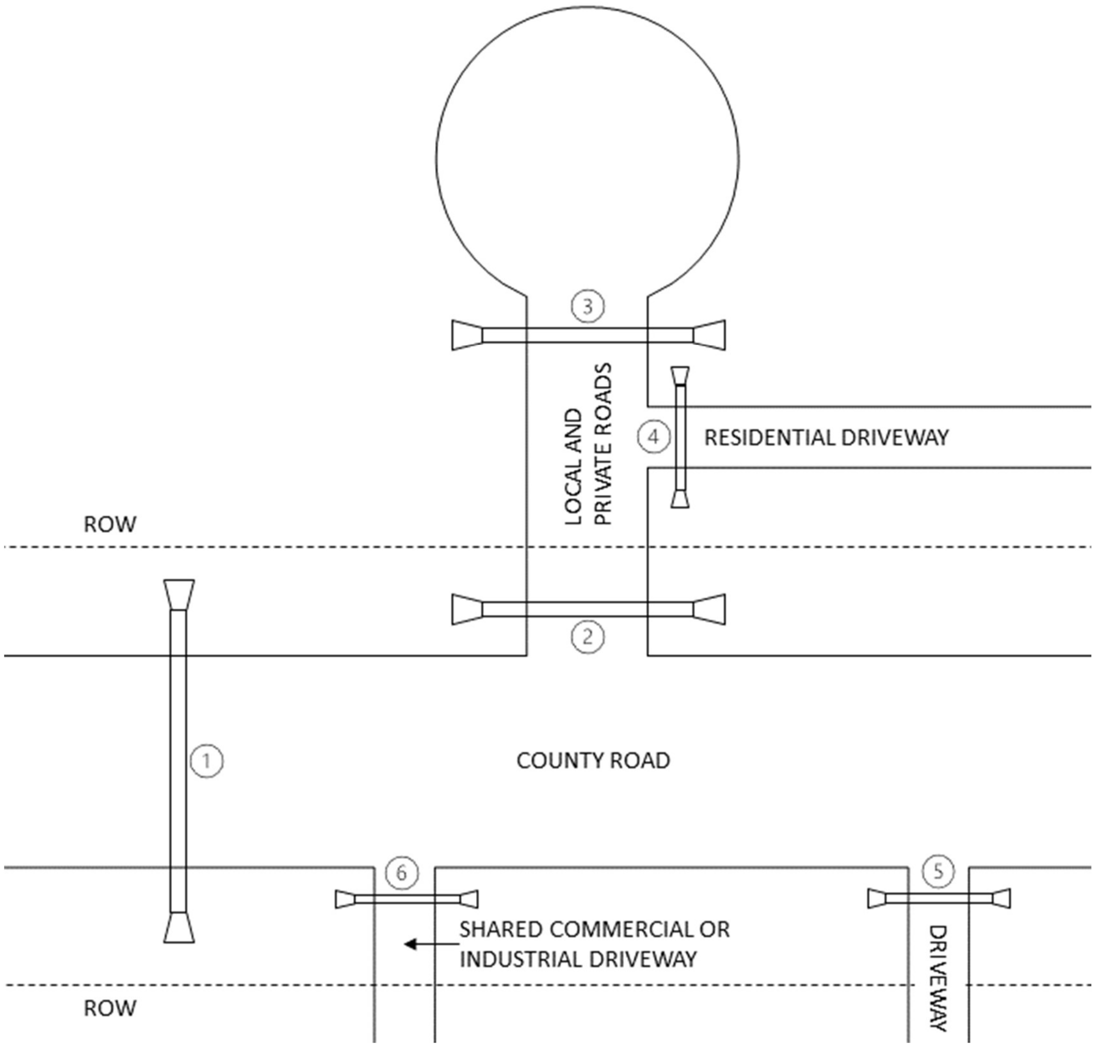

Figure 10-1. Culvert Classification Diagram

*Table 10-1. Design Event, Maximum Headwater Depth and Overtopping Depth Criteria**

Culvert Classification	Road Classification/Description	Minimum Design Event	Headwater to Depth Ratio	Maximum Allowable Overtopping Depth for 100-Year Event
1	Public, Local	10-year	$H_w/D \leq 1.5$	6 inches
1	Public, Minor Collector	25-year	$H_w/D \leq 1.5$	6 inches
1	Public, Major Collector	100-year	$H_w/D \leq 1.5$	Not allowed
1	Public, Arterial	100-year	$H_w/D \leq 1.5$	Not allowed
2	Private, Local (in ROW)	10-year	$H_w/D \leq 1.5$	n/a**
3	Private, Local (not in ROW)	10-year	$H_w/D \leq 1.5$	n/a
4	Private, Driveway (Local, Private Rd Access)	10-year	$H_w/D \leq 1.5$	n/a
5	Private, Driveway (County Rd Access)	10-year	$H_w/D \leq 1.5$	n/a
6	Private, Driveway (Shared Access)	10-year	$H_w/D \leq 1.5$	n/a

*Design criteria are subject to all applicable floodplain regulations, adopted storm drainage master plans and demonstration of no adverse impacts to adjacent property.

**n/a = not applicable

10.2.3 Culvert Size and Material

Table 10-2 presents the minimum size and materials that are allowed based on the culvert classification.

If a non-circular culvert will be used, then the opening area shall be at least equivalent to the opening area of the corresponding minimum diameter circular culvert. Single-walled HDPE pipe and fiberglass end sections are prohibited. CMP should be 16-gauge or heavier and RCP should be Class 3 or above.

Table 10-2. Culvert Size and Material Requirements

Culvert Classification	Road Classification/Description	Minimum Size	Material
1	Public, Local	18”	RCP
1	Public, Minor Collector	18”	RCP
1	Public, Major Collector	18”	RCP
1	Public, Arterial	18”	RCP
2	Private, Local (in ROW)	18”	RCP
3	Private, Local (not in ROW)	18”	RCP, HDPE, CMP
4	Private, Driveway (Local, Private Rd Access)	15”	RCP, HDPE, CMP
5	Private, Driveway (County Rd Access)	15”	RCP, HDPE, CMP
6	Private, Driveway (Shared Access)	15”	RCP, HDPE, CMP

10.2.4 Inlet and Outlet Design

All culverts shall have a flared end section, headwall and/or wingwalls at both the upstream and downstream ends to protect against piping and erosion. Refer to the *Hydraulic Structures* chapter of the MHFD Manual for design guidance for these types of end treatments. Figure 10-2 provides an example end section design for a reinforced concrete circular pipe from the Colorado Department of Transportation. Flared-end sections are generally most appropriate for culverts 36 inches diameter or less.

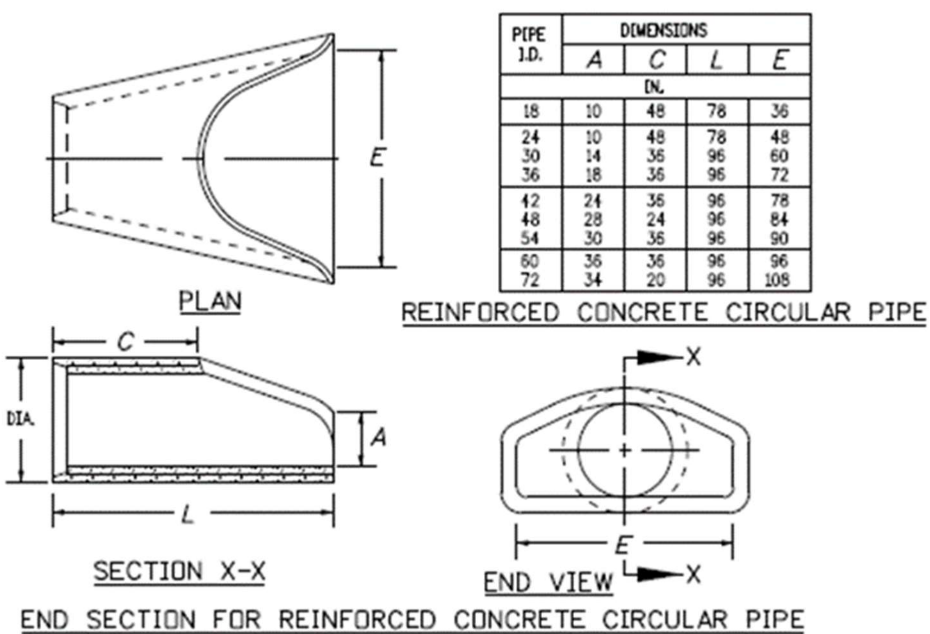

Figure 10-2. Example End Section for Reinforced Concrete Circular Pipe from CDOT Standard Plan No. M-603-10

10.2.5 Cover Depth

The cover depth above the crown of the culvert shall be a minimum of 12 inches for any culvert beneath a public roadway (e.g., Culvert Classification 1). The minimum cover depth for culverts under driveways directly accessing a County roadway shall also be 12 inches, unless otherwise allowed at the discretion of the County Engineer.

10.2.6 Velocity and Outlet Protection

Culverts shall be designed with a minimum velocity of 3 feet per second for the design flow to reduce sediment and debris accumulation. Outlet protection (typically rip-rap aprons) is required when velocities exceed 5 feet per second for the design discharge. For larger culverts a stilling basin may be required. The *Hydraulic Structures* chapter of the MHFD Manual contains design guidance for rip-rap aprons and other erosion protection measures located at culvert outlets.

10.2.7 Debris Control (Post-Fire Areas)

The engineer should consider if a new culvert may be impacted by recent wildfires in the contributing area upstream and take appropriate actions as necessary. These areas will produce higher than usual runoff rates and may also be subject to debris flows that can clog and damage culverts. The “Debris Control Structures Evaluation and Countermeasures” document from the Federal Highway Administration (FHWA, 2005) provides guidance for design of debris control structures.

10.3 Design Procedures

The engineer shall use the design procedures outlined in the *Culverts and Bridges* chapter of the MHFD Manual and/or methods presented in the “Hydraulic Design of Highway Culverts Manual” by the Federal Highway Administration (FHWA, 2012). These documents provide guidance on using capacity charts, nomographs and computer applications. The County encourages the use of either the MHFD-Culverts (formerly UD-Culverts) spreadsheet program or the FHWA HY-8 Culvert Analysis Program for computer applications. The use of other software programs for culvert design and analysis must be approved by the County Engineer.

10.4 Submittal Requirements

Submittal documents will vary based on the method and design procedures used. Capacity chart calculations may use the culvert design form provided in the *Culverts and Bridges* chapter of the MHFD Manual, or similar. All submittals shall include at least the following items:

- Headwater and tailwater depth/elevation,
- Embankment/roadway crown elevation,
- Design discharges,
- Culvert size, shape, and material,

- Inlet/outlet loss coefficients,
- Manning's *n* values,
- Minimum and maximum velocities,
- Printouts of inputs and outputs for all computer applications.

10.5 Permits

Culvert construction may require one or more permits from the County and other organizations. The applicant shall contact the County prior to providing any submittals to determine what permits will be required. Below is a list of some of the permits that may be required for culverts.

- Building Permit – Larimer County,
- Floodplain Development Permit – Larimer County,
- Right-of-Way Work Permit – Larimer County,
- Access Permit – Larimer County,
- Private Road Construction Permit – Larimer County,
- Development Construction Permit – Larimer County,
- Wild & Scenic Rivers – U.S. Forest Service,
- Section 404 Permit – Army Corps of Engineers,
- Native Endangered and Threatened Species – U.S. Fish and Wildlife Service,
- Water Quality Permits related to stormwater management and dewatering – Colorado Department of Public Health & Environment.

10.6 References

Bradley, J.B., Richards, D.L., and Bahner, C.D., 2005, "Debris Control Structures – Evaluation and Countermeasures", Hydraulic Engineering Circular No. 9, Third Edition, FHWA-IF-04-016, Federal Highway Administration, Washington, D.C.

Schall, J.D., Thompson, P.L., Zerges, S.M., Kilgore, R.T., and Morris, J.L., 2012, "Hydraulic Design of Highway Culverts", Hydraulic Design Series No. 5, Third Edition, FHWA-HIF-12-026, Federal Highway Administration, Washington, D.C.

CHAPTER 11.0 BRIDGES

11.1 Introduction

This chapter provides design criteria and procedures to be used for bridges within the County. Bridges provide passage above a surface water drainageway and are designed to minimize disturbance to flow.

11.2 Design Criteria and Considerations

Bridge design is dependent on several factors, including the roadway classification and the debris-potential of the stream. The design storm must pass underneath the low chord of the bridge with a minimum amount of freeboard to accommodate waves, debris, and ice. Most bridge construction results in some constriction of the stream channel, creating localized changes in flow, including the potential for backwater and increased velocity. Whether a stream is in a state of deposition or erosion influences the scour potential under the bridge. The design of any bridge is site specific, and the engineer is strongly encouraged to consult with the County early in the planning process.

These Standards do not provide guidance for structural design of bridges. For structural design, the engineer is directed to the American Association of the State Highway and Transportation Officials (AASHTO) *Standard Specifications for Highway Bridges*, the Colorado Department of Transportation (CDOT) *Bridge Design Manual*, *Larimer County Urban Area Street Standards* (LCUASS) and *Larimer County Rural Area Road Standards* (LCRARS).

11.2.1 Design Events

At a minimum, bridges shall be designed to convey the same minimum design event(s) required for culverts (Table 10-1), based on the road classification/description that the bridge is located on. However, different design events may be required under one or more of the following conditions:

1. Any bridge located in or crossing a FEMA floodplain shall be designed based on the 100-year design event. Bridges constructed in a regulatory floodway must demonstrate no rise in water surface elevation, or a Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR).
2. Bridges constructed within a Drainage Area of Interest may be required to meet more stringent requirements than other areas in the County. The County’s Bridges and Culverts guidance document provides additional information regarding regulations for construction of crossings in Larimer County Drainage Areas of Interest. This document may be accessed on the County’s website, and all technical requirements shall be met as prescribed therein.
3. Any bridge located in an adopted storm drainage basin master plan shall be designed based on design events/discharges defined in the plan.

11.2.2 Freeboard

Any bridge that must be designed to fully pass (without overtopping) the 100-year design event shall also provide freeboard between the low chord of the bridge and the energy grade line (EGL) according to the following:

1. If the 100-year design flow is less than 1,000 cfs, the freeboard shall be at least 1 foot
2. If the 100-year design flow is equal to or greater than 1,000 cfs, the freeboard shall be at least 2 feet.

11.2.3 Debris Control (Post-Fire Areas)

The engineer should consider if a new bridge may be impacted by recent wildfires in the contributing area upstream and take appropriate actions as necessary. These areas will produce higher than usual runoff rates and may also be subject to debris flows that can damage bridges. The *Debris Control Structures: Evaluation and Countermeasures* publication from the Federal Highway Administration (FHWA, 2005) provides guidance for design of debris control structures.

11.3 Design Procedures

11.3.1 Hydraulic Analysis

Guidance for performing hydraulic analysis can be found in the *Culverts and Bridges* chapter of the MHFD Manual. Additional references for bridge hydraulics include:

- Federal Highway Administration*, Hydraulic Design of Safe Bridges*, Hydraulic Design Series No. 7 (HDS-7), 2012.
- Federal Highway Administration, *River Engineering for Highway Encroachments – Highways in the River Environment*, Hydraulic Design Series No. 6 (FHWA HDS-6), December 2001.
- American Association of State Highway and Transportation Officials (AASHTO), Highway Drainage Guidelines, 2007. Chapter 7: Hydraulic Analysis for the Location and Design of Bridges.
- Arizona Department of Water Resources. Design Manual for Engineering Analysis of Fluvial Systems. March 1985.

11.3.2 Scour Analysis

Scour analysis shall be performed for all bridges to demonstrate the integrity of the structure will withstand flows in excess of the design event. All scour analysis shall be performed without the presence of riprap. Table 11-1 provides guidance for design flood frequencies to be used in scour analysis.

The following publications should be consulted for additional guidance for evaluating bridge scour and implementing countermeasures:

- Federal Highway Administration, *Evaluating Scour at Bridges*, Hydraulic Engineering Circular No. 18 (HEC-18), Fifth Edition, 2012.
- Federal Highway Administration, *Stream Stability at Highway Structures*, Hydraulic Engineering Circular No. 20 (HEC-20), Fourth Edition, 2012.
- Federal Highway Administration, *Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance*, Hydraulic Engineering Circular No. 23 (HEC-23), Third Edition, 2009. Volumes 1 and 2.
- Colorado Department of Transportation, *Drainage Design Manual: Chapter 10 Bridges*, 2019.

Table 11-1. Hydraulic Design, Scour Design, and Scour Design Check Flood Frequencies (modified from HEC-18)

Hydraulic Design Flood Frequency, Q_D	Scour Design Flood Frequency, Q_S	Scour Design Check Flood Frequency, Q_C
Q_{10}	Q_{25}	Q_{50}
Q_{25}	Q_{50}	Q_{100}
Q_{50}	Q_{100}	Q_{500}
Q_{100}	Q_{500}	Q_{500}

11.4 Submittal Requirements

Submittal documents will vary based on the method and design procedures used. All submittals must include at least the following items:

- Design discharge,
- Backwater calculations,
- Elevation of low chord of bridge,
- Freeboard,
- Hydraulic analysis,
- Scour analysis (include contraction scour and local scour of piers and abutments), and
- Printouts of inputs and outputs for all computer applications.

11.5 Permits

Bridge construction may require one or more permits from the County and other organizations. The applicant shall contact the County prior to providing any submittals to determine what permits will be required. Below is a list of some of the permits that may be required for bridges.

- Building Permit – Larimer County,
- Floodplain Development Permit – Larimer County,
- Right-of-Way Work Permit – Larimer County,
- Access Permit – Larimer County,
- Private Road Construction Permit – Larimer County,

- Development Construction Permit – Larimer County,
- Land Disturbance Permit – Larimer County,
- Water Quality Permits related to stormwater management and dewatering – Colorado Department of Public Health and Environment
- Section 404 Permit – Army Corps of Engineers

11.6 References

Colorado Department of Transportation (CDOT), *Drainage Design Manual*, 2019.

Federal Highway Administration, *Debris Control Structures: Evaluation and Countermeasures*, Hydraulic Engineering Circular No. 9, (HEC-9), October 2005.

CHAPTER 12.0 OPEN CHANNELS

12.1 Introduction

This chapter includes criteria and procedures for the design of open channels in the County. In the Standards, open channels are classified as swales, roadside ditches, or naturalized channels. Swales can be used to convey onsite runoff to a design discharge point, typically a water quality/storage facility or a major drainageway. Swales can also be used to route offsite runoff around a site. In general, swales are sufficient for conveying discharges from contributing areas less than 130 acres. Roadside ditches are primarily intended to convey roadway runoff to a major drainageway. Naturalized channels are generally considered to be major drainageways designed to convey larger flows with a more defined baseflow/low-flow channel and floodplains.

12.2 Design Criteria and Considerations – Swales

12.2.1 Type

Swales can either be grass or riprap-lined, depending on conditions. Grass swales are preferred wherever conditions allow because they provide greater infiltration and filtration benefits and less maintenance requirements compared to riprap-lined swales.

12.2.2 Design Event and Freeboard

All swales shall be designed to convey the 100-year peak discharge. A minimum of 18” of freeboard must be provided above the 100-year water surface elevation to the top of the bank or adjacent property lines (whichever is more restrictive).

12.2.3 Cross-Section

A trapezoidal cross section is recommended for swales as it is the most efficient shape for conveyance and minimizes erosional forces. The bottom width should be at least 2 feet wide and side slopes should be 5:1 (H:V) or flatter for grass swales and 2.5:1 (H:V) or flatter for riprap-lined channels. If these criteria are followed, the swale capacity charts provided in Figure 12-1, Figure 12-2Figure 12-3Figure 12-4 may be used for determining the type of swale for each application.

12.2.4 Hydraulic Design Requirements

12.2.4.1 Grass Swales

Grass swales shall be designed according to the criteria provided in Table 12-1 to maintain stability and reduce erosion potential. In addition, proper soil preparation and revegetation shall adhere to the criteria and guidelines provided in the *Revegetation* chapter of the Standards.

Table 12-1. Hydraulic design criteria for vegetated (grass) swales

Parameter	Erosive Soils	Erosion Resistant Soils
Maximum Velocity (2-year)	3.5 ft/sec	5.0 ft/sec
Maximum Velocity (100-year)	5.0 ft/sec	7.0 ft/sec
Maximum Froude Number (2-year)	0.5	0.7
Maximum Froude Number (100-year)	0.6	0.8

In some circumstances, grade control structures and/or riprap lined swales may be necessary. Refer to the *Hydraulic Structures* chapter of the Standards for design criteria on grade control structures.

12.2.4.2 Riprap-Lined Swales

Riprap-lined swales may use either soil riprap or void-filled riprap designs. Soil riprap is conducive to vegetation growth as the riprap voids are filled with topsoil. Void-filled riprap uses a well-graded mix of cobbles, gravels, sands, and soil to emulate a more natural streambed-like channel.

Design of riprap-lined swales requires determination of proper riprap size. Figure 12-1 through Figure 12-4 are swale stability charts showing the type of riprap to be used for various configurations of swale flowrate, longitudinal slope, bottom width, flow depth and side slope. Additional discussion on the development and application of the stability charts are available in the *Open Channels* chapter of the MHFD Manual.

If those conditions do not apply, the engineer may use alternative sizing methods. One method for riprap-lined swales with longitudinal slopes generally 2% or less is Equation 12-1 below (Hughes et al, 1983):

Equation 12-1

$$d_{50} \geq \left[\frac{VS^{0.17}}{4.5(G_s - 1)^{0.66}}\right]^2$$

Where:

V = mean channel velocity (ft/sec)
S = longitudinal channel slope (ft/ft)
d_{50} = mean rock size (ft)
G_s = specific gravity of rock (minimum = 2.50, typically 2.5 to 2.7)

Several methods for sizing riprap on steep slope conditions are suggested and discussed in the *Open Channels* chapter (see Rocks and Boulders section) in the MHFD Manual. Construction notes and specifications for riprap projects are available in the Rock and Boulders section as well as the MHFD website Resource Library. https://mhfd.org/resources/specifications/

12.2.5 Common Area Lots, Outlots and Easements

The County requires all swales to be placed in common area lots, outlots or easements. See related policy statement in CHAPTER 3.0.

12.3 Roadside Ditches

Roadside ditches shall follow the design criteria set forth for swales, with the following exceptions:

1. The ditch capacity shall be dictated by the allowable encroachment criteria set forth in the *Streets* chapter of the Standards.
2. Alternative cross-sections (besides trapezoidal) may be used where necessary to meet available space or other constraints.
3. Drainage easements are not required if the 100-year water surface elevation is fully contained within the right-of-way.

12.4 Naturalized Channels

Major drainageways, defined as drainageways receiving runoff from contributing areas greater than 130 acres, shall be designed according to the naturalized channels criteria and guidelines set forth in the *Open Channels* chapter of the MHFD Manual and the County's floodplain regulations.

12.5 Hydraulic Analysis

All open channel designs shall be supported by a proper hydraulic analysis. In most cases, swale and roadside ditch design can be performed using Manning's Equation for uniform flow conditions. Multiple engineering design software packages such as FlowMaster, Autodesk SSA, HEC-15 and EPA SWMM support application of this method. HEC-RAS may be required for more detailed analysis, particularly for naturalized channels where bridges, culverts and other crossings can significantly affect hydraulics and where flood extents may need to be mapped.

12.5.1 Manning's Equation

Manning's Equation for uniform flow conditions is generally sufficient for swale and roadside design. The County Engineer will accept results from common engineering software packages that implement Manning's Equation.

Equation 12-2

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Where:

Q = discharge (cfs)
n = Manning's roughness coefficient (see Roughness Coefficient sections below)
A = cross sectional area (ft^2)
R = hydraulic radius (ft/ft)
S = friction slope (ft/ft) (approximated by channel invert slope for normal depth calculation)
The channel velocity (ft/s) can be computed as V = Q/A.

The Froude number can be computed as follows:

Equation 12-3

$$Fr = \frac{V}{\sqrt{gD_h}}$$

Where:

Fr = Froude number (dimensionless)
g = gravitational acceleration (32.2 ft/s^2)
T = top width of flow area (ft)
D_h = hydraulic depth = A/T (ft)

12.5.2 Hydraulic Modeling

A more detailed analysis using software with one- or two-dimensional modeling capability will likely be required by the County for hydraulic analysis of naturalized channel projects. HEC-RAS remains a widely used and accessible program, and the engineer is encouraged to review the HEC-RAS modeling guidelines provided in the *Open Channels* chapter of the MHFD Manual as well as the HEC-RAS Hydraulic Reference Manual provided by the US Army Corps of Engineers. The County also has published guidelines for hydraulic analysis in its Floodplain Development Guide to support applications for floodplain permits. Other software, such as the U.S. Bureau of Reclamation's Sedimentation and River Hydraulics—Two-Dimension (SRH-2D) model, may be used with the County Engineer's approval.

12.5.3 Roughness Coefficients

Roughness coefficients are integral to open channel flow calculations and must be selected appropriately.

Table 12-2 provides typical roughness coefficients for various conditions. The engineer is responsible for field-verifying the conditions prior to use of the values in calculations.

Table 12-2: Typical roughness coefficients (based on Table 8-5 in MHFD Manual)

Location and Cover	For Velocity, Froude No., and Shear Stress Calculations	For Water Surface Elevation and Depth Calculations
Main Channel (bankfull channel)		
Sand or clay bed	0.03	0.04
Gravel or cobble bed	0.035	0.07
Vegetated Overbanks		
Turfgrass Sod	0.03	0.04
Native Grasses	0.032	0.05
Herbaceous wetlands (few or no willows)	0.06	0.12
Willow stands, woody shrubs	0.07	0.16

Roughness coefficients for void-filled or soil riprap-lined channels may be estimated using the equation below.

Equation 12-4

$$n = 0.0395 d_{50}^{1/6}$$

12.6 Submittal Requirements

Drainage Reports shall include the following information (at a minimum) to document swale design:

- Plans shall show location, type and ownership of all swales,
- Plans shall include cross-sections showing bottom width, top width, side-slope, maximum water surface elevation and freeboard,
- Summary tables showing swale discharges, velocities and Froude numbers,
- Documentation of all equations, parameter values and calculations,
- Schematics showing pipe network used in modeling software (if applicable), and
- Print outs of modeling software inputs and outputs.

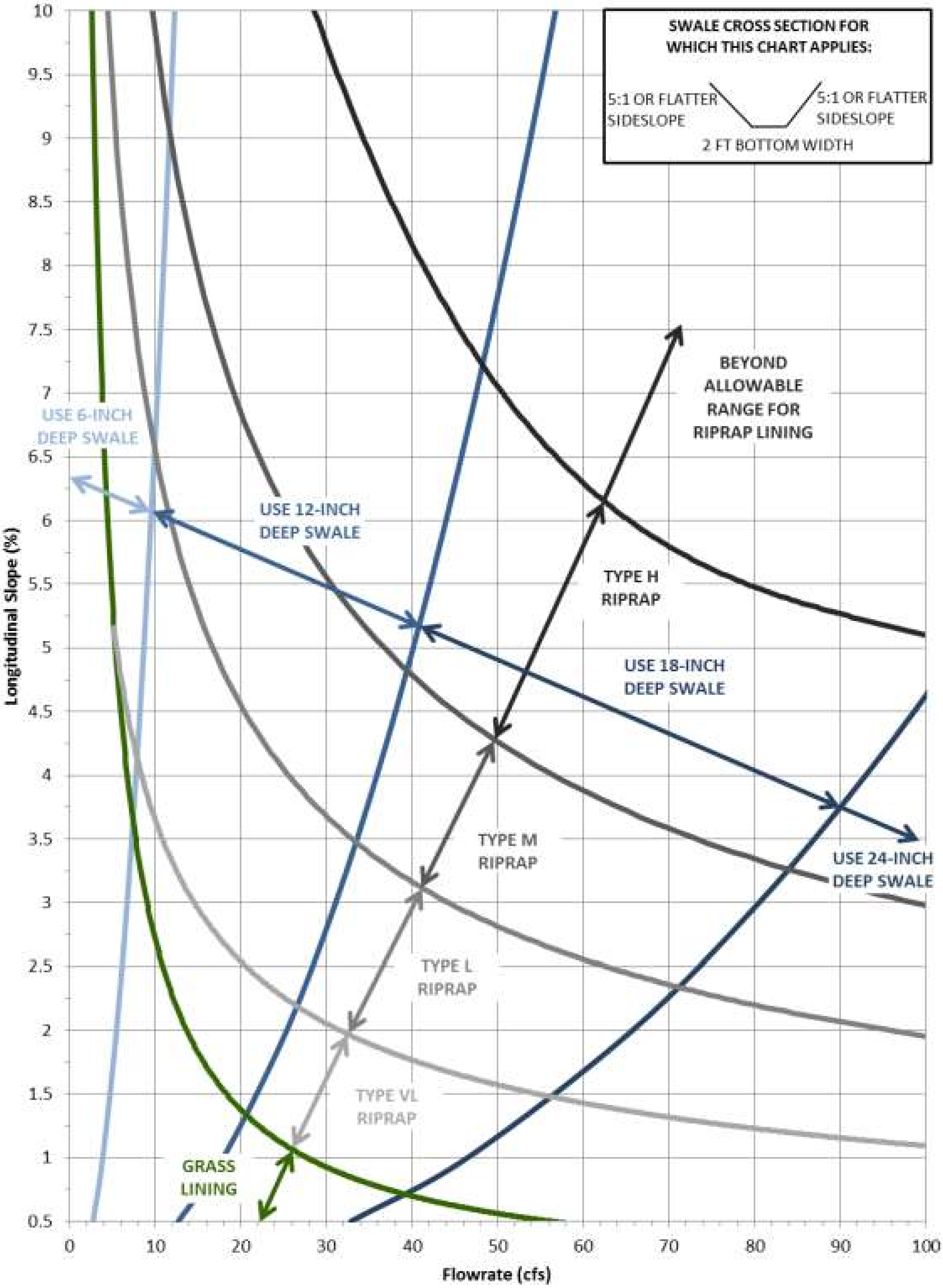

Figure 12-1. Swale stability chart: 2- to 4-foot bottom width and side slopes between 5:1 and 10:1 (Note: Riprap classifications refer to gradation for riprap used in soil riprap or void-filled riprap.) (Source: Muller Engineering Company from MHFD, USDCM Volume 1, Chapter 8)

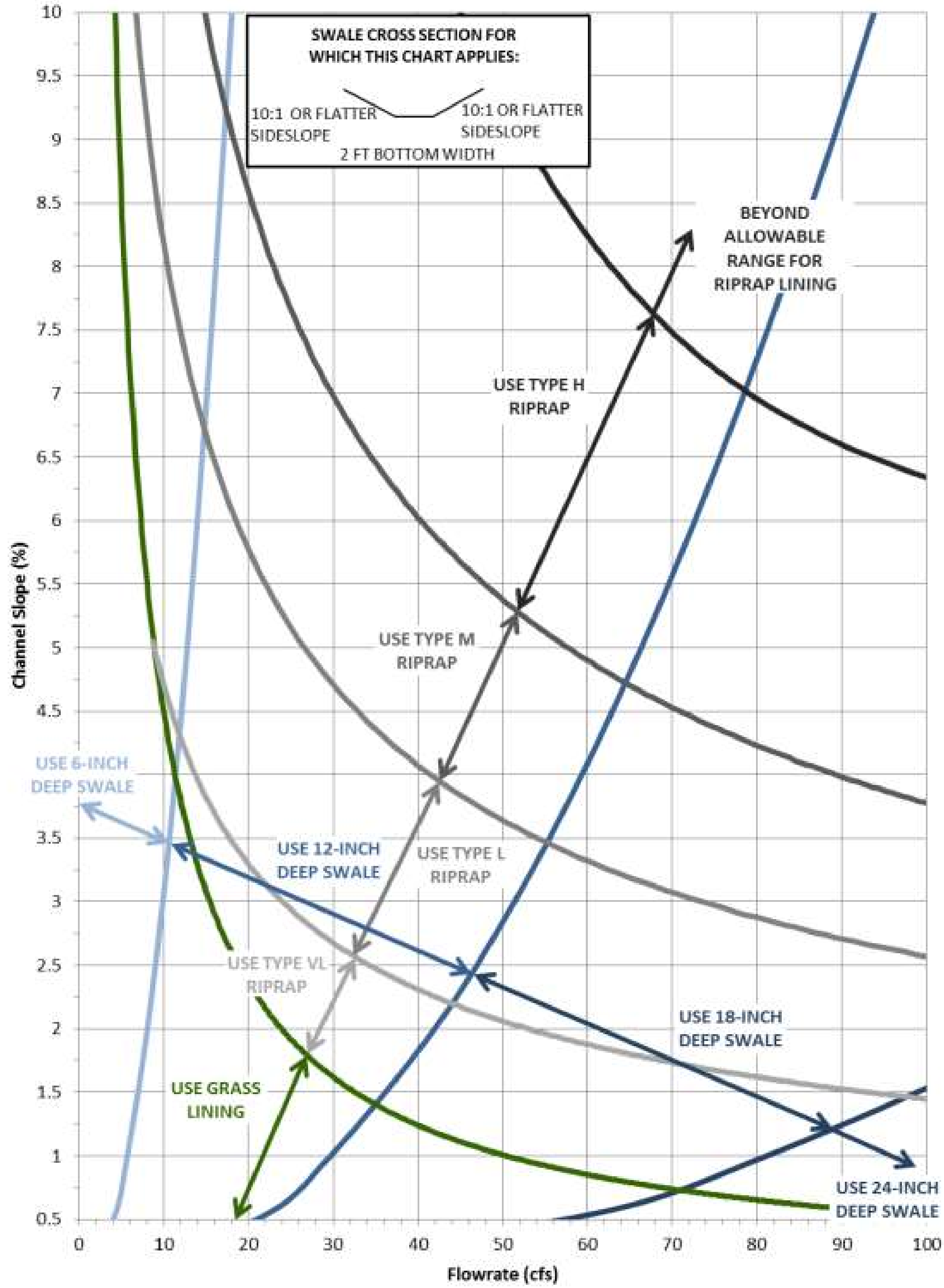

Figure 12-2. Swale stability chart: 2- to 4-foot bottom width and 10:1 (or flatter) side slopes (Note: Riprap classifications refer to gradation for riprap used in soil riprap or void-filled riprap.) (Source: Muller Engineering Company from MHFD, USDCM Volume 1, Chapter 8)

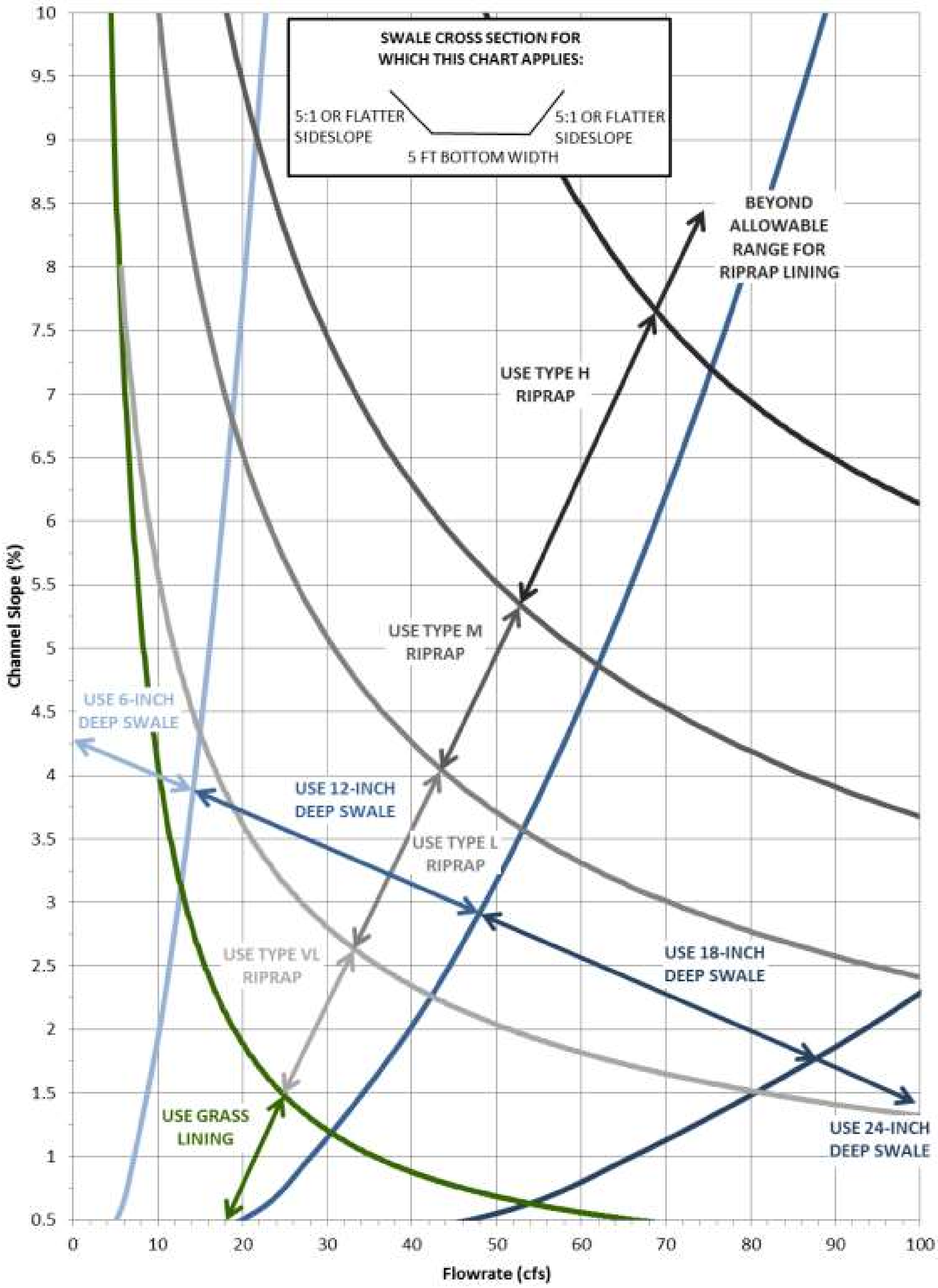

Figure 12-3. Swale stability chart: greater than 4-foot bottom width and side slopes between 5:1 and 10:1 (Note: Riprap classifications refer to gradation for riprap used in soil riprap or void-filled riprap.) (Source: Muller Engineering Company from MHFD, USDCM Volume 1, Chapter 8)

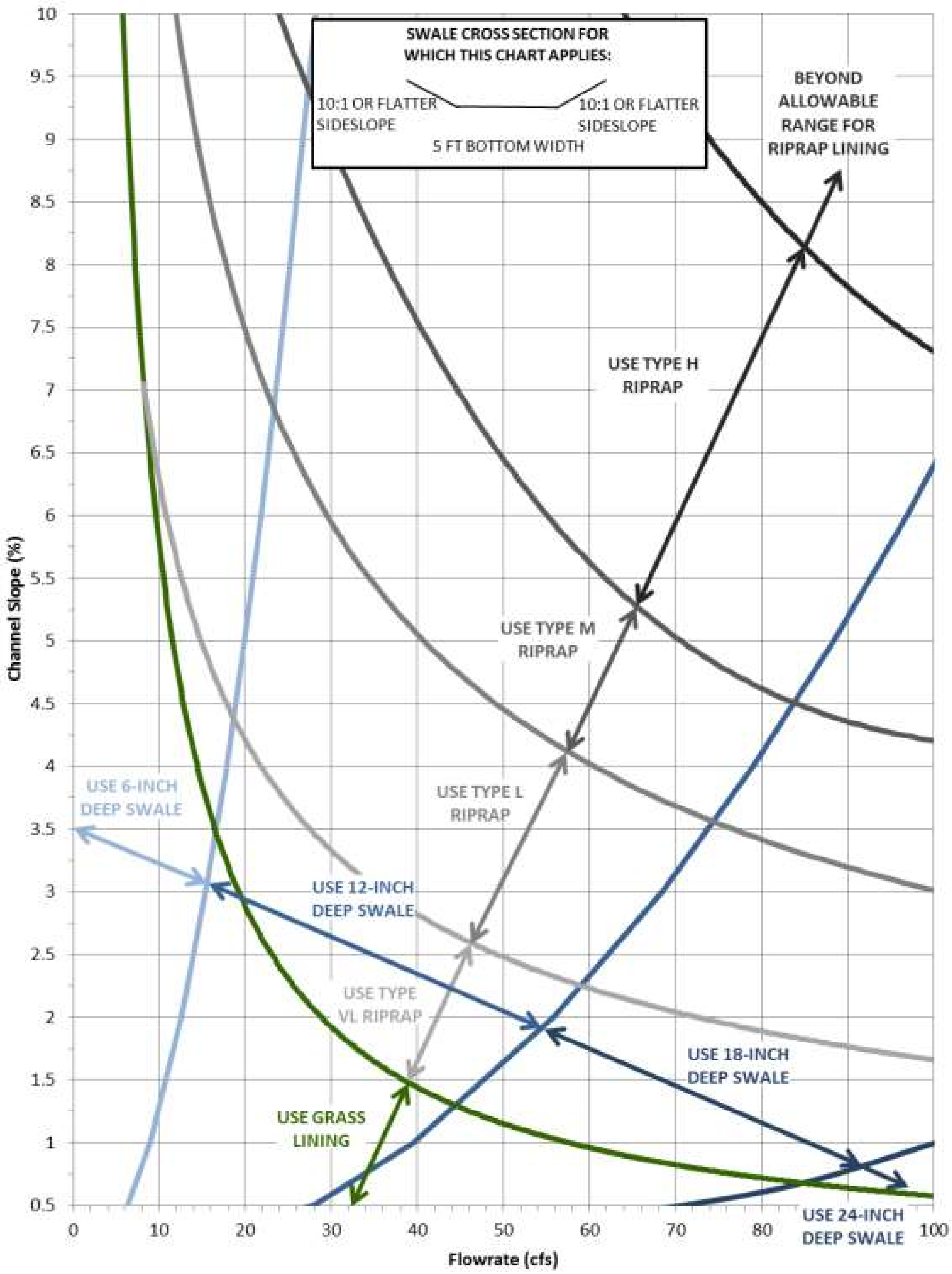

Figure 12-4. Swale stability chart: greater than 4-foot bottom width and 10:1 (or flatter) side slopes (Note: Riprap classifications refer to gradation for riprap used in soil riprap or void-filled riprap.) (Source: Muller Engineering Company from MHFD, USDCM Volume 1, Chapter 8)

CHAPTER 13.0 HYDRAULIC STRUCTURES

13.1 Introduction

Hydraulic structures include both grade control structures and pipe/culvert outfalls and rundowns. Grade control structures are used in open channels to reduce velocities and erosion potential. Outfalls and rundowns convey runoff from pipes and culverts into streams and open channels. The design criteria and considerations for hydraulic structures used in the County shall follow those provided in the *Hydraulic Structures* chapter of the MHFD Manual.

