

SECTION 600 STORM DRAINAGE FACILITIES

601.00	GENERAL CONDITIONS	3
610.00	STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA... 3	3
611.0	Design Methods	5
611.1	Minor and Major Design Storms	5
611.2	Storm Return Periods	5
611.3	Rainfall Intensities	6
611.4	Runoff Computations, Rational Method.....	6
611.5	Runoff Coefficients.....	6
612.0	Detention.....	7
612.1	General.....	7
612.2	Equation Method.....	8
612.3	Sequential Detention.....	8
613.0	Design Standards	8
613.1	Open Channels	8
613.2	Storm Sewers and Storm Inlets.....	11
613.3	Culverts.....	12
613.4	Street Flow Capacities	14
620.00	GENERAL PROVISIONS	16
621.00	General.....	16
622.00	Approved Plans.....	16
623.00	Permits Required.....	16
624.00	Traffic Control	16
630.00	EROSION CONTROL	16
631.00	General.....	16
632.00	Requirements	17
633.00	Submittal.....	17
634.00	Erosion Control Measures.....	17
635.00	Erosion Control Structures.....	17
640.00	STORM DRAINAGE CONSTRUCTION.....	18
641.0	Site Work and Earthwork.....	18
641.1	General.....	18
641.2	Trenching, Backfilling and Compacting.....	18
642.0	Materials	18
642.1	Pipe	18
642.2	Pipe Joints	19
642.3	Manholes, Inlets and Sidewalk Chases.....	19
642.4	Manhole Base Slabs & Base Beams	20
642.5	Concrete	20
642.6	Cast and Ductile Iron Fittings.....	20
642.7	Bedding Material	20
642.8	Riprap and Filter Cloth	20

643.0	Installation.....	22
643.1	Alignment and Grade.....	22
643.2	Protection of Existing Underground Utilities	22
643.3	Wet Trench.....	22
643.4	(Left Blank Intentionally)	22
643.5	Storm Sewer Pipe Installation.....	22
643.6	Connections to Existing Manholes	22
643.7	Construction of Manholes, Inlets and Sidewalk Chases	22
643.8	Construction of Open Channels and Special Structures	23
643.9	Riprap and Filter Cloth	23
643.10	Testing.....	24
644.00	Inspections	25
650.00	TRENCHING, BACKFILLING AND COMPACTING	26
660.00	RESTORATION AND CLEANUP	26
670.00	GRADING AND EXCAVATION	26

SECTION 600 STORM DRAINAGE FACILITIES

601.00 GENERAL CONDITIONS

Refer to Section 100 TITLE, SCOPE AND GENERAL CONDITIONS of these CONSTRUCTION STANDARDS & SPECIFICATIONS for additional requirements that apply to all projects within Elbert County.

610.0 STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA

All proposed construction plans and submittals shall be accompanied by a storm drainage analysis. Appropriate drainage system design shall be submitted for approval by the Road & Bridge Superintendent / Elbert County Engineer for each phase of construction. Approval of the analysis and design is subject to the following conditions:

- A. Construction of the system shall commence within 365 days of the date of the approval.
- B. No construction has been completed on any adjacent property that may have affected the drainage pattern within the basin.

New submittals may be required by the Road & Bridge Superintendent / Elbert County Engineer.

The proposed construction shall not damage upstream or downstream properties. The planning and design of the drainage system shall not transfer the problem from one location to another.

Except where specified in these CONSTRUCTION STANDARDS & SPECIFICATIONS, the procedure, criteria, and standards set forth in the latest revision of the Urban Drainage Flood Control District Storm Drainage Criteria Manual—hereby referred to as the UDFCD Manual—shall be instituted for the analysis of any drainage system. Current engineering practices and drainage methodology, as well as common sense, shall be involved with the analysis of any drainage system.

The runoff analysis for a particular area shall be based on the natural, undisturbed land for that area. Any contributing runoff from upstream areas shall be based on the existing land use and topographic characteristics of those areas.

Where a master drainage plan for a given area of Elbert County is available, proposed drainage systems shall conform to that plan. Consideration shall be given as to how the proposed master plan drainage systems shall tie into the existing upstream and downstream drainage system.

In areas where a master plan is not available, major drainageways and easements shall be located to provide continuity with existing drainage conditions. These drainageways and easements shall be shown on all drainage plans.

A CONSTRUCTION STORMWATER DISCHARGE (CDPS) PERMIT SHALL BE OBTAINED FROM THE COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT FOR DISTURBANCE OF ANY SITE LARGER THAN ONE ACRE.

FOR CAPITAL IMPROVEMENT PROJECTS, THE CONTRACTOR IS REQUIRED TO OBTAIN A CDPS PERMIT.

Permanent stormwater quality facilities shall be designed and constructed in accordance with the UDFCD Manual (Volume 3).

The Federal Emergency Management Agency (FEMA) floodplain boundaries are available from the Road & Bridge Superintendent / Elbert County Engineer and shall be shown on all preliminary and final drainage plans.

All ponding facilities shall be of the detention type. Retention facilities shall only be allowed with the written approval of the Road & Bridge Superintendent / Elbert County Engineer.

Construction that shall impair surface or subsurface drainage shall not be approved. Elbert County reserves the right to issue and enforce more stringent criteria shall adverse conditions exist. Designs that vary from the criteria shall require written approval of a variance by the Road & Bridge Superintendent / Elbert County Engineer prior to final approval of the plans.

Natural topographic features shall be the basis of location for easements and future runoff calculations. Where defined, existing drainage patterns and slopes shall be used. The drainage facilities shall be able to handle the design flows with no erosion damage to the system.

Streets shall not be used as primary floodways for major storm runoff. The amount of runoff in the streets shall not exceed the limits established in Section 613.04 Street Flow Capacities of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

For inlet and manhole details, refer to the CDOT *M&S Standards*.

