3.0 Erosion and Sediment Control

3.1 Introduction

Disturbed lands include all those lands from which vegetation has been either temporarily or permanently removed. Examples of disturbed land include construction sites, corrals, confined animal feeding operations, and overgrazed lands. Disturbed lands are subject to substantial erosion and can be a source of significant discharges of sediment and other pollutants to wetlands and Major Drainageways.

3.2 Discharge Goal

Erosion and Sediment Control plans shall be prepared and implemented for areas of disturbance in excess of 10,000 square feet. Projects with disturbed area less then 10,000 square feet may still be required to provide sediment and erosion control measures. The plan shall be designed to minimize the discharge of sediment to Major Drainageways, wetlands, storm sewer systems, and adjacent properties. The Discharge Goal is described as follows: There shall be no discharge of more than 15 percent of the potential sediment load from disturbed lands for storm events smaller than a one inch rainfall within a one hour period to a Major Drainageway, wetland, storm sewer system, or across the property boundary, whichever is most restrictive.

The Discharge Goal will be achieved through the avoidance, wherever possible, of disturbing lands with slopes in excess of 15 percent and the use of recognized Best Management Practices (BMPs) and sediment ponds in all disturbed areas. The purpose of the BMPs will be to minimize the erosion of soil and the production of sediment at the source to the maximum extent practicable. The BMPs are assumed to control 50% of the potential sediment discharge from the site. The balance of the potential sediment discharge shall be controlled using sediment entrapment facilities.

3.3 Principles of Erosion and Sediment Control

Soil erosion is caused by the action of wind, rainfall, and runoff on bare soil. Clearing, grading, and other construction activities remove the vegetation and compact the soil, increasing both runoff and erosion. Excessive runoff then causes erosion and results in increased off-site erosion, discharges of sediment to streams, flooding problems, and damage to wetlands. Effective erosion and sediment control can be achieved by careful implementation of the following management actions:

1) Fit the development to the existing topography, soils, and vegetation.
2) Minimize disturbance and soil exposure by retaining natural vegetation, adopting phased construction techniques, and using temporary cover.

3) Vegetate and mulch all exposed areas to protect the soil from precipitation. The primary effort for controlling sediment pollution from construction sites should be to minimize raindrop impact on bare soil.
4) Utilize proper grading, barriers, or ditches to minimize concentrated flows and divert runoff away from exposed areas.
5) Minimize the steepness of slopes and control the length of slopes by utilizing benches, terraces, contour furrows, or diversion ditches.
6) Utilize riprap, channel linings, or temporary structures in ditches, swales, and channels to slow runoff velocities and allow the drainageways to handle the increased runoff from disturbed and developed area.
7) Keep the sediment on-site by utilizing sediment basins, traps, or sediment barriers.
8) Monitor and inspect sites frequently to assure the measures are functioning properly and correct problems promptly.

3.4 Erosion and Sediment Control Plans

3.4.1 Plan Submission

The Erosion and Sediment Control Plan must be submitted with the building permit application. For projects with a disturbed area greater than 1 acre, the proposed Erosion and Sediment Control Plan shall be certified by a professional engineer licensed in the State of Colorado. The certification will be bound into the Erosion and Sediment Control Plan at the time of submittal to the City of Greenwood Village (Village) using the following form:

> I hereby certify that this Erosion and Sediment Control Plan for (name of site) was prepared by me or under my direct supervision in accordance with the Greenwood Village Construction Standards.
>
> _____
> Signature
>
> _____
> Colorado License Number
>
> _____
> Seal

Construction or clearing of the site cannot begin until the Erosion and Sediment Control Plan has been reviewed and approved by the City Manager or designee.

3.4.2 Contents of the Erosion and Sediment Control Plan

For projects with a disturbed area less than 1 acre, the proposed Erosion and Sediment Control plan shall include, as a minimum, the information shown in Item 8, Maps, shown in Table 3-1.