13.2 Supplemental Guidance

This section provides brief summaries of the circumstances that may require hydraulic structures and what hydraulic structures/design criteria may be required. This information is only intended to guide the engineer towards applicable design criteria and considerations and shall not be considered formal guidance from the County.

13.2.1 Grade Control Structures

Grade control structures are used in open channels to reduce velocities and erosion potential, for example, when grass swale velocities exceed those listed in Table 12-1. Grade control structures include the basic categories of grouted stepped boulder (GSB), sculpted concrete (SC) and vertical. The MHFD Manual includes a “simplified” design procedure and a “detailed” design procedure. In most cases, the design of grass swale and roadside ditch grade control structures can be performed using the “simplified” design approach with GSB or SC. Grade control structures in major drainageways will require a site-specific evaluation.

In all cases, GSB and SC are the preferred types of grade control structures. Vertical structures should only be considered where drop heights are lower than 2 feet and the use of GSB or SC is not practical.

13.2.2 Outfalls and Rundowns

All storm drain and culvert outlets are required to have proper end treatments and erosion control/energy dissipation structures. End treatments include flared-end sections or headwalls and wingwalls. Flared-end sections are generally most appropriate for pipes and culverts 36 inches diameter or less and may require a toe wall to prevent undercutting.

Table 13-1 includes several types of erosion control and energy dissipation structures and the conditions that typically warrant their application.

Table 13-1. Erosion control and energy dissipation structure types

Type	Typical application and considerations
Riprap Apron	• Conduit velocity < 15 ft/s • Discharge parallel to channel flow
Low Tailwater Basin	• Conduit velocity < 15 ft/s • Discharge perpendicular to channel flow • Low tailwater conditions (i.e., Tw < 1/3 conduit height)
Grouted Boulder "Rundown"	• Discharge into large streams/rivers, wetland channels • Outlet invert > 2 feet above tailwater elevation
Impact Basin (concrete)	• Conduit velocity > 15 ft/s • Low tailwater conditions

13.2.3 Rundowns

Rundowns convey channelized runoff from a pipe or paved area down a slope to an open channel or detention facility. Rundowns are strongly discouraged due to their high failure rate and maintenance requirements. Alternative options that should be evaluated include lowering the pipe invert or using level spreaders (from paved areas). If a rundown is required, grouted boulders are preferred over rip-rap or soil rip-rap.

13.3 Submittal Requirements

Submittal requirements for hydraulic structures will vary depending on the type and application and will generally include at the least the following:

- Discharge rates
- Flow velocities
- Hydraulic/erosion/energy dissipation calculations
- Explanation for selecting type of hydraulic structure

CHAPTER 14.0 DETENTION (STORAGE)

14.1 Introduction

This chapter provides design criteria and procedures to be used for detention facilities within the County. Detention facilities are designed to attenuate the increased runoff rates that occur as a result of development, namely those that increase the amount of impervious surface.

While this chapter focuses primarily on detention required to control downstream flooding and stream erosion, the engineer should understand that some Projects will also require water quality control to be provided. If both water quality and detention are required, it is often beneficial to consider facilities that can provide both. CHAPTER 15.0 addresses water quality controls and should be reviewed prior to developing detention plans and designs.

The engineer should also understand that incorporated communities within the County may have other detention requirements, some of which may be based on master planning efforts that extend into the community’s growth management area (GMA). In general, a Project that is located within a GMA will be subject to that community’s detention requirements. The County Engineer should be consulted to determine the appropriate detention requirements.

Finally, the engineer should refer to the *Storage* chapter of the MHFD Manual for any design criteria, considerations and guidance not specifically addressed in this chapter.

14.2 Threshold for Requiring Detention

The County will require detention for any Project that increases runoff to the extent that downstream properties and/or infrastructure could reasonably be perceived to experience adverse impacts (e.g., increased flooding, increased erosion, decreased level of service) as a direct result of the increased runoff from the development. This criterium is intended to protect public health, safety and the environment while also providing flexibility for requiring detention only where it is necessary to achieve those objectives.

The County will generally require detention for Projects with any of the following characteristics:

- Any Project with a disturbance of 1 acre or greater,
- Any Project that results in 5,000 square feet or more of new impervious surface, or
- Any Project that increases the imperviousness by 10% or greater compared to pre-development[1] conditions.
- Any Project where existing master plans require detention

[1] “Pre-development” in this case is considered to be the conditions of the site/property prior to the planned development. For example, if the existing conditions have 25% impervious surface, detention may only be required if the development increases the impervious surface to 35% or more.

The County may provide exemptions from detention requirements for Projects with the following characteristics:

- Additions to an existing structure on a residential lot,
- Development of a single parcel where total imperviousness is less than 25%,
- Single-lot residential development that is not part of a common plan of development, or
- Other situations that the County Engineer deems to be low risk for adverse downstream impacts.

If detention requirements are waived, the County may still require post-construction water quality and/or runoff reduction practices (see CHAPTER 15.0).

14.3 Detention Volume Requirements and Allowable Release Rates

The County requires detention be designed and operated according to the "Full Spectrum Detention" (FSD) approach outlined in the *Storage* chapter of the MHFD Manual. The FSD approach includes capture and control of two different runoff volumes, the excess urban runoff volume (EURV) and the 100-year runoff volume. The County allows the water quality capture volume (WQCV) to be "nested" within the EURV. The allowable release rate for the EURV is based on the allowable drain time for the type of detention facility being used. For example, extended detention basins must have an EURV drain time 52-72 hours when the WQCV is incorporated into the design. The 100-year runoff volume must be released at a rate no greater than 90% of the pre-development 100-year maximum runoff rate.

The EURV and 100-year runoff volumes shall be calculated based on the methods described in the *Storage* chapter of the MHFD Manual. Note: The "Simplified Equation" is only valid for contributing areas equal to or less than 10 acres.

The 100-year pre-development discharge may be calculated using Equation 12-5 of the *Storage* chapter of the MHFD Manual or more detailed hydrologic modeling. In either case, the undeveloped watershed imperviousness used must be no greater than 2%.

14.4 Types of Detention Facilities

See Table 14-1 for discussion on allowable and non-allowable types of detention facilities, as well as general application considerations.

Table 14-1: Types of Detention Facilities and Allowable Applications

Detention Facility Type	Application Considerations
Extended Detention Basin	Most common application of FSD. Best suited for larger sites with more than 2 acres of impervious area because orifice sizes become too small to avoid clogging.
Bioretention	Generally used for WQCV only, but can be modified to include FSD. Best suited for smaller sites with impervious areas less than 2 acres.
Sand Filter	Generally used for WQCV only, but can be modified to include FSD. Best suited for smaller sites with impervious areas less than 2 acres. Should only be considered over bioretention where sediment loads are expected to be high.
Parking Lot	Parking lot detention is <u>not allowed</u> in the County.
Underground	Underground detention is <u>not allowed</u> in the County due to inspection and maintenance difficulties.
Retention Ponds	Retention ponds are <u>not allowed</u> in the County due to complexities with verifying they can operate in accordance with *CRS §37-92-602(8)*. Retention basins also require acquisition of a water right and/or augmentation plan that often make them infeasible for most developments.

14.5 Detention and Water Rights

All detention facilities must be designed and operated in accordance with Colorado Revised Statute *CRS §37-92-602(8).* This statute requires, among others, that 97% of captured runoff from rainfall events equal to or less than the 5-year event must be drained or infiltrated within 72 hours. It also requires 99% of captured runoff from rainfall events equal to or greater than the 5-year event must be drained or infiltrated within 120 hours.

New stormwater detention and infiltration facilities requiring notification (see Table 14-2) must be reported to all parties on the Substitute Water Supply Plan (SWSP) Notification List maintained by the State Engineer. Information that must be provided includes:

1. Location of the facility,
2. Approximate surface area at design volume, and
3. Data demonstrating the facility has been designed in compliance with the release rate requirements of the statute, as described above. The Stormwater Detention and Infiltration Design Data (SDI) Sheet, downloadable from MHFD as the *Compliance Design Data Workbook*, is organized in the preferred format for the State Engineer's Office portal, and its use is recommended.

The Stormwater Detention and Infiltration Facility Notification portal, developed by MHFD, may be used to complete the reporting requirement for new facilities and will automatically direct notifications to the required recipients. The compliance portal is located here:

https://maperture.digitaldataservices.com/gvh/?viewer=cswdif

Table 14-2: Types of facilities requiring notification per CRS §37-92-602(8) (From MHFD Memorandum regarding CRS §37-92-602(8))

BMP	Water Quality Only	Flood Control Included
Grass Buffers	Not Required	Not Required
Grass Swales	Not Required	Not Required
Bioretention (with or without an underdrain)	Not Required	Required
Green Roof	Not Required	N/A
Extended Detention Basin	Required	Required
Sand Filter	Not Required	Required
Permeable Pavement Systems	Not Required	Required
Media Filter Drain	Not Required	Not Required
Underground Detention Vaults	Required	Required
Constructed Wetland Pond	N/A, Subject to Water Rights	
Constructed Wetland Channel	N/A, Subject to Water Rights	
Retention Pond	N/A, Subject to Water Rights	

14.6 Design Criteria and Considerations

The design of detention facilities shall follow the criteria, methods and guidance provided in the *Storage* chapter of the MHFD Manual. These address aspects of detention facility design such as grading, embankments, side slopes, freeboard, emergency spillways, outlet structures, trash racks and others.

- In addition, the lowest floor elevation for buildings adjacent to a storage facility must be higher than the embankment crest elevation of the storage facility.

14.7 Impacts to Downstream Property and Infrastructure

All designs shall also consider impacts to downstream property and infrastructure. The engineer shall demonstrate that downstream infrastructure has sufficient capacity to safely convey design discharges from the detention facility. If sufficient capacity or infrastructure does not exist, the developer may be responsible for downstream improvements.

14.8 Maintenance

All detention facilities shall be considered privately-owned, and maintenance will be the responsibility of the property owner. The property owner is encouraged to follow maintenance procedures and recommendations outlined in *Volume 3* of the MHFD Manual. The County has the right to inspect a facility at any time and require maintenance at the owner's expense.

The design engineer is encouraged to employ design techniques that reduce maintenance needs and expense. There is guidance on these design techniques in both the *Storage* chapter and Volume 3 of the MHFD Manual.

14.9 Submittal Requirements

Drainage Reports shall include the following information (at a minimum) to document detention facility design:

- Plans shall show location, type and ownership of detention facilities,
- Plans shall show water surface elevations and volumes of the WQCV, EURV and 100-year and 100-year freeboard elevation,
- Plans shall show the emergency overflow location, direction of flow and discharge.
- Summary tables of required WQCV, EURV and 100-year storage volumes along with supporting calculations,
- Summary tables of required and provided discharge rates and drawdown times along with supporting calculations, and
- Print outs of modeling software inputs and outputs.

The County recommends use of the MHFD-Detention workbook for FSD design and calculations.

14.10 References

Mile High Flood District. New Colorado Revised Statute §37-92-602(8) explanation memo and FAQ's:https://mhfd.org/wp-content/uploads/uploads/resources/guidance%20documents/UDFCD_Stormwater_Legislation_Memo_2016-03-09.pdf

Colorado Division of Water Resources. Administrative Statement Regarding the Management of Storm Water Detention Facilities and Post-Wildland Fire Facilities in Colorado: https://dnrweblink.state.co.us/dwr/ElectronicFile.aspx?docid=3576581&dbid=0

CHAPTER 15.0 POST-CONSTRUCTION STORMWATER CONTROLS

15.1 Introduction

Development projects can increase runoff and the discharge of undesirable pollutants that, if left untreated, may be detrimental to the health of receiving waters. This chapter addresses the use of post-construction stormwater control measures (SCMs) that are intended to reduce runoff and prevent or reduce discharge of pollutants to the County's waterways.

The Standards set forth in this chapter are based on the MHFD's Four Step Process for the protection of receiving waters from stormwater impacts, and the County's MS4 permit requirements for post-construction stormwater controls.

15.1.1 Four Step Process for Stormwater Quality Management

The Four Step Process is a long-standing approach recommended by the MHFD for stormwater quality management. The four steps are summarized below and additional information can be found in Volume 3 of the MHFD Manual.

Step 1: Employ Runoff Reduction Practices

This step aims to reduce the amount of runoff generated from a development by implementing low impact development (LID) practices and minimizing directly connected impervious area (MDCIA). Effective implementation of these practices requires careful planning at the beginning of the design process – looking for opportunities to route runoff through vegetated areas, preserve areas with high soil infiltration capacity, and minimizing impervious area overall. Quantifying runoff reduction via procedures in Volume 3 of the MHFD Manual can also result in smaller water quality and storage facilities downstream.

Principles of Low Impact Development (LID) and Minimizing Directly Connected Impervious Areas (MDCIA)

- Preserve natural hydrologic features and minimize disturbance
- Direct impervious surface runoff onto pervious areas
- Avoid concentrated flows where possible
- Utilize multiple controls throughout the site
- Use vegetated swales, buffers and distributed bioretention (rain gardens)
- Reduce volume, resulting in lower peak flows, reduced pollutant loadings, and hydrologic processes that more closely mimic the natural flow regime

Step 2: Implement SCMs That Provide a Water Quality Capture Volume with Slow Release

> **Water Quality Capture Volume (WQCV):**
> The volume of runoff used for optimal stormwater control measure design. Sizing for smaller volumes results in too many events exceeding the capacity of the facility, while designing for larger volumes results in drain times too short for effective pollutant removal.

The runoff that is generated from a development should be captured in a SCM designed to contain and slowly release the water quality capture volume (WQCV). These SCMs provide pollutant removal benefits and, in some cases, additional runoff reduction. A wide variety of SCMs are available to achieve to these objectives; however, proper selection is important as not all SCMs are appropriate for all sites.

Step 3: Stabilize Streams

Steps 1 and 2 may not always be sufficient to protect streams from erosion and additional measures may be necessary to keep a stream stabilized. In this context, the County considers “streams” to represent both major drainageways and minor drainageways that exist on or adjacent to a site. CHAPTER 12.0 of these standards addresses open channel design and stabilization techniques.

Step 4: Implement Site Specific and Other Source Control SCMs

This step aims to reduce or eliminate the potential for pollutants to enter the stormwater system on a site. This is particularly important for commercial and industrial sites that may handle or store chemicals, petroleum products or other materials that could cause severe impacts to receiving waters if discharged.

15.2 Runoff Reduction Practices (LID/MCDIA)

Runoff reduction practices shall be implemented to the extent practicable for all Projects. These requirements apply county-wide and regardless of Project size. If the Project is located within a GMA, more stringent requirements may apply.

15.2.1 Runoff Reduction Practices and Design Criteria

The following are the most common runoff reduction practices that can be used to achieve these requirements.

Grass Buffers: Grass buffers are densely-vegetated (typically turfgrass) areas designed to convey sheet flow from upstream impervious areas. The most important aspects of grass buffer design are to ensure that sheet flow is distributed evenly across the width of the buffer and that the buffer length (in the direction of flow) is long enough for effective treatment and infiltration.

Design criteria for grass buffers shall follow those included in Grass Buffer Fact Sheet in Volume 3 of the MHFD Manual.

Grass Swales: Grass swales are densely-vegetated channels designed to convey channelized flow from one location to another. They are most effective at runoff reduction and pollutant removal when designed with low flow depths and velocities – therefore design criteria for runoff reduction grass swales are different than open channel swales and roadside ditches. Design criteria for grass swales shall follow those included in Grass Swale Fact Sheet in Volume 3 of the MHFD Manual.

Permeable Pavement: Permeable pavement allows precipitation to flow through the pavement surface rather than producing runoff. It can also be used to store runoff below the pavement surface to achieve WQCV requirements or detention of larger flood control volumes. Design criteria for permeable pavement shall follow those included in Permeable Pavement Fact Sheet in Volume 3 of the MHFD Manual.

15.2.2 Submittal Requirements

At a minimum, the design engineer shall provide a qualitative discussion in the drainage report/letter on how runoff reduction practices will be implemented to the extent practicable and the design plans shall identify the runoff reduction practice locations and contributing impervious areas.

If the applicant intends to quantify runoff reduction for purposes of reducing downstream WQCV requirements, the design engineer shall also submit runoff reduction volume calculations using the most recent version of the UD-BMP Runoff Reduction Worksheet and detailed design plans/calculations for each practice to demonstrate they are designed according to the design criteria.

If runoff reduction practices cannot be feasibly implemented, a written justification must be provided to the County Engineer.

15.3 Water Quality SCMs

All Projects that disturb an area greater than or equal to 1 acre shall implement SCMs to meet one of the following base design standards, per the County's MS4 permit.

WQCV Standard: Control measures must be designed to provide treatment and/or infiltration of the WQCV for the entire Project site.

Pollutant Removal Standard: Requires treatment of the 80th percentile event to reduce the mean concentration of total suspended solids to 30 mg/L or less for the entire Project site.

Runoff Reduction Standard: Requires infiltration, evaporation, or evapotranspiration of 60% of the WQCV for the entire Project site.

Regional WQCV Facility Standard: If the Project site drains to a regional WQCV facility, at least 20% of the impervious area must be disconnected from the storm drainage system and drain through a receiving pervious area control measure comprising a footprint of at least 10% of the upstream disconnected impervious area.

Constrained Redevelopment Site Standard: If the Project is redevelopment with greater than 75% impervious area and the applicant demonstrates it is not practicable to meet any of the above standards, then the SCM(s) must meet one of the following:

- Meet the WQCV Standard for at least 50% of the impervious area
- Meet the Pollutant Removal Standard for at least 50% of the impervious area
- Infiltrate, evaporate or evapotranspirate 30% of the WQCV calculated based on the overall site impervious area.

These base design standards are summarized from the County's MS4 permit and shall not be interpreted differently from the permit requirements. These standards are also subject to change with future permit revisions.

Exemptions to the water quality SCM requirements may be provided if the Project meets any of the following characteristics:

- Single-family residential lots greater than or equal to 3 acres with a single dwelling and total imperviousness less than 10%, or
- Other "Excluded Sites" as defined in the County's current MS4 permit.

If the Project is located within a GMA, more stringent requirements may apply.

15.3.1 SCM Selection and Application

There is a wide variety of SCMs that can be used to meet the WQCV requirements, however not all SCMs are appropriate for all Projects. The design engineer shall consider factors such as the contributing impervious area, soil type, depth to bedrock/groundwater and impaired waters when selecting the appropriate SCM(s) for a site. Additionally, some SCMs can be incorporated into full-spectrum detention facilities to provide both water quality and storage requirements in a single facility. Table 15-1 below summarizes the most common SCMs and general guidance for selection and application. Volume 3 of the MHFD Manual provides additional guidance that should be considered.

Table 15-1. Water Quality SCM Selection and Application

SCM	Selection and Applicability Considerations
Bioretention	Best-suited for capturing runoff from less than 5 acres of impervious area. Partial- or full-infiltration designs depend on soil type or infiltration rate testing results. Can be designed as a stand-alone WQCV SCM, or incorporated as the WQCV/EURV component of a full-spectrum detention facility.
Constructed Wetland Pond	Best-suited for capturing runoff from more than 5 acres and where consistent baseflows are present. Subject to water rights law that may require reporting and augmentation plans. Can be designed as a stand-alone WQCV SCM, or incorporated as the WQCV/EURV component of a full-spectrum detention facility.
Extended Detention Basin (EDB)	Best-suited for capturing runoff from more than 5 acres of impervious area and are <u>not allowed for contributing areas with less than 1 impervious area</u>. Can be designed as a stand-alone WQCV SCM, or incorporated as the WQCV/EURV component of a full-spectrum detention facility.
Grass Swale	Applicable as a runoff reduction practice only. They do not capture and treat the WQCV. They may be used to achieve MS4 permit requirements if it can be demonstrated that they meet volume reduction requirements.
Grass Buffer	Applicable as a runoff reduction practice only. They do not capture and treat the WQCV. They may be used to achieve MS4 permit requirements if it can be demonstrated that they meet volume reduction requirements.
Green/Blue Roof	Applicable as a runoff reduction practice only or WQCV practice, depending on design. They may be used to achieve MS4 permit requirements if it can be demonstrated that they meet the Runoff Reduction or WQCV standards.
Permeable Pavement	Best-suited for parking lots, driveways and alleys with relatively low traffic loadings. Can be designed as a stand-alone WQCV SCM, or with additional flood detention. Partial- or full-infiltration designs depend on soil type or infiltration rate testing results.
Sand Filter	Best-suited for capturing runoff from less than 5 acres of impervious area. Partial- or full-infiltration designs depend on soil type or infiltration rate testing results. Can be designed as a stand-alone WQCV SCM, or incorporated as the WQCV/EURV component of a full-spectrum detention facility. Bioretention is preferred over sand filters in most applications; however, sand filters may be more appropriate where maintenance is expected to be more frequent due to higher solids loadings from the contributing area. Sand filters avoid the need for irrigation to establish or maintain vegetation.

Retention Pond	Best-suited for capturing runoff from more than 5 acres. Subject to water rights law that may require reporting and augmentation plans. Can be designed as a stand-alone WQCV SCM, or incorporated as the WQCV/EURV component of a full-spectrum detention facility. WQCV must be provided above the permanent pool and reliance on pumps to discharge captured runoff will not be allowed. Cannot be used with flood control in Larimer County.
Underground (proprietary) SCMs	Underground SCMs for water quality will not be allowed unless aboveground SCM options are infeasible. The applicant must demonstrate that the proposed SCM meets one of the MS4 permit base design standards.

SCM Selection for Impaired Waters

Waterbodies with a pollutant concentration exceeding the water quality standard established for a designated use are listed as "impaired waters" under Section 303(d) of the Clean Water Act. A total maximum daily pollutant load, or TMDL, is established for impaired waters and places limits on the pollutant load that may be discharged to a receiving water body. For areas within the County draining to impaired waters, SCM selection must be predicated on the effectiveness of a control measure at treatment of the specific pollutant named in the TMDL. The International BMP Database is one resource that can be used to determine the effectiveness of different SCMs at treating specific pollutants. https://bmpdatabase.org/

15.3.2 Water Quality SCM Design Criteria

The WQCV shall be calculated according to following equation from Volume 3 of the MHFD Manual:

$$WQCV = a(0.91I3 - 1.19I2 + 0.78I) \qquad \text{Equation 15- 1}$$

Where:

WQCV = Water Quality Capture Volume (watershed-inches)

a = Coefficient corresponding to SCM type and based on WQCV design drain time (See Table 15-2 below, taken from the MHFD Manual, Volume 3, *Calculating the WQCV and Volume Reduction* Chapter)

I = Contributing area imperviousness (percent expressed as a decimal) - Note: At a planning level, the imperviousness can be estimated based on the zoned density. When finalizing design, calculate imperviousness based on the site plan.

Table 15-2. Drain Time Coefficients for WQCV Calculations (Taken from MHFD Manual Volume 3)

Drain Time (hours)	Coefficient, *a*
12	0.8
24	0.9
40	1.0

SCMs shall be designed according to the criteria presented in the most recent version of Volume 3 of the MHFD Manual. Those criteria are presented in a series of Fact Sheets and are updated on a regular basis. Any exceptions to those criteria, or the use of SCMs not identified in Table 15-1, will require prior approval from the County Engineer.

15.3.3 Maintenance

The County requires all water quality SCMs be designed with consideration of maintenance access and requirements. In addition, an Operation and Maintenance Plan must be completed for all water quality SCMs and provided to the owner and the County. The owner will be responsible for maintaining the SCM such that it continues to function as designed. Per the Development Agreement, the County reserves the right to perform maintenance activities if the owner refuses or is incapable doing so and the County may seek reimbursement for all costs from the Owner.

15.3.4 Submittal Requirements

Drainage reports and plans shall include the following information (at a minimum) for all proposed water quality SCMs:

- Description and discussion of SCM type(s) and contributing area characteristics (e.g., total area, impervious area, etc.),
- Soil type and/or infiltration test results for infiltration-based SCMs (e.g., bioretention, sand filters, permeable pavement),
- WQCV calculations, and
- Operation and Maintenance Plan.

The County recommends use of the MHFD's UD-BMP workbooks to document many of the requirements above. Additional information may be required by the County Engineer on a case-by-case basis.

CHAPTER 16.0 CONSTRUCTION STORMWATER MANAGEMENT

16.1 Introduction

Larimer County maintains a construction stormwater management program to reduce or prevent the discharge of pollutants from construction activities to the storm drainage system and receiving waters. Stormwater quality is particularly vulnerable during construction activities due to exposed and disturbed soils, and the presence of various construction equipment and materials.

The County's construction stormwater management program is implemented to comply with the requirements of the County's MS4 Permit. The program is also designed to conform with requirements of the statewide General Permit for Stormwater Discharges Associated with Construction Activity, although the County is not directly responsible for enforcing the requirements of the latter. As such, the County's construction stormwater management program is based primarily on the following items:

- Development Construction Permit and Land Disturbance Permit – permits required by the County for various construction-related activities.
- Erosion and Sediment Control Plan (ESCP) – required by the County to document construction stormwater management plans.
- Construction Stormwater Management Guidance Document – a guidance document developed by the County to provide additional guidance on this topic, which may be updated more frequently than these Standards.
- The Construction BMPs chapter of the MHFD Manual for design and implementation of construction stormwater control measures (incorporated by reference).

Additional discussion of those items is presented in the following sections of this chapter.

16.2 Development Construction Permit

A Development Construction Permit (DCP) is one mechanism that the County uses to permit construction activities. All applications for DCPs are reviewed by County staff to determine if a drainage report or drainage letter is required as part of the submittals package. If a drainage report or drainage letter is required, County staff will also require an ESCP (see Section 16.4) and possibly a Land Disturbance Permit (see Section 16.3).

16.3 Land Disturbance Permit

A Land Disturbance Permit (LDP) was implemented in the County in 2023 (corresponding to the development and approval of these Standards). An LDP will be required for any project that disturbs at least 1 acre, or is part of a common plan of development, and is located within the

County's MS4 permit boundary area. All LDPs will require submittal of an ESCP. The threshold for requiring an LDP will also require the applicant to obtain a statewide General Permit for Stormwater Discharges Associated with Construction Activity from CDPHE and prepare a Stormwater Management Plan (SWMP) in accordance with the requirements of that permit.

Larimer County MS4 Permit Boundary

- https://maps1.larimer.org/gvh/?Viewer=LIL
- Under "Layer List" turn on "Flood Information" Layer
- Under "Stormwater Layer" turn on "MS4 Permit Area"

16.4 Erosion and Sediment Control Plan

An Erosion and Sediment Control Plan (ESCP) shall be submitted and approved by the County prior to the start of any construction activities that require a Drainage Letter, Drainage Report, DCP, or LDP. In addition, the County may require an ESCP for projects that are in close proximity to wetlands and receiving waters, and/or are identified by County staff as having potential for significant erosion.

The primary elements of an ESCP are outlined below. The submittal requirements and level of detail required for each of the elements will vary by project and be based on the County Engineer's discretion. Appendix C contains the ESCP checklist, which must be completed and submitted with the ESCP. The applicant shall refer to the Construction Stormwater Management Guidance Document and associated appendices for additional guidance and requirements on these elements.

16.4.1 General Information and Site Description

The ESCP must describe the characteristics of the site and the construction activities that are proposed and how those activities will affect land disturbance and stormwater drainage. Identify areas that will be disturbed and where stormwater runoff will discharge to during various stages of construction.

16.4.2 Construction Stormwater Control Measures

The ESCP must describe and display on maps all potential sources of pollutants associated with the construction activities and appropriate stormwater control measures (SCM) that will be used to reduce or eliminate the potential for those pollutants to discharge to receiving waters and storm drainage system. The applicant is encouraged to follow the Construction BMPs chapter of the MHFD Manual in the design and implementation of construction SCMs.

Components of Effective Construction Stormwater Management

- Erosion control practices are focused on preventing erosion and mobilization of soils/sediment from occurring in the first place. Typical erosion control practices include mulching, check dams and surface roughening.
- Sediment control practices are focused on preventing soils/sediments from reaching waterways once they have been mobilized by runoff. Typical soil control practices include sediment control logs, silt fences and inlet protection.
- Materials management practices are implemented to provide protection against various construction-related materials reaching waterways. Examples include fuel spills/leaks, concrete washout areas and portable toilets.
- Site management includes a variety of other activities that can be both structural and non-structural. Common types of site management practices include construction phasing, street sweeping and vehicle tracking controls. Practices that are typically more project-specific include dewatering operations and temporary stream crossings.

16.4.3 Inspections and Maintenance

The County requires routine site inspections be completed by the permittee to ensure that control measures function as designed and maintenance needs are promptly addressed.

16.4.4 Final Stabilization and Long-term Stormwater Management

At the completion of construction, all sites are required to reach final stabilization. A site will not be considered to have achieved final stabilization until the vegetation density of all disturbed areas reaches at least 70% of pre-construction density. A description of all practices used to achieve final stabilization and a revegetation plan are required as part of the ESCP.

16.4.5 Plan Map/Drawings

A spatial representation of the site must be included that depicts the area(s) of disturbance and the location of all potential sources of pollutants. The direction of stormwater flow through the site should be indicated, along with all SCMs used and any waters of the state. Additional details regarding items to be depicted on the drawings, standard construction symbols that should be used, and standard notes that must be included are described in the Guidance Document and associated appendices.

16.4.6 Erosion Control Escrow

The County requires an erosion control escrow be provided before construction will be approved. The developer is encouraged to contact the County early in the planning process for escrow amounts and calculation methods.

16.5 Enforcement

The ESCP shall be enforced following procedures outlined in the LCLUC.

16.6 REFERENCES

City of Fort Collins, 2018. Fort Collins Stormwater Criteria Manual.

Larimer County, 2021. Larimer County Land Disturbance Permit Checklist.

Larimer County, 2021. Larimer County Urban Area Street Standards.

Mile High Flood District, 2010. Urban Storm Drainage Criteria Manual, Volume 3: Stormwater Best Management Practices.

CHAPTER 17.0 REVEGETATION

17.1 Introduction

This chapter provides guidance for revegetation following land disturbance activities in the County. Construction activities typically result in soil disturbance and loss of stabilizing vegetation, often leading to erosion and creating an opportunistic environment for the establishment of invasive and nuisance weedy species. Restoring a healthy vegetation community protects topsoil, reducing erosion in upland areas and stabilizing channel banks. Healthy native plant communities suppress weeds, sustain ecosystems, sequester carbon and provide value to the local community. Proper revegetation is necessary to satisfy the requirements of most construction-related permits.

The *Revegetation* chapter of the MHFD Manual provides extensive guidance for revegetation of upland, riparian and wetland areas. These Standards provide a high-level overview of the various processes involved with revegetation and discussion of County-specific requirements that are not included in the MHFD Manual.

17.2 Site Preparation

Initial site preparation is essential for the successful re-establishment of vegetation and may vary depending on location and land use. For example, site preparation in an area devastated by wildfire will differ from that resulting from residential development. Evaluate the site and determine the type of plant community to be established based on elevation and hydrology. Prior to beginning construction, plan to stockpile as much topsoil as possible to be replaced following completion of construction activities. Soil testing is highly recommended to determine any necessary soil amendments.

Table 17-1 shows critical activities related to site preparation. Refer to the corresponding section of the *Revegetation* chapter of the MHFD Manual for discussion and guidance on these activities. In addition, the following County-specific requirements apply:

Weed Control - An integrated weed management plan (IWM), both during construction and following revegetation, shall be developed and implemented. Please refer to the Larimer County Weed District website (https://www.larimer.gov/naturalresources/weeds) for additional resources on preventing and managing weed infestations.

Table 17-1: Site preparation activities for revegetating upland, riparian and wetland habitats, with chapter references from the Revegetation chapter of the MHFD Manual

Revegetation Guidance Topic	
Activity	Section of *Revegetation* Chapter of MHFD Manual
Initial Hydrologic Evaluation	3.1
Initial Weed Evaluation and Control	3.2
Topsoil Preservation (including Existing Wetland Soil)	3.3
Soil Testing	3.4
Soil Amendment	3.5
Seed Bed Preparation	3.6
Tree Protection	3.7

17.3 Plant Material Selection

Plant selection will vary based on habitat type, schedule, budget and overall goals of a project. A vegetation site plan should be provided by a specialist trained in plant selection and revegetation.

Table 17-2 shows plant materials appropriate for different habitat types. Refer to the corresponding section of the *Revegetation* chapter of the MHFD Manual for additional discussion and guidance on these activities. In addition, the following County-specific requirements apply:

Seed Mix – The County has developed a preferred seed mix (see Appendix J) for revegetation. Alternative seed mixes may be used with prior approval from the County. Please refer to Section 17.8 of this chapter for seed mixes applicable to post-fire burn areas.

Table 17-2: Plant material for revegetating upland, riparian and wetland habitat types, with chapter references from the Revegetation chapter of the MHFD Manual

Plant Material	Section of *Revegetation* Chapter of MHFD Manual	Applicability to Habitat Type		
		Upland	Riparian	Wetland
Seed (permanent and temporary)	4.2	√	√	√ (limited)
Plugs	4.4.1	√	√	√
Containers	4.4.2	√	√	√
Bare Root	4.4.3	√	√	√
Balled and Burlapped (B&B)	4.4.4	√	√	√
Cuttings	4.4.5		√	√
Wetland Sod, Rhizones, Tubers	4.5			√

Additional Plant Selection Resources

The Colorado Native Plant Society has produced a series of publications titled *Native Plant Garden Guides* as a resource for selecting low-water native plant species appropriate for planting in the various regions of Colorado. These resources are available on the Colorado State University (CSU) Extension office website.

17.4 Plant Installation

Installation methods will vary depending on the plant selection and habitat type for the project. Table 17-3 shows plant installation methods appropriate for different habitat types. Please refer to the corresponding section of the *Revegetation* chapter of the MHFD Manual for additional discussion and guidance on these activities.

Table 17-3: Installation methods for revegetating upland, riparian and wetland habitat types, with chapter references from the Revegetation chapter of the MHFD Manual

Installation Method	Section of *Revegetation* Chapter of MHFD Manual	Applicability to Habitat Type		
		Upland	Riparian	Wetland
Seeding (multiple methods)	5.1 & 5.2	√	√	√ (limited)
Herbaceous Plug, Containerized, B&B, and Bare Root Stock Installation	5.3	√	√	√
Cutting Installation	5.4		√	√
Transplanting Wetland Plants (Wetland Sod, Rhizomes, Tubers)	5.5			√

17.5 Mulching

Mulching serves to provide a protective layer for newly planted vegetation in upland and riparian areas. Proper mulching can provide benefits such as moisture retention, erosion protection and weed control that increase the chances for successful revegetation.

Please refer to the *Revegetation* chapter of the MHFD Manual for additional discussion and guidance on the mulching topics below:

- Individual Planted Trees and Shrubs,

- Seeded Areas, and
- Types of Mulch (straw, rolled erosion control products, hydromulch, compost).

In addition, the following County-specific requirements apply:

Use of Straw Mulch – The use of straw mulch will require prior approval by the County so that it is not used in sensitive areas. Approved use of straw must be crimped and applied with a tackifier to assure it remains in place.

17.6 Maintenance

Any successful revegetation plan must address long-term maintenance. Revegetated areas often need to be replanted in subsequent years and are vulnerable to opportunistic weed infestation before desirable plant species become well-established. Temporary or permanent irrigation may be required. Plans should include provisions for long-term monitoring and adaptive management of revegetated areas to ensure successful outcomes.

Maintenance topics in the *Revegetation* chapter of the MHFD Manual include the following:

- Irrigation,
- Replacing dead trees/shrubs and spot reseeding bare areas,
- Vegetation protection from animals,
- Weed management,
- Managing erosion in riparian areas, and
- Maintenance of wetland areas

17.7 Post-construction Monitoring

Post-construction monitoring may be required to ensure vegetation is properly re-established prior to closure of permits. During post-construction monitoring, it is important to replace dead vegetation as soon as the planting window is appropriate so that the warranty period is not unnecessarily extended.

A Development Construction Permit from the County will generally have a 2-year warranty period after construction activities are substantially complete. The warranty period for a Land Disturbance Permit and/or Erosion Control Plan will vary by project. Specific requirements for those permits are subject to change and shall follow the most recent permit guidance.

Refer to the MHFD Manual *Revegetation* chapter for additional discussion and guidance on monitoring during warranty periods and long-term.

17.8 Post-Fire Revegetation

The Larimer County Department of Natural Resources has produced a document, *Seed Mixes, BMPs and Guidelines for Seeding and Mulching in the Cameron Peak Burn Area,* providing guidance on seed selection and best management practices for revegetating post-fire areas. Included in the document are seed mixes and directions for reseeding at different tiers of elevation, beginning with 6,000 ft. The document may be downloaded here: https://www.larimer.org/sites/default/files/uploads/2021/cpr_seedmix_bmps_2021.pdf.