Stormwater detention facilities or natural drainageways are to be used whenever feasible. Any alteration to natural drainage patterns shall not be approved unless a thorough investigation and analysis shows no hazard or liability. The Road & Bridge Superintendent / Elbert County Engineer shall have final authority over any system design.

ALL DRAINAGE FACILITIES SHALL BE IN AN EASEMENT OR PUBLIC R.O.W.

All drainage improvements shall be as natural in appearance as possible to be aesthetically pleasing. Maintenance access shall be provided for all drainage and flood control facilities.

Irrigation ditches shall not be used as the outfall of any drainage basin.

611.0 Design Methods**611.1 Minor and Major Design Storms**

Every urban area has two separate and distinct drainage systems whether or not they are actually planned for and designed. One is the initial system, which corresponds to the minor (or ordinary) storm recurring at regular intervals. The other is the major system, which corresponds to the major (or extraordinary storm), which is unlikely to occur more often than once in one-hundred (100) or more years ("100-year storm"). Since the effects and routing of stormwaters for the major storm may not be the same as for the minor storm, all storm drainage plans submitted for approval shall be submitted in detail in two separate phases: one indicating the effects of the minor storm and the other showing the effects of the major storm.

- A. Minor storm provisions: The objectives of the minor storm planning are to minimize inconvenience, to protect against recurring minor damage, to reduce rising maintenance costs, to create an orderly drainage system and to provide a sociological benefit to the urban resident. The minor storm drainage system may include curb and gutter, storm sewer, swales, and other open drainageways and detention facilities.
- B. Major storm provisions: The major storm shall be considered the 100-year storm. The objectives of the major storm planning are to eliminate substantial property damage or loss of life and shall be as directed and approved by the Road & Bridge Superintendent / Elbert County Engineer. Major drainage systems may include storm sewers, open drainageways and detention facilities. The correlation between the minor and major storm system shall be analyzed to ensure a well coordinated drainage system.

611.2 Storm Return Periods

The minor and major storm design return periods shall not be less than those shown below:

DESIGN STORM RETURN PERIODS

Land Use or Zoning	Design Storm Return Period	
	Minor Storm	Major Storm
Residential	2-year	100-year
Business	5-year	100-year
Public Building Areas	5-year	100-year
Parks, Greenbelts, etc.	2-year	100-year
Open Channels and Drainageways	-	100-year
Detention Facilities	10-year ¹	100-year

¹A two (2) year storm return period shall be used if the detention facility does not have a water quality outlet.

611.3 Rainfall Intensities

The rainfall intensities to be used in the computation of runoff shall be obtained from the Time-Intensity-Frequency Curves shown in the Detail Drawings.

611.4 Runoff Computations, Rational Method

The Rational Method shall be utilized for sizing storm sewers and for determining runoff magnitude for all watersheds

The procedures for the Rational Method, as explained in the latest edition of the UDFCD Manual (Volume 1), shall be followed in the preparation of drainage reports and storm drainage facility designs in Elbert County.

611.5 Runoff Coefficients

Rational method runoff coefficients: The runoff coefficient (C) to be used in conjunction with the Rational Method shall not be less than those listed below:

RUNOFF COEFFICIENTS (C) FOR RATIONAL METHOD

Land Use or Surface Characteristics	Percent Impervious	Frequency			
		2	5	10	100
Business					
Commercial Areas	95	.79	.81	.83	.88
Neighborhood Areas	85	.66	.68	.69	.75
Residential					
Single-Family	*	*	*	*	*
Multi-Unit (detached)	60	.37	.41	.46	.63
Multi-Unit (attached)	75	.51	.54	.58	.66
1/2 Acre Lot or Larger	*	*	*	*	*
Apartments	80	.57	.59	.63	.70
Industrial					
Light Areas	80	.57	.59	.63	.70
Heavy Areas	90	.71	.73	.75	.81
Parks, Cemeteries	5	.08	.18	.28	.52
Playgrounds	10	.11	.21	.30	.53
Schools	50	.34	.40	.46	.60
Railroad Yard Areas	15	.14	.24	.32	.54
Undeveloped Areas					
Historic Flow Analysis	2	(See "Lawns")			
Greenbelts, Agricultural	2				
Offsite Flow Analysis (when land use not defined)	45	.31	.37	.44	.59
Streets					
Paved	100	.89	.90	.92	.96
Gravel	40	.28	.35	.42	.58
Drives and Walks	90	.71	.73	.75	.81
Roofs	90	.71	.73	.75	.81
Lawns, Sandy Soil	0	.00	.01	.05	.20
Lawns, Clay Soil	0	.04	.15	.25	.50

*Refer to the graphs in the Runoff Chapter of the UDFCD Manual.

612.0 Detention

612.1 General

Onsite detention is required for all new development, expansion and redevelopment. The required minimum detention volume and maximum release rates at these volumes for the 2-year, 5-year and 100-year storms shall be determined in accordance with the procedure and data set forth in these criteria. If the pond does not include a water quality outlet, which controls about the one and one-half (1½) year storm, the pond shall be designed to release the two (2) year historic rate.

Exemptions from the detention requirement may be granted if it can be demonstrated that the developed area does not adversely affect the downstream major drainageways (assuming the entire drainage area is fully developed) and that the water quality is maintained.

Offsite flows cannot be passed through the detention pond. Offsite areas shall be included in the drainage area contributing to the pond. In certain cases offsite flow can be routed around the detention pond.

Parking lots that serve as detention storage ponds shall not have a storage depth of more than one (1) foot. Parking lots that serve as detention storage ponds shall place notification signs that the area ponds during a rainfall event. The signs shall be permanent and high quality, and shall meet Elbert County's specifications for traffic signs.

612.2 Equation Method

The equation method found in the Storage section of the UDFCD Manual may be used to design detention ponds for drainage areas smaller than ninety (90) acres; however, if the calculated allowable release is greater than the historic runoff, a different method shall be used to determine the storage requirements.