For projects with a disturbed area of at least 1 acre, the proposed Erosion and Sediment Control Plan shall include, as a minimum, the information shown in Table 3-1.

Table 3-1: Erosion and Sediment Control Plan Checklist

Item
Engineer's Certificate
1) General Location and Description
a. Location
i. Local streets within and adjacent to the development.
ii. Township, range, section, and ¼ section.
iii. Major Drainageways, drainage facilities, perennial streams, and wetlands near the development.
iv. Names of surrounding developments.
b. Description of Property
i. Area in acres.
ii. Ground cover (type of trees, shrubs, and vegetation).
iii. Major Drainageways, drainage facilities, perennial streams, and wetlands within the development.
iv. General project description.
v. Areas of moderate or highly erodible soils.
2) Erosion and Sediment Control Design Criteria
a. Regulations
i. Discussion of compliance with or deviation from these Construction Standards.
ii. Discussion and justification of other criteria or methods used that are not presented in or referenced by these Construction Standards or UDFCD Drainage Criteria Manual.
3) Erosion and Sediment Control Design
a. General Concept
i. Discussion of existing drainage patterns that affect the control measure design.
ii. Discussion of proposed drainage patterns that affect the control measure design.
iii. Discussion of the content of tables, charts, figures, or drawings.
b. Specific Details
i. Discussion of each erosion and sediment control measure.

Item
ii. Discussion of the schedule of implementation for each erosion and sediment control measure used to meet the requirements of these Construction Standards.
4) Maintenance Plan
a. Maintenance Activities
i. Frequency of inspection.
ii. Repair and reconstruction of damaged measures.
iii. Cleanout and disposal of trapped sedimentation.
iv. Duration of maintenance program.
v. Final disposition of the measures when sitework is complete.
5) Conclusions
a. Compliance with Standards
i. Drainage Criteria Manual.
ii. UDFCD Drainage Criteria Manual.
b. Erosion and Sediment Control Concept
i. Effectiveness of facility design to control erosion and sediment.
6) References
a. Reference all criteria and technical information used.
7) Appendices
a. Erosion and Sediment Discharge Calculations
i. Calculation of average annual soil erosion rates without control measures for the entire area proposed for development.
ii. Sediment pond calculations.
8) Maps
a. General Location Map
i. A general location map showing the general drainage patterns around the property. The map should be at a scale of 1” = 1000’ or 2000’ and show the path of all drainage to and from any off-site basins. The map shall identify any development or facilities (i.e., irrigation ditches, existing detention facilities, culverts, and storm sewers) along the path of the off-site and on-site drainage.
b. Erosion and Sediment Control Plan
i. Map(s) of the proposed development shall be provided at a scale of 1” = 20’ to 1” = 200’ on 24” x 36” sheets.

Item
ii. A topographic map shall be provided with two-foot existing and proposed contours tied to the Greenwood Village "Control Diagram" (Figure 2-1). The topographic map shall extend a minimum of 50-feet beyond the property lines.
iii. Property lines, easements, and purposes of easements.
iv. Streets.
v. Existing drainage facilities and structures, including irrigation ditches, roadside ditches, gutters, culverts, Major Drainageways, and existing wetlands. All pertinent information such as materials, size, shape, slope and location shall also be included.
vi. Proposed type of street flow (i.e., vertical or combination curb and gutter), roadside ditch, gutters, and cross pans.
vii. Proposed storm sewers and open channels, including inlets, manholes, culverts, and other appurtenances.
viii. Location of each control measure.
ix. Details of control measures or reference to standard UDFCD details.
x. Location and elevations of all floodplains affecting the property.

3.5 Inspection, Maintenance, and Modification of Erosion and Sediment Control Plan

It can be anticipated that erosion control measures beyond those included in the Erosion and Sediment Control Plan will be necessary due to unforeseen circumstances or because the plan may not work as intended. For this reason, an inspection and maintenance program will be a necessary component of every Erosion and Sediment Control Plan.