17.9 Submittal Requirements

Revegetation plans must be included in construction stormwater management plans and/or erosion and sediment control plans and should include the following items:

- Percent vegetative cover (pre-construction)
- Soil types
- Description of seedbed preparation strategy (e.g., decompaction, soil testing, soil amendments)
- Seed mixes and seed tags that identify species name, common name, seed application rate (lbs of PLS/acre) and method of seeding (drill, drill depth, broadcast, hydroseed, etc.)
- Description mulching strategy (e.g., product, application method) with justification that the strategy is appropriate for site slopes and estimated length of vegetation re-establishment.
- Weed Management Plan per requirements of the County Natural Resources Department

17.10 Permits

Revegetation plans may be required and reviewed as part of one or more of the following permits:

- Development Construction Permit – Larimer County,
- Land Disturbance Permit – Larimer County,
- Construction Stormwater Discharge Permit – Colorado Department of Public Health and Environment, and
- CWA 404 Permit – US Army Corps of Engineers.

17.11 References and Resources

The following provide revegetation guidance:

Colorado State University (CSU) Extension Office: https://extension.colostate.edu/

Natural Resources Conservation Service (NRCS):
https://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/

Larimer County Weed District: https://www.larimer.gov/naturalresources/weeds

Larimer County Department of Natural Resources. Seed Mixes, BMPs and Guidelines for Seeding and Mulching in the Cameron Peak Burn Area. April 2021.

MHFD, USDCM Volume 2, *Revegetation* chapter

Colorado Natural Areas Program. *Native Plant Revegetation Guide for Colorado*. October 1998.

Colorado Native Plant Society. Low-Water Native Plants for Colorado Garden

APPENDIX A

SUBMITTALS CHECKLIST

CONSTRUCTION DRAWINGS CHECKLIST

PROJECT INFORMATION				
1. Project Name/Applicant Name:		2. Prepared by:		
3. Location/Address:				
4. Submittal Date:	(1)	(2)	(3)	(4)
5. Submitted by:	Firm:			
	Contact (name and email):			
	Phone:			

ITEM	Submittee to complete: Included (I), not included (NI), or not applicable (N/A)	Reviewer to complete: I, NI, or N/A
GENERAL SUBMITTAL REQUIREMENTS		
Overall submittal typed, bound study or PDF equivalent		
Signed and sealed P.E. certification statement and stamps and signatures on reports and plans		
I. General Information		
Title block (lower right-hand corner)		
North arrow		
Scale indicated (plan and profile)		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Date and revisions		
Name of professional engineer or firm		
Professional engineer's seal and signature		
Certification statement (see below)		
Street names and easements with width descriptions		
Existing or planned utilities and structures (water, gas, telephone, storm drain, irrigation ditches, sanitary sewers)		
II. Plan Drawings		
North arrow		
Property lines and ownership or subdivision information		
III. Profile Drawings		
Vertical and horizontal grids with scales		
Ground surface existing (dotted) and proposed (solid)		
Existing utility lines where crossed		
Bench marks (USGS Datum)		
Elevations (USGS Datum)		
IV. Proposed Construction		
A. Pipes		
Plan and profile		
Size, type and structural class of pipe, including ASTM specification		
Grades		
Inlet and outlet details		
Manhole details (station number and invert elevations)		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Bedding and backfilling details		
B. Open Channels		
Plan showing stationing		
Profile, including water-surface profiles		
Grades		
Typical cross-section		
Lining details		
C. Special Structures (manholes, culverts, headwalls, trash grates, etc.)		
Plan		
Elevation and water-surface profiles, details of design and appurtenances		
D. Streets, curb and gutter		
Reviewer Comments:		

Statement:

All work shall be constructed in accordance with Larimer County Standard Specifications as provided by the County Engineer, except as noted.

APPROVED: ____DATE: ________________

SUBMITTALS CHECKLISTS

LARIMER COUNTY

DRAINAGE LETTER CHECKLIST

PROJECT INFORMATION					
1. Project Name/Applicant Name:			2. Prepared by:		
3. Location/Address:					
4. Submittal Date:	(1)		(2)	(3)	(4)
5. Submitted by:	Firm:				
	Contact (name and email):				
	Phone:				

ITEM	Submittee to complete: Included (I), not included (NI), or not applicable (N/A)	Reviewer to complete: I, NI, or N/A
GENERAL SUBMITTAL REQUIREMENTS		
Overall submittal typed, bound study or PDF equivalent		
Signed and sealed P.E. certification statement and stamps and signatures on reports and plans, if required		
DRAINAGE NARRATIVE		
Project location		
General project description		
Proposed land use(s)		
Discuss how water flows onto the site, how flows are conveyed across the site, and where flows go when leaving the site		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Easements within and adjacent to the site		
Approximate area of land disturbance		
Sediment and erosion control during and after construction		
Applicable calculations and plan sets if changes to basin or drainage is proposed		
DRAINAGE FEATURES		
On-site or nearby drainage features (culverts, drainages, lakes/reservoirs, rivers, irrigation ditches, low ponding areas, wetlands)		
Photos of existing drainage features		
DRAINAGE PLAN		
Scale indicated		
North arrow		
Contours		
Property boundaries		
Flow arrows		
Drainage features		
Approximate location of existing and proposed structures		
Existing and proposed roads and access points		
Approximate location of any known drainage easements		
Approximate area of disturbance		
Reviewer Comments:		

FINAL DRAINAGE REPORT CHECKLIST

PROJECT INFORMATION				
1. Project Name/Applicant Name:		2. Prepared by:		
3. Location/Address:				
4. Submittal Date:	(1)	(2)	(3)	(4)
5. Submitted by:	Firm:			
	Contact (name and email):			
	Phone:			
ITEM			**Submittee to complete: Included (I), not included (NI), or not applicable (N/A)**	**Reviewer to complete: I, NI, or N/A**
GENERAL REPORT SUBMITTAL REQUIREMENTS				
Overall submittal typed, bound study or PDF equivalent				
Signed and sealed P.E. certification statement and stamps and signatures on reports and plans				
DRAINAGE NARRATIVE				
I. Introduction				
General project description				
Proposed land use(s)				

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
II. General Location and Description		
A. Location		
City, county, and local streets within and adjacent to the site		
Township, range, section, ¼ section, lot(s) and block(s)		
Names of surrounding developments		
Location map		
B. Description of Property		
Site area		
Ground cover		
Soil types		
Infiltration test results or geotechnical study		
Groundwater characteristics, including depth to water table		
Identify major and sub-basins		
Existing drainage and water quality facilities		
Irrigation facilities on site or nearby related to site drainage		
Effect of development on hazard ratings of any reservoirs in area		
History of flooding		
Easements within and adjacent to the site		
III. Drainage Basins and Sub-basins		
A. Major Basin Descriptions		
Reference relevant MDP reports and FEMA FIRM panels		
Areas, existing and proposed land uses, imperviousness, soils information, overland and channelized slopes, and other parameters used in calculations		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
All nearby irrigation facilities that may be affected by local drainage		
All outfalls to major drainageways		
B. Sub-basin Descriptions		
Historical on-site and off-site sub-basin drainage patterns of the property and surrounding areas		
Proposed on-site and off-site sub-basin characteristics and impacts of development		
Sub-basin characteristics for existing and proposed conditions including area, existing and proposed land uses, imperviousness, hydrologic soil groups, overland and channelized slopes, and other physical parameters used for drainage calculations or analyses		
IV. Drainage Design Criteria		
A. Development Criteria References and Constraints		
Previous drainage studies		
Adjacent drainage studies		
Drainage impacts of site constraints		
B. Hydrologic Criteria		
Design rainfall and design storm recurrence intervals		
Hydrologic soil groups		
Calculate imperviousness		
Runoff calculation method		
Detention discharge and storage calculation method		
Other criteria or calculation methods		
C. Hydraulic Criteria		
Capacity analysis of existing and proposed drainage infrastructure		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Floodplain analyses (if required)		
Other drainage facility design criteria used		
D. Stormwater Quality		
Describe how the project will satisfy MS4 permit		
V. Drainage Facility Design		
A. General Concept		
General drainage concepts		
Off-site runoff considerations		
Anticipated and proposed drainage patterns		
Discuss tables, charts, figures, and drawings		
B. Specific Details		
Drainage problems and solutions		
Design flows and detention storage volumes		
Existing stormwater conveyance and storage facilities		
Proposed stormwater conveyance, storage facilities, and outlet structures		
Spillway design included		
Structural and Non-structural Control Measures (SCMs)		
Maintenance access and aspects		
Easements and tracts		
Compliance with local, state, and federal requirements		
Describe safety hazards that may be associated with various drainage structures and the provisions that have been included in the design to minimize safety hazards		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
C. Variances		
Any requested variances from Larimer County drainage criteria or approved master plans		
VI. Conclusions		
A. Compliance with Standards		
Compliance with criteria in Larimer County Manual		
Compliance with Larimer County and FEMA floodplain rules and regulations		
B. Drainage Concept		
Drainage design will control damage from storm runoff		
Compatibility of proposed development with approved master plans		
Drainage impacts of proposed development on upstream and downstream properties		
C. Water Quality		
Compliance with CDPS MS4 Permit		
Post-construction design standards in the MS4 Permit will be met		
VII. References		
Criteria and technical information used		
VIII. Appendices		
A. Hydrologic Computations		
Land use assumptions for adjacent properties		
Historic and proposed runoff computations		
Calculations for WQCV, EURV, detention storage volumes, release rates, and drain time		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
B. Hydraulic Computations		
Culvert capacity calculations		
Street capacity and inlet calculations for minor storm runoff and major storm runoff		
Storm drain capacity calculations and profile showing hydraulic grade lines, ground surface grade, and pipe grade for the minor and major storms		
Detention area/volume capacity and outlet capacity calculations; include historic inflow, developed inflow, and outflow design hydrographs for detention facilities		
Stage-volume curves, outlet rating curves, spillway rating curves, and the method used to determine the rating curves for storm water storage facilities		
Documentation, water surface profiles for open channel. Designs for low-flow and trickle channel, stabilization (erosive velocities), and grade control		
Backwater profiles for open channels for the minor and major storm runoff with input data and procedures used for calculations		
Energy dissipation and calculations		
Downstream/outfall system capacity		
C. Floodplain Information		
FIRM		
D. Soils Information		
Soils map		
Soils report		
DRAINAGE PLAN		
IX. Drainage Plan Maps/Drawings		
A. Overall Drainage Map		
Scale indicated		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Title block, legend, and north arrow		
Engineering firm name, professional engineering stamp, signature, and date		
Major basin and sub-basin boundaries		
Project/development boundaries		
Flow path for major drainageways		
Location and elevations of floodplain boundaries		
Drainage patterns entering, leaving, and within the site		
Existing and proposed stormwater management facilities		
B. Detailed Drainage Plan		
Scale indicated		
Title block, legend, and north arrow		
Existing/proposed contours at 2-foot maximum intervals on USGS Datum		
Location and elevations of USGS Benchmarks. All elevations shall be on USGS Datum		
Minimum lowest floor elevations for protection from major storm runoff		
Major basin and sub-basin boundaries, area, and imperviousness		
Definition of overland and channelized flow paths used for time of concentration calculation		
Location and elevations of floodplain boundaries		
Routing and accumulation of flows at design points for minor and major storm runoff		
Property lines, easements, and right-of-way		
Location and elevations of existing and proposed utilities and structures		
Streets, names, and grades		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Off-site features influencing drainage through the development		
Existing drainage facilities and structures		
Proposed types of curb and gutter and gutter flow direction, including cross pans		
Proposed storm drains and open drainageways, including proposed inlets, manholes, culverts, and other appurtenances		
Proposed outfall points for runoff from study area		
Locations and footprints of water quality and/or detention facilities		
Volumes and release rates for detention storage facilities		
EROSION CONTROL PLAN		
Reviewer Comments:		

Certification:

I hereby certify that this report (plan) for the final drainage design of ____ was prepared by me (or under my direct supervision) for the owners thereof and meets or exceeds the criteria in the Larimer County Stormwater Design Standards.

____

Licensed Professional Engineer
State of Colorado No. ___________
(Seal)

PRELIMINARY DRAINAGE REPORT CHECKLIST

PROJECT INFORMATION				
1. Project Name/Applicant Name:		2. Prepared by:		
3. Location/Address:				
4. Submittal Date:	(1)	(2)	(3)	(4)
5. Submitted by:	Firm:			
	Contact (name and email):			
	Phone:			

ITEM	Submittee to complete: Included (I), not included (NI), or not applicable (N/A)	Reviewer to complete: I, NI, or N/A
GENERAL REPORT SUBMITTAL REQUIREMENTS		
Overall submittal typed, bound study or pdf equivalent		
Signed and sealed P.E. certification statement and stamps and signatures on reports and plans		
DRAINAGE NARRATIVE		
I. Introduction		
General project description		
Proposed land use(s)		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
II. General Location and Description		
A. Location		
City, county, and local streets within and adjacent to the site		
Township, range, section, ¼ section, lot(s) and block(s)		
Names of surrounding developments		
Location map		
B. Description of Property		
Site area		
Ground cover		
Soil types		
Infiltration test results or geotechnical study		
Groundwater characteristics, including depth to water table		
Identify major and sub-basins		
Existing drainage and water quality facilities		
Irrigation facilities on site or nearby related to site drainage		
Effect of development on hazard ratings of any reservoirs in area		
History of flooding		
Easements within and adjacent to the site		
III. Drainage Basins and Sub-basins		
A. Major Basin Descriptions		
Reference relevant MDP reports and FEMA FIRM panels		
Areas, existing and proposed land uses, imperviousness, soils information, overland and channelized slopes, and other parameters used in calculations		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
All nearby irrigation facilities that may be affected by local drainage		
All outfalls to major drainageways		
B. Sub-basin Descriptions		
Historical on-site and off-site sub-basin drainage patterns of the property and surrounding areas		
Proposed on-site and off-site sub-basin characteristics and impacts of development		
Sub-basin characteristics for existing and proposed conditions including area, existing and proposed land uses, imperviousness, hydrologic soil groups, overland and channelized slopes, and other physical parameters used for drainage calculations or analyses		
IV. Drainage Design Criteria		
A. Development Criteria References and Constraints		
Previous drainage studies		
Adjacent drainage studies		
Drainage impacts of site constraints		
B. Hydrologic Criteria		
Design rainfall and design storm recurrence intervals		
Hydrologic soil groups		
Calculate imperviousness		
Runoff calculation method		
Preliminary detention discharge and storage calculation method		
Other criteria or calculation methods		
C. Hydraulic Criteria		
Preliminary capacity analysis of existing and proposed drainage infrastructure		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Floodplain analyses (if required)		
Other preliminary drainage facility design criteria used		
D. Stormwater Quality		
Describe how the project will satisfy MS4 permit		
V. Drainage Facility Design		
A. General Concept		
General drainage concepts		
Off-site runoff considerations		
Anticipated and proposed drainage patterns		
Discuss tables, charts, figures, and drawings		
B. Specific Details		
Drainage problems and preliminary solutions		
Preliminary design flows and detention storage volumes		
Existing stormwater conveyance and storage facilities		
Proposed stormwater conveyance, storage facilities, and outlet structures		
Structural and Non-structural Control Measures (SCMs)		
Maintenance		
Easements		
Compliance with local, state, and federal requirements		
C. Variances		
Any requested variances from Larimer County drainage criteria or approved master plans		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
VI. Conclusions		
A. Compliance with Standards		
Compliance with criteria in Larimer County Manual		
Compliance with Larimer County and FEMA floodplain rules and regulations		
B. Drainage Concept		
Drainage design will control damage from storm runoff		
Compatibility of proposed development with approved master plans		
Drainage impacts of proposed development on upstream and downstream properties		
C. Water Quality		
Compliance with CDPS MS4 Permit		
Post-construction design standards in the MS4 Permit will be met		
VII. References		
Criteria and technical information used		
VIII. Appendices		
A. Hydrologic Computations		
Land use assumptions for adjacent properties		
Historic and proposed runoff computations		
Preliminary calculations for WQCV, EURV, detention storage volumes, release rates, and drain time		
B. Hydraulic Computations		
Detention area/volume capacity		
Preliminary capacity analysis for any proposed control measures		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
C. Floodplain Information		
FIRM		
D. Soils Information		
Soils map		
Soils report		
DRAINAGE PLAN		
I. Overall Drainage Map		
Scale indicated		
Title block, legend, and north arrow		
Engineering firm name, professional engineering stamp, signature, and date		
Major basin and sub-basin boundaries		
Project/development boundaries		
Flow path for major drainageways		
Location and elevations of floodplain boundaries		
Drainage patterns entering, leaving, and within the site		
Existing and proposed stormwater management facilities		
II. Detailed Drainage Plan		
Scale indicated		
Title block, legend, and north arrow		
Existing/proposed contours at 2-foot maximum intervals on USGS Datum		
Location and elevations of USGS Benchmarks. All elevations shall be on USGS Datum.		
Minimum lowest floor elevations for protection from major storm runoff		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Major basin and sub-basin boundaries, area, and imperviousness		
Definition of overland and channelized flow paths used for time of concentration calculation		
Location and elevations of floodplain boundaries		
Routing and accumulative flows at design points for minor and major storm runoff		
Property lines, easements, and right-of-way		
Location and elevations of existing and proposed utilities and structures		
Streets, names, and grades		
Off-site features influencing drainage through the development		
Existing drainage facilities and structures		
Proposed types of curb and gutter and gutter flow direction, including cross pans		
Proposed storm drains and open drainageways, including proposed inlets, manholes, culverts, and other appurtenances		
Proposed outfall points for runoff from study area		
Locations and footprints of water quality and/or detention facilities		
Proposed volumes and release rates for detention storage facilities		
Reviewer Comments:		

Certification:

I hereby certify that this report (plan) for the preliminary drainage design of ____ was prepared by me (or under my direct supervision) for the owners thereof and meets or exceeds the criteria in the Larimer County Stormwater Design Standards.

____

Licensed Professional Engineer
State of Colorado No. ___________
(Seal)

APPENDIX B

CONSTRUCTION STORMWATER MANAGEMENT GUIDANCE DOCUMENT

GUIDANCE DOCUMENT

INTRODUCTION

Any activity that decreases vegetative cover and disturbs the land surface increases vulnerability to wind and rainfall erosion. Therefore, land disturbing activities must provide a plan for addressing potential erosion and discharge of pollutants to waters of the state. The County mandates that an Erosion and Sediment Control Plan (ESCP) be developed for all construction activities for which submittal of a Drainage Letter or Drainage Report is required. This document is intended to provide guidance for the development of the ESCP. In addition, Chapter 7 *Construction BMPs* of Volume 3 of the MHFD Manual provides comprehensive information regarding management of stormwater quality on construction sites and is incorporated herein.

APPLICABILITY

An ESCP must be submitted with all Drainage Letters or Drainage Reports in the County. Other projects, such as those in close proximity to wetlands or waterways, may require an ESCP as deemed appropriate by the County Engineer. Construction activities with a land disturbance of at least one acre, or part of a larger common plan of development disturbing at least one acre, are also required to apply for coverage under the State's Construction Stormwater Discharge permit and implement a Stormwater Management Plan (SWMP). Those sites requiring coverage under the State permit that reside within the County's MS4 must also apply for a Land Disturbance Permit (LDP) from the County and complete all submittal requirements as described in the Land Disturbance Permit Checklist[1]. The flowchart in Figure 1 provides guidance regarding the type of erosion control submittal(s) required for various projects within the County, including projects requiring a Development Construction Permit (DCP) or LDP.

It is expected that the ESCP requirements contained herein will also apply to the SWMP; however, additional requirements may be needed for compliance with the State permit, and the applicant is encouraged to consult the State permit directly for the most current SWMP requirements. The County also recognizes the wide diversity of construction projects that occur

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[1] Please note the ESCP is referred to as a SWMP in the LDP checklist. The SWMP referenced in the LDP also meets the requirements of the ESCP as described in this document, and only one plan for erosion control is required to be submitted to the County.

within the County, and many of the ESCP items described herein may be waived for smaller projects at the discretion of the County Engineer.

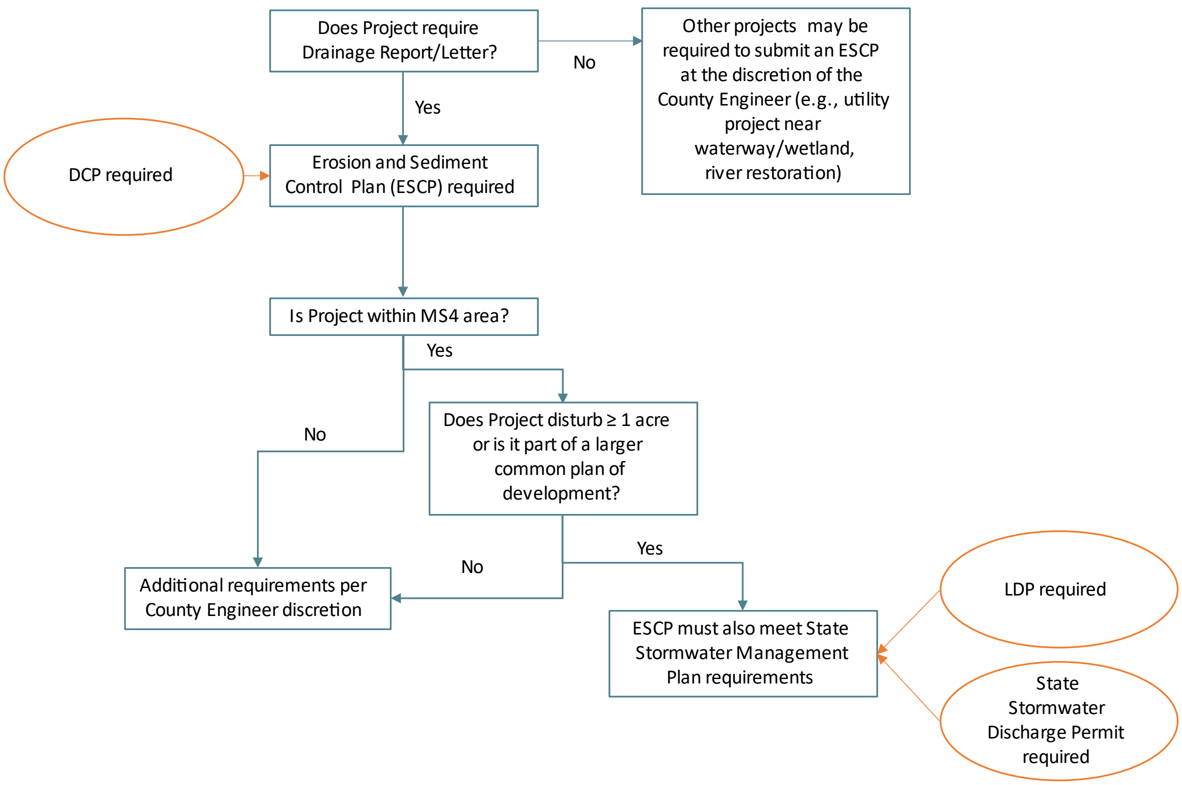


Figure 1. Type of Erosion Control Submittal(s) Required by Project within County

EROSION AND SEDIMENT CONTROL PLAN

As described in Chapter 7 *Construction BMPs* of Volume 3 of the MHFD Manual, there are four components to effective management of stormwater discharges from construction sites: erosion control, sediment control, materials management, and site management. The Erosion and Sediment Control Plan shall encompass all four aspects and include a narrative portion describing the construction activities to occur on the site, as well as a site map/drawing with all elements of drainage and erosion and sediment control indicated. A completed Erosion and Sediment Control Plan Checklist (Appendix C) shall be submitted with each ESCP submittal.

General Information and Site Description

Construction best management practices (BMPs) must be designed and implemented in response to the specific character of the site and the construction activity taking place on it. The erosion control narrative shall include a description of the nature and type of construction activity that will take place on the site as well as the proposed schedule and sequencing. Control measures shall be chosen to address potential pollutant discharges at each phase. This information should be provided in a table format, a template for which is provided in Appendix D of the Standards.

Describe characteristics influencing the erodibility of the site, including soil types, slope, and ground cover. The Revised Universal Soil Loss Equation is a tool that may be helpful in assessing the potential for erosion on a site, and more detail regarding the method and its application can be found in the *Construction BMPs* chapter of the MHFD Manual. Include any stream crossings located within the construction boundary. Measure the distance between construction activity and sensitive areas. Describe areas that may receive discharge from the site as well as areas that might receive discharge onto the site. Include a table with calculations that includes an estimate of the total acreage, the acreage that is expected to be disturbed, and percent of existing vegetation ground cover relative to the entire site. Include the method used to determine vegetative cover. Measure the *maximum unsheltered distance* for the project. An example table with possible details and calculations is included in Appendix D.

Types of Development in the County Requiring Drainage Planning*

New Development: Any construction activity or site alteration on a site that has not been previously developed.

Minor Expansion: Any development activity that includes the following: 1) Expansion of a mixed use-building by more than 2,000 square feet of non-residential space or the lesser of more than 10 dwelling units or 10% of the number of dwelling units; or 2) Expansion of a non-residential building by the greater of either 2,000 square feet or more than 20% of the total square footage of the building.

Change of Use: Any change of use that involves or requires on-site or off-site improvements, including but not limited to parking; landscaping, screening, or buffering; drainage facilities; outdoor uses on the lot, including sales, display, and storage.

Major Redevelopment: Any development activity on a mixed-use or non-residential site that involves change to 75 percent or more of the square footage of a primary structure. Major redevelopment shall be measured cumulatively over a rolling five-year period in the same ownership, starting with the applicant's most recent development application.

*All of these types of developments are collectively referred to as "**Projects**" throughout these Standards

Construction Stormwater Management Controls for Potential Pollutant Sources

To adequately address construction water quality, all potential sources of pollutants resulting from the construction activities must be identified and control measures carefully chosen to address each. Effective management of construction stormwater encompasses practices aimed at controlling erosion, capturing sediment, managing materials, and implementing construction site procedures designed to prevent pollutant discharges from leaving the site. Table 1, taken from the MHFD Manual, provides an overview of control measures and the component of construction stormwater management to which each applies. The MS4 General Permit requires that, at a minimum, any discharges associated with the following activities must be addressed:

1. Land disturbance and storage of soils
2. Vehicle tracking
3. Loading and unloading operations
4. Outdoor storage of construction site materials, building materials, fertilizers, and chemicals
5. Bulk storage of materials
6. Vehicle and equipment maintenance and fueling
7. Significant dust or particulate generating processes
8. Routine maintenance activities involving fertilizers, pesticides, detergents, fuels, solvents, and oils
9. Concrete truck/equipment washing, including the concrete truck chute and associated fixtures and equipment
10. Dedicated asphalt and concrete batch plants
11. Other areas or operations where spills can occur
12. 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.

The above information should be presented in a table of potential pollutant sources that indicates whether each is present on the site and the control measure used to address each source. An example table is included in Appendix D – Standard Forms.

For each control measure identified, the ESCP shall include any specifications for its design, implementation, and maintenance. Fact sheets corresponding to standard construction BMPs are provided in Chapter 7 *Construction BMPs* in Volume 3 of the MHFD manual. Copies of the fact sheets have been included in Appendices G – J of the Standards, and the relevant sheet(s) may be included with the ESCP submittal.

Table 1. Overview of Construction BMPs (from MHFD Manual, Volume 3)

Functions	Erosion Control	Sediment Control	Site/Material Management
Erosion Control BMPs			
Surface Roughening	Yes	No	No
Temporary/Permanent Seeding	Yes	No	No
Soil Binders	Yes	No	Moderate
Mulching	Yes	Moderate	No
Compost Blankets and Filter Berms	Yes	Moderate	No
Rolled Erosion Control Products	Yes	No	No
Temporary Slope Drains	Yes	No	No
Temporary Outlet Protection	Yes	Moderate	No
Rough Cut Street Control	Yes	Moderate	No
Earth Dikes / Drainage Swales	Yes	Moderate	No
Terracing	Yes	Moderate	No
Check Dams	Yes	Moderate	No
Streambank Stabilization	Yes	No	No
Wind Erosion / Dust Control	Yes	No	Moderate
Sediment Control BMPs			
Silt Fence	No	Yes	No
Sediment Control Log	Moderate	Yes	No
Straw Bale Barrier	No	Moderate	No
Brush Barrier	Moderate	Moderate	No
Rock Sock (perimeter control)	No	Yes	No
Inlet Protection (various forms)	No	Yes	No
Sediment Basins	No	Yes	No
Sediment Traps	No	Yes	No
Vegetative Buffers	Moderate	Yes	Yes
Chemical Treatment	Moderate	Yes	No
Materials Management			
Concrete Washout Area	No	No	Yes
Stockpile Management	Yes	Yes	Yes
Good Houskeeping (multiple practices)	No	No	Yes
Site Management and Other Specific Practices			
Construction Phasing	Moderate	Moderate	Yes
Protection of Existing Vegetation	Yes	Moderate	Yes
Construction Fence	No	No	Yes
Vehicle Tracking Control	Moderate	Yes	Yes
Stabilized Construction Roadway	Yes	Moderate	Yes
Stabilized Staging Area	Yes	Moderate	Yes
Street Sweeping / Vacuuming	No	Yes	Yes
Temporary Diversion Channel	Yes	No	No
Dewatering Operations	Moderate	Yes	Yes
Temporary Stream Crossing	Yes	Yes	No
Temporary Batch Plants	No	No	Yes
Paving and Grinding Operations	No	No	Yes

Inspection and Maintenance

The County requires that routine site inspections be conducted by the permittee every 7 days or every 14 days when inspections also occur within 24 hours of storm or snowmelt events that cause surface erosion, per the State Construction Stormwater permit requirements. Inspections shall confirm that all control measures are functioning as designed and make note of any maintenance requirements. The County shall inspect all sites within the MS4 every 45 days. For other projects, the County shall inspect the site with a frequency appropriate for the type of project and potential for erosion.

The County also requires an inspection and maintenance plan that includes the following:

1. Designated person responsible for performing inspections of the site and all control measures
2. Inspection frequency
3. Maintenance activities required and frequency

Final Stabilization and Long-term Stormwater Management

Describe all practices used to achieve final stabilization of the Project location. A site will not be considered to have achieved final stabilization until the vegetation density of all disturbed areas reaches at least 70% of pre-construction density. Please refer to the State's "Guidance for Achieving Final Stabilization" document prepared to assist applicants in meeting the final stabilization requirements of the Construction Stormwater permit. This document may be found on the CDPHE website under "WQ construction compliance assistance and guidance". Include a description of structural post-construction or permanent control measure practices to manage stormwater runoff once construction activities have been completed.

Seeding and Vegetation

Re-establishing vegetation communities is a critical step in the final stabilization of a site. Chapter 17.0 of the Standards, *Revegetation*, provides guidance for site preparation, plant selection and installation, and maintenance of replanted areas following a disturbance and should be consulted for revegetation of construction sites in the County. A revegetation plan must be submitted as part of the ESCP.

Plan Map/Drawings

The Erosion and Sediment Control Plan shall include a map/drawing of the construction site with all the following components included. Standard symbols shall be used on each plan sheet and are included in Appendix E. The following list has been adapted from the State Construction Stormwater permit SWMP Site Map requirements.

1. Construction site boundaries
2. All areas of ground surface disturbance shown, including areas of borrow and fill
3. Flow arrows depicting stormwater flow directions on-site and runoff direction

4. Areas used for soil storage indicated
5. Locations of all waste accumulation areas, including areas for liquid, concrete, masonry, and asphalt
6. Locations of dedicated asphalt, concrete batch plants, and masonry mixing stations
7. Locations of all structural controls, sediment basins, and vehicle tracking controls
8. Location of all non-structural control measures
9. Locations of all springs, streams, wetlands, and other state waters
10. Locations of all stream crossings located within the construction site boundary

Standard Notes

Appendix F includes standard notes that shall be included in every ESCP submittal.

Erosion Control Escrow

The County requires an erosion control escrow be provided before construction will be approved. Construction of the erosion control measures shown on the approved ESCP shall not begin without the developer submitting proof of deposit of security to ensure control measures are constructed as planned and any disturbed land is rehabilitated. An irrevocable letter of credit, or cash escrow, acceptable to the County, and naming the County as the protected party, is required. The developer is encouraged to contact the County early in the planning process for escrow amounts and calculation methods.

A table showing the escrow calculation shall be submitted with the ESCP. The table should include the control measures to be used, the units of measure, the number of units, and the planned cost per unit. For the approved revegetation plan, the number of acres to be reseeded should be indicated, as well as per acre costs for implementing the revegetation plan (i.e., costs for seed, mulch, amendments, etc.). The erosion control escrow may be applied in phases where appropriate, with release of funds granted as each phase is completed and the County has determined that the required control measures have been implemented and maintained as described in the ESCP. In such cases, a map showing the planned phasing must be included.

Should the provisions of the approved ESCP not be complied with, the County may call the security. In these cases, the County may administer the construction of the measures shown on the erosion control plans. The County reserves the right to enter upon the land to have the measures constructed and make repairs as necessary.

Such bond, cash escrow, or irrevocable letter of credit shall further guarantee the continued maintenance and replacement of the measures for a period of one year after installation of structural measures and two years after installation of vegetative measures. Any cash escrow or irrevocable letter of credit shall be released upon certification by the County that the required measures have been completed and maintained in accordance with the ESCP.

ENFORCEMENT

Enforcement of the ESCP shall follow the procedures outlined in Section 1.9 of LCLUC.

REFERENCES

City of Fort Collins, 2018. *Fort Collins Stormwater Criteria Manual*.

Larimer County, 2021. *Larimer County Land Disturbance Permit Checklist*.

Larimer County, 2021. *Larimer County Urban Area Street Standards*.

Mile High Flood District, 2010. *Urban Storm Drainage Criteria Manual, Volume 3: Stormwater Best Management Practices*.

APPENDIX C

CONSTRUCTION STORMWATER MANAGEMENT
EROSION & SEDIMENT CONTROL PLAN CHECKLIST

EROSION AND SEDIMENT CONTROL PLAN CHECKLIST

PROJECT INFORMATION				
1. Project Name/Applicant Name:		2. Prepared by:		
3. Location/Address:				
4. Submittal Date:	(1)	(2)	(3)	(4)
5. Submitted by:	Firm:			
	Contact (name and email):			
	Phone:			

ITEM	Submittee to complete: Included (I), not included (NI), or not applicable (N/A)	Reviewer to complete: I, NI, or N/A
EROSION CONTROL NARRATIVE		
I. General Information and Site Description		
Describe general nature and type of construction activity.		
Provide a proposed schedule and sequence for major construction activities and the planned implementation of control measures for each phase		
Estimate the total acreage of the site and the acreage expected to be disturbed by clearing, excavation, grading, and any other construction activities		
Indicate soil types on the site and the potential for soil erosion		
Describe the percent of existing vegetative ground cover relative to the entire site and the method for determining the percentage		
Describe any areas receiving discharge from the site.		
Describe any stream crossings located within the construction site boundary		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
II. Control Measure Requirements		
Describe all potential pollution sources, including surface disturbing activities, vehicle fueling areas, fertilizer or chemical storage, concrete truck washouts, etc.		
Discuss control measures selected to address each potential source of pollution		
Describe design specifications and implementation procedures for all control measures		
III. Inspection and Maintenance		
Describe inspection frequency and maintenance practices		
IV. Final Stabilization and Long-Term Stormwater Management		
Describe the practices that will be used to achieve final stabilization of the site		
Describe any structural post-construction or permanent control measures that will be used to manage stormwater runoff once construction is complete		
V. References		
Criteria and technical information used		
VI. Appendices		
A. Construction phase and control measure implementation sequencing chart		
B. Calculations worksheet		
C. Table of potential pollution sources and control measures to be implemented to address each		
D. Fact sheets describing all structural and non-structural control measures to be used		
E. Revegetation plan		
EROSION CONTROL PLAN		
VII. Plan Maps/Drawings		
Construction site boundaries		
All areas of ground surface disturbance on the site including areas of borrow and fill		
Flow arrows that depict stormwater flow directions on-site and runoff direction		
Areas used for storage of soil		
Locations of all waste accumulation areas, including areas for liquid, concrete, masonry, and asphalt		
Locations of dedicated asphalt, concrete batch plants, and masonry mixing stations		
Locations of all structural controls, sediment basins, and vehicle tracking controls		

ITEM	Submittee to complete: I, NI, or N/A	Reviewer to complete: I, NI, or N/A
Location of all non-structural control measures		
Locations of all springs, streams, wetlands, and other state waters		
Locations of all stream crossings located within the construction site boundary		
County Reviewer Comments:		

Does the ESCP submittal meet the requirements of County regulations? ____

ESCP submittal initial review on: ____

Date of final acceptance the ESCP submittal: ____

Reviewer's Name: ____

Reviewer's Signature (to be signed upon final review and acceptance):

____

Note: The Larimer County Engineering Department has reviewed the Construction Erosion and Sediment Control Plan (ESCP) for local-level purposes, including conformance with Larimer County Land Use Code (LUC) pertaining to erosion and sediment control. Importantly, the ESCP was not reviewed for conformance with the Colorado Discharge Permit System (CDPS) general permit for *Stormwater Discharges Associated with Construction Activities* (state stormwater discharge permit); therefore, Larimer County's review does not ensure compliance with the state stormwater discharge permit or the required SWMP contents. Additional control measures may be requested in the field if the reviewed control measures are not adequate for field conditions.