612.3 Sequential Detention

The sequential detention method shall be used for ponds that drain into each other. Use the Sequential Detention Form at the end of Section 600 of these CONSTRUCTION STANDARDS & SPECIFICATIONS to size sequential detention ponds.

613.0 **Design Standards**

613.1 Open Channels

Except as modified herein, open channels shall be designed for the 100-year storm and shall conform to the UDFCD Manual. In addition, the channel design shall also be analyzed with respect to minor storm runoff. Whenever practical, the channel shall have slow flow characteristics, be wide and shallow, and be natural in its appearance and functioning.

Channels shall be designed so that critical depth and super-critical flows are avoided. Channel capacities shall be computed from Manning's Formula for uniform flow, except at crossings and transitions where the design shall account for backwater effects.

The channel cross-section may be any type suitable to the location; however, the limitations for design for the major storm and minor storm design flows shall include:

- A. Capacity: The channel and overbank areas shall have adequate capacity for the 100-year storm runoff.
- B. Side slopes: Side slopes shall be as flat as practical. Side slopes of 4:1 (run:rise) shall be considered a normal minimum. Under special conditions, slopes of 3:1 may be utilized with written approval of the Road & Bridge Superintendent / Elbert County Engineer. The practical slope for mowing equipment is 4:1 or less.
- C. Depth: The maximum design depth of flow for the major storm shall be limited to five (5) feet of depth in the channel cross section outside of the low-flow or trickle channel. Any design variation exceeding the maximum depth of flow shall be submitted in writing for approval by the Road & Bridge Superintendent / Elbert County Engineer. Critical depths and velocities shall be investigated and reported for both the major and minor storm runoffs.
- D. Freeboard: Except where localized overflow in certain areas is desirable for additional ponding benefits or other reasons, the minimum allowable freeboard shall be one (1) foot.
- E. Bottom width: The bottom width shall be designed to satisfy the hydraulic capacity of the cross-section recognizing the limitations on velocity, depth and Froude number.
- F. Slope of channel: Grass-lined channel slopes are dictated by velocity and Froude number requirements. Grass-lined channels normally shall have slopes of 0.2% to 0.6%. Where the natural topography is steeper than desirable, drops may be utilized.
- G. Curvature: The centerline curvature shall have a radius of not less than twice the design flow top width, but not less than one hundred (100) feet.
- H. Trickle channels: Concrete trickle channels to carry low flows may be required for all new urban grassed channels. The capacity of a trickle channel shall be approximately two (2) percent of the major design flow. The shape of concrete trickle channels shall be parabolic. Where two (2) percent of the major design flow exceeds ninety (90) cfs, a low flow channel shall be required. Low flow channels shall be in accordance with the UDFCD Manual (Volume 2). **All concrete trickle channels shall have a minimum slope of one (1) percent.**
- I. Design velocity: The maximum velocity for the major storm design runoff shall not exceed seven (7) feet per second for grass-lined channels, except in sandy soil where the maximum velocity shall not exceed five (5) feet per second. The Froude number (turbulence factor) shall be less than 0.8 for grass-lined channels.

- Grass-lined channels having a Froude number greater than 0.8 shall not be permitted. Minimum velocities for all channels shall not be less than two (2) feet per second for the minor storm runoff.
- J. Erosion: All channels shall be designed with the proper and adequate erosion control features.
 - K. Grass lining: The grass lining for channels shall be in accordance with the UDFCD Manual (Volume 2).
 - L. Water surface profile: A water surface profile for the major storm runoff shall be computed for all channels and clearly shown on the construction plans submitted for approval. Computations of the water surface profile shall utilize standard backwater methods such as HEC-2, and shall take into consideration all losses due to velocity changes, drops, bridge and culvert openings, and other obstructions. A Computations Report shall be submitted along with the construction plans. The energy gradient line shall be shown on the construction plans.
 - M. Roughness coefficient (n): The value of the roughness coefficient (n) to be used in Manning's Formula shall not be less than those listed below:

MINIMUM VALUES OF ROUGHNESS COEFFICIENT (n)

Type of Channel and Description		Minimum
Closed Conduits:		
Concrete Pipe:		
	Culverts with bends, connections & debris	0.013
	Storm sewer	0.013
	Subdrain with open joints	0.016
	PVC Pipe	0.011
Concrete Surfaces (bottom & sides):		
	Smooth finish	0.015
	Unfinished	0.017
Concrete Bottom (with sides of):		
	Mortared stone	0.020
	Dry rubble or riprap	0.030
Gravel Bottom (with sides of):		
	Formed concrete	0.020
	Dry rubble or riprap	0.040
Excavated or Dredged Channels and Ditches:		
Earthen, Straight & Uniform, no brush or debris:		
	Grassed, less than 6" high with:	
	Depth of flow < 2.0 feet	0.035
	Depth of flow > 2.0 feet	0.030
	Grassed, approx. 12" high with:	
	Depth of flow < 2.0 feet	0.060
	Depth of flow > 2.0 feet	0.035

	Grassed, approx. 24" high with:	
	Depth of flow < 2.0 feet	0.070
	Depth of flow > 2.0 feet	0.035
	Earth bottom with riprap on sides	0.040
Rock or Shale Cuts:		
	Smooth and uniform	0.035
	Jagged and irregular	0.040
	Curb and Gutter (concrete)	0.016

613.2 Storm Sewers and Storm Inlets

Except as subsequently modified, the design of storm sewers and inlets shall conform to the criteria set forth in the UDFCD Manual. Storm sewers and inlets shall be of sufficient capacity to adequately carry the expected runoff from the initial design storm. Computer programs such as UDFCD’s UDSEWER and UDINLET are encouraged in the design of the storm sewer system.