The BMPs and sediment ponds shall be inspected by the Property Owner's Representative after each storm event. The actual performance of each BMP and sediment pond will be evaluated and compared with performance anticipated in the approved Erosion and Sediment Control Plan and any necessary maintenance will be completed within 24 hours. If the performance does not meet the goals of the Erosion and Sediment Control Plan, including the Discharge Goal, the BMPs and sediment ponds will be modified as necessary to meet the Discharge Goal within seven days. Modifications to the plan will be submitted to the Village for review and approval by the City Manager or designee within seven days of the stormwater discharge event which does not meet the Discharge Goal.

3.6 Estimating Potential Erosion and Sediment Discharge

3.6.1 Soil Classification

Soil classification provides a way to concisely express the general characteristics of different soils into groups or classes having similar properties. Soils include a wide variety of materials such as gravel and sand, clay mixtures deposited by glaciers, and the alluvial sands, silts, and clays in the floodplains of the Major Drainageways. Classification makes it possible to estimate performance by grouping soils with similar properties into the same class. Soil texture classifications developed by the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) are based on particle-size limits for sand, silt, and clay. The size of soil particles play an important role in the engineering properties and are more strongly influenced by surface forces than by gravity forces.

3.6.2 Calculation of Potential Erosion and Sediment Discharge

Soils that exist within the Village have been identified to assist the applicant in estimating the potential erosion and sediment discharge. The information used to develop the tables was obtained from NRCS Soil Survey Soils Maps, U.S. Geological Survey (USGS) Quadrangle topographic maps, and the NRCS Soils Inventory List for Arapahoe County.

The Universal Soil Loss Equation (USLE), Equation 3-1, consists of five factors. The ULSE provides a model for the prediction of erosion by water in areas where field measurements have not been made. Widespread field use of the USLE has substantiated its usefulness and validity for this purpose. Improvements in the USLE over the years have provided methods for predicting the effects of land uses, climatic conditions, and management practices on the potential erosion.

The erosion rate for a given area is determined from the combination of many physical and management variables. The USLE model predicts annual soil erosion rates even though short-time variables in specific storm events vary considerably from storm to storm. The USLE is:

$$A = (R)\,(K)\,(LS)\,(C)\,(P) \qquad (3\text{-}1)$$

where: A = Computed spatial average soil loss and temporal average soil loss per unit of area, ton/acre/yr.

R = Rainfall-runoff erosivity factor. Defines the total annual erosive potential that is due to climatic effects. This factor reflects the impact of the geographical location on erosion, including lakes or mountain ranges, and the dominance of frontal or cyclonic activity. For the Village, R = 40.0.

K = Soil erodibility factor. Quantifies the susceptibility of soil erosion by water and predicts the long-term average soil loss that results from sheet and rill erosion. The erodibility factor, obtained experimentally, varies from 0.02 to 0.69 depending upon the NRCS soil classification. The erodibility factors for the Village range from 0.02 to 0.64 and are shown in Table 3-2. Figure 2-4 shows the locations for the different classes of soils in the Village.

LS = Slope length and steepness factor. The effects of slope length and steepness have been evaluated separately in research; however, considering them as a single topographic factor in the field is more convenient. This factor represents the ratio of soil loss for a uniform slope length and steepness. Table 3-3 provides a LS value for a given length and steepness of uniform slopes for freshly prepared construction and other highly disturbed soil conditions with little or no cover.

C = Cover-management factor. This is the ratio of soil loss from land cropped under specific conditions to the corresponding loss from clean-tilled soil that is left fallow on a continuous basis. Disturbed lands that remove the vegetation and leave the surface with minimal protection are comparable to continuous fallow conditions. So C = 1.0.

P = Support practice factor. This is the ratio of soil loss with a specific support practice to the corresponding soil loss with upslope and downslope tillage. The impact of support practices for soil conservation planning on cropland would rarely have a counterpart on disturbed land areas. Because the slope length and steepness are accounted for in LS, P = 1.0.