APPENDIX D

STANDARD FORMS FOR CONSTRUCTION STORMWATER MANAGEMENT

Standard Form 1. Sequencing

BMPs Employed	Initial clearing and grading (i.e., mobilization, demolition, grading)			Utility, infrastructure, and building construction (i.e., utilities installation, flat work installation, vertical installation)			Final stabilization (i.e., landscape, demobilization)		
Non-structural	Phase I	Phase II	Phase III	Phase IV	Phase V	Phase VI	Phase VII	Phase VIII	Phase IX
Structural									
Vegetative									

Standard Form 2. Calculations Chart

Project Details and Calculations	Value	Units
Total acreage of the site		
Total acreage to be disturbed		
Total "onsite" area of disturbance		Sq ft or acres
Total "offsite" area of disturbance		Sq ft or acres
Total storage/staging areas not incorporated into onsite and offsite calculations		Sq ft or acres
Total area of new or improved haul roads (offsite)		
Heavy construction vehicle traffic areas offsite		
Approximate percent of the project that will be disturbed at any one time		
Percent of existing vegetative ground cover relative to the entire site		
Existing soil type		
Depth to groundwater (data taken during high groundwater months)		Ft
Number of project phases		Phases
Total volume of material imported to (+), or exported from (-), the project		Cubic yards
Total area of offsite stockpiling of fill from the project or borrow from stripping the offsite area		Sq ft or acres
Steepest slope (H:V)		
Distance from wetland areas of one acre or less (50 ft minimum buffer per section 4.4.2.I. of LCLUC)		Ft
Distance from wetland areas of more than one acre or Class 3 and 4 wetlands of any size (100 ft minimum buffer per section 4.4.2.I. of LCLUC)		Ft

Distance from riparian areas (100 ft minimum per section 2.9.4.F. of LCLUC)		Ft
Distance from sensitive areas (i.e., raptor/eagle nests, etc.)		Ft

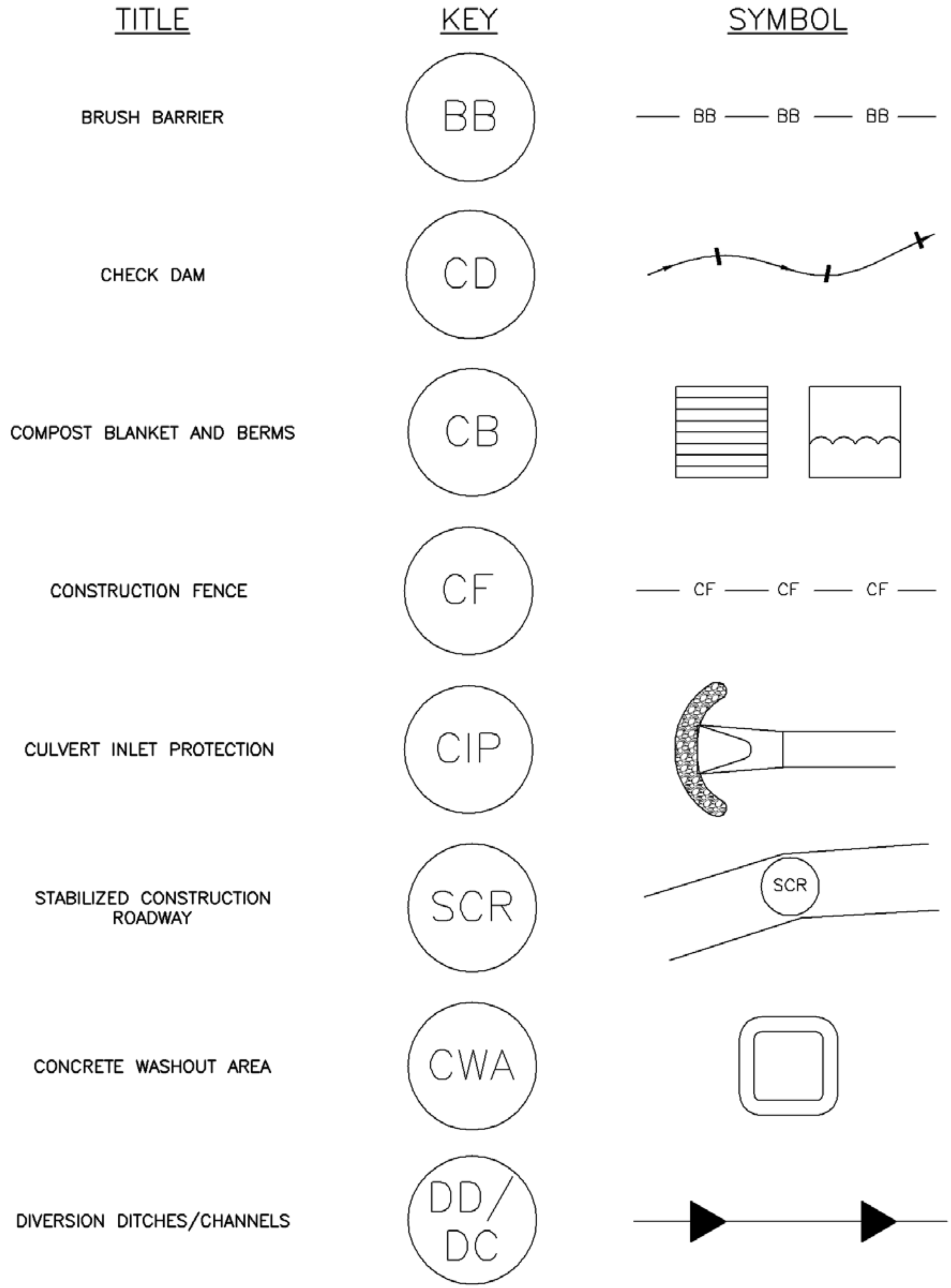
Standard Form 3. Potential Pollutants

Pollutant Sources	Present (Y/N)	Control Measure
Land disturbance and storage of soils		
Vehicle tracking		
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		
Concrete truck/equipment washing, including the concrete truck chute and associated fixtures and equipment. Note there must be adequate buffering capacity for excavated washouts.		
Dedicated asphalt and concrete batch plants and masonry mixing stations		
Other areas or operations where potential spills can occur		
Other non-stormwater discharges including construction dewatering not covered under the Construction Dewatering Discharges general permit and wash water that may contribute pollutants		

APPENDIX E

CONSTRUCTION PLAN SYMBOLS

Construction BMP Plan Symbols



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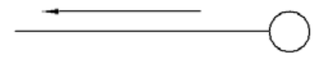
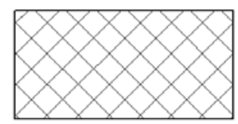
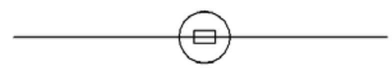
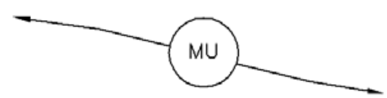
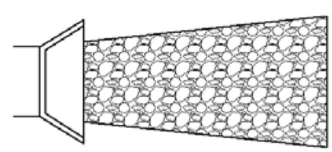
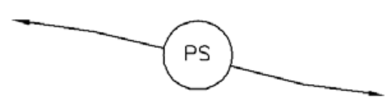
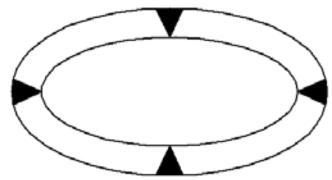
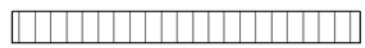
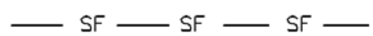
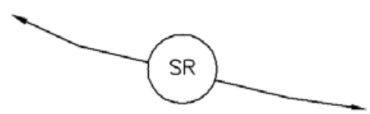
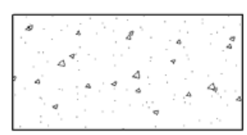
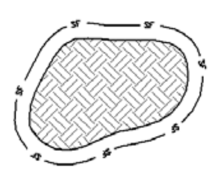
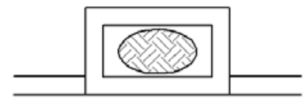
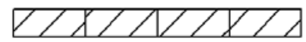
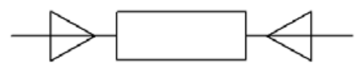
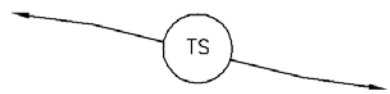
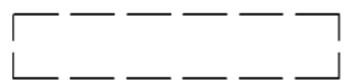
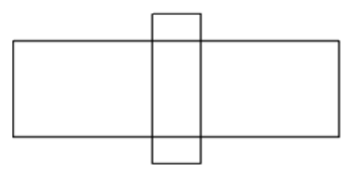
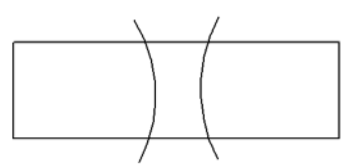
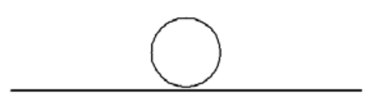
DEWATERING OPERATIONS	DW	
EARTH DIKES AND DRAINAGE SWALES	ED/ DS	
EROSION CONTROL BLANKET	ECB TRM	
INLET PROTECTION	IP	
MULCHING	MU	
OUTLET PROTECTION	OP	
PERMANENT SEEDING	PS	
REINFORCED CHECK DAM	RCD	

Construction BMP Plan Symbols

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	

TITLE	KEY	SYMBOL
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	

LARIMER COUNTY

APPENDIX F

STANDARD NOTES

Construction Stormwater Control Standard Notes

The following standard notes for erosion control on construction sites must be included in each ESCP prepared for the County. The list is not exhaustive but represents the minimum requirements for addressing stormwater quality management on construction sites in the County. Additional notes addressing project specific conditions may be added.

General erosion control requirements

1. The property owner, owner's representative, developer, design engineer, general contractor, sub-contractors, or similar title for the developing entity (hereafter referred to as the Developer) has provided these erosion control materials in accordance with the erosion control criteria set forth in the Standards as an attempt to identify erosion, sediment, and other potential pollutant sources associated with these construction activities and to prevent those pollutants from leaving the project site as an illicit discharge.
2. The Developer shall make themselves thoroughly familiar with the provisions and the content of the specifications laid out in the Standards, 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 County 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 the County 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, maintained, 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 to, or different from, 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 County Erosion Control Inspector. The Developer shall ensure that all Erosion and Sediment 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 County.

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 commencement of the relevant activity. These permits or copies shall be made available upon request by the County.
11. The Developer shall furnish all conveniences and assistances to aid the Erosion Control Inspector's review of materials, workmanship, records, and self-inspections, etc., of the control measures in use at the construction site.
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 Standards.
14. The County 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 Standards.
16. Inspection: The Developer 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 Developer.
17. All temporary control measures shall be cleaned, repaired, or reconstructed as necessary 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 drainageway.

18. Any control measure may be substituted for another standard control measure so long as that control measure provides protection that is equal to or greater than the original control measure that was to be used in that location (e.g., silt fence for wattles or for compact berms). Wattles alone on commercial construction sites have shown to be an ineffective substitute for silt fence or compact berms unless accompanied by a construction fence to prevent vehicle traffic.
19. Any implementation or replacement of existing control measures with a non-standard control, or alternative control measure, shall require the review and acceptance of the County erosion control staff before the measure will be allowed to be used on this project. The control measure details shall be submitted, reviewed, and accepted as in conformance with the County's erosion control criteria based upon the functionality and effectiveness of the control measure 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 County. Disturbances beyond these limits shall 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 or by limiting grading to small areas. When practical, this should also include 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. All stockpiles shall be flattened to meet grade or removed from the site as soon as practical and no later than the completion of construction activities or abandonment of the project. 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 and sediment control plan.

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 have the ability to be tracked onto the nearby hardscape shall have some form of effective sediment control as, or as part of, the perimeter control.
29. All exposed slopes should be protected. All exposed steep slopes (steeper than 3H:1V) 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 County 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.

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.), the Developer shall have installed at least one structural tracking control measure to prevent vehicle tracking. All areas not protected by 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 where 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 protected from the introduction of sediment into the drainage system.
34. If repeated deposit of material occurs on a site, additional structural tracking controls may be required of the Developer by the County Erosion Control Inspector.

Loading and unloading operations

35. The Developer shall apply control measures to limit traffic impacts (site worker or public) and proactively locate material delivered to the site in close proximity to the work area or immediately incorporate materials into construction to limit operational impacts to disturbed areas, vehicle tracking, and sediment deposition that could impact water quality.
36. Any materials of a non-polluting nature (steel, rock, brick, lumber, etc.) shall be routinely inspected for any residue coming off the material and will generally be located at least fifty (50) feet from any permanent or interim drainageways, where practical.
37. Any pollutant with potential for significant environmental impact that is highly likely 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 off-site storage is not practical, pollutants should be stored inside (vehicle, trailer, conex, building, etc.) and out of contact with stormwater or stormwater runoff. Where interior storage is not available, pollutants shall be stored outside in a raised (high spots or on pallets), covered (plastic or tarped), and sealed (leak proof) secondary containment location. The secondary containment or other control measure shall be adequately sized, located at least fifty (50) feet from any permanent or interim stormwater structures or drainageways (where practical), and monitored as part of the routine inspections.

Vehicle and equipment maintenance and fueling

38. Parking, refueling, and maintenance of vehicles and equipment should be limited to 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 drainageways and shall be monitored as part of the routine inspections. All areas shall keep spill kits and supplies close.

Concrete truck/equipment washing, including the concrete truck chute and associated fixtures and equipment

39. 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 drainageways and shall be monitored as part of the routine inspections. These areas shall be clearly identified, and any wash prevented 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.
40. 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 onto the dirt or in other uncontrolled locations.

Dedicated asphalt and concrete batch plants

41. Dedicated asphalt and concrete batch plants are not acceptable on construction sites within the County without an expressed written request, plan to reduce pollutants associated with that type of activity, and approval by the County's Erosion Control Inspector. The Developer shall inform the erosion control inspection staff of any dedicated asphalt or concrete batch plant that is to be used on site.

Waste materials storage and sanitary facilities

42. 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 drainageways and shall be monitored as part of the routine inspections. These facilities shall be located out of the wind and covered as able. Where not able to cover, locate 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.
43. 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 conveyance 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 drainageways.

Other site operations and potential spill areas

44. Spills: For those spills less than 5 gallons that have no potential to impact state waters, notify the County by email at eng-stormwater@larimer.org. For spills 5 gallons or greater or that have the potential to impact state waters or human health, contact the County Health Department (LCDHE) through Larimer County Sheriff Dispatch (970) 416-1985. All spills shall be cleaned up immediately.
45. Selection of "plastic welded" erosion control blankets shall not be used in areas where wildlife, such as snakes, are likely to be located as these have proven to cause entrapment issues.

Final stabilization and project completion

46. Any stormwater facilities used as temporary control measures shall be restored and storm sewer lines shall be cleaned upon completion of the project and before turning maintenance over to the owner, Homeowners Association (HOA), or other party responsible for long term maintenance of those facilities.
47. All disturbed areas designed to be vegetated shall be amended, seeded and mulched, or landscaped as specified in the landscape plans within 14 working days of final grading.
48. All seeding shall refer to landscaping plans for species mixture, application rates, and depth requirements.
49. 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 3H:1V 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.

50. All seeded areas must be mulched within twenty-four (24) after planting. All mulch shall be mechanically crimped and/or have an adequately applied tackifier. The use of crimped mulch or tackifier may require multiple re-applications if not properly installed or if weathering or degradation occurs 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.
51. 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.
52. The Developer shall maintain, monitor, repair, and replace 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 the site has been deemed stabilized and verified by the County Erosion Control Inspector, all temporary control measures can be fully removed. 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. All measures shall be removed within 30 days after final stabilization is achieved.
53. 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 measures have been 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.

Other Standard Notes

The following notes are adapted from the LC Urban Area Street Standards and should also be included in the ESCP.

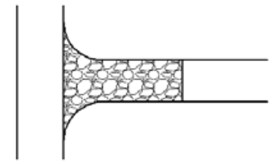
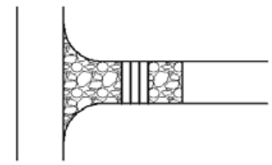
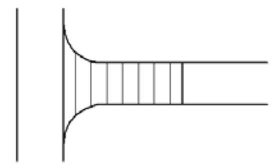
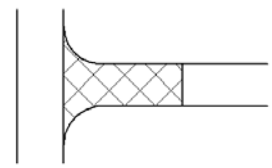
1. All references to any published Standards shall refer to the latest revision of said Standard, unless specifically stated otherwise.
2. The Developer shall comply with all terms and conditions of the Colorado Permit for Storm Water Discharge (Contact Colorado Department of Health, Water Quality Control Division, (303) 692-3517), the Storm Water Management Plan, and the Erosion and Sediment Control Plan.
3. The Local Entity shall not be responsible for the maintenance of storm drainage facilities located on private property. Maintenance of onsite drainage facilities shall be the responsibility of the property owner(s).

4. Prior to final inspection and acceptance by the Local Entity, certification of the drainage facilities, by a registered engineer, must be submitted to and approved by the Stormwater Utility Department. Certification shall be submitted to the Stormwater Utility Department at least two weeks prior to the release of a certificate of occupancy for single family units. For commercial properties, certification shall be submitted to the Stormwater Utility Department at least two weeks prior to the release of any building permits in excess of those allowed prior to certification per the Development Agreement.
5. All recommendations of the final drainage and erosion control study (name of the study and date) by (Engineering Firm) shall be followed and implemented.
6. Temporary erosion control during construction shall be provided as shown on the Erosion and Sediment Control Plan. All erosion control measures shall be maintained in good repair by the Developer, until such time as the entire disturbed area is stabilized with hard surface or landscaping.
7. The Developer shall be responsible for ensuring that no mud or debris shall be tracked onto the existing public street system. Mud and debris must be removed within 24 hours by an appropriate mechanical method (i.e., machine broom sweep, light duty front-end loader, etc.) or as approved by the Local Entity’s street inspector.
8. At all times during construction, the Developer shall be responsible for preventing and controlling on-site erosion including keeping the property sufficiently watered so as to minimize wind-blown sediment. The Developer shall also be responsible for installing and maintaining all erosion control facilities shown herein.
9. The stormwater volume capacity of detention ponds will be restored, and storm sewer lines will be cleaned upon completion of the project and before turning the maintenance over to the Owner or Homeowners Association (HOA).

References

Larimer County, 2021. *Larimer County Urban Area Street Standards*.

Construction BMP Plan Symbols

TITLE	KEY	SYMBOL
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 G

EROSION CONTROL

Contents

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.

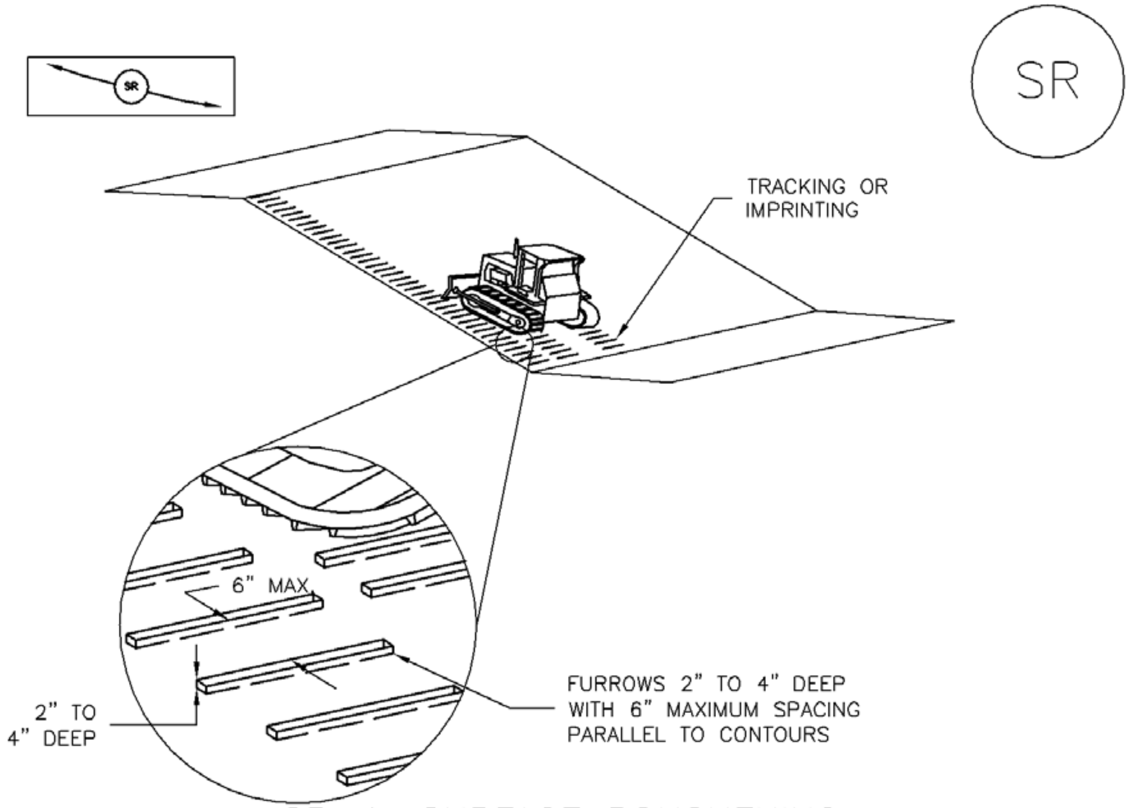
Surface Roughening	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	No

Maintenance and Removal

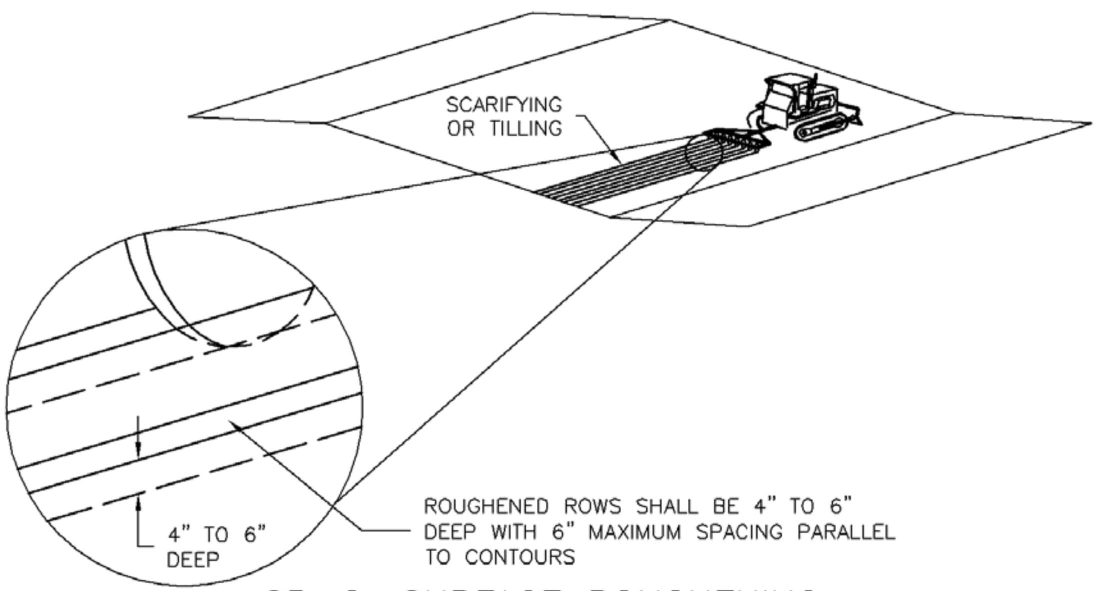
Care should be taken not to drive vehicles or equipment over areas that have been surface roughened. Tire tracks will smooth the roughened surface and may cause runoff to collect into rills and gullies.

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

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

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 preparing a seedbed, selecting an appropriate seed mixture, using proper planting techniques, and protecting the seeded area with mulch, geotextiles, or other appropriate measures.

Appropriate Uses

When the soil surface is disturbed and will remain inactive for an extended period (typically determined by local government requirements), proactive stabilization measures, including planting a temporary seed mix, 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 of up to one year, temporary seeding and mulching can provide effective erosion control. Permanent seeding should be used on finished areas that have not been otherwise stabilized.

The USDCM Volume 2 *Revegetation* Chapter contains suggested annual grains and native seed mixes to use for temporary seeding. Alternatively, local governments may 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, selecting an appropriate seed mixture, using appropriate seeding equipment to ensure proper coverage and density, and protecting seeded areas with mulch or fabric until plants are established.

The USDCM Volume 2 *Revegetation* Chapter contains detailed seed mixes, soil preparation practices, and seeding and mulching recommendations that should 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.

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

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 and compaction, 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 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. If present, at a minimum of 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 upper 12 inches of the surface prior to placing topsoil. If adding compost to the existing soil surface, rototilling is necessary. Surface roughening will assist in placing a stable topsoil layer on steeper slopes, and allow infiltration and root penetration to greater depth. Topsoil should not be placed when either the salvaged topsoil or receiving ground are frozen or snow covered.

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.

Refer to MHFD's Topsoil Management Guidance for detailed information on topsoil assessment, design, and construction.

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. Temporary grain seed mixes suitable for the Denver metropolitan area are listed in Table TS/PS-1. Native temporary seed mixes are provided in USDCM Volume 2, Chapter 13, Appendix A. 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.

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 seed mix tables in the USDCM Volume 2 *Revegetation* Chapter 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. 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.

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 seed mixes 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 (*Salix 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.

Timing of seeding is an important aspect of the revegetation process. For upland and riparian areas on the Colorado Front Range, the suitable timing for seeding is from October through May. The most favorable time to plant non-irrigated areas is during the fall, so that seed can take advantage of winter and spring moisture. Seed should not be planted if the soil is frozen, snow covered, or wet.

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-2 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. Winter wheat	Cool	20–35	1 - 2
7. Winter barley	Cool	20–35	1 - 2
8. Winter rye	Cool	20–35	1 - 2
9. 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-2 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. 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		1,2,3	✓	✓
May 1–May 15			✓	
May 16–June 30	5			
July 1–July 15	5			
July 16–August 31				
September 1–September 30		6, 7, 8, 9		
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 USDCM Volume 2 *Revegetation* Chapter and Volume 3 Mulching BMP Fact Sheet (EC-04) 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.

If a temporary annual seed was planted, the area should be reseeded with the desired perennial mix when there will be no further work in the area. To minimize competition between annual and perennial species, the annual mix needs time to mature and die before seeding the perennial mix. To increase success of the perennial mix, it should be seeded during the appropriate seeding dates the second year after the temporary annual mix was seeded. Alternatively, if this timeline is not feasible, the annual mix seed heads should be removed and then the area seeded with the perennial mix.

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, rock, 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. Consider the following:

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

- Clean, weed-free and seed-free cereal grain straw should be applied evenly at a rate of 2 tons per acre and must be tacked or fastened by a method suitable for the condition of the site. Straw 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.

- Grass hay may be used in place of straw; however, because hay is comprised of the entire plant including seed, mulching with hay may seed the site with non-native grass species which might in turn out-compete the native seed. Alternatively, native species of grass hay may be purchased, but can be difficult to find and are more expensive than straw. Purchasing and utilizing a certified weed-free straw is an easier and less costly mulching method. When using grass hay, follow the same guidelines as for straw (provided above).

- 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.

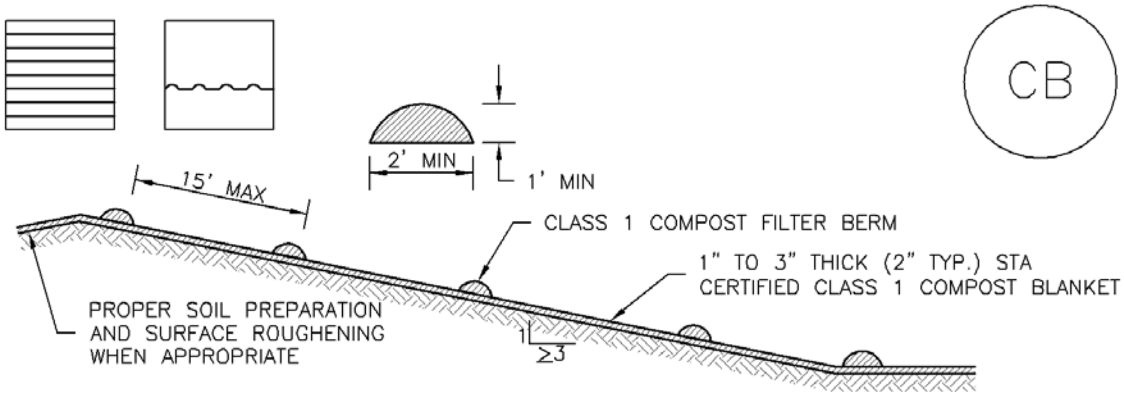


TABLE CB-1. CLASS 1 COMPOST	
PARAMETERS	CHARACTERISTIC
MINIMUM STABILITY INDICATOR	STABLE TO VERY STABLE
SOLUBLE SALTS	MAXIMUM 5 mmhos/cm
PH	6.0 – 8.0
AG INDEX	> 10
MATURITY INDICATOR EXPRESSED AS PERCENTAGE OF GERMINATION/VIGOR	80+/80+
MATURITY INDICATOR EXPRESSED AS AMMONIA N/ NITRATE N RATIO	< 4
MATURITY 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.

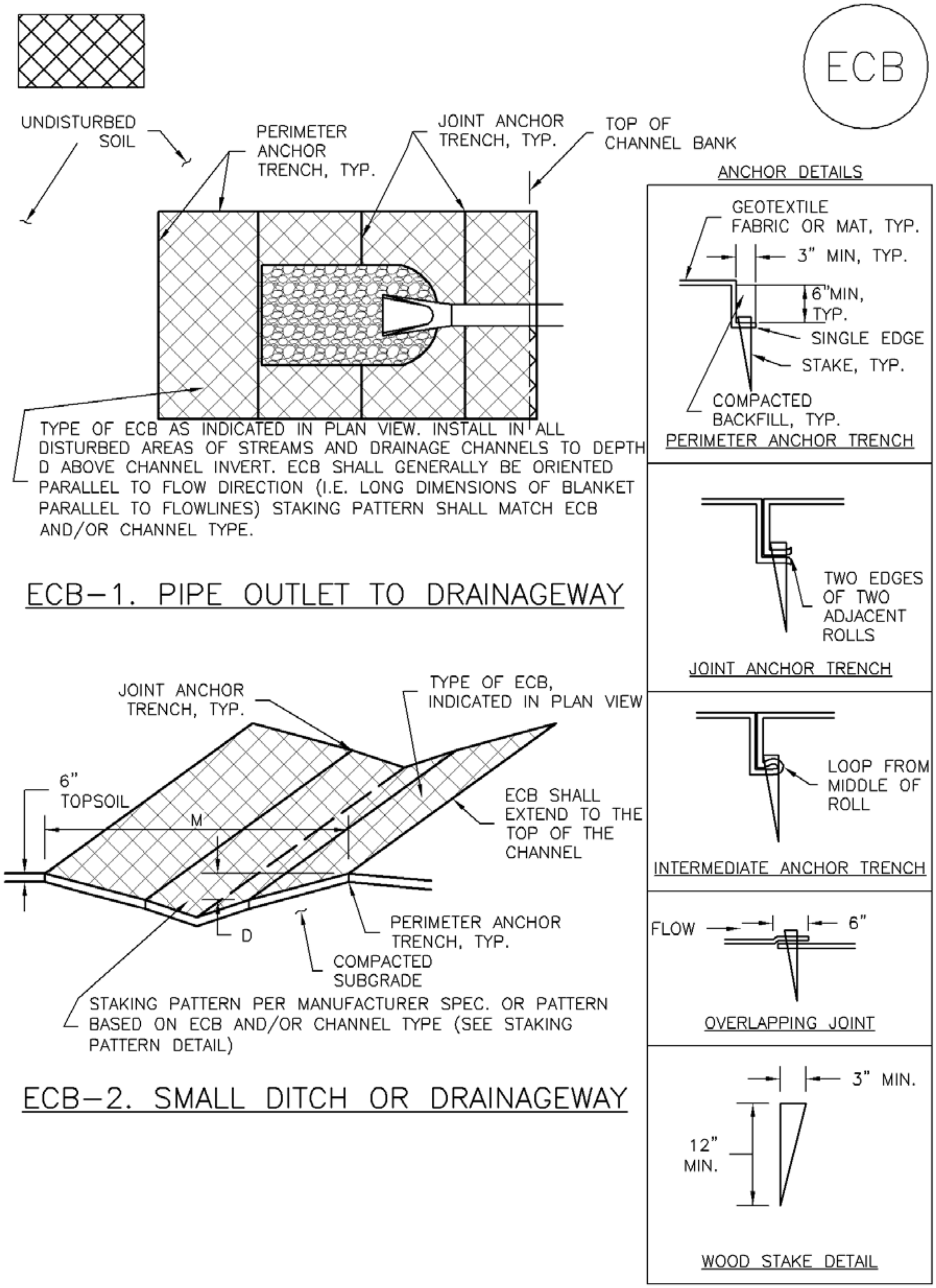
Maintenance and Removal

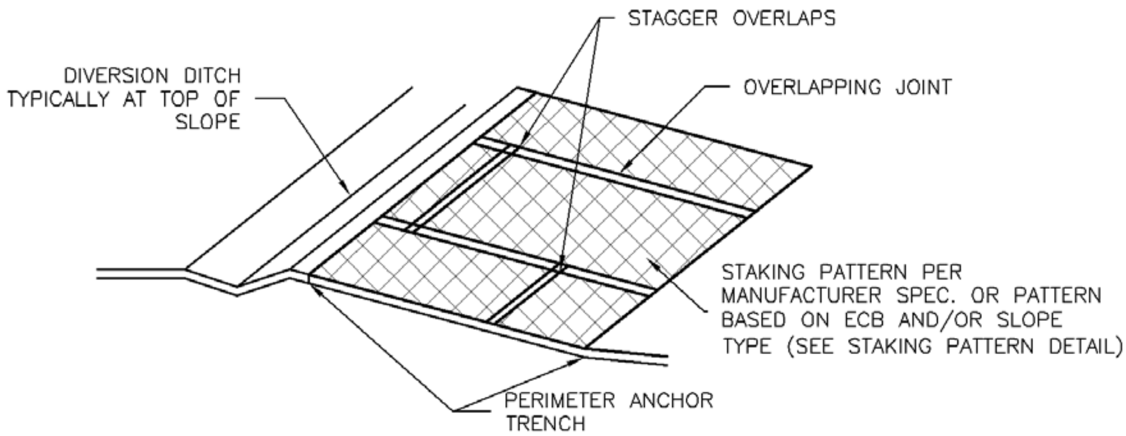
Inspection of erosion control blankets and other RECPs includes:

- 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.

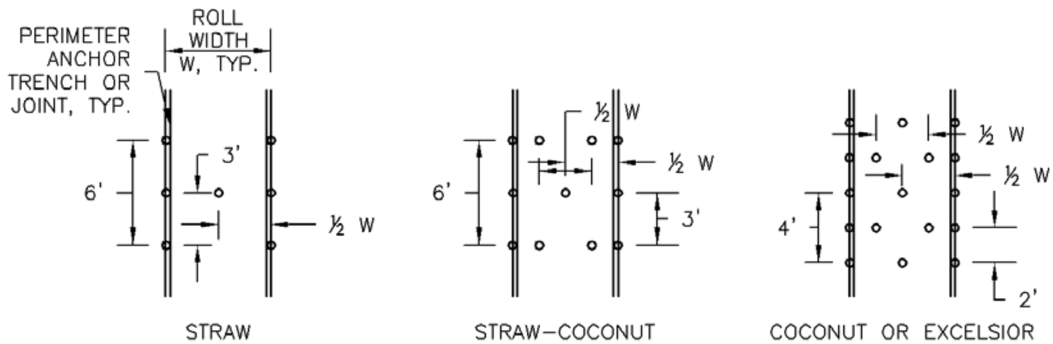
Erosion control blankets and other RECPs that are biodegradable typically do not need to be removed after construction. If they must be removed, then an alternate soil stabilization method should be installed promptly following removal.

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.

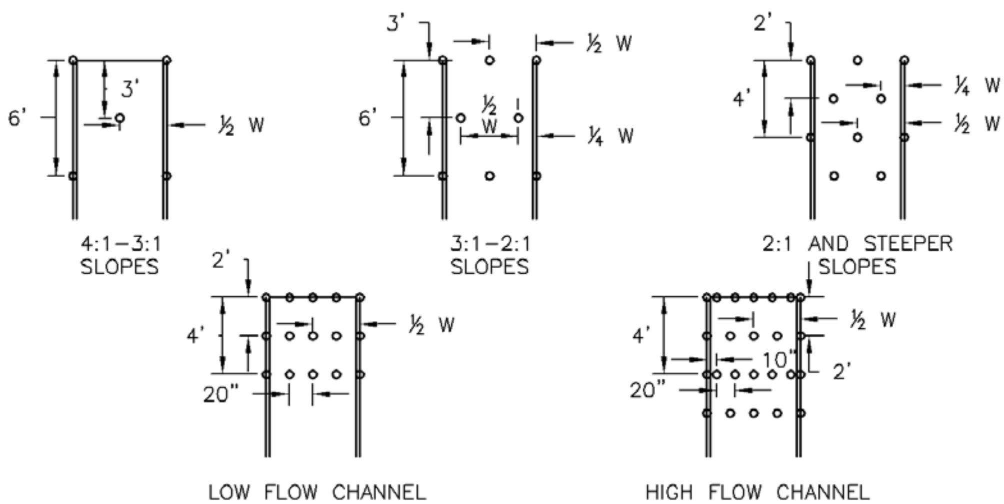

ECB
UNDISTURBED SOIL
PERIMETER ANCHOR TRENCH, TYP.
JOINT ANCHOR TRENCH, TYP.
TOP OF CHANNEL BANK
TYPE OF ECB AS INDICATED IN PLAN VIEW. INSTALL IN ALL DISTURBED AREAS OF STREAMS AND DRAINAGE CHANNELS TO DEPTH D ABOVE CHANNEL INVERT. ECB SHALL GENERALLY BE ORIENTED PARALLEL TO FLOW DIRECTION (I.E. LONG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

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.

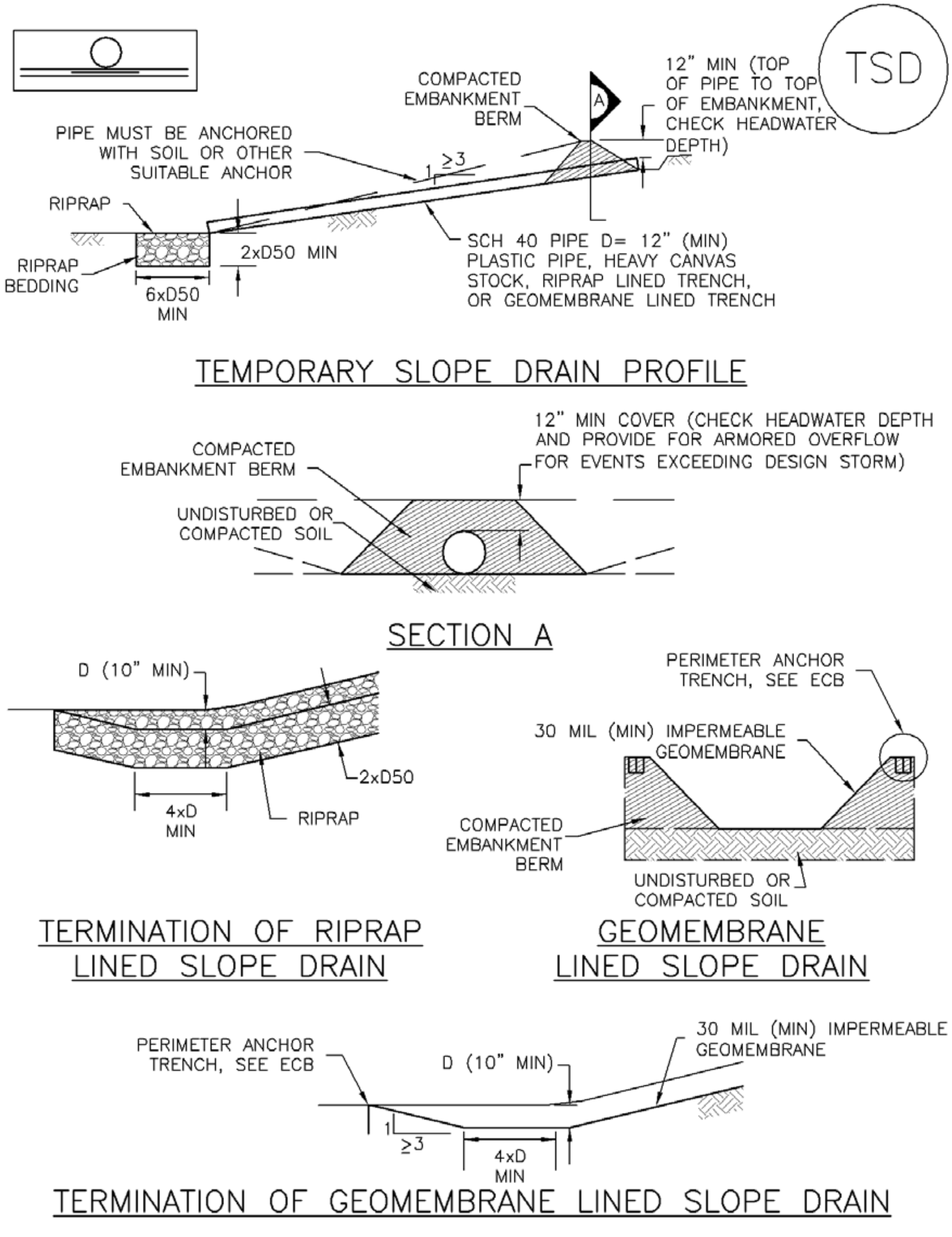
See Detail TSD-1 for additional sizing and design information.