THE STORM DRAINAGE SYSTEM DESIGN FORM IN THE BACK OF SECTION 600 OF THESE CONSTRUCTION STANDARDS & SPECIFICATIONS SHALL BE USED IN THE DESIGN OF STORM SEWERS AND INLETS. The completed form shall be included in the drainage report.

The storm sewer system shall be installed at all locations where the allowable street capacity is exceeded or wherever ponding of water is likely to occur.

The invert elevation of storm sewer outfalls into channels shall be at least one (1) foot above the channel invert.

The minimum allowable pipe size for storm sewer systems shall be as follows:

MINIMUM ALLOWABLE PIPE SIZE

Type of conduit	Min. Inside Pipe Dia.
Main Trunk Sewer	21"
Individual laterals/Driveway Culverts	18"

Pipe diameters of less than eighteen (18) inches may be allowed; however, a variance request shall be submitted to the Road & Bridge Superintendent / Elbert County Engineer in writing, and approval shall be obtained from the Road & Bridge Superintendent / Elbert County Engineer prior to final design.

Arch pipes may be allowed where design conditions dictate, provided that the minimum cross-sectional areas are not less than those specified above. All storm

sewer conduits shall have sufficient structural strength to withstand an H-20 design load.

Manholes shall be a minimum of sixty (60) inches for lines eighteen (18) inches to twenty-one (21) inches diameter, and seventy-two (72) inches for lines twenty-four (24) inches to thirty (30) inches diameter. For storm pipe larger than thirty (30) inches diameter, the Road & Bridge Superintendent / Elbert County Engineer shall approve the manhole design size. Where two or more pipes enter a manhole, the Road & Bridge Superintendent / Elbert County Engineer shall approve the manhole design size.

The maximum allowable distance between manholes or other suitable appurtenances for cleanouts shall not exceed those listed below:

MAXIMUM ALLOWABLE MANHOLE SPACING

Inside Diameter	Maximum Allowable Distance Between Manholes and Cleanouts
18" - 36"	400 feet
36" - 60"	500 feet
60" & Larger	750 feet

The velocity for the minor flows in conduits shall not be less than two (2) feet per second.

Storm inlets shall be utilized at all points where ponding or sump conditions exist. Inlets shall be curb opening inlets, type "R", or grated inlets with curb openings. All inlets shall be similar and equal to those in the Detail Drawings or as approved by the Road & Bridge Superintendent / Elbert County Engineer.

Grated inlets shall be recommended for bicycle traffic. Grated Inlets shall be Neenah Foundry model number R-3157A or R-3233 or an approved equivalent.

The theoretical capacity and spacing of storm inlets shall be analyzed using the criteria—including reduction factors—set forth in the UDFCD Manual.

The size of outlet pipes from stormwater inlets shall be based on the theoretical capacity of the inlet. All pipe outlets shall be protected in accordance with the Detail Drawings.

613.3 Culverts

Culvert capacities shall be at least equal to the capacities of culverts designed in accordance with the procedures outlined in Federal Highway Administration

Hydraulic Design Series Number 5, "Hydraulic Design of Highway Culverts". The Road & Bridge Superintendent / Elbert County Engineer shall approve the shape, location and type of construction of culverts.

Culverts shall be sized to have sufficient capacity to pass all of the runoff from the major storm if twenty (20) percent of the pipe is plugged.

The following design criteria shall be utilized for all culvert design:

- A. The culvert, including inlet and outlet structures, shall properly convey water and debris at all stages of flow.
- B. Culvert inlets shall be designed to minimize entrance and friction losses. Inlets shall be provided with either flared end sections or head walls with wing walls. Projecting ends are not acceptable. Large structures shall be designed to resist hydrostatic uplift forces.
- C. Culvert outlets shall be designed to avoid sedimentation, undermining of culvert, or erosion of downstream channels. Outlets shall be provided with either flared end sections or headwalls, with wingwalls and riprap. Projecting ends are not acceptable. Additional outlet control, in the form of riprap, channel shaping, etc., may be required.
- D. Culvert slopes shall be selected to eliminate excessive velocities and scour. Generally, the minimum slope of culverts shall be limited to one-half (½) percent.
- E. Headwater ponding above culvert inlets shall not be acceptable if such ponding appears likely to cause property or roadway damage, culvert clogging, saturation of fills, detrimental upstream deposits of debris, or inundation of existing or future utilities and structures.
- F. Tailwater height at the outlet shall be subject to approval by the Road & Bridge Superintendent / Elbert County Engineer.
- G. Culverts shall be analyzed to determine whether discharge is controlled by inlet or outlet conditions for both the minor storm discharge and the major storm discharge. Computations for selected culvert sizes shall be submitted to the Road & Bridge Superintendent / Elbert County Engineer for approval. Computer programs such as the FHWA HY8 may be used to design culverts.
- H. Minimum Allowable Size: The required size of a culvert shall be based on adequate hydraulic design analysis.
 - 1. Circular culverts under roadways/driveways shall have a minimum diameter of twenty-four (24) inches.
 - 2. Oval culvert dimensions shall be forty-three (42) inches by twenty-seven (27) inches or larger.
 - 3. Box culverts shall have a minimum height of four (4) feet.

Smaller culvert sizes may be approved by the Road & Bridge Superintendent / Elbert County Engineer.

- I. An overflow path shall be provided in case the culvert becomes plugged.
- J. Where physical conditions dictate, multiple culvert installations may be approved by the Road & Bridge Superintendent / Elbert County Engineer.
- K. The structural design of culverts shall conform to the methods and criteria recommended by the manufacturer of a specific type of culvert for the specified embankment conditions.