Table 3-2: USLE Erosion Factor (K)

Map Symbol	Soil Series	Dominant USDA Soil Texture	Erosion Factor (K)
FoC	Fondis-Colby Silt Loam 3 to 5 % slope	Clay and silty clay loam, clay loam and silt loam, silt loam	0.43
BxD	Buick Loam 5 to 9 % slope	Loam to clay loam, sandy clay loam	0.37
BxC	Buick Loam 3 to 5 % slope	Loam to clay loam, sandy clay loam	0.37
Lv	Loamy Alluvial Land nearly level		0.37
RhE	Renohill-Buick Loams 9 to 20 % slope	Clay loam, loam to clay loam, sandy clay loam	0.37
RhD	Renohill-Buick Loams 3 to 9 % slope	Clay loam, loam to clay loam, sandy clay loam	0.37
Tc	Terrace Escarpments nearly vertical		0.37
RtE	Renohill-Litle-Thedalund Complex 9 to 30 % slope	Clay loam, clay, silty clay loam	0.32
FdC	Fondis Silt Loam 3 to 5 % slope	Clay and silty clay loam, clay loam, silt loam	0.32
FdB	Fondis Silt Loam 1 to 3 % slope	Clay and silty clay loam, clay loam, silt loam	0.32
WeB	Weld Silt Loam 0 to 3 % slope	Silty clay loam to silty clay, silt loam	0.32
NIB	Nunn Loam 0 to 3 % slope	Clay, stratified sands and loams	0.28
be	Bresser-Truckton Sandy Loam 5 to 20 % slope	Sandy loam and sandy clay loam, sandy loam, loamy sand	0.24
Gr	Gravelly Land 6 to 50 % slope	Sandy loam, gravelly clay loam, gravel sand and silt	0.10
Wt	Wet Alluvial Land nearly level	Loam to sand, gravel	0.10

Table 3-3: USLE Slope Length and Steepness Factor (LS)

Slope %	Horizontal Slope Length (ft)																
	<3	6	9	12	15	25	50	75	100	150	200	250	300	400	600	800	1000
0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
0.5	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.12	0.12	0.13
1.0	0.09	0.09	0.09	0.09	0.09	0.10	0.13	0.14	0.15	0.17	0.18	0.19	0.20	0.22	0.24	0.26	0.27
2.0	0.13	0.13	0.13	0.13	0.13	0.16	0.21	0.25	0.28	0.33	0.37	0.40	0.43	0.48	0.56	0.63	0.69
3.0	0.17	0.17	0.17	0.17	0.17	0.21	0.30	0.36	0.41	0.50	0.57	0.64	0.69	0.80	0.96	1.10	1.23
4.0	0.20	0.20	0.20	0.20	0.20	0.26	0.38	0.47	0.55	0.68	0.79	0.89	0.98	1.14	1.42	1.65	1.86
5.0	0.23	0.23	0.23	0.23	0.23	0.31	0.46	0.58	0.68	0.86	1.02	1.16	1.28	1.51	1.91	2.25	2.55
6.0	0.26	0.26	0.26	0.26	0.26	0.36	0.54	0.69	0.82	1.05	1.25	1.43	1.60	1.90	2.43	2.89	3.30
8.0	0.32	0.32	0.32	0.32	0.32	0.45	0.70	0.91	1.10	1.43	1.72	1.99	2.24	2.70	3.52	4.24	4.91
10.0	0.35	0.37	0.38	0.39	0.40	0.57	0.91	1.20	1.46	1.92	2.34	2.72	3.09	3.75	4.95	6.03	7.02
12.0	0.36	0.41	0.45	0.47	0.49	0.71	1.15	1.54	1.88	2.51	3.07	3.60	4.09	5.01	6.67	8.17	9.57
14.0	0.38	0.45	0.51	0.55	0.58	0.85	1.40	1.87	2.31	3.09	3.81	4.48	5.11	6.30	8.45	10.40	12.23
16.0	0.39	0.49	0.56	0.62	0.67	0.98	1.64	2.21	2.73	3.68	4.56	5.37	6.15	7.60	10.26	12.69	14.96
20.0	0.41	0.56	0.67	0.76	0.84	1.24	2.10	2.86	3.57	4.85	6.04	7.16	8.23	10.24	13.94	17.35	20.57
25.0	0.45	0.64	0.80	0.93	1.04	1.56	2.67	3.67	4.59	6.30	7.88	9.38	10.81	13.53	18.57	23.24	27.66
30.0	0.48	0.72	0.91	1.08	1.24	1.86	3.22	4.44	5.58	7.70	9.67	11.55	13.35	16.77	23.14	29.07	34.71
40.0	0.53	0.85	1.13	1.37	1.59	2.41	4.24	5.89	7.44	10.35	13.07	15.67	18.17	22.95	31.89	40.29	48.29
50.0	0.58	0.97	1.31	1.62	1.91	2.91	5.16	7.20	9.13	12.75	16.16	19.42	22.57	28.60	39.95	50.63	60.84
60.0	0.63	1.07	1.47	1.84	2.19	3.36	5.97	8.37	10.63	14.89	18.92	22.78	26.51	33.67	47.18	59.93	72.15