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.

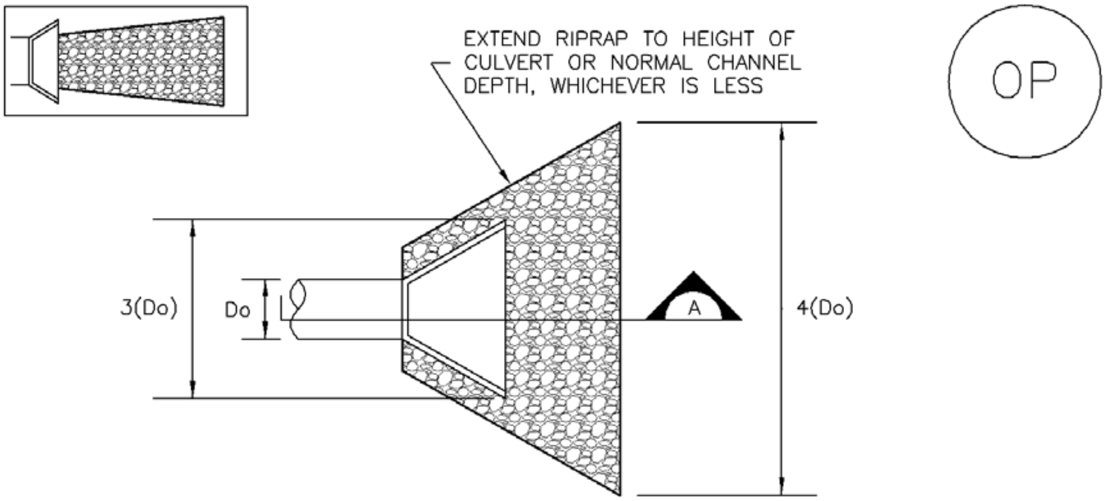
Maintenance and Removal

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.

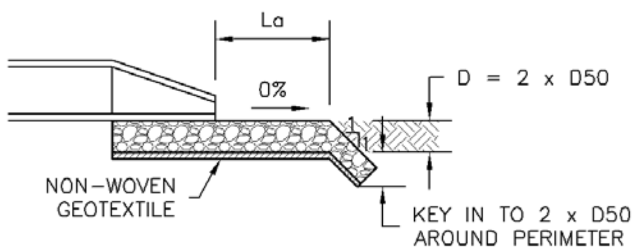
Remove sediment accumulated at the outlet before the outlet protection becomes buried and ineffective. When sediment accumulation is noted, check that upgradient BMPs, including inlet protection, are in effective operating condition.

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 ≤ 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)

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.

Photograph RCS-1. Rough cut street controls.

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.

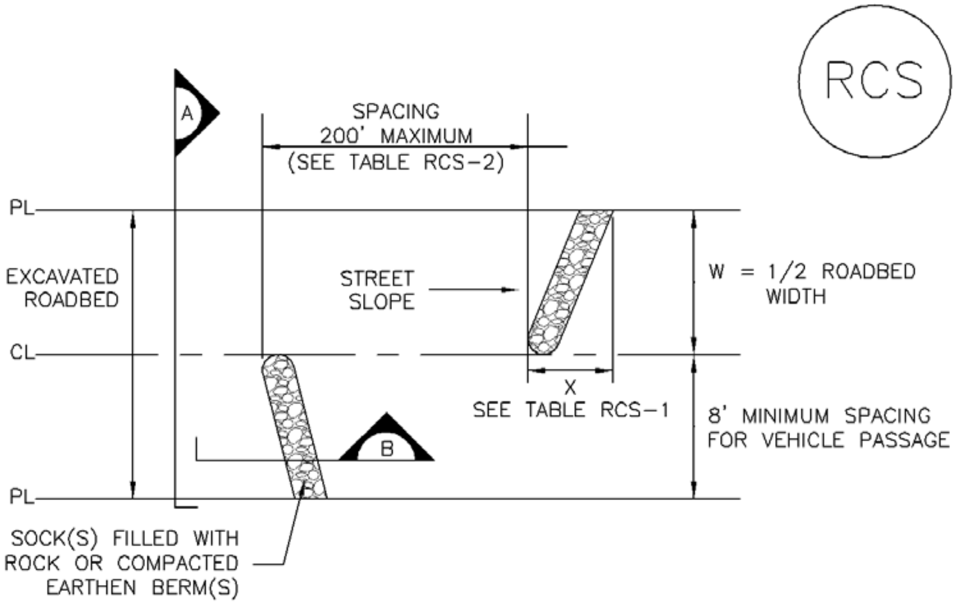
Design and Installation

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.

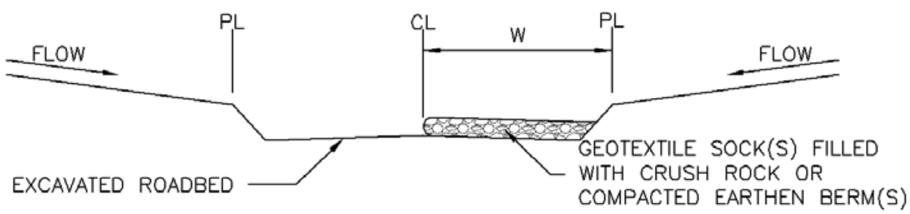
Maintenance and Removal

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



ROUGH CUT STREET CONTROL PLAN



SECTION A

SECTION B

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

ROUGH CUT STREET CONTROL INSTALLATION NOTES

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.

ROUGH CUT STREET CONTROL 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.

(DETAILS ADAPTED FROM 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.

Earth Dikes and Drainage Swales (ED/DS) EC-10

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

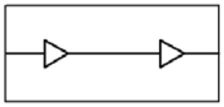
DS-5. Riprap-lined Swale

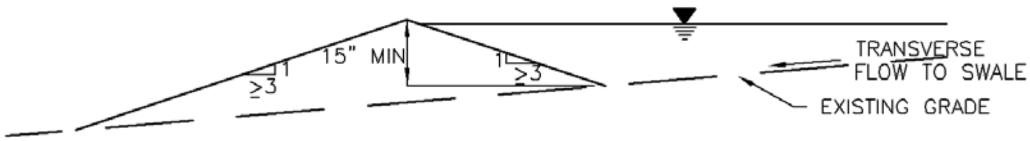
The details also include guidance on permissible velocities for cohesive channels if unlined approaches will be used.

Maintenance and Removal

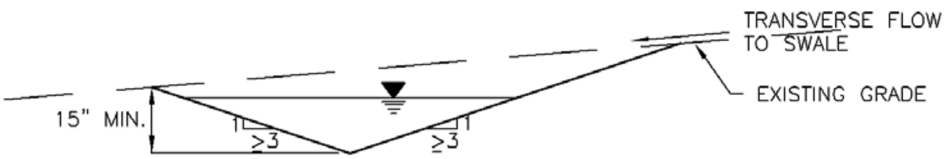
Inspect earth dikes for stability, compaction, and signs of erosion and repair. Inspect side slopes for erosion and damage to erosion control fabric. Stabilize slopes and repair fabric as necessary. If there is reoccurring extensive damage, consider installing rock check dams or lining the channel with 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.

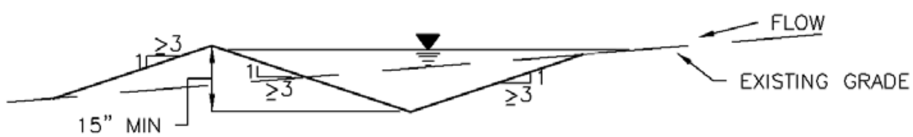




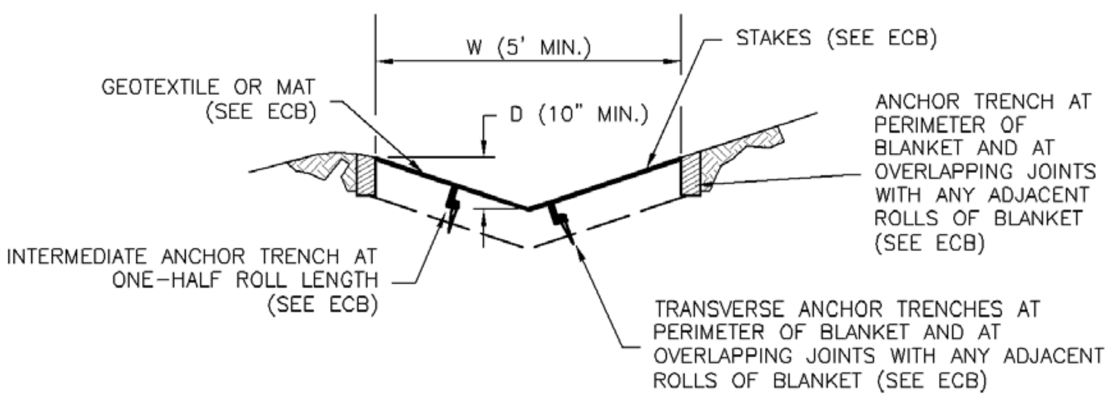
ED-1. COMPACTED UNLINED EARTH DIKE FORMED BY BERM



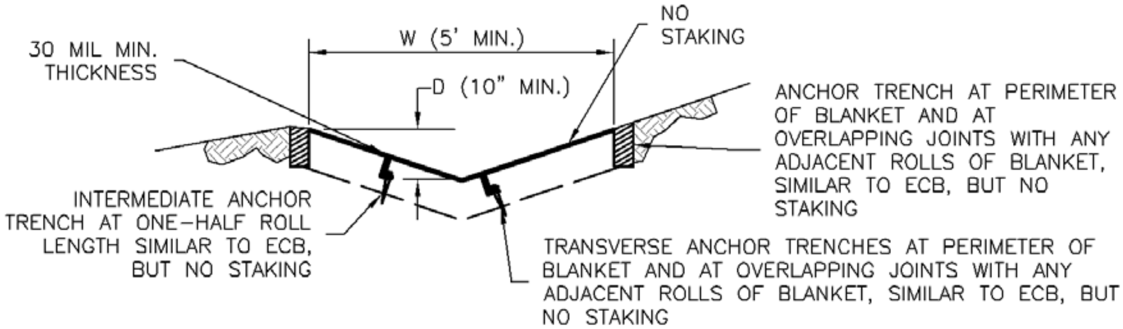
DS-1. COMPACTED UNLINED EXCAVATED SWALE



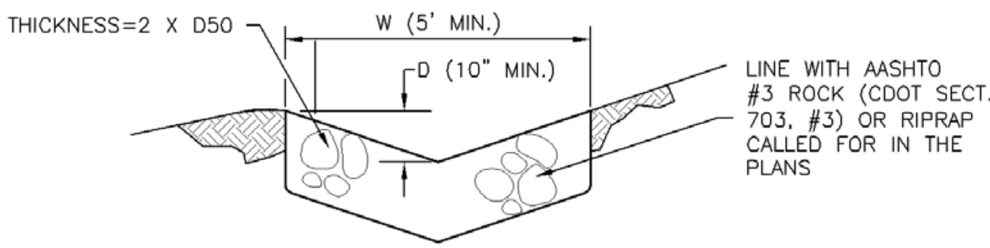
DS-2. COMPACTED UNLINED SWALE FORMED BY CUT AND FILL



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

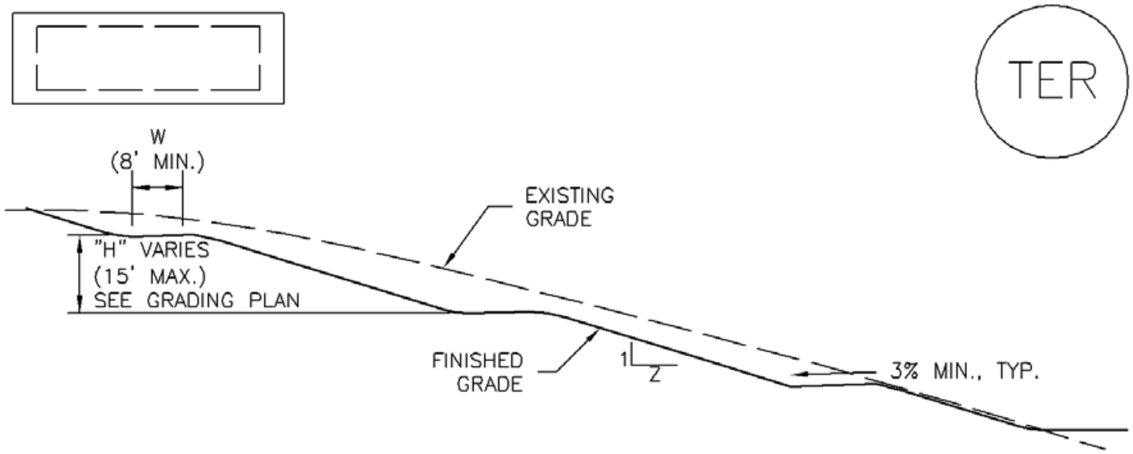
Design details with notes are provided in Detail TER-1.

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

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.

Photograph CD-1. Rock check dams in a roadside ditch. Photo courtesy of WWE.

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)

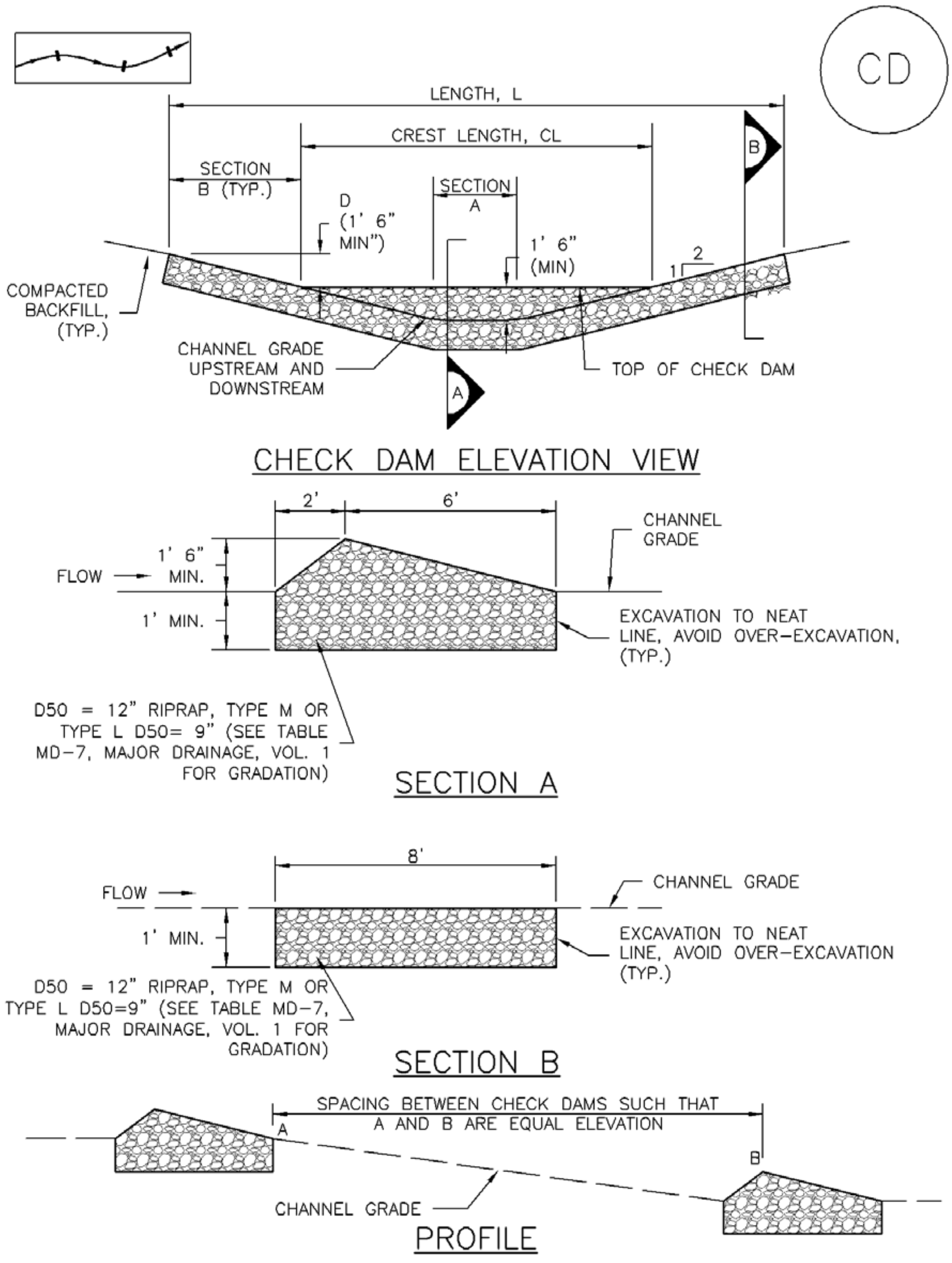
Sediment control logs may also be used as check dams; however, silt fence is not appropriate for use as a check dam. Many jurisdictions also prohibit or discourage use of straw bales for this purpose.

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.

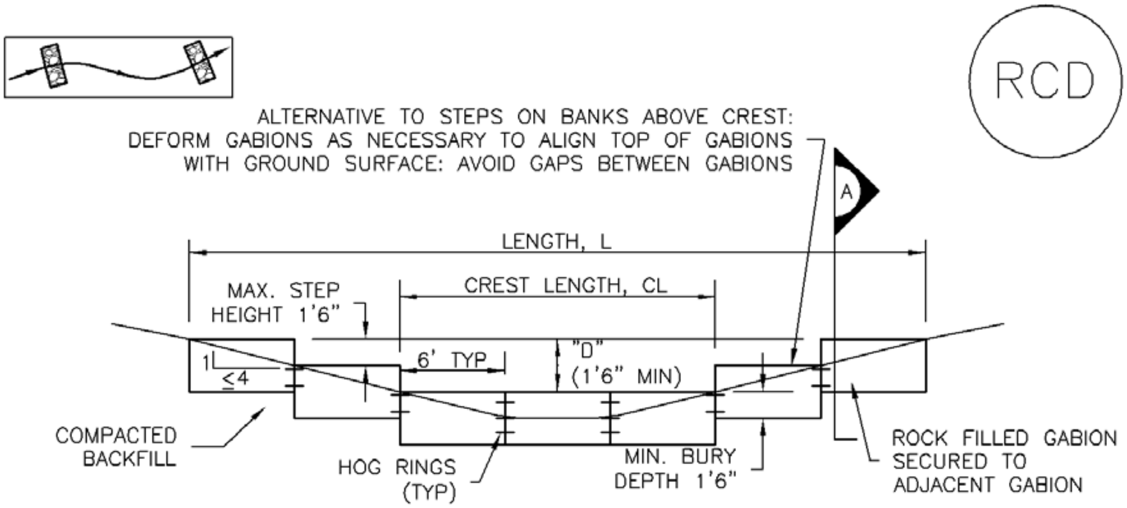
4. SEDIMENT ACCUMULATED UPSTREAM OF THE CHECK DAMS SHALL BE REMOVED WHEN THE SEDIMENT DEPTH IS WITHIN ½ OF THE HEIGHT OF THE CREST.

5. CHECK DAMS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND APPROVED BY THE LOCAL JURISDICTION.

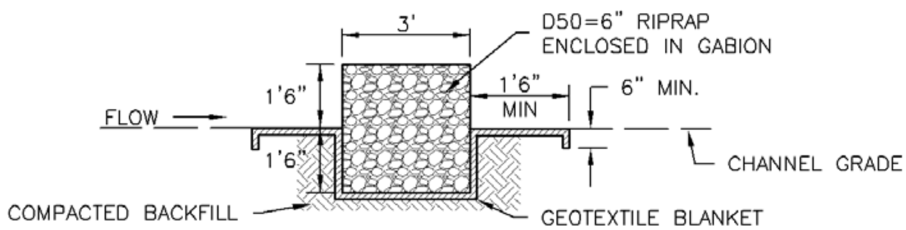
6. WHEN CHECK DAMS ARE REMOVED, EXCAVATIONS SHALL BE FILLED WITH SUITABLE COMPACTED BACKFILL. DISTURBED AREA SHALL BE SEEDED AND MULCHED AND COVERED WITH GEOTEXTILE OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE LOCAL JURISDICTION.

(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

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.

Photograph DC-1. Water truck used for dust suppression. Photo courtesy of Douglas County.

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.

APPENDIX H

SEDIMENT CONTROL

Contents

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.

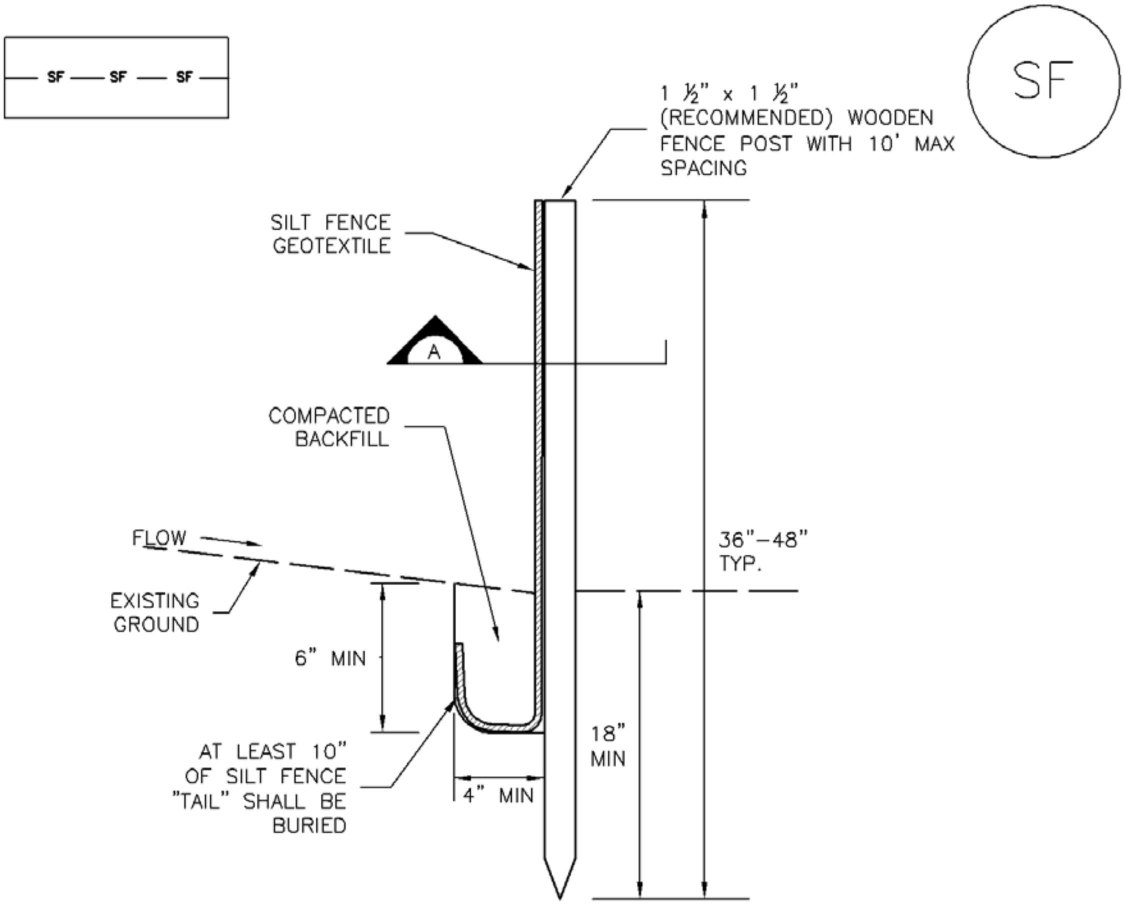
Silt Fence	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No

Maintenance and Removal

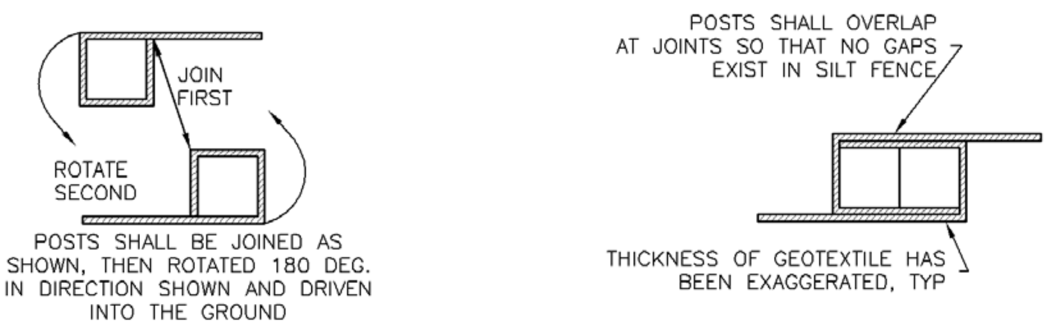
Inspection of silt fence includes observing the material for tears or holes and checking for slumping fence and undercut areas bypassing flows. Repair of silt fence typically involves replacing the damaged section with a new section. Sediment accumulated behind silt fence should be removed, as needed 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.

Description

A sediment control log is a linear roll made of natural materials such as straw, coconut fiber, or compost. The most common type of sediment control log has straw filling and is often referred to as a "straw wattle." All sediment control logs 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 as if they are impermeable.

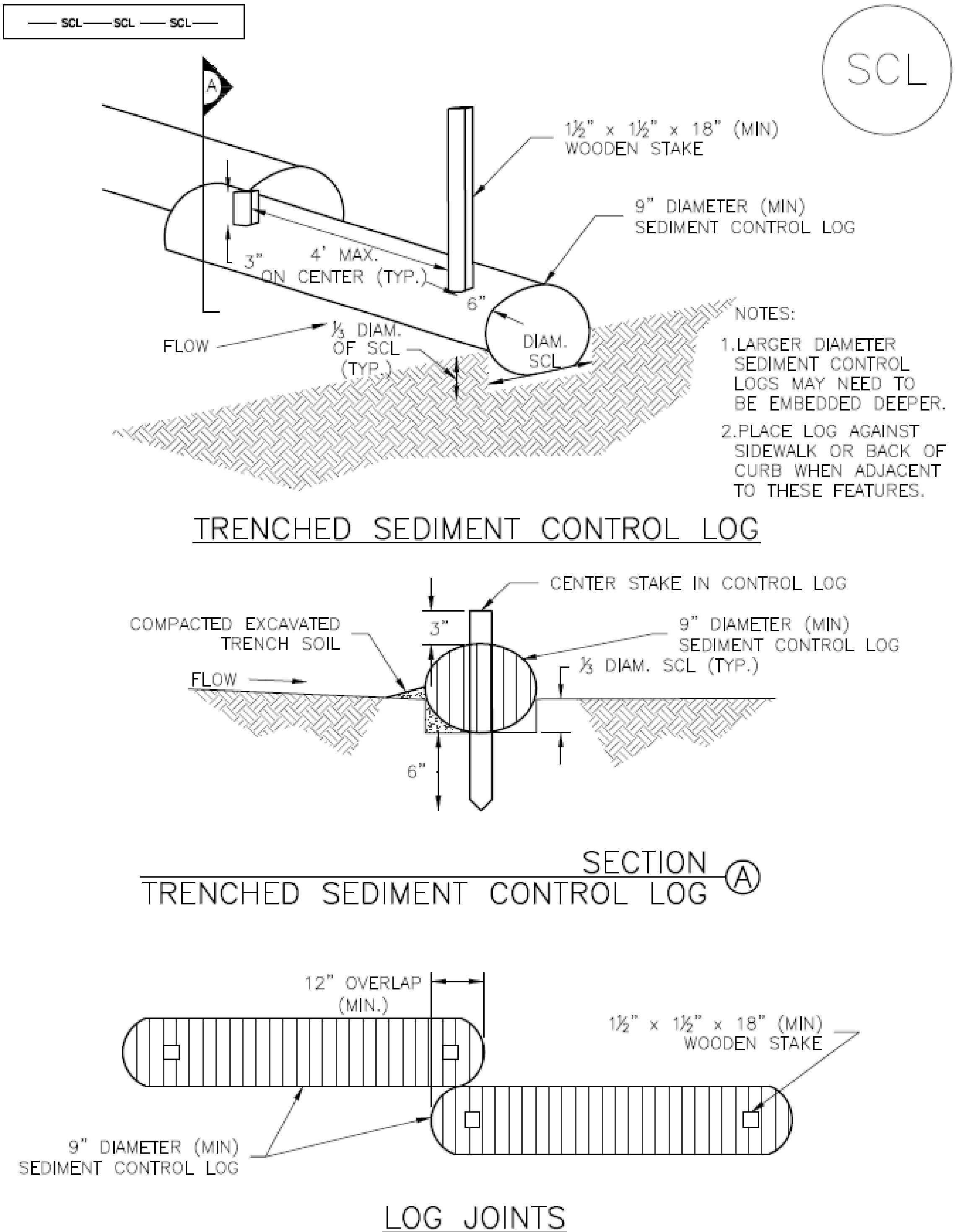
Design details and notes for sediment control logs are provided in the following details. Sediment logs must be properly installed per the detail to prevent undercutting, bypassing and displacement. When installed on slopes, sediment control logs should be installed along the contours (i.e., perpendicular to flow).

Improper installation can lead to poor performance. Be sure that sediment control logs are properly trenched (if lighter than 8 lb/foot), anchored and tightly jointed.

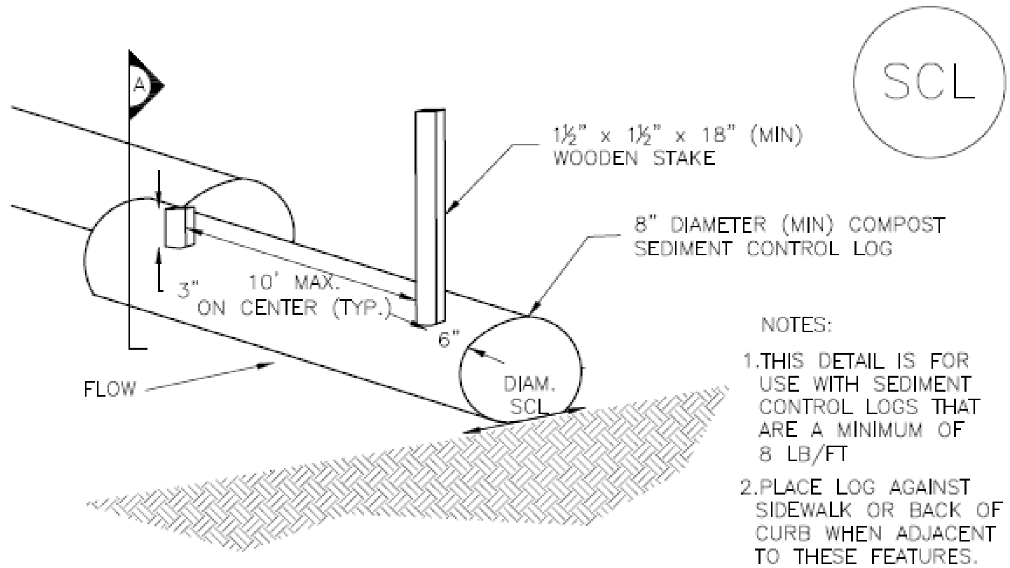
Maintenance and Removal

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.

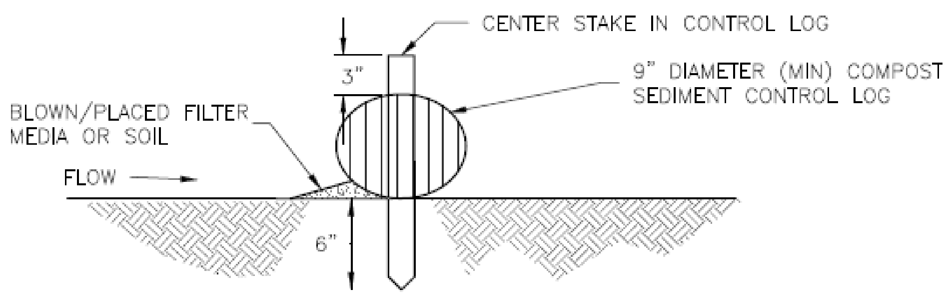
Once the upstream area is stabilized, remove and properly dispose of the logs. Areas disturbed beneath the logs may need to be seeded and mulched. Sediment control logs that are biodegradable may occasionally be left in place (e.g., when logs are used in conjunction with erosion control blankets as permanent slope breaks). However, removal of sediment control logs after final stabilization is typically appropriate when used in perimeter control, inlet protection and check dam applications. Compost from compost sediment control logs may be spread over the area and seeded as long as this does not cover newly established vegetation.



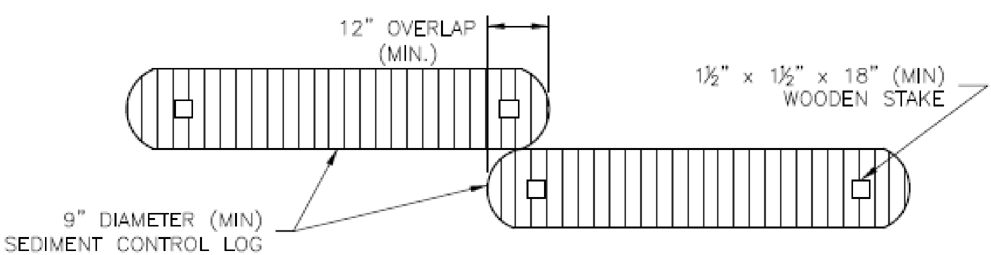
SCL-1. TRENCHED SEDIMENT CONTROL LOG



COMPOST SEDIMENT CONTROL LOG (WEIGHTED)

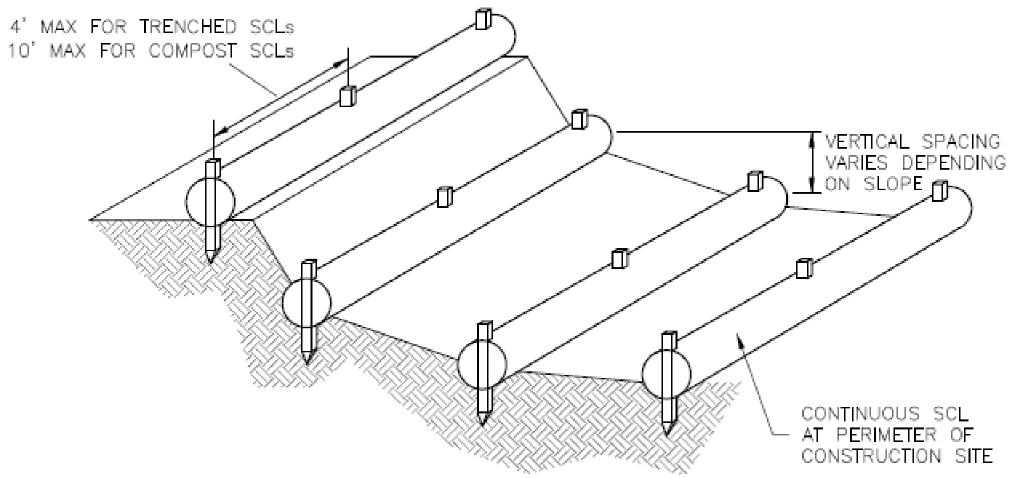


SECTION (A)
COMPOST SEDIMENT CONTROL LOG



LOG JOINTS

SCL-2. COMPOST SEDIMENT CONTROL LOG (WEIGHTED)



SCL-3. 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.

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. COMPOST LOGS THAT ARE 8 LB/FT DO NOT NEED TO BE TRENCHED.

6. THE UPHILL SIDE OF THE SEDIMENT CONTROL LOG SHALL BE BACKFILLED WITH SOIL OR FILTER MATERIAL 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 OR BLOWN IN PLACE.

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. COMPOST LOGS SHOULD BE STAKED 10' ON CENTER.

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.COMPOST FROM COMPOST LOGS MAY BE LEFT IN PLACE AS LONG AS BAGS ARE REMOVED AND THE AREA SEEDED. 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

Photograph SBB-1. Straw bale barrier used for perimeter control. Photo courtesy of Tom Gore.

A straw bale barrier is a linear wall of straw bales designed to intercept sheet flow and trap sediment before runoff exits a disturbed area.

Appropriate Uses

Appropriate uses of properly installed straw bale barriers may include:

- As a perimeter control for a site or soil stockpile.
- As a sediment control at the toe of an erodible slope.
- Along the edge of a stream or drainage pathway to reduce sediment laden runoff from entering the waterway.
- As part of an inlet protection design in sump conditions (See Inlet Protection BMP).

Do not use straw bale barriers in areas of concentrated flow or in areas where ponding is not desirable. Straw bales tend to degrade quickly, so they should generally not be used in areas where longer term disturbance is expected.

Due to a history of inappropriate placement, poor installation, and short effective lifespan, the use of straw bales is discouraged or prohibited by some communities.

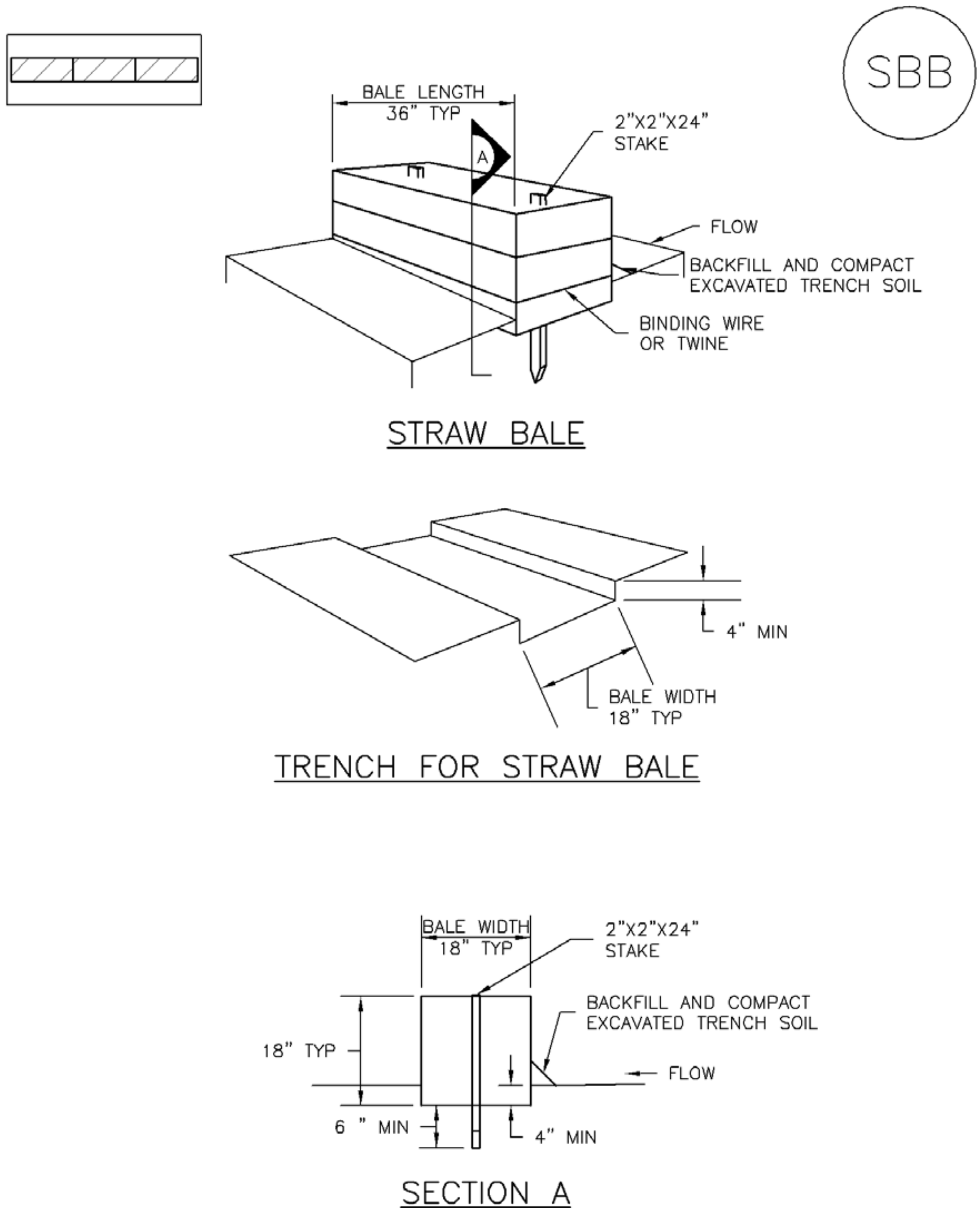
Design and Installation

The maximum recommended tributary drainage area per 100 lineal feet of straw bale barrier is 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. Design details with notes are provided in Detail SBB-1. To be effective, bales must be installed in accordance with the design details with proper trenching, staking, and binding. Jute and cotton string must not be used to bind the straw bale. The bales should be certified weed-free prior to use.