613.4 Street Flow Capacities

Except as modified herein, the criteria set forth in the UDFCD Manual shall be used to analyze and to determine the adequacy of streets as a function of the drainage system. Both the minor storm runoff and major storm runoff shall be considered, and calculations showing such runoff at critical sections shall be submitted. The following criteria shall apply in the determination of allowable street flow capacities:

- A. Street, curb and gutter, sidewalks, crosspans and curb cuts shall conform to all applicable Sections of these CONSTRUCTION STANDARDS & SPECIFICATIONS.
- B. Street encroachment for the minor design storm shall not exceed the limitations set forth below:

ALLOWABLE STREET ENCROACHMENT AND DEPTH OF FLOW FOR MINOR STORM RUNOFF

Street Classification	Maximum Encroachment
Local	If curb present no curb overtopping. Flow may spread to crown of street.
Connector	If curb present no curb overtopping. Flow spread shall leave the equivalent of one 10 foot driving lane clear of water.
Arterials	If curb present no curb overtopping. Flow spread shall leave the equivalent of two 10 foot driving lanes clear of water – one lane in each direction. No more than two lanes in each direction shall be flooded.

Where no curb exists, street encroachment shall not extend past the public R.O.W.

A storm sewer system shall be installed at all points where the maximum allowable street encroachment occurs.

- C. The allowable depth of flow and inundated area for the major design storm shall not exceed the following limitations:

ALLOWABLE DEPTH OF FLOW AND INUNDATED AREA FOR MAJOR STORM RUNOFF

Street Classification	Allowable Depth and Inundated Areas
Local & Connector	Lowest entry to residential dwellings and public, commercial, and industrial buildings shall not be less than twelve (12) inches above the 100-year water surface elevation. The depth of water over the gutter flowline shall not exceed twelve (12) inches.
Arterial	Lowest entry to residential dwellings and public, commercial, and industrial buildings shall be not less than twelve (12) inches above the 100-year water surface elevation. The depth of water at the street crown shall not exceed six (6) inches to allow operation of emergency vehicles. Depth of water over gutter flow line shall not exceed twelve (12) inches.

- D. Cross-street flow occurs when runoff flowing in a gutter flows across the street to the opposite gutter or inlet. Allowable cross-street flow is summarized in the following table:

ALLOWABLE CROSS-STREET FLOW

Street Classification	Initial Storm Flow	Major Storm Flow
Local	Six (6) inches depth in crossspan	Twelve (12) inches of depth above gutter flow line
Collector	Six (6) inches of depth in crossspan	Twelve (12) inches of depth above gutter flow line
Arterial	None	No cross-street flow. Maximum depth of upstream gutter of twelve (12) inches.

620.00 GENERAL PROVISIONS**621.00 General**

All storm drainage construction in the Elbert County R.O.W./Dedicated Easements shall comply with these CONSTRUCTION STANDARDS & SPECIFICATIONS. These standards shall include new storm drainage construction and repairs and maintenance of existing facilities within Elbert County.

622.00 Approved Plans

All storm drainage construction shall be in accordance with engineered construction plans prepared under the direction of a Colorado Registered Professional Engineer. Storm drainage plans shall include an Area Grading Plan and an Erosion Control plan as defined in Section 161.09 Area Grading Plan Details and Section 161.10 Erosion Control Plan Details of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

Where work is to be performed over, under or in an irrigation ditch, written approval of the ditch owner is required prior to written approval by the Road & Bridge Superintendent / Elbert County Engineer.

623.00 Permits Required

A PPIP or Grading Permit issued by Elbert County shall be required and shall not be issued until the Road & Bridge Superintendent / Elbert County Engineer has approved the storm sewer plans. A NPDES permit shall be obtained for any disturbance of one acre or more. Refer to Section 150.00 PERMITS AND INSPECTIONS of these CONSTRUCTION STANDARDS & SPECIFICATIONS for additional requirements.

624.00 Traffic Control

Traffic control shall comply with Section 141.12 Traffic Control, Barricades and Warning Signs of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

630.00 EROSION CONTROL**631.00 General**

Erosion and sedimentation are natural processes, the intensity of which is increased by land disturbing activities that reduce or destroy the aesthetic and practical values of neighboring properties, streams and lakes. The purpose of these erosion control criteria is to reduce intensified erosion—caused by either wind or water—to an acceptable level without placing undue burdens on the landowner, builder or community.

632.00 Requirements

Erosion control measures shall be designed in conformance with the UDFCD Manual (Volume 3). All land-disturbing activities within Elbert County shall comply with the Colorado Department of Public Health and Environment Regulations.

633.00 Submittal

A discussion that summarizes erosion control methods shall be submitted as part of the preliminary and final drainage reports, as required in Section 162.00 Engineering Reports of these CONSTRUCTION STANDARDS & SPECIFICATIONS. A detailed erosion control plan shall accompany the Area Grading Plan and approved Drainage Plan, as required in Section 161.10 Erosion Control Plan Details of these CONSTRUCTION STANDARDS & SPECIFICATIONS. The erosion control plan shall be approved by Elbert County prior to receiving a PPIP or Grading Permit.

634.0 Erosion Control Measures

A CONSTRUCTION STORMWATER DISCHARGE PERMIT (NPDES PERMIT) SHALL BE OBTAINED FROM THE COLORADO DEPARTMENT OF HEALTH AND ENVIRONMENT FOR SITE DISTURBANCE LARGER THAN ONE ACRE.

Detailed erosion control measures shall be provided to protect the following:

- A. Inlets and culverts
- B. Drainageways
- C. Streams or other water bodies immediately adjacent to land disturbed by construction activity
- D. Cut and fill areas
- E. Properties and improved streets adjacent to construction activity
- F. Others as required by the Road & Bridge Superintendent / Elbert County Engineer

Temporary erosion control measures such as sediment traps, straw bales or silt fence shall be properly placed in accordance with the Colorado Department of Public Health and Environment approved Stormwater Management Plan (SWMP) (CDPS Permit) prior to any earthmoving on the site. Erosion control measures shall be kept in good repair and fully functional until erosion potential from the site no longer exists.