3.7 Recognized Best Management Practices and Sediment Ponds

BMPs shall be used to minimize soil erosion and control at least 50% of the potential sediment discharges from the site. Several recognized BMPs can be used for this purpose. The applicant may also identify additional BMPs for consideration by the Village. It remains the responsibility of the applicant to ensure that the BMPs included in the Erosion and Sediment Control Plan will control at least 50% of the potential sediment discharges from the site. Normally, this will require the consideration of the following BMPs in the Erosion and Sediment Control Plan:

1) Scheduling,
2) Minimization of Disturbed Areas and Buffer Strips,
3) Grading to Minimize Erosion,
4) Surface Roughening,
5) Vehicle Tracking Control,
6) Temporary Diversion Dike,
7) Geotextiles,
8) Silt Fence Barrier,
9) Straw Bale Barrier,
10) Inlet Protection,
11) Rock Check Dam, and
12) Revegetation (including timeline for seeding and mulching.)

The balance of the potential sediment discharge shall be controlled using sediment entrapment facilities.

The design of the BMPs and sediment entrapment facilities shall be in accordance with the criteria presented in the Construction BMPs Chapter, Volume 3 of the UDFCD Drainage Criteria Manual. Detailed design criteria and design procedures specific for the Village are highlighted in the following Sections.

The design policy of the Village is to provide guidelines that are consistent with regional stormwater drainage policy. The guidelines are intended to serve as a minimum standard and are not intended to replace site-specific analysis and design requirements of individual projects.

If one or more of these BMPs are not included in the Erosion and Sediment Control Plan, the certifying engineer must include a specific rationale for its exclusion. Cost alone shall not be considered an adequate reason for exclusion. Adequate reasons for exclusion could include:

1) Absence of any discernible drainage channels or all drainage channel slopes are less than 1%.
2) Absence of drop inlets.
3) Absence of surface slopes in excess of 2%.

3.7.1 Scheduling

DEFINITION: Scheduling is the sequencing of the project activities to reduce the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking. The schedule is a listing of all land disturbing activities together with the necessary erosion and sediment control measures planned for the project. This schedule guides the contractor on work to be completed before other work is started so that erosion and sedimentation problems can be avoided.

PURPOSE: The work schedule coordinates the timing of land disturbing activities and the implementation of control measures and is perhaps the most cost-effective way of controlling erosion during construction. The removal of ground cover leaves a site vulnerable to erosion. Construction procedures that limit clearing, provide the timely installation of erosion and sediment control measures and restore ground cover can significantly reduce the erosion potential of a site.