Maintenance and Removal

Check bales for rotting and replace as necessary. Straw bales degrade, and rotting bales require replacement on a regular basis (as often as every three months) depending on environmental conditions. Check for undercutting, bypassed flows, and displacement. Repair by properly re-installing the straw bale barrier and repairing washouts around the bales. Remove sediment accumulated behind the bale when it reaches one-quarter of the bale height. Remove and properly dispose of the straw bale once the upstream area has been stabilized. Areas of disturbance beneath the bale should be seeded and mulched when the bale is removed.

Straw Bale Barrier	
Functions	
Erosion Control	No
Sediment Control	Moderate
Site/Material Management	No



SBB-1. STRAW BALE

STRAW BALE INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   -LOCATION(S) OF STRAW BALES.

2. STRAW BALES SHALL CONSIST OF CERTIFIED WEED FREE STRAW OR HAY. LOCAL JURISDICTIONS MAY REQUIRE PROOF THAT BALES ARE WEED FREE.

3. STRAW BALES SHALL CONSIST OF APPROXIMATELY 5 CUBIC FEET OF STRAW OR HAY AND WEIGH NOT LESS THAN 35 POUNDS.

4. WHEN STRAW BALES ARE USED IN SERIES AS A BARRIER, THE END OF EACH BALE SHALL BE TIGHTLY ABUTTING ONE ANOTHER.

5. STRAW BALE DIMENSIONS SHALL BE APPROXIMATELY 36"X18"X18".

6. A UNIFORM ANCHOR TRENCH SHALL BE EXCAVATED TO A DEPTH OF 4". STRAW BALES SHALL BE PLACED SO THAT BINDING TWINE IS ENCOMPASSING THE VERTICAL SIDES OF THE BALE(S). ALL EXCAVATED SOIL SHALL BE PLACED ON THE UPHILL SIDE OF THE STRAW BALE(S) AND COMPACTED.

7. TWO (2) WOODEN STAKES SHALL BE USED TO HOLD EACH BALE IN PLACE. WOODEN STAKES SHALL BE 2"X2"X24". WOODEN STAKES SHALL BE DRIVEN 6" INTO THE GROUND.

STRAW BALE 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. STRAW BALES SHALL BE REPLACED IF THEY BECOME HEAVILY SOILED, ROTTEN, OR DAMAGED BEYOND REPAIR.

5. SEDIMENT ACCUMULATED UPSTREAM OF STRAW BALE BARRIER SHALL BE REMOVED AS NEEDED TO MAINTAIN FUNCTIONALITY OF THE BMP, TYPICALLY WHEN DEPTH OF ACCUMULATED SEDIMENTS IS APPROXIMATELY ¼ OF THE HEIGHT OF THE STRAW BALE BARRIER.

6. STRAW BALES ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND APPROVED BY THE LOCAL JURISDICTION.

7. WHEN STRAW BALES ARE REMOVED, ALL DISTURBED AREAS SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

(DETAILS ADAPTED FROM TOWN OF PARKER, 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

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.

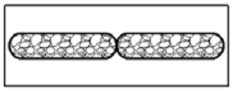
When placed in the gutter adjacent to a curb, rock socks should protrude no more than two feet from the curb in order for traffic to pass safely. If located in a high traffic area, place construction markers to alert drivers and street maintenance workers of their presence.

Maintenance and Removal

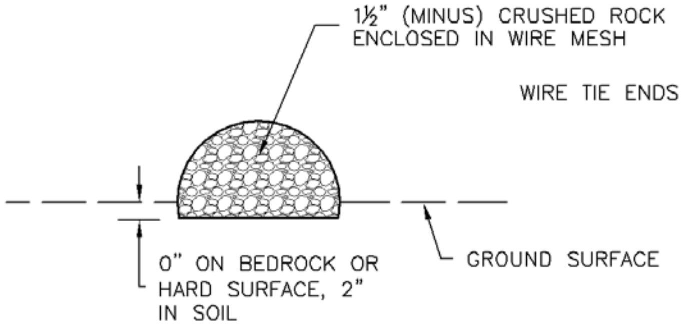
Rock socks are susceptible to displacement and breaking due to vehicle traffic. Inspect rock socks for damage and repair or replace as necessary. Remove sediment by sweeping or vacuuming as needed to maintain the functionality of the BMP, typically when sediment has accumulated behind the rock sock to one-half of the sock's height.

Once upstream stabilization is complete, rock socks and accumulated sediment should be removed and properly disposed.

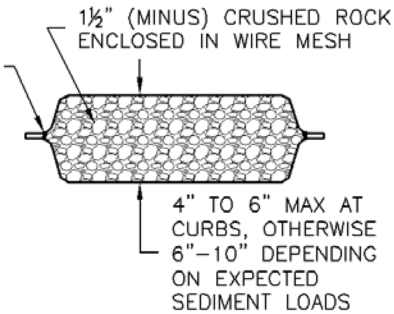
Rock Sock	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No



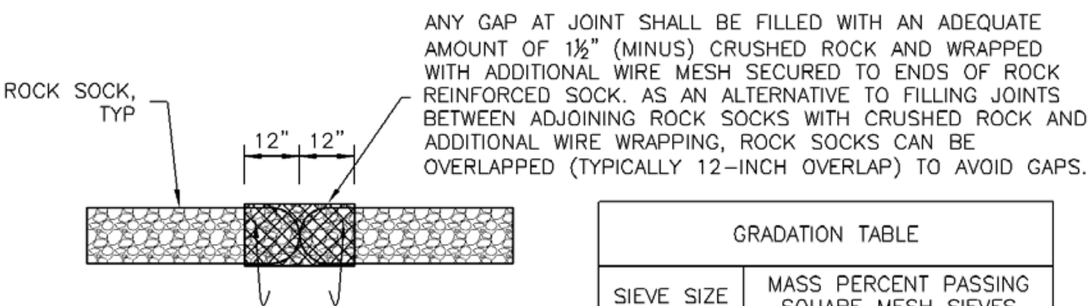
RS



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

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.

Photograph IP-1. Inlet protection for a curb opening inlet.

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 not 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.

Inlet Protection (various forms)	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No

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

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.

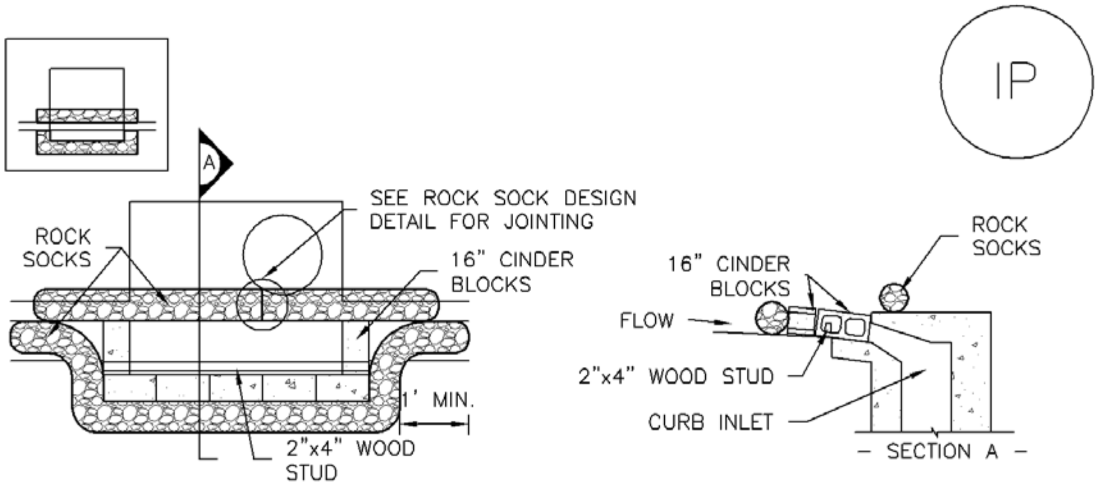
- Look for displaced BMPs that are no longer protecting the inlet. Displacement may occur following larger storm events that wash away or reposition the inlet protection. Traffic or equipment may also crush or displace the BMP.

- 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.



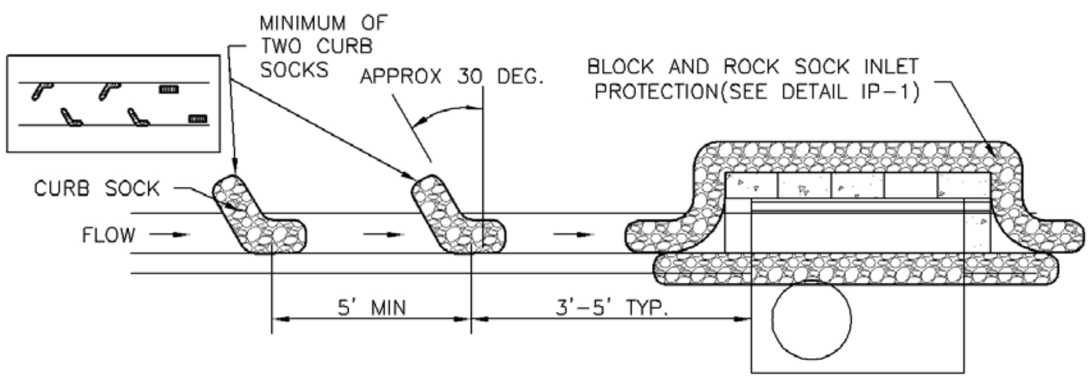
IP-1. BLOCK AND ROCK SOCK SUMP OR ON GRADE INLET PROTECTION

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

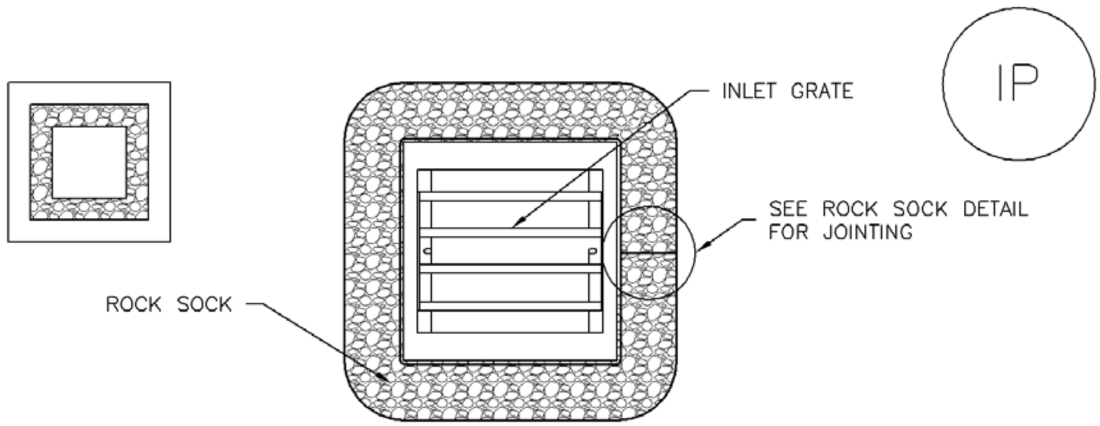
CURB ROCK SOCK INLET PROTECTION INSTALLATION NOTES

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.

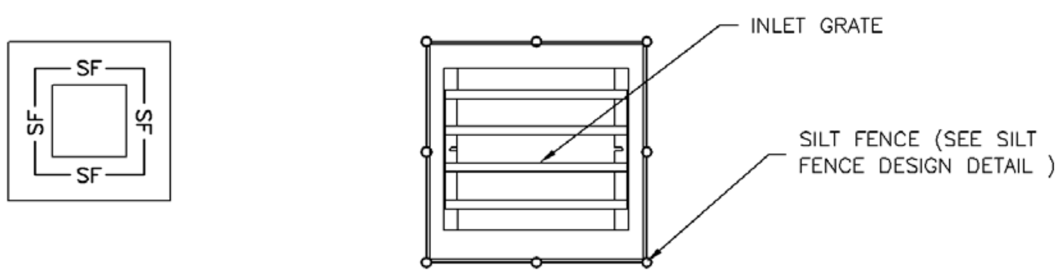


IP–3. ROCK SOCK SUMP/AREA INLET PROTECTION

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.



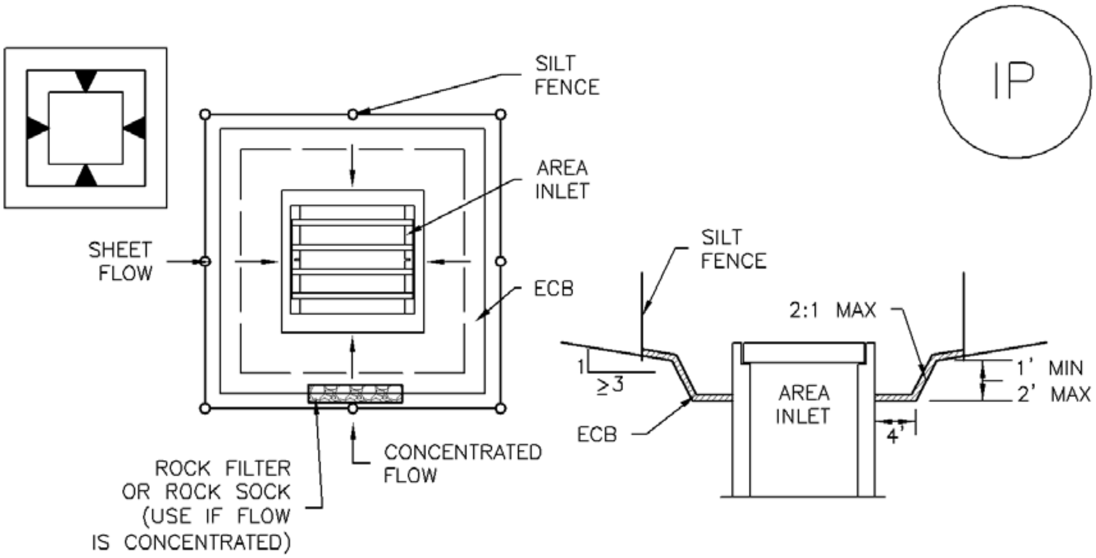
IP–4. SILT FENCE FOR SUMP INLET PROTECTION

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.



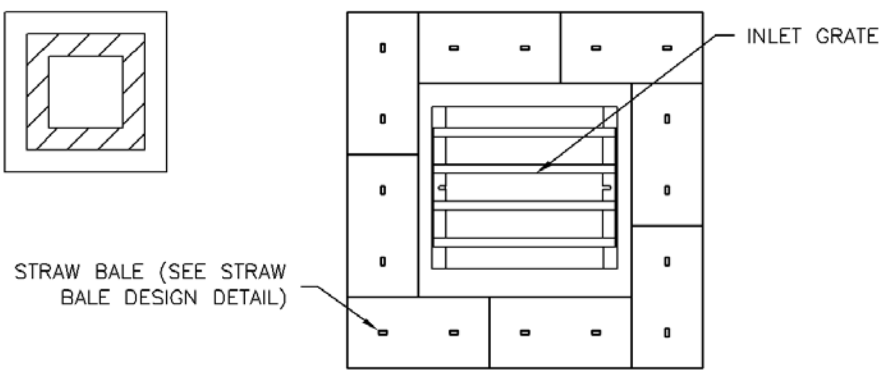
IP-5. OVEREXCAVATION INLET PROTECTION

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.

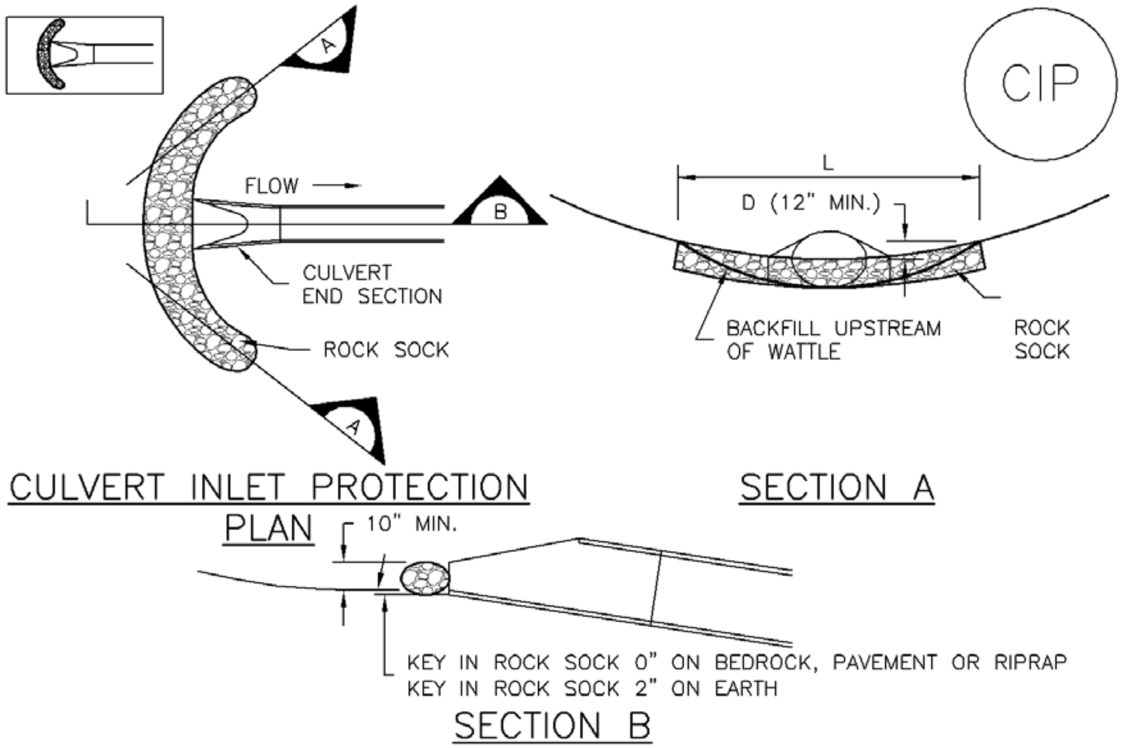


IP-6. STRAW BALE FOR SUMP INLET PROTECTION

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.



CIP-1. CULVERT INLET PROTECTION

CULVERT INLET PROTECTION INSTALLATION NOTES

1. SEE PLAN VIEW FOR
   -LOCATION OF CULVERT INLET PROTECTION.

2. SEE ROCK SOCK DESIGN DETAIL FOR ROCK GRADATION REQUIREMENTS AND JOINTING DETAIL.

CULVERT 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 THE CULVERT SHALL BE REMOVED WHEN THE SEDIMENT DEPTH IS ½ THE HEIGHT OF THE ROCK SOCK.

5. CULVERT INLET PROTECTION SHALL REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS PERMANENTLY STABILIZED AND APPROVED BY THE LOCAL JURISDICTION.

(DETAILS ADAPTED FROM 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.

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 Tributary Areas 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:
  - **Riser Pipe (Simplified Detail):** Detail SB-1 provides a simplified design for basins treating no more than 15 acres.
  - **Orifice Plate or Riser Pipe**: Follow the design criteria for Full Spectrum Detention outlets in the EDB 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 trash rack, pack uniformly sized 1½ - to 2-inch gravel in front of the plate or surrounding the riser pipe. 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 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.

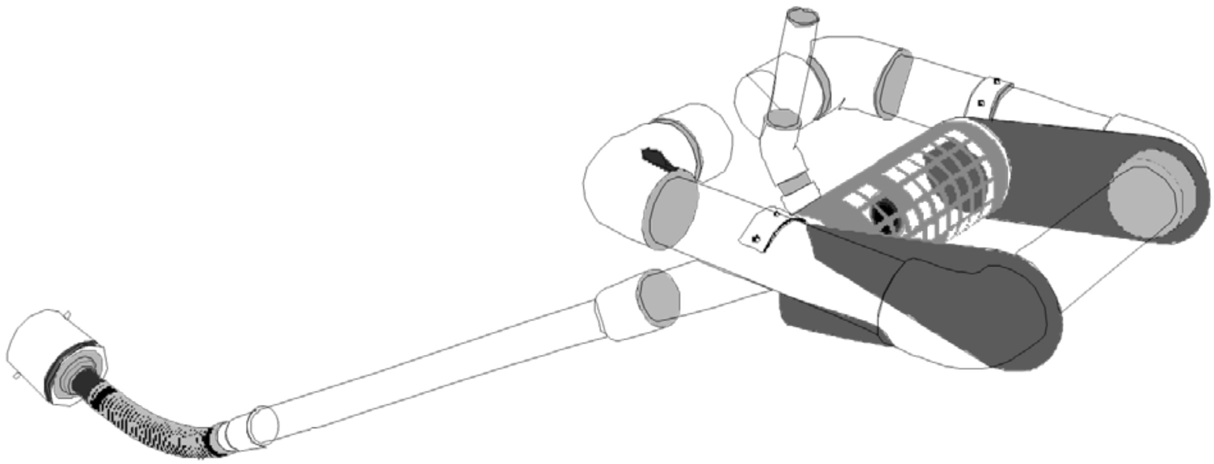


Illustration SB-1. Outlet structure for a temporary sediment basin - Faircloth Skimmer Floating Outlet. Illustration courtesy of J. W. Faircloth & Sons, Inc., FairclothSkimmer.com.

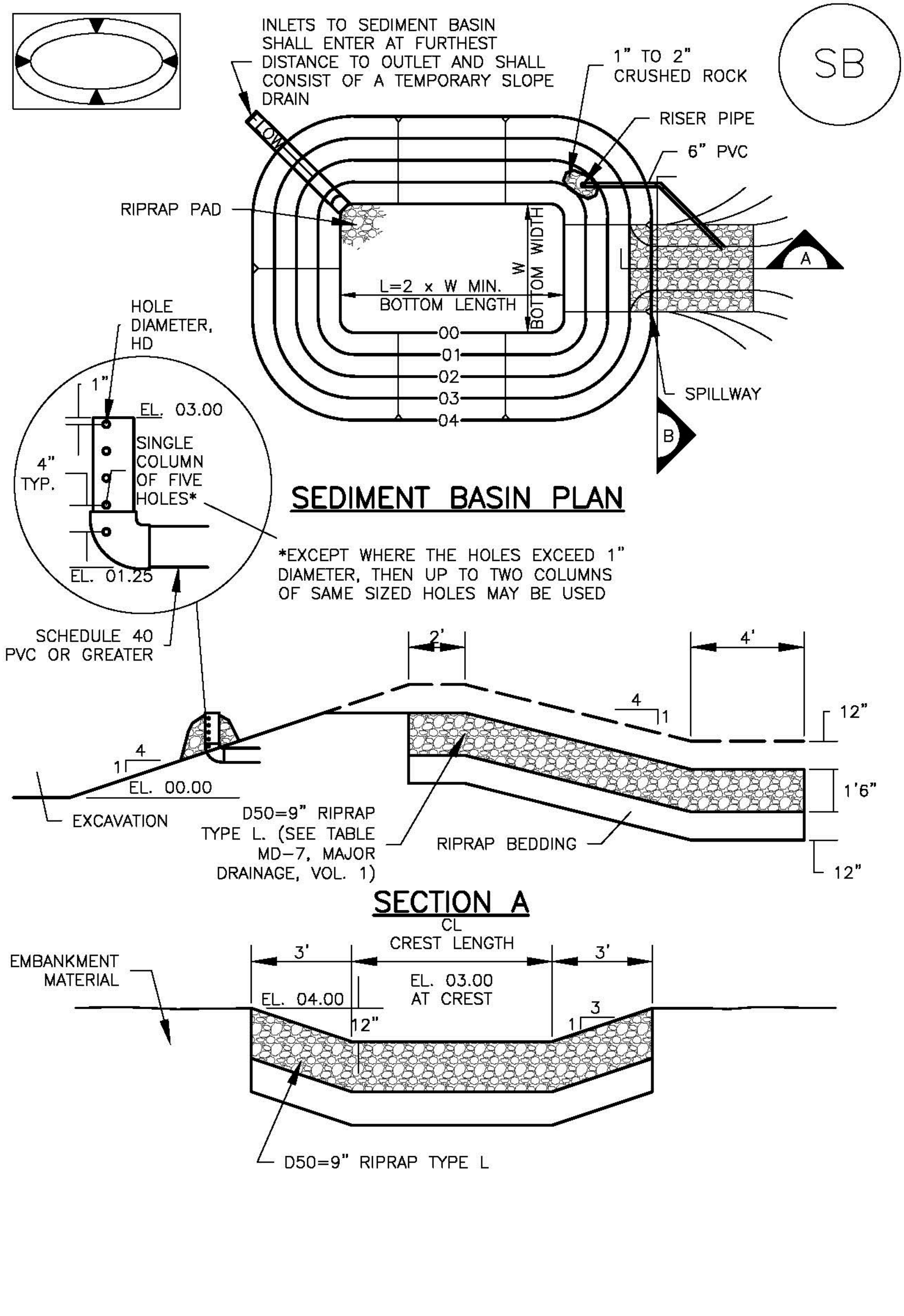
- **Outlet Protection and Spillway:** Consider all flow paths for runoff leaving the basin, including protection at the typical point of discharge as well as overtopping.
  - **Outlet Protection:** Outlet protection should be provided where the velocity of flow will exceed the maximum permissible velocity 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.



INLETS TO SEDIMENT BASIN SHALL ENTER AT FURTHEST DISTANCE TO OUTLET AND SHALL CONSIST OF A TEMPORARY SLOPE DRAIN
1" TO 2" CRUSHED ROCK
SB
RISER PIPE
6" PVC
FLOW
RIPRAP PAD
L=2 x W MIN. BOTTOM LENGTH
W BOTTOM WIDTH
A
00
01
02
03
04
SPILLWAY
B
HOLE DIAMETER, HD
1"
EL. 03.00
SINGLE COLUMN OF FIVE HOLES*
4" TYP.
EL. 01.25
SEDIMENT BASIN PLAN
*EXCEPT WHERE THE HOLES EXCEED 1" DIAMETER, THEN UP TO TWO COLUMNS OF SAME SIZED HOLES MAY BE USED
SCHEDULE 40 PVC OR GREATER
2'
4'
4
1
12"
1'6"
12"
1
4
EL. 00.00
EXCAVATION
D50=9" RIPRAP TYPE L. (SEE TABLE MD-7, MAJOR DRAINAGE, VOL. 1)
RIPRAP BEDDING
SECTION A
CL
CREST LENGTH
3'
3'
EMBANKMENT MATERIAL
EL. 04.00
EL. 03.00 AT CREST
12"
3
1
D50=9" RIPRAP TYPE L

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	7/8
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 1/8
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

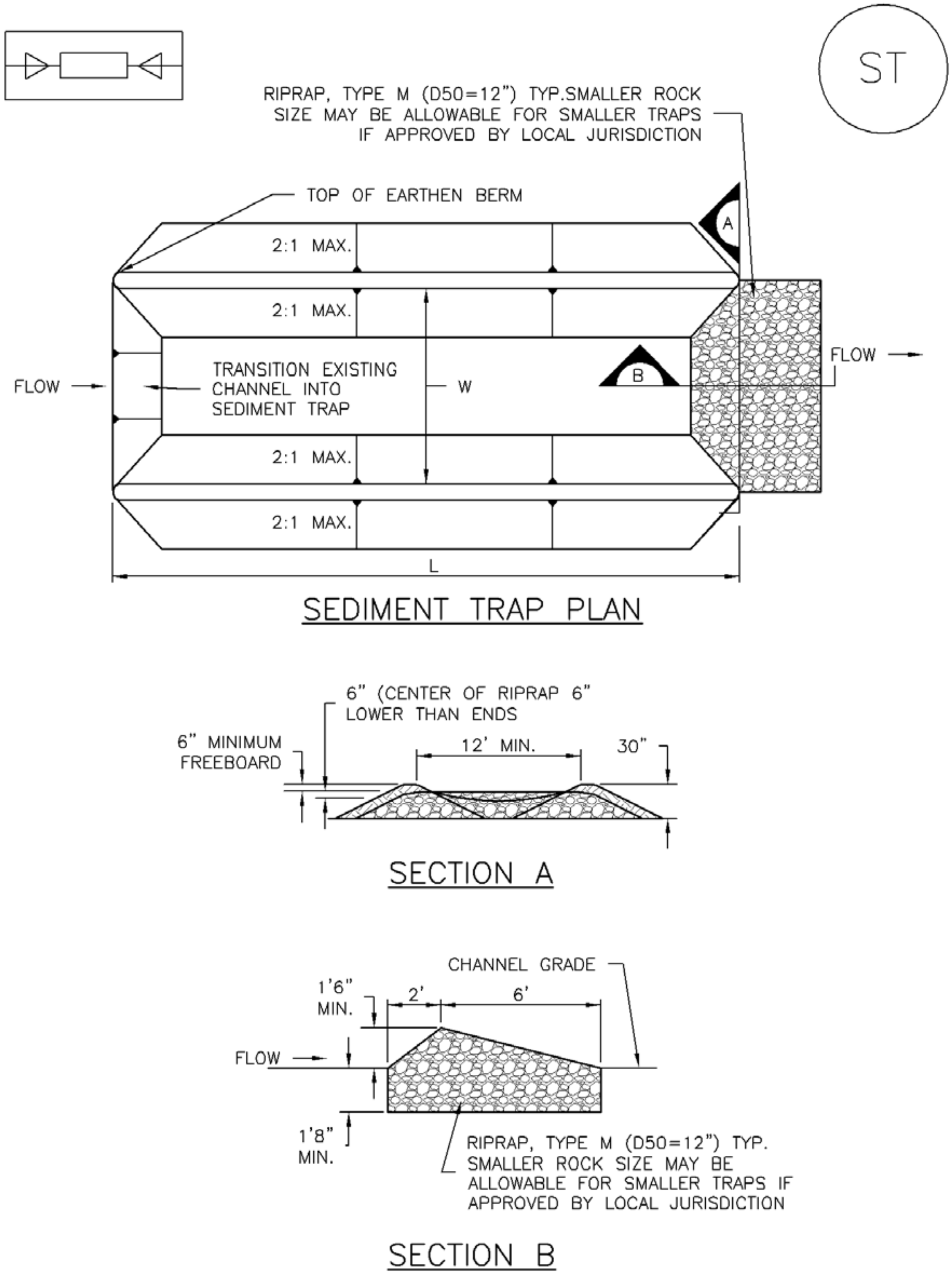
Inspect the sediment trap embankments for stability and seepage.

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.

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.

Photograph VB-1. A vegetated buffer is maintained between the area of active construction and the drainage swale. Photo courtesy of WWE.

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

Chemical Treatment (CT) SC-10

Description

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").

Photograph CT-1. Proprietary chemical treatment system being used on a construction site with sensitive receiving waters. Photo courtesy of WWE.

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.

APPENDIX I

MATERIALS MANAGEMENT

Contents

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

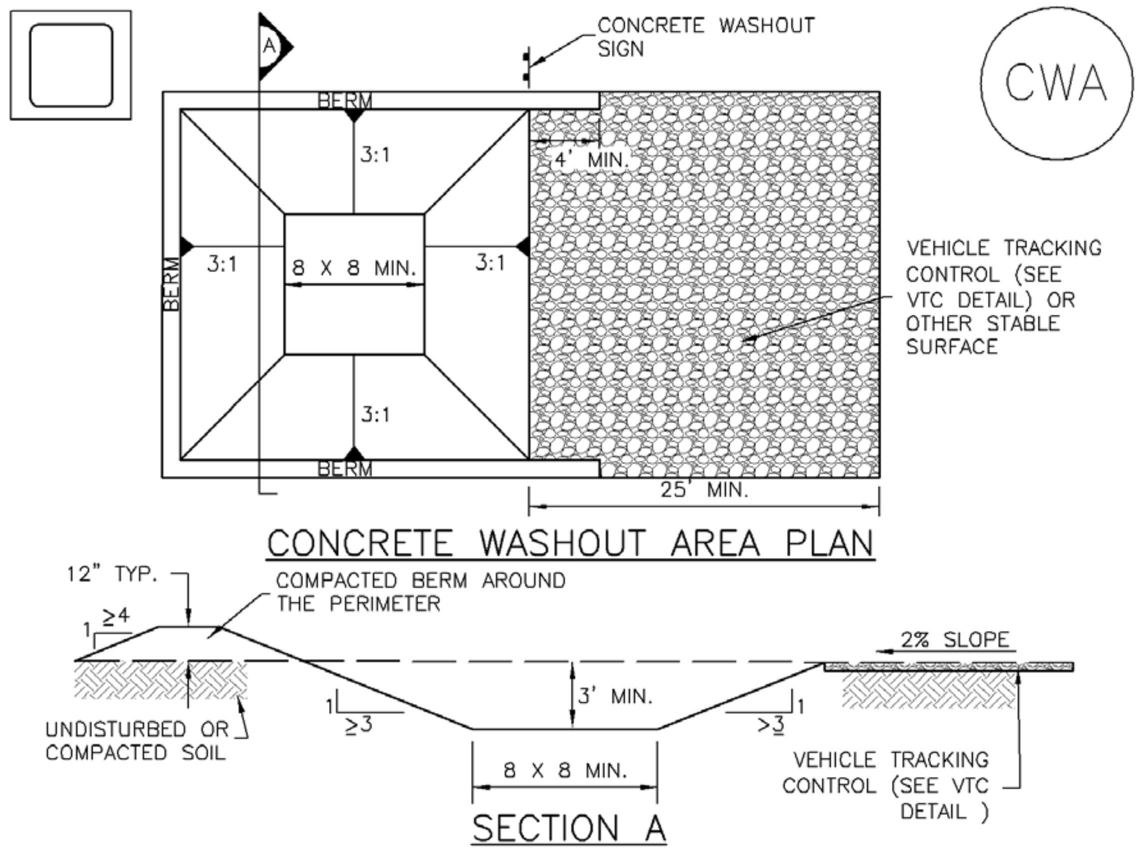
A key consideration for concrete washout areas is to ensure that adequate signage is in place identifying the location of the washout area. Part of inspecting and maintaining washout areas is ensuring that adequate signage is provided and in good repair and that the washout area is being used, as opposed 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.

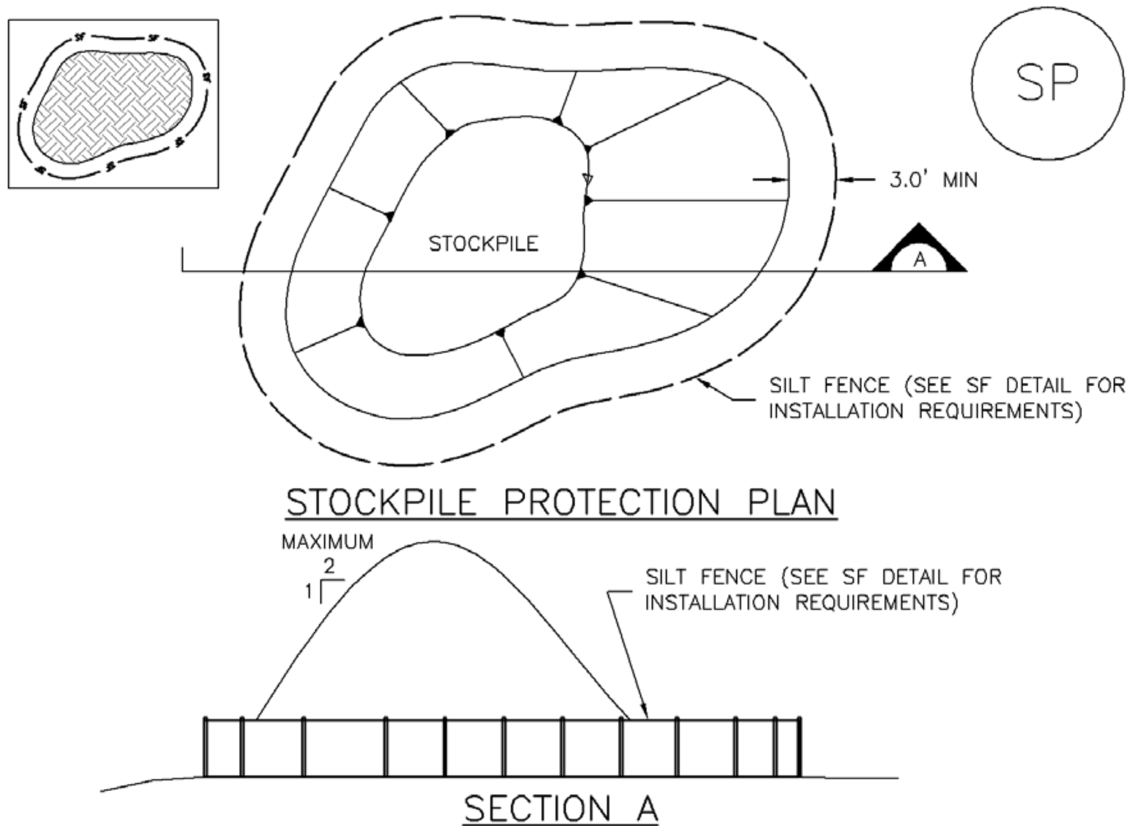
Maintenance and Removal

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.



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.

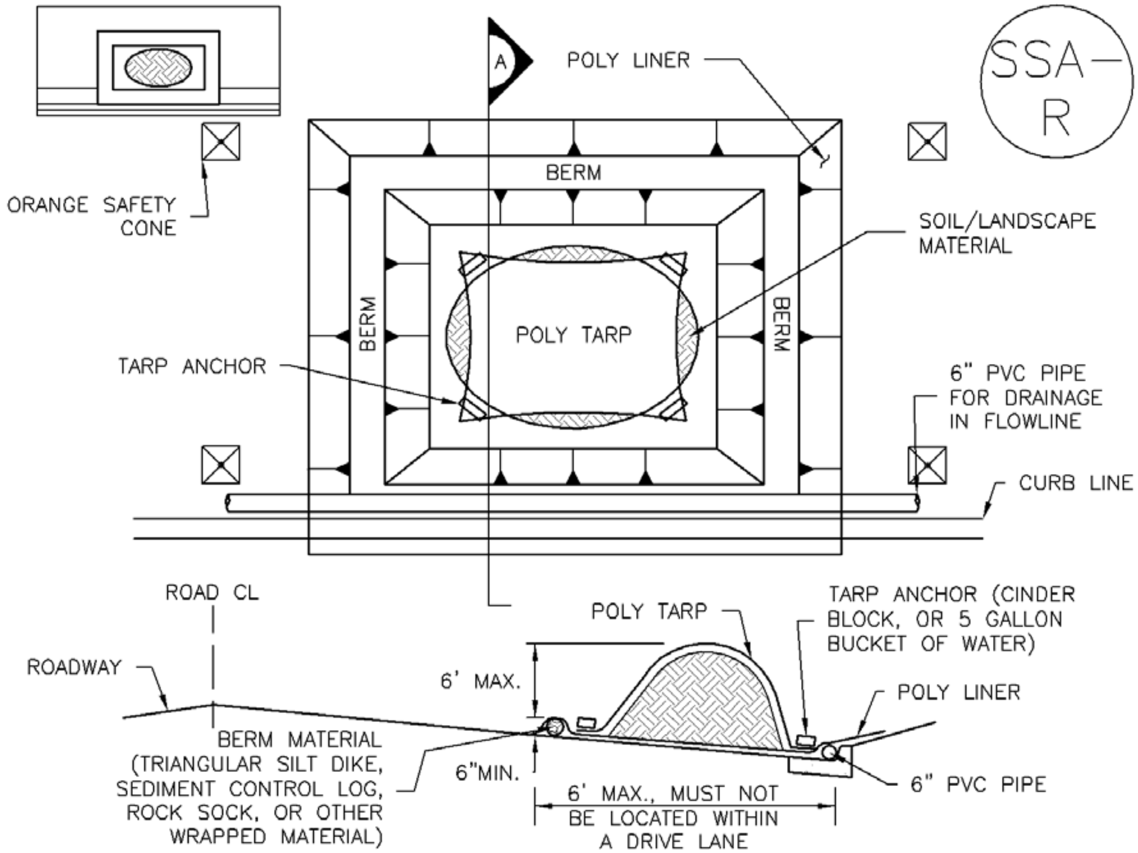
STOCKPILE PROTECTION MAINTENANCE NOTES

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.