Permanent erosion control (sod, seed, mulching, etc.) shall be in place prior to the request for a Certificate of Occupancy or Letter of Final Acceptance.

635.00 Erosion Control Structures

Refer to the Detail Drawings for erosion control installation. When applicable, details of additional erosion control measures may be obtained from the UDFCD Manual (Volume 3).

640.00 STORM DRAINAGE CONSTRUCTION

641.0 Site Work and Earthwork

641.1 General

Site work and earthwork shall be performed in accordance with Section 300.00 SOILS AND EARTHWORK of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

641.2 Trenching, Backfilling and Compacting

Trenching, backfilling and compacting shall be performed in accordance with Section 350.00 TRENCHING, BACKFILLING AND COMPACTING of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

642.0 Materials

642.1 Pipe

Reinforced Concrete Pipe (RCP) shall be manufactured to comply with ASTM C76. All applicable portions of Section 706 Concrete and Clay Pipe of the CDOT *Standard Specifications for Road and Bridge Construction* shall apply.

Polyvinyl Chloride Pipe (PVC) shall be manufactured to comply with ASTM F794/F949 (ribbed) or ASTM D3034, SDR-35 (smooth). All joints shall be factory prepared compression type (elastomeric gasket joint), providing a watertight seal.

Non Reinforced Concrete Pipe (NRCP) shall be manufactured to comply with ASTM C14. NRCP shall be specified under the criteria of Section M-603-2 of the CDOT *M&S Standards* for all sizes thirty-six (36) inches diameter and smaller.

Polymer Coated Steel Pipe (PCSP) shall be manufactured to comply with AASHTO Section 36. All applicable portions of Section 707 Metal Pipe of the CDOT *Standard Specifications for Road and Bridge Construction* shall apply. The corrugation of the pipe shall be 3/4" x 3/4" x 7 1/2" spiral rib. Polymer coating, grade 250/250, shall be applied prior to corrugating in conformance with AASHTO 26.3.7.

Corrugated aluminum pipe (CAP) shall be manufactured to comply with all applicable portions of Section 707 Metal Pipe of the CDOT *Standard Specifications for Road and Bridge Construction*. The pipe sizes shall be as shown on the project plans. The corrugation profile of the pipe shall be 3/4" x 3/4" x 7 1/2" spiral rib. At all locations where corrugated aluminum pipe is proposed to be installed, a corrosion resistance level test shall be performed and a test report detailing any corrosion protection requirements shall be submitted to the Road & Bridge Superintendent / Elbert County Engineer for approval.

Corrugated polyethylene pipe (CPP) or High Density Polyethylene Pipe (HDPEP) shall be manufactured to comply with ASTM D3350, with the minimum cell classification of 315412C. Requirements for test methods, dimensions and markings shall comply with AASHTO Designation M-294. The minimum pipe stiffness shall be 46 psi to comply with ASTM D2412 at five (5) percent deflection.

Corrugated steel pipe (CSP) shall be manufactured to comply with all applicable portions of Section 707 Metal Pipe of the CDOT *Standard Specifications for Road and Bridge Construction*. The pipe sizes shall be as shown on the project plans. These conduits and coupling bands shall conform to the requirements of AASHTO M 36M (M 36).

Other storm sewer pipe materials may be approved at the discretion of the Road & Bridge Superintendent / Elbert County Engineer. Pipe class designation or gauge shall be as shown on the approved plans or as designated by the Road & Bridge Superintendent / Elbert County Engineer for each individual project. Pipe material shall be selected based on strength and soil conditions.

All pipe shall be inspected by the Elbert County Inspector/Representative in order to allow for rejection of pipe that fails to conform to the requirements of these CONSTRUCTION STANDARDS & SPECIFICATIONS. Defects shall be marked so as not to disfigure the rejected pipe. Rejected pipe shall be removed from the job site within twenty-four (24) hours.

642.2 Pipe Joints

All pipe joints shall be watertight. RCP and NRCP joints shall comply with ASTM C443. CPP joints shall comply with ASTM D3212. PCSP and CAP joints shall comply with AASHTO Section 26.4.2.4.f. Cement mortar joints shall be constructed with mortar mixture composed of one (1) part Portland cement to three (3) parts sand and enough water to produce a workable mix. Mortar that has started to set shall be discarded and a new batch prepared.

642.3 Manholes, Inlets and Sidewalk Chases

Manhole bases, vaults and inlets may be constructed of cast-in-place or pre-cast concrete. Manhole materials, including access ring and cover sets for all inlet types, shall comply with all applicable portions of Section 532.03 Manholes of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

Inlets, except as modified above, shall be constructed in accordance with the Detail Drawings and all CDOT *M&S Standards*.

642.4 Manhole Base Slabs & Base Beams

Refer to Section 532.04 Manhole Base Slabs and Base Beams of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

642.5 Concrete

Concrete shall conform to Section 800.00 CONCRETE MIX DESIGN AND CONSTRUCTION of these CONSTRUCTION STANDARDS & SPECIFICATIONS. Type II cement shall be used except where sulfate resistant cement is required. Concrete encasement of pipe shall conform to the details shown on the approved plans.

642.6 Cast and Ductile Iron Fittings

Refer to Section 532.06 Cast and Ductile Iron Fittings of these CONSTRUCTION STANDARDS & SPECIFICATIONS. Lids shall be furnished with the words "STORM SEWER" cast on top.

642.7 Bedding Material

All applicable portions of Section 353.00 Bedding for Pipelines and Service Lines of these CONSTRUCTION STANDARDS & SPECIFICATIONS shall apply.

642.8 Riprap and Filter Cloth

Riprap and filter cloth shall be installed at locations shown on the approved plans, or in locations designated by the Road & Bridge Superintendent / Elbert County Engineer.