DESIGN CONSIDERATIONS:

1) Design project to integrate into existing land contours.
2) Schedule major grading operations during dry months, allowing enough time before rainfall begins to stabilize the soil with vegetation or to install temporary sediment control measures.
3) Locate temporary soil stockpiles and staging areas to minimize additional land disturbance.
4) Practice erosion and sediment control year round, erosion may be caused by unexpected precipitation, wind, and vehicle tracking.
5) Apply perimeter control measures.
6) Schedule projects that disturb only small portions of the site at any one time, complete grading as soon as possible, and immediately stabilize the disturbed portion before starting the next phase.
7) Close and stabilize trenches as soon as possible.

TYPICAL SCHEDULE: A typical schedule shall include the following deadlines as a minimum:

1) Silt fencing and vehicle tracking control: prior to initial grading activities.
2) Sediment ponds: initial phase of grading activities.
3) Seeding and mulching: within 15 days from completion of grading activities.
4) Inlet/outlet protection: within 1 week after inlet installation.
5) Straw bale check dams: within 1 week after completion of swale or ditch grading.

3.7.2 Minimization of Disturbed Areas and Buffer Strips

DEFINITION: Minimizing disturbed areas and maintaining buffer strips retains the natural vegetative cover and maintains vegetative buffer strips near wetlands, Major Drainageways, and adjacent properties.

PURPOSE: Minimizing the amount of disturbed soil on the project site will decrease the amount of soil which erodes from the site and decrease the number of required control measures. Buffer zones are used to decrease the velocity of runoff, which in turn helps to prevent soil erosion.

DETAILS:

1) Designate areas of no disturbance. Clearly show on the plans and flag or fence in the field areas of no disturbance and vehicle exclusion.
2) Designate and protect trees and shrubs that are to be preserved.
3) Designate wetland and Major Drainageway buffer strips.
4) Maintain and preserve riparian and naturally vegetated buffer strips along wetlands, Major Drainageways, and other natural channels.
5) The width of a buffer strip between the disturbed area and the protected area is 50 feet plus four times the slope of the land in percent, measured between the edges of the disturbed area and the protected area.

3.7.3 Grading to Minimize Erosion

DEFINITION: Grading to minimize erosion is the contouring of slopes to lessen the impacts of surface erosion and runoff.

PURPOSE: Careful grading will minimize the erosion potential and encourage ground cover establishment. Generally, grading to minimize erosion will not be necessary if slopes are less than 3%.

SLOPE CONTOUR FURROWS:

1) Stair-step grade or groove cut slopes that are steeper than 4 (horizontal) to1 (vertical).
2) Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some soil are particularly suited to stair-step grading.
3) Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in toward the vertical portion.
4) Do not make individual vertical cuts more than 2 feet high in soft materials or more than 3 feet high in rocky materials.
5) Groove the slope using machinery to create a series of ridges and depressions that run across the slope at the same elevation.

3.7.4 Surface Roughening

DEFINITION: Surface roughening is a technique to shallow groove a bare soil surface by normal tilling, disking, harrowing, or tracking with construction equipment.

PURPOSE: Surface roughening is intended to reduce runoff velocity, increase infiltration and provide for sediment trapping.

INSPECTION AND MAINTENANCE: Periodically check the seeded slopes for rills and washes. Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

3.7.5 Vehicle Tracking Control

The vehicle tracking control shall be used on all sites that have the potential for vehicles to track sediment off the site. Access that crosses a curb shall include a stepped wood ramp to protect the curb. Gravel or dirt ramps are prohibited.

3.7.6 Silt Fence

Silt fencing shall be placed downgrade of all disturbed areas that have the potential for sediment to be transported off the site by runoff. Projects with small areas of disturbance may have the bottom of the fence anchored on top of the ground using gravel or dirt. A minimum of 9” of the bottom of the fence shall be so anchored.

3.7.7 Sediment Entrapment Facilities

For locations with a tributary area less than 1 acre, a silt fence or other barrier may be used to create the sediment entrapment facility. For locations with a tributary area of at least 1 acre, a sediment basin shall be used to create the sediment entrapment facility.