- o 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:

  - o Train employees and subcontractors in proper handling and storage practices.

  - o 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).

  - o 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.

  - o Ensure that storage containers are regularly inspected for leaks, corrosion, support or foundation failure, or other signs of deterioration and tested for soundness.

  - o 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.

- Do not washout concrete trucks or equipment into storm drains, streets, gutters, uncontained areas, or streams. Only use designated washout areas.
- Establish washout areas and advertise their locations with signs. Ensure that signage remains in good repair.
- Provide adequate containment for the amount of wash water that will be used.
- Inspect washout structures daily to detect leaks or tears and to identify when materials need to be removed.
- 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.
  - Train employees and subcontractors in proper fueling procedures (stay with vehicles during fueling, proper use of pumps, emergency shutoff valves, etc.).
  - Inspect on-site vehicles and equipment regularly for leaks, equipment damage, and other service problems.
  - Clearly designate vehicle/equipment service areas away from drainage facilities and watercourses to prevent stormwater run-on and runoff.
  - Use drip pans, drip cloths, or absorbent pads when replacing spent fluids.
  - 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:
  - Educate employees and subcontractors on proper washing procedures.
  - Use off-site washing facilities, when available.
  - Clearly mark the washing areas and inform workers that all washing must occur in this area.
  - 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.

APPENDIX J

SITE MANAGEMENT

Contents

Description

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.

Photograph CP-1. Construction phasing to avoid disturbing the entire area at one time. Photo courtesy of WWE.

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.

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.

Photograph CF-1. A construction fence helps delineate areas where existing vegetation is being protected. Photo courtesy of Douglas County.

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

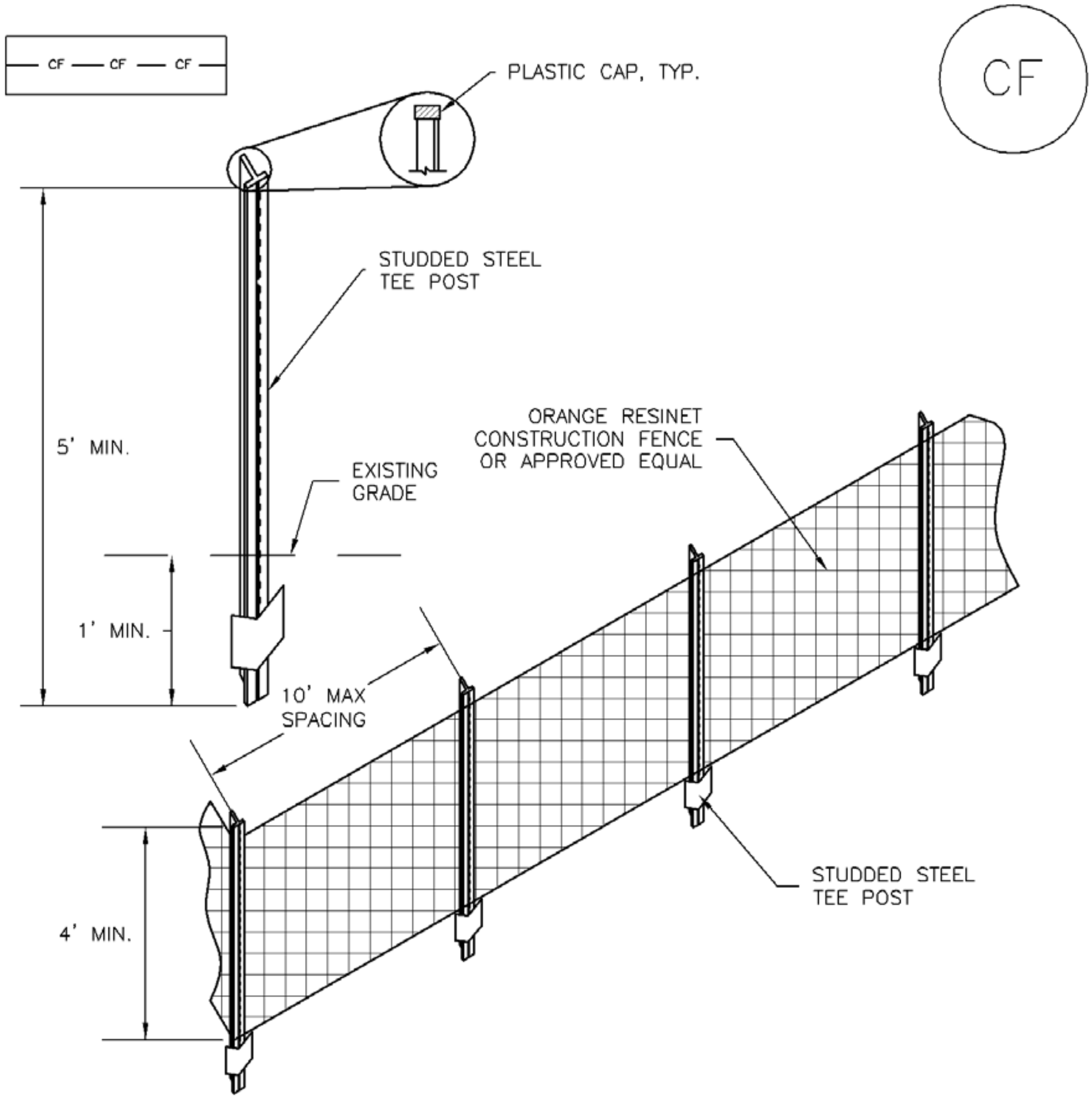
Construction fencing may be chain link or plastic mesh and should be installed following manufacturer's recommendations. See Detail CF-1 for typical installations.

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

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.

Photograph VTC-1. A vehicle tracking control pad constructed with properly sized rock reduces off-site sediment tracking.

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.

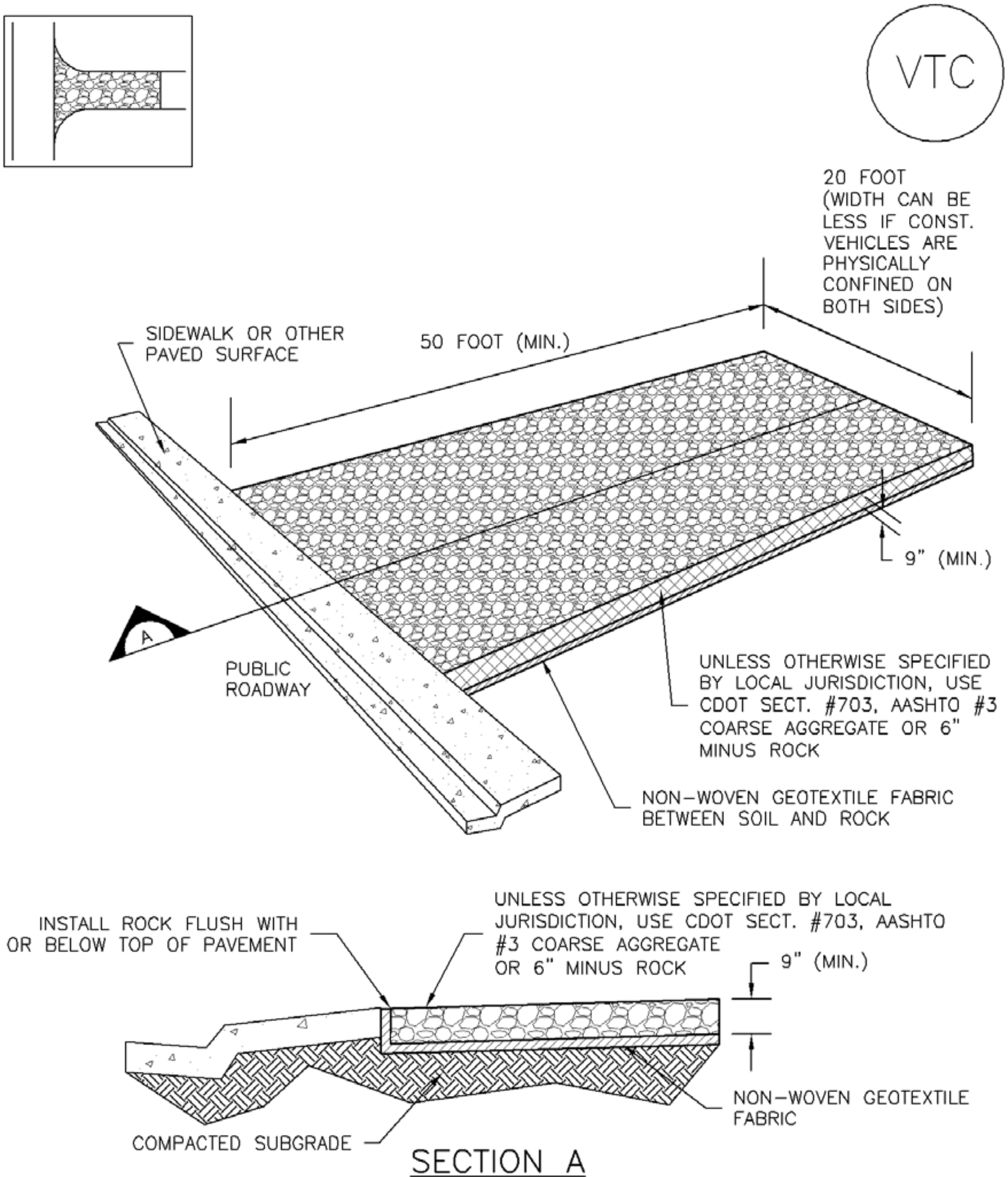
Ensure that drainage ditches at the entrance/exit area remain clear.

Photograph VTC-2. A vehicle tracking control pad with wheel wash facility. Photo courtesy of Tom Gore.

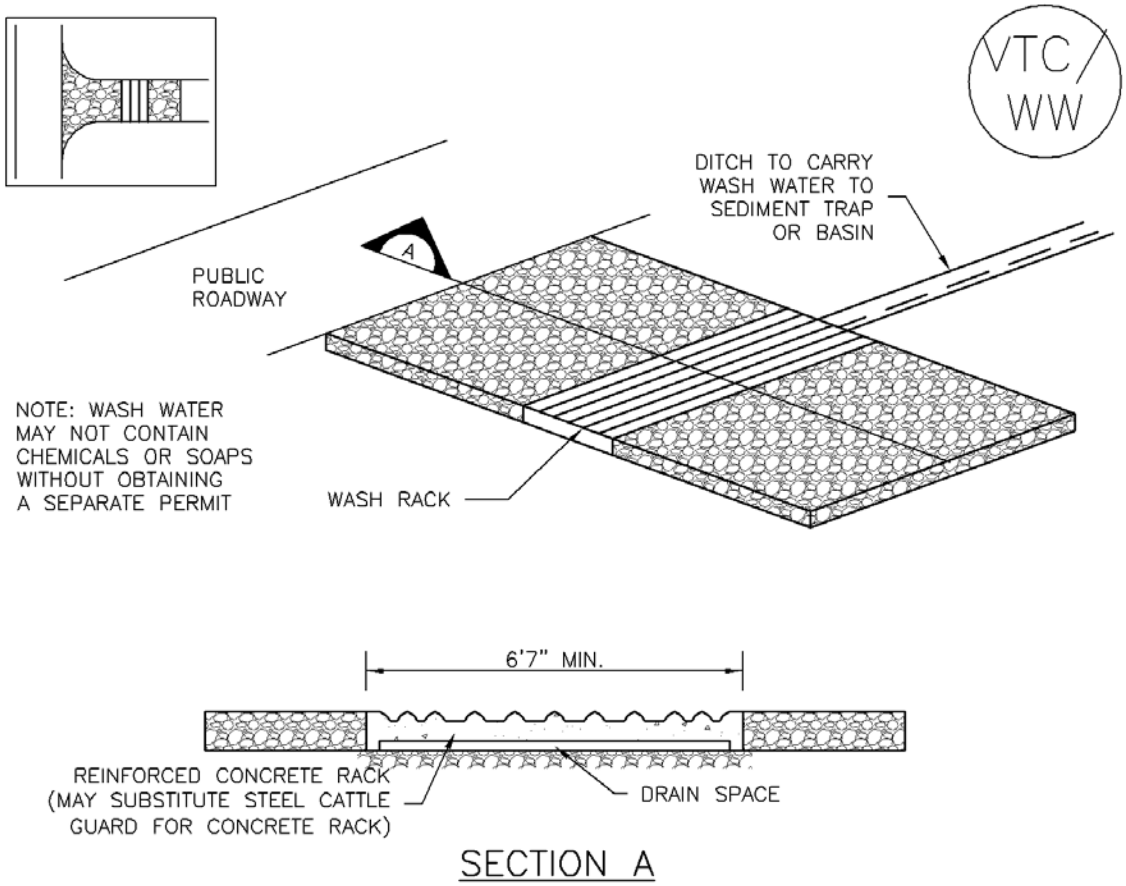
A stabilized entrance should be removed only when there is no longer the potential for vehicle tracking to occur. This is typically after the site has been stabilized.

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.

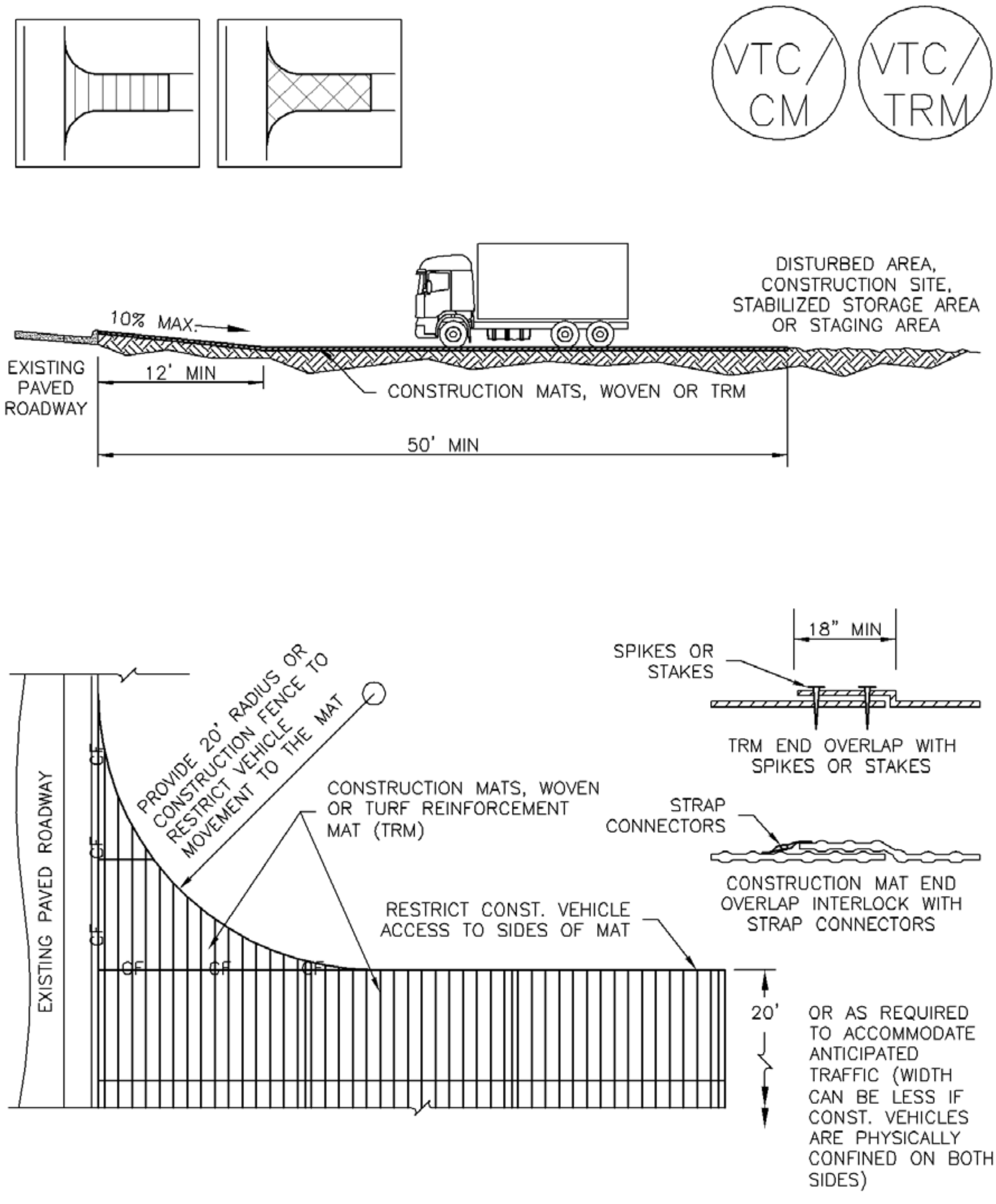
When a construction entrance/exit is removed, excess sediment from the aggregate should be removed and disposed of appropriately. The entrance should be promptly stabilized with a permanent surface following removal, typically by paving.



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

Stabilized Staging Area (SSA) SM-6

Photograph SSA-1. Example of a staging area with a gravel surface to prevent mud tracking and reduce runoff. Photo courtesy of Douglas County.

Description

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

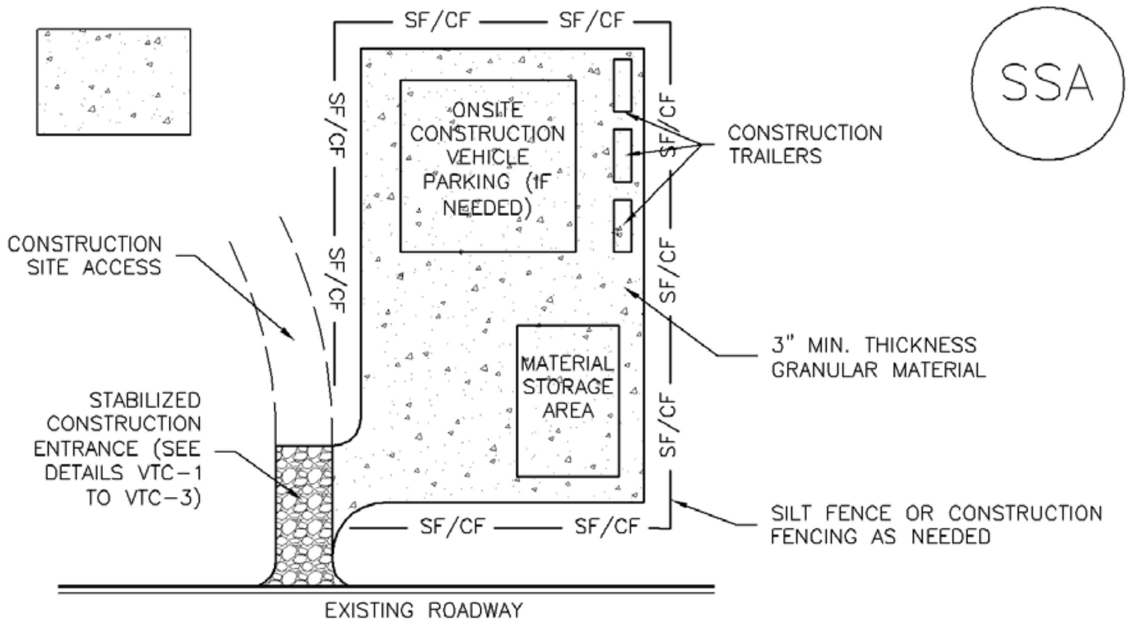
- Utilize off-site parking and restrict vehicle access to the site.
- Use construction mats in lieu of rock when staging is provided in an area that will not be disturbed otherwise.
- Consider use of a bermed contained area for materials and equipment that do not require a stabilized surface.
- Consider 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

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.

Photograph SS-1. A street sweeper removes sediment and potential pollutants along the curb line at a construction site. Photo courtesy of Tom Gore.

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

Temporary diversion methods are used to reroute water from a stream or restrict flows to a designated portion of the stream channel to allow for construction activities to take place in the stream, along the banks or beneath the active channel. Temporary diversion methods are often required during the construction of detention ponds, dams, in-stream grade control structures, utility installation and other activities, including maintenance, that require working in waterways. Temporary diversion methods include temporary diversion channels, pump-arounds, piped diversions, coffer dams and other similar practices. The primary purpose of all temporary diversion methods is to protect water quality by passing upstream flows around the active construction zone.

Photograph TDM-1. This coffer dam, installed to allow grading and stabilization of the stream bank, consists of concrete blocks covered by an impermeable linear held in place by sand bags.

Appropriate Uses

Temporary diversion methods are appropriate in situations when it is necessary to divert the flow around the area where work is being conducted. Temporary diversion methods vary with the size of the waterway that is being diverted.

Temporary Diversion Channel	
Functions	
Erosion Control	Yes
Sediment Control	No
Site/Material Management	No

For large streams, a temporary diversion may consist of berms or coffer dams constructed within 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 method may divert the entire waterway. For short duration projects (typically less than a month of active construction) with low baseflows, a pump and/or bypass pipe may serve as a temporary diversion. Whenever a temporary diversion is used, construction should be scheduled during drier times of the year (November through March) to the extent feasible, and construction in the waterway should progress as quickly as practical to reduce the risk of exceeding the temporary diversion capacity. Timing and duration of construction are primary considerations for determining the design flow most appropriate for a diversion. A sizing method that does not consider these variables is overly simplistic and can result in inflated project costs and land disturbances that provide little to no water quality benefit. Additionally, disturbing more area than necessary can result in increased erosion.

Temporary diversion method section and approach should occur on a project- and site-specific basis. For short duration projects (typically associated with maintenance of utilities and stream crossings and minor repairs to outfalls and eroded banks) constructed during dry times of the year, diversion construction can create greater disturbance and mobilization of sediment than all of the other earth disturbing activities of the project combined, and the cost of the diversion could be a significant percentage of the overall project cost. 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 occur through installation of a temporary diversion, it is reasonable to exempt these activities from the requirement to construct a temporary diversion.

On the other end of the spectrum, a basis of design for a temporary diversion in excess of the methodology presented in this Fact Sheet may be appropriate for longer duration projects and/or projects where the consequences of exceeding diversion capacity are significant in terms of public safety, damage to infrastructure and property, environmental impacts, damage or delay to the project and other factors. In short, engineers should recognize that temporary diversions must be thoughtfully analyzed on a case-by-case basis, considering site-specific circumstances.

Design Considerations

Selection and design of temporary diversion methods should consider many factors, including:

- Will construction of a temporary diversion cause greater environmental impacts than if the project is constructed without a temporary diversion? This frequently applies to short duration, small scale projects associated with maintenance activities such as bank erosion repair, drop structure and pond maintenance, outfall improvements/repair and other limited construction activities.

- Size of stream, tributary watershed area and anticipated flow rates during construction. Special consideration should be given to large streams with large tributary areas with higher flow rates since the sizing methodology presented in this Fact Sheet is based on data from watersheds less than 20 square miles.

- Any special water quality or aquatic life conditions the waterway.

- Nature of surrounding land use, property ownership, and easements in the project area are important considerations in determining feasibility and methods for temporary diversions. For example, in a highly urbanized setting or an area with limited right-of-way, there may not be adequate space to construct a diversion channel.

- Seasonal variations in stream hydrology (baseflow vs. peak flow).
  - Irrigation flows: If an irrigation ditch enters the stream, it is recommended that the ditch company be contacted to confirm when flows from the ditch may be expected.
  - Weather (storm runoff): If diversions are constructed in summer months when thunderstorms and flash flooding can occur, contractors will need to track weather forecasts closely and provide additional protection when higher flows from runoff are anticipated. The UDFCD Alert System can be used for daily forecasts and to provide warnings for severe weather.

- Probability of flood flows exceeding diversion capacity and/or diversion failure. Consider the consequences of exceedance or failure such as:
  - Public safety
  - Environmental
  - Legal
  - Regulatory
  - Economic
  - Project disruption/delay

- Realistic estimation of project duration and time of year during which construction will occur.

- Comparison of the overall project costs to the temporary diversion costs (design and construction) and determining the costs and benefits of different diversion strategies relative to the protection that they provide.
- Permitting requirements for overall project and for diversion methods (United States Army Corps of Engineers, United States Fish and Wildlife Service, Colorado Department of Public Health and Environment, Federal Emergency Management Agency, Division of Water Resources, local governments, and others). Permit requirements and existing vegetative cover may limit the allowable area disturbance.
- Public safety aspects. For example, if a pipeline is being used, consideration should be given to public access and inlet protection.
- Legal considerations, which are a function of many different factors such as property ownership, history of localized flooding, or parties that will have interest in project.

Design and Installation

1. Determine if a diversion is appropriate based on appropriate uses and design considerations stated earlier. As noted, in some cases, constructing a project under wet conditions is preferable to constructing a temporary diversion to create dry conditions, especially if construction of the temporary diversion will require a significant amount of disturbance relative to the overall project.
2. Determine project duration.
   - "Long duration" projects are projects that last <u>longer than three months</u> and in many cases are Capital Improvement Projects or traditional land development projects.
   - "Short duration" projects are projects that are completed within <u>one month or less</u> and generally are associated with maintenance and repair activities.
   - "Interim duration" projects are projects that will last <u>longer than one month but up to three months</u>.
3. Determine the time of year in which construction will occur.
4. Gather necessary temporary diversion sizing parameters that may include tributary area, imperviousness, project duration safety factor, and seasonal sizing coefficient.
5. Apply applicable sizing methodology and perform necessary calculations (provided following this section). Use engineering judgment to determine if the temporary diversion design flow is adequate for the specific project.
6. Determine appropriate method of diversion. Follow the design steps for the selected method discussed below.
   - <u>Channel Diversion</u> – For smaller streams, construction of dams and detention basins, or as the site allows, a channel diversion may divert the entire waterway as illustrated in Figure TDM-1.

- Berm or Coffer Dam – A berm or coffer dam is appropriate for streams of all sizes to confine flow to one side of the stream.

- Piped Diversion – A bypass pipe is generally appropriate for short duration projects with low baseflows.

- Pumped Diversion – A pumped diversion may be appropriate for short duration projects with low baseflows. It may also be the only option where space for the diversion is limited as shown in photograph TDM-2.

Selecting a Diversion Method

Selection of the appropriate diversion type is largely site specific. The best choice represents the most efficient method while keeping disturbance to a minimum.

7. Consider developing an emergency action plan, as a precaution, for rapidly removing equipment and materials with potential to contribute pollutants to runoff from the waterway in advance of imminent runoff with the potential to exceed diversion capacity. The emergency action plan should designate an individual who will be on the site throughout most of the construction project with the authority to order that work be halted and equipment and materials with potential to contribute to stormwater pollution be moved to high ground outside of the active channel. The emergency action plan should identify where equipment and materials removed from the channel will be stored temporarily during a runoff event that is expected to exceed temporary diversion capacity. The UDFCD Alert System and warnings of the potential for severe weather issued by UDFCD should be consulted daily during construction.

Channel Diversion

1. Use sizing methodology to determine temporary diversion design flow rate.

2. 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. Pay particular attention to diversion channel entrance, bends, transitions and downstream return to stream where scour forces may require greater protection. Unlined channels should not be used. Table TDM-1 gives Manning's "n" values for the most commonly used lining materials.

   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.

3. Determine the channel geometry and check the capacity using Manning's Equation and the "n" value given in Table TDM-1. The steepest side slope allowable is two horizontal to one vertical (2:1), unless vertical walls are installed using sheet piling, concrete or stacked stone. Consideration for public access and safety should be accounted for when determining channel geometry.

4. Determine depth of flow. A maximum depth of 1-foot is allowed for flows less than 20 cfs and a maximum of 3 feet 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). Provide a minimum of 0.5 feet of freeboard above the design water surface elevation.

Table TDM-1. Manning’s n Values for Temporary Diversion Channel Design

Lining Material	Manning's n Depth = 0 to 1.0 ft	Manning's n Depth = 1.0 to 3.0 ft	Manning's n Depth = 3.0 to 5.0 ft
Plastic Membrane	0.011	0.010	0.009
Straw/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

Note: Use manufacturer's Manning's n when available. See the *Major Drainage* chapter of the USDCM for riprap gradation. Erosion protection should extend a minimum of 0.5 feet above the design water depth.

Berm or Coffer Dam

For coffer dams or berms that are intended to isolate a portion of the stream from the work area steps 1-4 should be applied to the “wet” side of the coffer dam or berm.

1. Use sizing methodology to determine temporary diversion design flow rate.

2. Determine channel slope based on existing and proposed site conditions.

3. Perform initial channel sizing calculations using Manning's Equation. Determine maximum permissible velocities based on lining material. Because temporary diversion measures 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 to the stream-side of berms when berms are used to isolate a work area within a stream.

4. Determine the channel geometry and check the capacity using Manning's Equation and the "n" value given in Table TDM-1. The steepest side slope allowable is two horizontal to one vertical (2:1), unless vertical walls are installed using sheet piling, concrete or stacked stone. Provide a minimum of 0.5 feet of freeboard above the design water surface elevation.

Piped Diversion

1. Use sizing methodology to determine temporary diversion design flow rate.

2. Size the pipe to accommodate the design flow using no more than 80 percent of the pipe full flow capacity. Select a Manning’s n value based on the type of pipe material that will be used (concrete n = 0.013 [typ.], corrugated metal pipe n = 0.024 [typ.]).

Pumped Diversion

1. Use sizing methodology to determine temporary diversion design flow rate.

2. A backup pump (or pumps) with capacity equal to or greater than the diversion design flow rate should be on site and in good working order at all times.

Photograph TDM-2. Despite a relatively significant baseflow, a pumped diversion was selected for this Lakewood Gulch project due to a lack of space crossing Federal Boulevard. Photo courtesy of City and County of Denver.

Sizing Methodology

The methodology for sizing of temporary diversion methods was developed using baseflow observations and Crest Stage Indicator (CSI) peak flow data collected from 21 watersheds within the UDFCD boundary. These data were collected over extended periods of time (up to 31 years) and, as a result, provide a sound statistical basis for the sizing methodology.

Determine sizing procedure to use based on the project duration.

“Long duration” projects last longer than three months.

“Short duration” projects are completed within one month or less.

“Interim duration” projects last longer than one month and up to three months.

- “Long duration” projects last longer than three months and in many cases are Capital Improvement Projects or traditional land development projects.

- “Short duration” projects are completed within one month or less and generally are associated with maintenance and repair activities. For these projects, it is recommended that the temporary diversion be sized based on the statistics identified for baseflows (i.e., vs. peak flows) and be of sufficient size to convey a flow that has a less than 50% chance of being exceeded between November – March, including a project duration safety factor.

- “Interim duration” projects will last longer than one month but up to three months. In these projects, engineering judgment must be applied, drawing on sizing methods for “short duration” and “long duration” project criteria and the time of year of construction to develop a basis of design for the temporary diversion method that is appropriate for the project.

It is highly recommended that projects involving temporary diversions be constructed between November and March. If a short duration project requiring a temporary diversion must be conducted between April and October, the extended weather forecast should be evaluated to avoid periods of anticipated precipitation and a conservative safety factor should be applied. Additional protection may need to be provided for the site if higher flows from runoff are anticipated.

Sizing Procedure for Long Duration Projects (duration greater than three months)

1. Determine the tributary drainage area, *A*, in square miles.

2. Determine the watershed imperviousness (adjusted as appropriate for disconnected impervious area, see Chapter 3).

3. Determine the design peak flow rate according to Figure TDM-2. Note: For long duration projects, or where the consequences of diversion failure warrant, a larger design flow may be necessary, and/or a more detailed, site-specific hydrologic analysis.

Figure TDM-2 may be used to estimate the design discharge for the sizing of temporary diversion methods for projects exceeding three months in duration. The curves in this figure were originally developed using annual peak flow data collected from 17 watersheds within the UDFCD boundary and then updated in 2012 using annual peak flow data from 21 watersheds with CSI gages. These data were collected over extended periods of time (up to 31 years) and, as a result, provide a sound statistical basis for the figure. The data supporting Figure TDM-2 were taken during the high flood potential period of April through September.

Figure TDM-2 provides estimated 2-year peak flow rates with the upper 5% and lower 95% confidence limits shown and is based on watershed imperviousness for small waterways (25 square miles or less).[1] Because Figure TDM-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 hydrologic analysis and risk assessment will be necessary to evaluate the appropriate level of protection to be provided by the temporary diversion. For any size watershed, it is important that the designer understand watershed characteristics to determine applicability of the simplified method and how these characteristics influence the choice of diversion method. 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.

[1] There are a multitude of factors affecting rainfall-runoff response of a watershed in addition to impervious area. Other factors include soil types, total area, fraction of connected/disconnected impervious area, watershed shape, topography and many other factors). Figure TDM-2 provides a simplified design tool based on watershed imperviousness but should not be blindly relied upon without due consideration of other factors including those listed above and others.

Sizing Procedure for Short Duration Projects (one month or less of active construction)

1. Determine the tributary drainage area, *A*, in square miles.
2. Select a safety factor, *S*, based on project duration from Table TDM-2. Short duration projects have been broken down further into projects less than two weeks and projects from two weeks up to one month.
3. Select the sizing coefficient, *K*, corresponding to the month in which the project will occur (see Table TDM-2). For projects that span two months with different *K* values, use the greater of the two *K* values. For short duration projects that will occur during the traditionally dry period of the year (November through March) a *K* value of 0.2 is recommended. For short duration projects that will occur April through October, and wet weather is not predicted, a *K* value of 0.5 is recommended.

When a diversion is determined to be appropriate, safety factors and *K* values in Table TDM-2 are **minimum** recommended values. Depending on the many factors to consider in selecting and sizing a temporary diversion listed above, higher values for *K* and *S* may be appropriate.

Table TDM-2.Temporary Diversion Sizing Coefficients and Safety Factors for Short Duration Projects

Time of Year	Project Duration	Safety Factor, S	Temporary Diversion Sizing Coefficient, K
November - March	Less than 2 weeks	1.0	0.2
November - March	2 weeks to 1 month	1.5	0.2
April - October	Less than 2 weeks (during dry weather conditions)	1.0	0.5
April - October	2 weeks to 1 month	1.5	0.5

Note: K coefficients were developed from regression analysis of baseflow data from USGS Crest Stage Indicator (CSI) data to approximate flows that have a less than 50% chance of being exceeded between November - March.

4. Calculate the recommended temporary diversion design flow rate using equation TDM-1:

$$Q = S \quad K \quad A \qquad \text{(Equation TDM-1)}$$

In which,

Q = temporary diversion design flow rate for short-duration projects (cfs).

S = safety factor coefficient from Table TDM-2 based on duration.

K = diversion sizing coefficient from Table TDM-2 based on seasonality.

A = tributary area (square miles).

Of course, if the observed condition at the construction site suggests a higher flow, this should be estimated and used instead.

Example of Short-Duration Temporary Diversion Sizing Methodology

Project Location: Goldsmith Gulch Downstream (north) of E. Cornell Avenue

Planned project will involve approximately 0.12 acres of disturbance for bank stabilization, which will be completed within two weeks during the November to March time period. Using StreamStats, the gross contributing watershed area was determined to be approximately 6.2 mi^2. Based on project duration and seasonal timing, Table TDM-2 yields S = 1.0, K = 0.2. Equation TDM-1 can be used to calculate the recommended diversion flow:

$$Q = S\ K\ A$$

$$Q = 1.0 \bullet 0.2 \bullet 6.2\ mi^2 = 1.2\ cfs$$

Had this been a larger restorative maintenance project that will last 4 weeks, but will be started and completed within the November through March period, application of Equation TDM-1 and the recommended safety factor suggest the following diversion design flow:

$$Q = S\ K\ A$$

$$Q = 1.5 \bullet 0.2 \bullet 6.2\ mi^2 = 1.9\ cfs$$

Sizing Procedure for Interim Duration Projects (longer than one month and up to three months)

When projects last longer than one month but up to three months, a combination of sizing methods should be applied. The recommended temporary diversion flow rate should be evaluated using both the sizing procedure for short duration projects as well as the sizing procedure for long duration projects. These calculated flow rates should be weighed in combination with site-specific factors to determine an appropriate design flow rate. Each site should be evaluated individually to determine factors that may affect the design flow choice. For example, the designer may select to use the more conservative design flow for an interim duration project occurring in July and August where a chance for wet weather is forecast and flooding or damage to the area surrounding the project is unacceptable.

Maintenance and Removal

Because temporary diversions 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. For diversion channels, 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, temporary diversion measures should be removed. For temporary diversion channels, lining materials should be removed, and 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.