Rock used for riprap shall be hard, durable, angular in shape, and be free from cracks, overburden, shale and organic matter. Neither breadth nor thickness of a single stone shall be less than one-third ($\frac{1}{3}$) its length, and rounded stone shall not be approved. The rock shall sustain the abrasion test (Los Angeles machine - ASTM C0535-69) and shall sustain a loss of not more than ten (10) percent after twelve (12) cycles of freezing and thawing (AASHTO test 103 for ledge rock procedure A). The rock shall have a minimum specific gravity of 2.50. Classification and gradation for riprap are shown below.

The riprap designation and total thickness of riprap shall be as specified on the approved plans. The maximum stone size shall not be larger than the thickness of the riprap.

CLASSIFICATION AND GRADATION OF RIPRAP

Riprap Designation	% Smaller Than Given Size By Weight	Intermediate Rock Dimension (Inches)	d(50) * (Inches)
Type VL	70-100	12	
	50-70	9	
	35-50	6	6**
	2-10	2	
Type L	70-100	15	
	50-70	12	
	35-50	9	9**
	2-10	3	
Type M	70-100	21	
	50-70	18	
	35-50	12	12
	2-10	4	
Type H	70-100	30	
	50-70	24	
	35-50	18	18
	2-10	6	
Type VH	70-100	42	
	50-70	33	
	35-50	24	24
	2-10	9	

*d (50) = Mean particle size

** To minimize vandalism, mix Types VL and L riprap with thirty (30) percent (by volume) topsoil and bury it with a minimum of six (6) inches of topsoil, vibration compacted and revegetated.

Filter cloth shall be manufactured especially for the stability of erosion control construction and made from polyethylene, polypropylene or polyester yarns in accordance with the following:

Filter cloth shall be manufactured especially for the stability of erosion control construction and shall meet the requirements of CDOT Class B drainage geotextile as specified in Section 712 of the CDOT *CONSTRUCTION STANDARDS & SPECIFICATIONS for Road and Bridge Construction*.

Filter material which is to be placed on top of the filter cloth (at specified thickness) prior to placement of the riprap shall meet the bedding requirements in of the UDFCD Manual (Volume 1).

When requested by the Road & Bridge Superintendent / Elbert County Engineer, the Contractor shall furnish copies of test reports from a certified testing laboratory for the following:

- A. Gradation and soundness of riprap
- B. Gradation of filter material
- C. Strength and characteristic tests for filter cloth
- D. Compaction tests of the prepared subgrade

643.0 Installation

Refer to Section 533.01 General of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.1 Alignment and Grade

Refer to Section 533.02 Alignment and Grade of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.2 Protection of Existing Underground Utilities

Refer to Section 533.03 Protection of Existing Underground Utilities of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.3 Wet Trench

Refer to Section 352.00 Trench Excavation for Pipelines and Service Lines of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.4 (Left Blank Intentionally)**643.5 Storm Sewer Pipe Installation**

Refer to Section 533.04 Sewer Pipe Installation of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.6 Connections to Existing Manholes

Refer to Section 533.06 Connections to Existing Manholes of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.7 Construction of Manholes, Inlets and Sidewalk Chases

Manholes and inlets shall be constructed in accordance with applicable portions of Section 533.07 Construction of Manholes and Clean-outs of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.8 Construction of Open Channels and Special Structures

All work shall conform to details in the approved plans and supplemental specifications. Construction shall comply with Section 533.02 Alignment and Grade of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

When approved, sidewalk chases shall be constructed in accordance with the Detail Drawings.

643.9 Riprap and Filter Cloth

Excavation for riprap shall conform to Section 300.00 SOILS AND EARTHWORK of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

Filter cloth shall be placed according to the manufacturer's specifications. Holes, rips or other damage to the filter cloth shall be repaired at the Contractor's expense, in accordance with the manufacturer's recommendations.

Stabilization material, as described in Section 340.01 Definitions of these CONSTRUCTION STANDARDS & SPECIFICATIONS, shall be placed on top of the filter cloth (where filter cloth is used) to the required thickness. The material shall be placed using equipment that shall not rip, tear or otherwise damage the filter cloth. Any damaged areas shall be promptly repaired at the Contractor's expense. The material shall be leveled to a finished surface that is within one (1) inch of the specified thickness.

Riprap shall be placed to conform to the details shown on the approved plans. The larger size stones shall be placed first and roughly arranged in close contact. The toe trench and foundation course shall be closed first. The spaces between the larger stones shall then be filled with smaller stone of suitable size, and placed as to leave the surface evenly stepped, conforming to the contour required. The finished surface shall be even and tight and shall not vary from the planned surface grade by more than three (3) inches per foot of depth. The material may be machine placed with sufficient handwork to conform to these CONSTRUCTION STANDARDS & SPECIFICATIONS.

All riprap shall be grouted. The stones shall be laid with care to prevent earth and sand from filling the joints. Joints shall be filled with grout and the surfaces swept with a stiff broom. The work shall be protected and kept moist during hot weather for at least three (3) days after grouting, or coated with a clear membrane curing compound. Grout shall consist of one (1) part cement and three (3) parts

aggregate, by volume. The Portland Cement shall be Type II and aggregate shall be two (2) parts sand and one (1) part gravel passing a three-eighths ($\frac{3}{8}$) inch square mesh screen. Grout shall be mixed with enough water to permit gravity flow of grout into the interstices with limited spading and brooming. A six (6) inch by six (6) inch concrete mow strip is required around the edges of riprap structures.

When concreting is permitted during cold weather, the temperature of the mix shall not be less than sixty (60) degrees Fahrenheit at the time of placing. Filter cloth, stabilization material, or riprap shall not be placed on frozen ground. Concrete grout shall not be placed when there is frost in the subgrade.

643.10 Testing

643.10.1 Pipe – Water Tightness

All pipe shall be tested for water tightness in accordance with manufacturer's requirements.