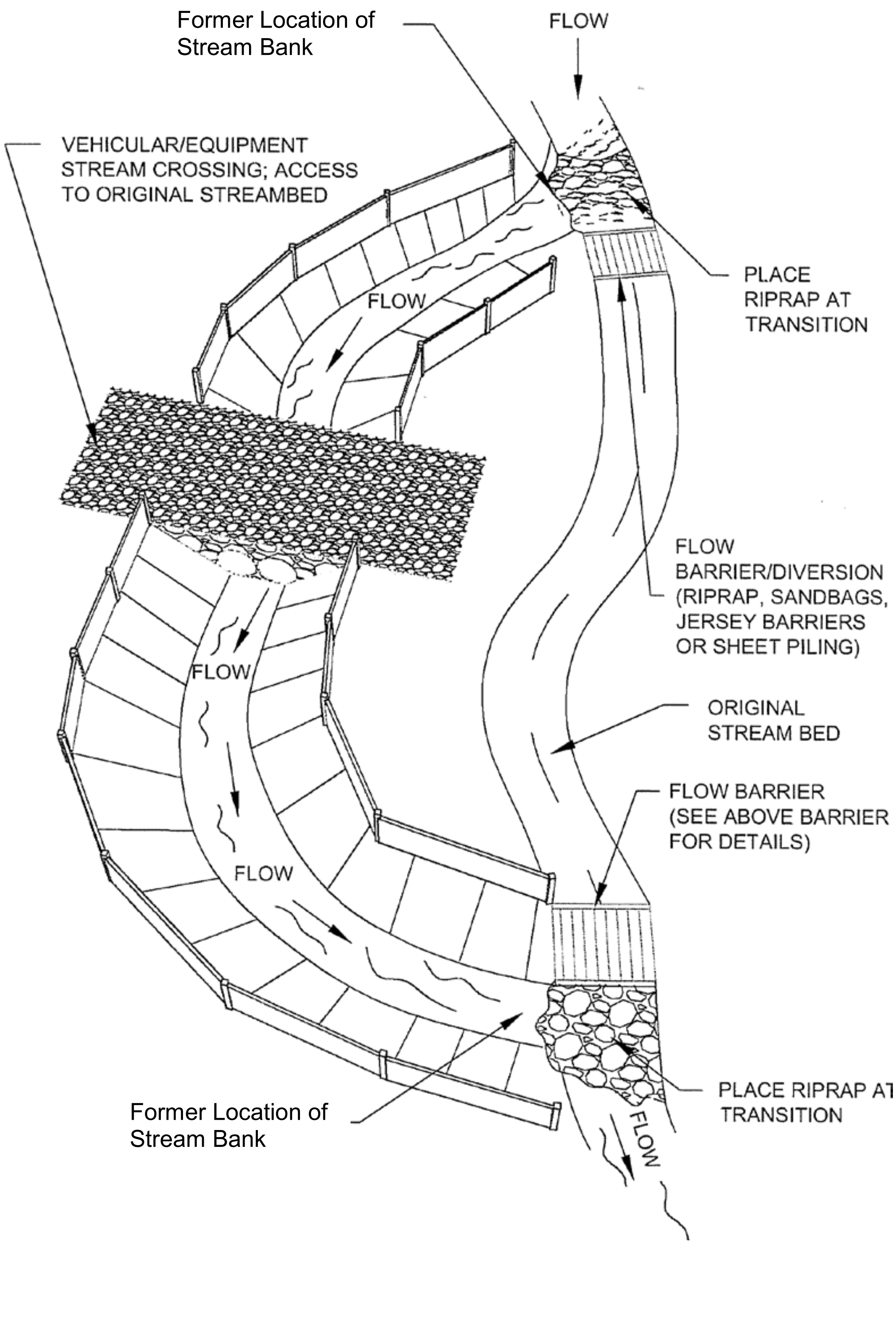


Figure TDM-1. Typical Temporary Diversion Channel

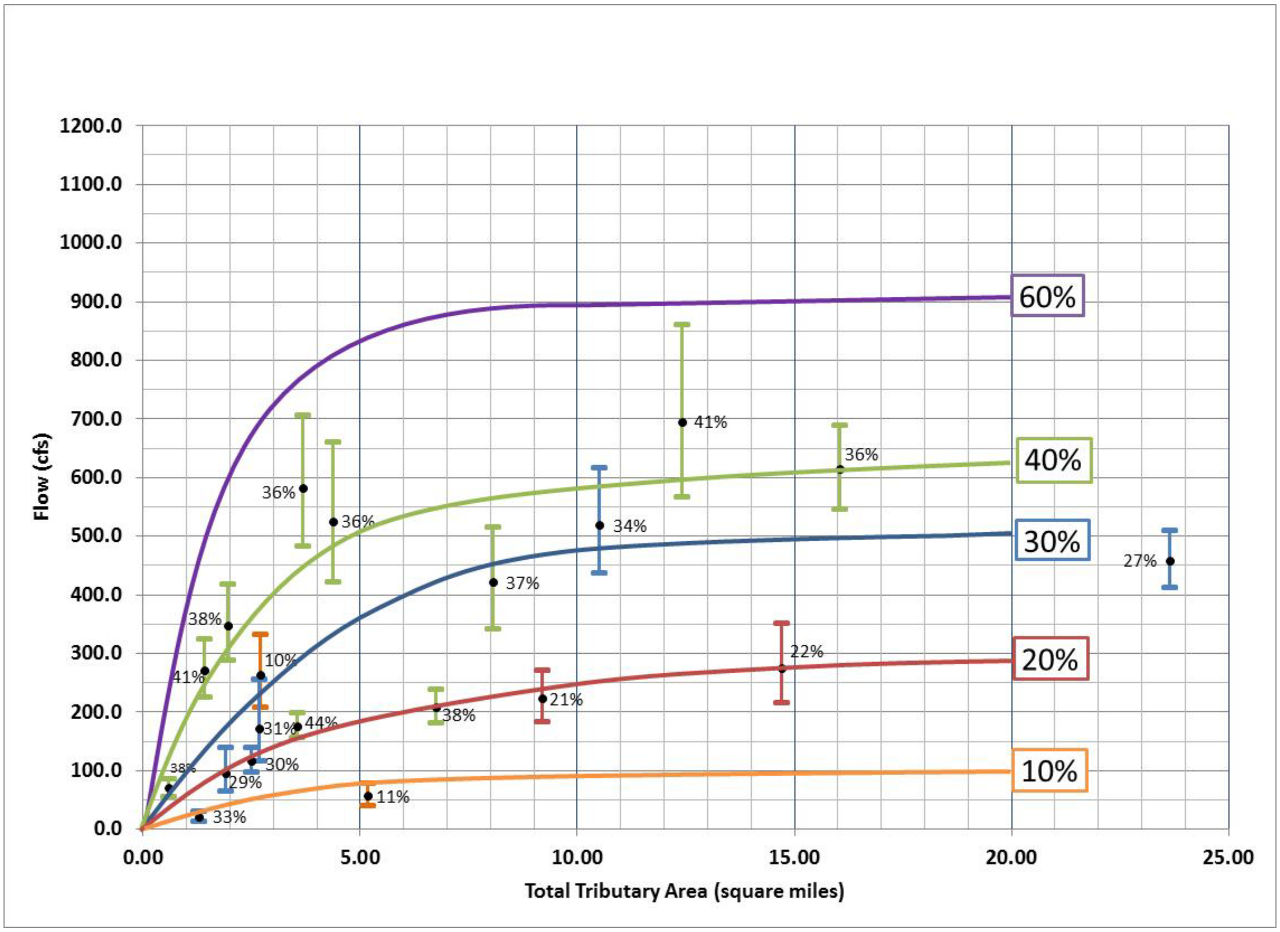
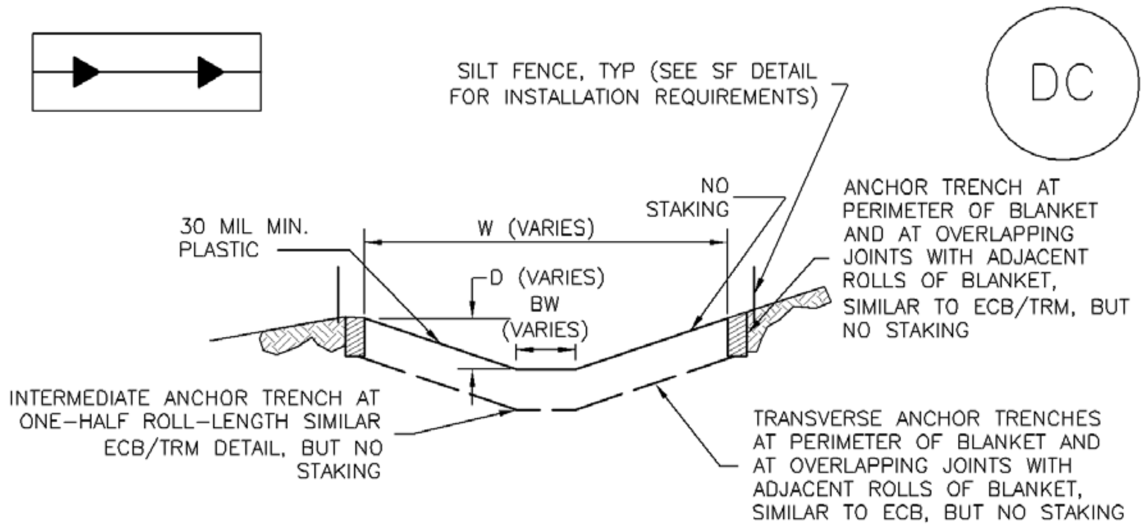
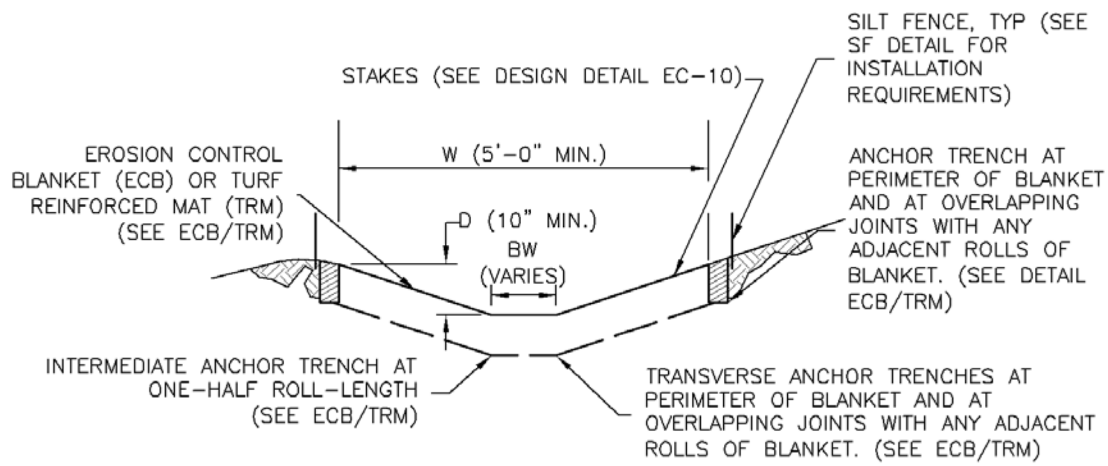


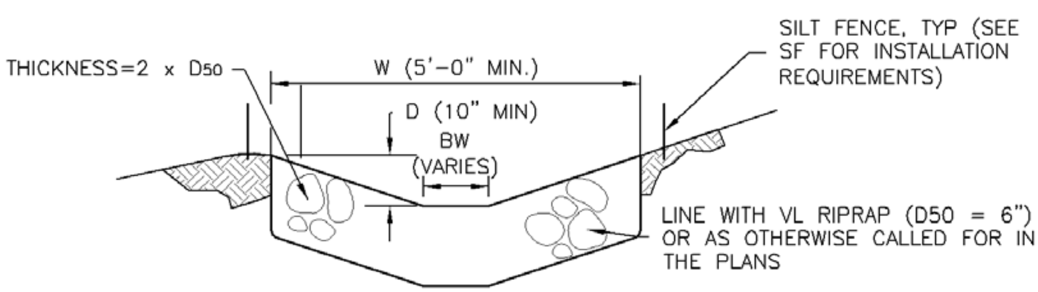
Figure TDM-2. Temporary Diversion Facility Sizing Nomograph for Long Duration Projects (Duration in excess of three months) Based on 2-year Peak Flows - Denver Metropolitan and Adjacent Areas, Updated April 2012



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

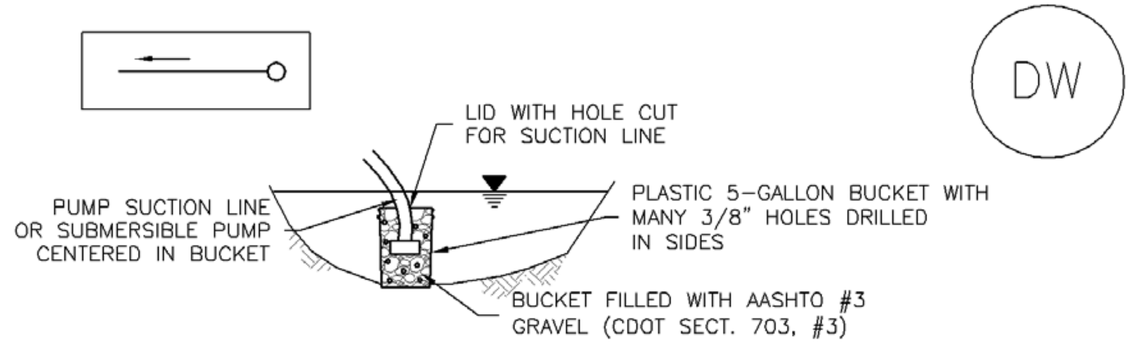
DW-3 Sump Discharge Settling Basin

DW-4 Dewatering Filter Bag

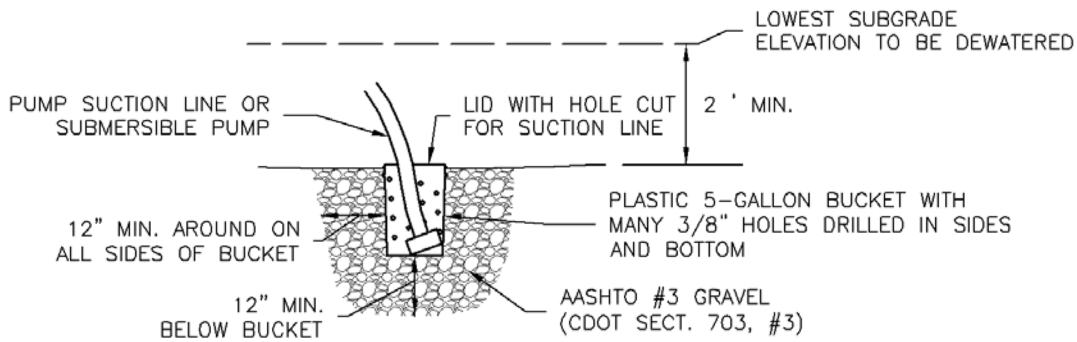
Maintenance and Removal

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.

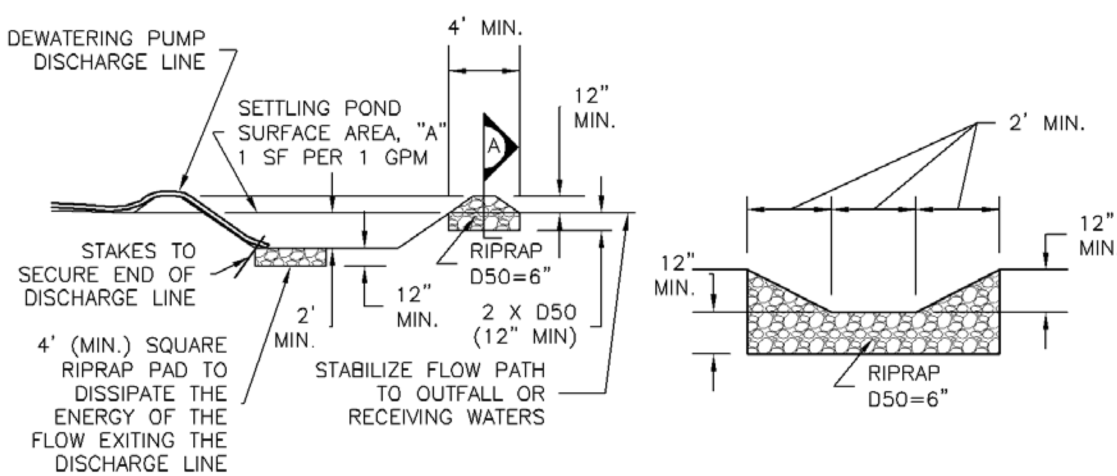
Properly dispose of used dewatering bags, as well as sediment removed from the dewatering BMPs. Depending on the size of the dewatering operation, it may also be necessary to revegetate or otherwise stabilize the area where the dewatering operation was occurring.



DW-1. DEWATERING POND ALREADY FILLED WITH WATER

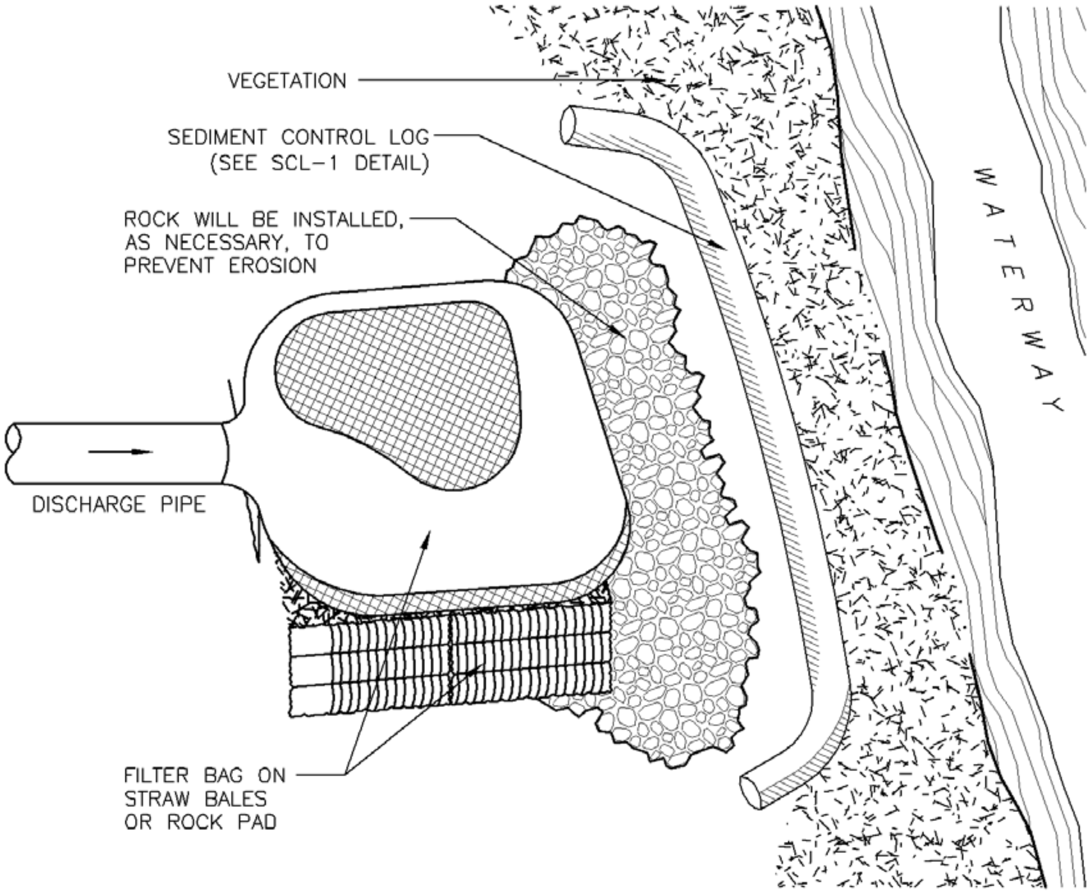


DW-2. DEWATERING SUMP FOR SUBMERSED PUMP



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 sized appropriately with consideration for the duration of construction and seasonal variation of flows. The sizing methodology provided in the Temporary Diversion Methods Fact Sheet is also appropriate for determining the design flow for temporary stream crossings. 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.

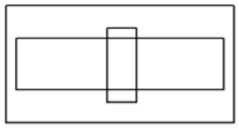
When a ford must be used, namely when a culvert is not practical or the best solution, the ford should be lined with at least a 12-inch thick layer of Type VL (D_{50} = 6 inches) or Type L (D_{50} = 9 inches) riprap with void spaces filed with 1-1/2 inch diameter rock. Ford crossings are recommended primarily for crossings of ephemeral (i.e. intermittently, briefly flowing) streams.

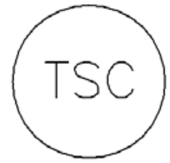
For a temporary bridge crossing, consult with a structural and/or geotechnical engineer for temporary bridge design or consider pre-fabricated alternatives.

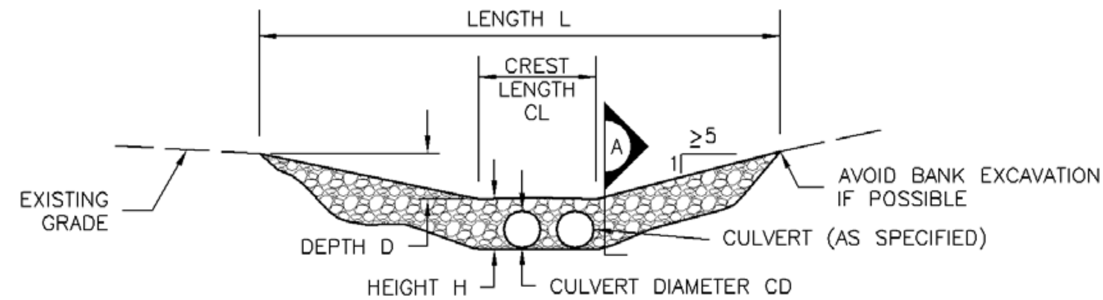
Maintenance and Removal

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. If sediment is accumulating upstream of the crossing, remove excess sediment as needed to maintain the functionality of the crossing.

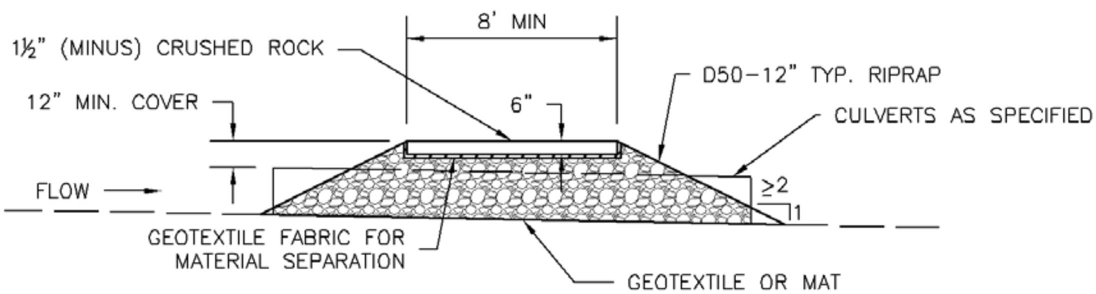
Remove the temporary crossing when it is no longer needed for construction. Take care to minimize the amount of sediment lost into the stream upon removal. Once the crossing has been removed, stabilize the stream banks with seed and erosion control blankets.





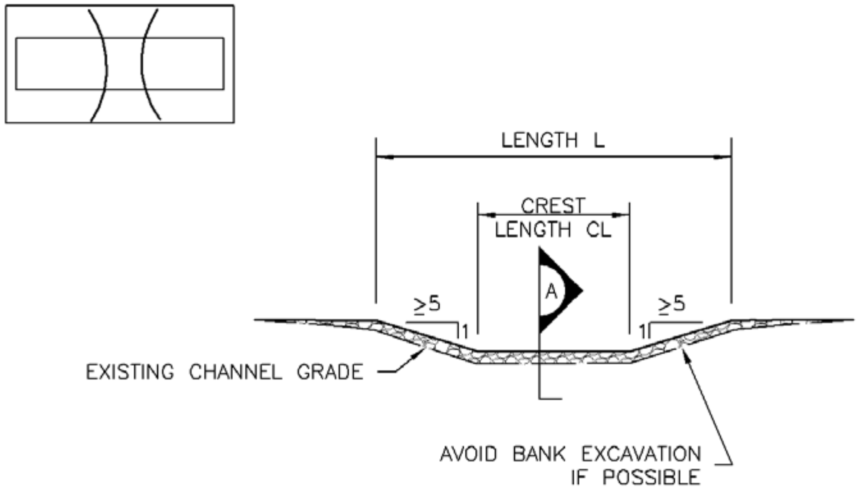


CULVERT CROSSING SECTION

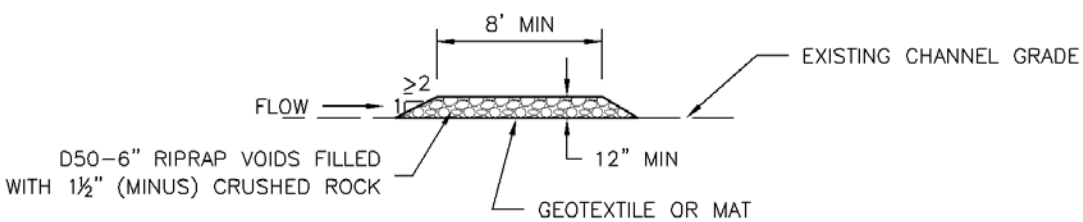


SECTION A

TSC-1. CULVERT CROSSING

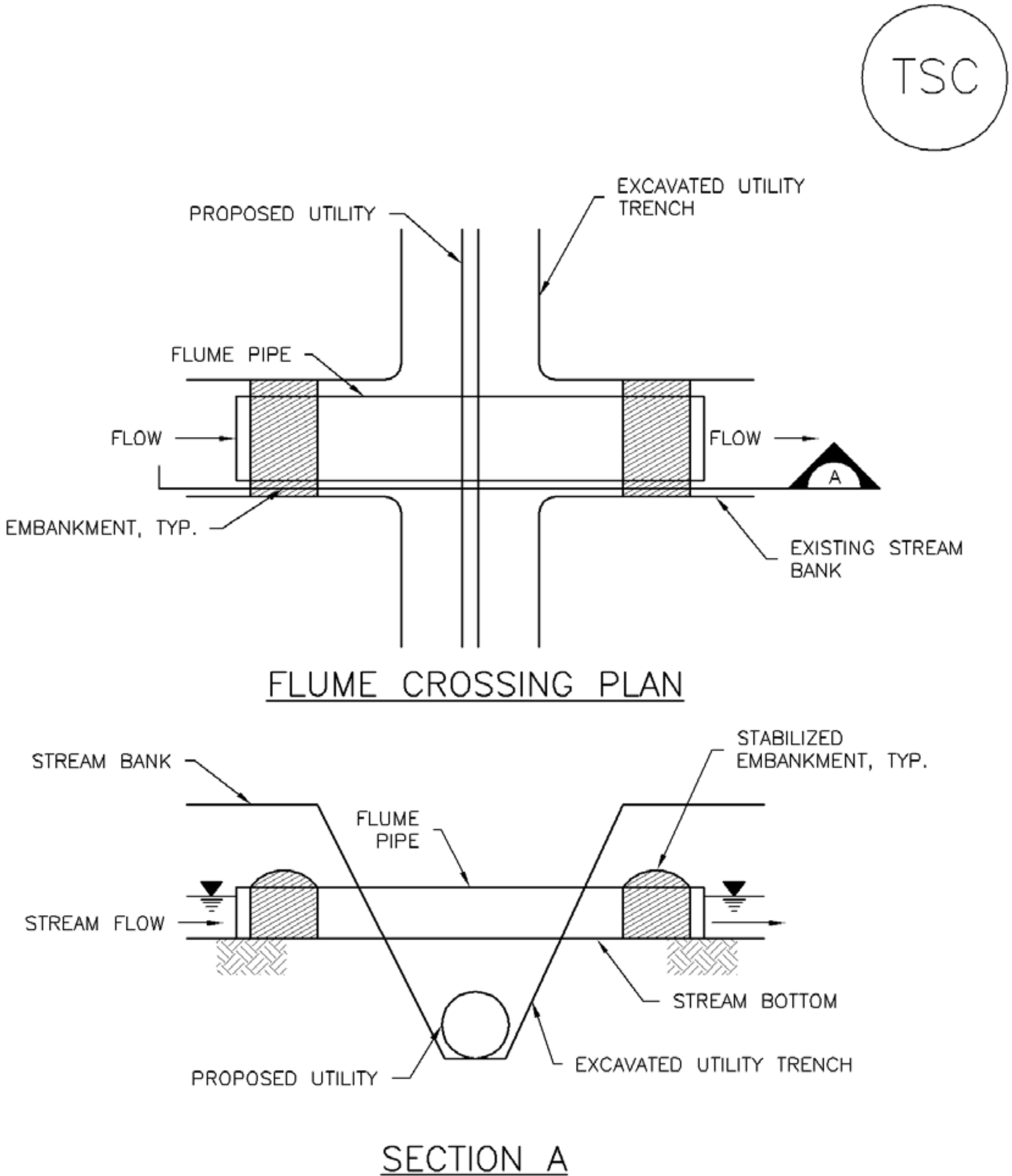


FORD CROSSING SECTION



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

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.

Photograph TBP-1. Effective stormwater management at temporary batch plants requires implementation of multiple BMPs. Photo courtesy of California Stormwater BMP Handbook.

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.

Appropriate Uses

Use runoff management practices during all paving and grinding operations such as surfacing, resurfacing, and saw cutting.

Photograph PGO-1. Paving operations on a Colorado highway. Photo courtesy of CDOT.

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 K

LARIMER COUNTY RECLAMATION SEED MIXES BY ECOTYPE

Contents

Life History Codes used in Seed Mixes

NPF = Native Perennial Forb (e.g., insect pollinated wildflower).

NBF = Native biennial forb.

NAF = Native annual forb.

NPG-L = Native perennial grass or grass-like plant

Table K-1: Bioswale Seed Mix.
Used in Larimer County Bureau of Reclamation administered properties.

Scientific Name	Common Name (USDA)	Cultivar or Ecotype	Life History	Pounds PLS Needed
Sporobolus airoides	Alkali sacaton	VNS	NPG-L	0.75
Verbena hastata	Blue vervain	VNS	NPF	1.00
Rhudbeckia hirta	Blackeyed Susan	VNS	NPF	1.00
Glyceria striata	Fowl mannagrass	VNS	NPG-L	1.00
Nassella viridula	Green Needlegrass	Lodorm	NPG-L	7.00
Distichlis spicata	Inland saltgrass	VNS	NPG-L	3.00
Helianthus nuttallii	Nuttal's sunflower	VNS	NPF	12.0
Dalea pupurea	Purple prairie clover	VNS	NPF	4.00
Triticum aestivum x Secale cereale	Quickguard	Quickguard	cover crop	15.0
Elymus trachycaulus ssp. Trachycaulus	Slender wheatgrass	San Louis	NPG-L	11.0
Elymus trachycaulus	Slender wheatgrass	First strike	NPG-L	11.0
Panicum Virgatum	Switchgrass	Neb. 28, Blackwell	NPG-L	2.50
Monarda fistulosa	Wild bergamot	VNS	NPF	1.00
Achillea millefolium	Yarrow	Occidentalis	NPF	1.00

PLS = Pure Live Seed. Due to low mix weight, buffer with rice hauls. If broadcasting use 2X seeding rate

Table K-2: Grassland Mix < 6,000 ft a.s.l.

Scientific Name	Common Name (USDA)	Cultivar or Ecotype	Life History	Pounds PLS Needed
Pascopyrum smithii	Western wheatgrass	Arriba	NPG-L	0.80
Bouteloua barbata	Sideoats grama	Vaughn	NPG-L	0.50
Bouteloua gracilis	Blue grama	Lovington	NPG-L	0.06
Nassella viridula	Green needlegrass	Lodorm	NPG-L	0.75
Panicum Virgatum	Switchgrass	Neb. 28, Blackwell	NPG-L	0.15
Andropogon gerardii	Big bluestem	Kaw, Bison, Champ	NPG-L	0.39
Schizachyrium scoparium	Little bluestem	Pastura, Blaze	NPG-L	0.35
Sporobolus cryptandrus	Sand dropseed	Borden	NPG-L	0.03
Bouteloua dactyloides	Buffalograss	Sharps, Cody, Bowie	NPG-L	1.0
Sporobolus airoides	Alkali sacaton	Salado	NPG-L	0.04
Elymus trachycaulus ssp. Trachycaulus	Slender wheatgrass	San Louis	NPG-L	0.88
Achillea millefolium	Yarrow	Occidentalis	NPF	0.03
Dalea purpurea	Purple prairie clover	Kaneb	NPF	0.40
Gaillardia aristata	Blanket flower	Meriwether	NPF	0.40
Ratiba columnifera	Prairie coneflower	Stillwater	NPF	0.06
Linum lewisii	Blue flax	Maple Grove	NPF	0.27
Cleome serrulata	Rocky Mountain bee plant	Pursh	NPF	0.72
Penstemon strictus	Rocky Mountain penstemon	Bandera	NPF	0.15
Monarda fistulosa	Wild bergamot	CO Ecotype (or VNS)	NPF	0.05
Ratiba columnifer	Mexican hat	VNS	NPF	0.07
Sphaeralcea coccinea	Scarlet globemallow	VNS	NPF	0.10
Triticum aestivum x Secale cereale	Quickguard	Quickguard	cover crop	15.00

PLS = Pure Live Seed. Due to low mix weight, buffer with rice hauls. If broadcasting use 2X seeding rate

Table K-3: Foothills Seed Mix < 6,000 – 7,500 ft a.s.l.

Scientific Name	**Common Name (USDA)**	**Cultivar or Ecotype**	**Life History**	**Pounds PLS Needed**
Bouteloua gracilis	blue grama	Fremont CO ecotype	NPG-L	0.32
Cleome serrulata	Rocky Mountain beeplant	CO Ecotype (or VNS)	NAF	0.84
Bouteloua curtipendula	sideoats grama	Niner	NPG-L	2.52
Coreopsis tinctoria	plains coreopsis	CO Ecotype (or VNS)	NBF	0.10
Elymus elymoides	squirreltail	Pueblo or Wapiti	NPG-L	2.50
Elymus trachycaulus	slender wheatgrass	Pryor or First Strike or San Luis	NPG-L	4.63
Festuca arizonica	Arizona fescue	Redondo	NPG-L	0.80
Gaillardia aristata	blanketflower	CO Ecotype (or VNS)	NPF	0.51
Helianthus annuus	common sunflower	CO Ecotype (or VNS)	NAF	0.83
Monarda fistulosa	wild bergamot	CO Ecotype (or VNS)	NPF	0.10
Pascopyrum smithii	western wheatgrass	Arriba	NPG-L	5.05
Poa secunda	Sandberg bluegrass	Sims Mesa or High Plains	NPG-L	0.37
Pseudoroegneria spicata	bluebunch wheatgrass	Anatone	NPG-L	2.87
Quickguard	Quickguard	Quickguard	cover crop	3.42

PLS = Pure Live Seed. Due to low mix weight, buffer with rice hauls. If broadcasting use 2X seeding rate

Acceptable Alternatives (Foothills Seed Mix)			
Scientific Name	**Common Name (USDA)**	**Cultivar or Ecotype**	**Life History**
Achillea lanulosa var. occidentalis	Western yarrow	Eagle or Yakima	NPF
Achnatherum hymenoides	Indian ricegrass	Paloma	NPG-L
Adenolinum lewisii	Lewis flax	CO ecotype or Maple Grove	NPF
Artemisia frigida	prairie sagewort	CO Ecotype preferred	NPF
Bouteloua curtipendula	sideoats grama	Niner	NPG-L
Dalea candida	white prairie clover	CO Ecotype preferred	NPF
Dalea purpurea	purple prairie clover	Kaneb or Stephanie	NPF
Festuca idahoensis	Idaho fescue	Trident	NPG-L
Helianthus petiolaris	prairie sunflower	CO Ecotype (or VNS)	NAF
Nassella viridula	green needlegrass	Cucharas	NPG-L
Poa fendleriana	muttongrass	Ruin Cyn	NPG-L
Regreen	Regreen	Regreen	cover crop
Symphyotrichum laeve	smooth blue aster	CO Ecotype (or VNS)	NPF
Achillea lanulosa var. occidentalis	Western yarrow	Eagle or Yakima	NPF
Achnatherum hymenoides	Indian ricegrass	Paloma	NPG-L
Adenolinum lewisii	Lewis flax	CO ecotype or Maple Grove	NPF
Artemisia frigida	prairie sagewort	CO Ecotype preferred	NPF
Bouteloua curtipendula	sideoats grama	Niner	NPG-L

Table K-4: Lower Montane Seed Mix < 7,501 – 8,500 ft a.s.l.

Scientific Name	Common Name (USDA)	Cultivar or Ecotype	Life History	% mix	Pounds PLS Needed
Adenolinum lewisii	Lewis flax	CO Ecotype or Maple Grove	NPF	2.0	0.32
Bouteloua gracilis	blue grama	Fremont CO ecotype	NPG-L	8.0	0.52
Cleome serrulata	Rocky Mountain beeplant	CO Ecotype (or VNS)	NAF	2.0	0.84
Elymus elymoides	squirreltail	Pueblo or Wapiti	NPG-L	10.0	2.50
Elymus trachycaulus	slender wheatgrass	Pryor or First Strike or S	NPG-L	14.0	4.63
Festuca arizonica	Arizona fescue	Redondo	NPG-L	10.0	1.00
Gaillardia aristata	blanketflower	CO Ecotype	NPF	3.0	0.77
Pascopyrum smithii	western wheatgrass	Arriba	NPG-L	14.0	5.89
Poa secunda	Sandberg bluegrass	Sims Mesa or High Plains	NPG-L	12.0	0.55
Pseudoroegneria spicata	bluebunch wheatgrass	Anatone	NPG-L	8.0	3.28
Quickguard	Quickguard	Quickguard	Cover Crop	1.0	3.42
Rudbeckia hirta	blackeyed Susan	CO ecotype	NBF	3.0	0.09
Bromus marginatus	mountain brome	Cold Springs Ecotype	NPG-L	12.0	6.85
Penstemon strictus	Rocky Mountain penstemon	Bandera	NPF	1.0	0.11

PLS = Pure Live Seed. Due to low mix weight, buffer with rice hauls. If broadcasting use 2X seeding rate

Acceptable Alternatives (Lower Montane Mix)			
Scientific Name	**Common Name (USDA)**	**Cultivar or Ecotype**	**Life History**
Elymus lanceolatus ssp. lanceolatus	thickspike wheatgrass	Critana	NPG-L
Achillea lanulosa var occidentalis	Western yarrow	Eagle or yakima	NPF
Achnatherum hymenoide	indian ricegrass	Paloma	NPG-L
Achnatherum robustum	sleepy grass	0	NPG-L
Artemisia frigida	prairie sagewort	CO Ecotype preferred	NPF
Erigeron speciosus	aspen fleabane	CO Ecotype (or VNS)	NPF
Festuca idahoensis	Idaho fescue	Trident	NPG-L
Helianthus petiolaris	prairie sunflower	CO Ecotype (or VNS)	NAF
Heliomeris multiflora	showy goldeneye	CO Ecotype (or VNS)	NPF
Hesperostipa comata	needl-n-thread	CO Ecotype or Bluebuckle	NPG-L
Koeleria macranth	prairie junegrass	Sims Mesa	NPG-L
Penstemon virgatus	Front Range beardtongue	CO Ecotype (or VNS)	NPF
Poa fendleriana	muttongrass	Ruin Cyn	NPG-L
Regreen	Regreen	Regreen	Cover Crop
Symphyotrichum laeve	smooth blue aster	CO Ecotype (or VNS)	NPF
Chamerion angustifolium	fireweed	CO Ecotype (or VNS)	NPF

Table K-5: Upper Montane Seed Mix < 9,501 – 10,500 ft a.s.l.

Scientific Name	Common Name (USDA)	Cultivar or Ecotype	Life History	% mix	Pounds PLS Needed
Elymus trachycaulus	slender wheatgrass	Pryor or First Strike or S	NPG-L	16.0	5.77
Poa secunda	Sandberg bluegrass	Sims Mesa or High Plains	NPG-L	14.0	0.70
Quickguard	Quickguard	Quickguard	Cover Crop	1.0	3.73
Bromus marginatus	mountain brome	Cold Springs Ecotype	NPG-L	16.0	9.96
Deschampsia cespitosa	tufted hairgrass	Peru Creek	NPG-L	14.0	0.37
Elymu glaucus	blue wildrye	Elkton	NPG-L	10.0	3.89
Festuca saximontana	Rocky Mountain fescue	CO Ecotype preferred	NPG-L	12.0	0.52
Trisetum spicatum	spike trisetum	CO Ecotype preferred	NPG-L	12.0	0.25
Festuca idahoensis	Idaho fescue	Trident	NPG-L	5.0	0.58

PLS = Pure Live Seed. Due to low mix weight, buffer with rice hauls. If broadcasting use 2X seeding rate

Acceptable Alternatives (Upper Montane Mix)			
Scientific Name	**Common Name (USDA)**	**Cultivar or Ecotype**	**Life History**
Erigeron speciosus	aspen fleabane	CO Ecotype (or VNS)	NPF
Heliomeris multiflora	showy goldeneye	CO Ecotype (or VNS)	NPF
Koeleria macranth	prairie junegrass	Sims Mesa	NPG-L
Poa fendleriana	muttongrass	Ruin Cyn	NPG-L
Regreen	Regreen	Regreen	Cover Crop

References

Larimer County Natural Resources Department, 2021. *Seed Mixes, BMPs and Guidelines for Seeding and Mulching in the Cameron Peak Burn Area*. Available at: https://www.larimer.gov/naturalresources/weeds