- A. Reinforced concrete pipe (RCP) shall be tested in accordance with ASTM C443.
- B. High density polyethylene pipe (HDPE) shall be tested in accordance with ASTM D3212.
- C. Polyvinyl chloride pipe (PVC) shall be tested in accordance with ASTM D3212.
- D. Spiral-ribbed aluminized steel pipe (CMP, ASP) does not require water tight joints.

643.10.2 Pipe – Deflection

All flexible pipe shall be tested for deflection in accordance with Section 534.03 Deflection Testing Pipe of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.10.3 Manholes

All manholes shall be tested in accordance with Section 534.02 Vacuum Testing Manholes of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

643.10.4 Infiltration and Exfiltration

If deemed necessary by the Road & Bridge Superintendent / Elbert County Engineer, the storm sewer system shall be tested in accordance with Section 534.04 Infiltration and Exfiltration Testing of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

644.0 Inspections

Refer to Section 154.00 Inspections of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

Adequate inspections assure compliance to Elbert County requirements and are the basis for Elbert County's recommendation that said improvements be accepted for maintenance and for release of performance guarantees. It is the responsibility of the Contractor to contact the Road & Bridge Superintendent / Elbert County Engineer a minimum of one (1) full working day (twenty-four [24] hours) in advance of the required inspections. Required inspections shall include:

- A. Stockpiled Materials – Verify that materials meet CONSTRUCTION STANDARDS & SPECIFICATIONS and approved submittals, including but not limited to: bedding material, pipe, fittings, valves, valve boxes, and fire hydrants. Verify that pipe meets roundness specifications and that bells and spigots are not cracked or chipped.
- B. Excavation – Verify proper trench depths, shoring, spoil pile location, dewatering, and location and protection of existing utilities.
- C. Installation – Verify proper bedding depth, alignment and grade, clean pipe and lubricants. Verify “slicing in” of bedding at haunches and that all lifting holes in RCP are plugged.
- D. Backfill and Compaction – Verify proper methods of backfill and compaction, depths of lifts, moisture control, backfill material free of large rock and organic or frozen material, and proper compaction effort and passing tests.
- E. Testing – Verify that testing methods comply with these CONSTRUCTION STANDARDS & SPECIFICATIONS. Verify that Elbert County has witnesses all low pressure air tests, joint testing, vacuum testing of manholes and any other testing requirements.
- F. Construction Acceptance – Refer to Section 200 ACCEPTANCE PROCEDURES of these CONSTRUCTION STANDARDS & SPECIFICATIONS. General items include:
 - 1. All temporary structures, debris, mud and waste materials shall be removed from public property.
 - 2. All relative testing certifications and documentation shall be submitted to Elbert County, including all compaction tests. Copies of originals are acceptable.
 - 3. All storm sewer manholes and inlets are at construction grade, clean, and grouted, ladders straight, inlet protection installed, and storm sewerlines jetted. Verify that storm

sewer drainage swales have erosion and sediment control measures installed in accordance with the approved plans.

Prior to requesting a Construction Acceptance inspection, the Contractor shall clean storm sewer mains and shall have the lines inspected with TV video equipment. A copy of the videotape and written report shall be submitted to Elbert County for review. Video shall also include an audio description of pipe and manhole deficiencies, and camera location during the inspection. Any sections that contain debris or obstructions shall be cleaned and re-videotaped. Video shall be continuous from manhole to manhole, and all notations shall correspond to the approved construction plans. If, after visual inspection of the storm sewer lines the Road & Bridge Superintendent / Elbert County Engineer suspects that there is a problem, alignment, infiltration, exfiltration and/or deflection tests may be required at the Contractor's expense.

G. Final Acceptance – Refer to Section 200 ACCEPTANCE PROCEDURES of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

1. Verify that all temporary structures, debris, mud, and waste materials are removed from public property.
2. Verify that all storm sewer manholes and inlets are clean.

650.00 TRENCHING, BACKFILLING AND COMPACTING

Refer to Section 350.00 TRENCHING BACKFILLING AND COMPACTING of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

660.00 RESTORATION AND CLEANUP

Refer to Section 370.00 RESTORATION AND CLEANUP of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

670.00 GRADING AND EXCAVATION

Refer to Section 330.00 SITE PREPARATION of these CONSTRUCTION STANDARDS & SPECIFICATIONS.

TIME OF CONCENTRATION

SUBDIVISION: _____

CALCULATED BY: _____ **DATE:** _____

$$t_c = t_i + t_t$$

SUB-BASIN DATA			INITIAL / OVERLAND TIME (t _i)			TRAVEL TIME (t _t)				t _c CHECK (URBANIZED BASINS)		FINAL t _c	REMARKS
DESIGN (1)	C _s (2)	AREA Ac (3)	LENGTH Ft (4)	SLOPE % (5)	t _i Min (6)	LENGTH Ft (7)	SLOPE % (8)	VEL. FPS (9)	t _t Min (10)	TOTAL LENGTH Ft (11)	t _c = (L/180) + 10 Min (12)	Min (13)	

**STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)**

CALCULATED BY: _____

DATE: _____

CHECKED BY: _____

JOB NO: _____

PROJECT: _____

DESIGN STORM: _____

STREET	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
		AREA DESIGN	AREA (AC)	RUNOFF COEFF	C * A (AC)	t _c (MIN)	I IN/HR	Q (CFS)	t _c (MIN)	I (IN/HR)	Σ(C * A) (AC)	Q (CFS)	SLOPE (%)	STREET FLOW (CFS)	DESIGN FLOW (CFS)	SLOPE (%)	PIPE SIZE	LENGTH (FT)	VELOCITY (FPS)	t _t (MIN)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
1																					
2																					
3																					
4																					
5																					
6																					
7																					

SEQUENTIAL DETENTION CALCULATION

SUBDIVISION _____

CALCULATED BY: _____ DATE: _____

	FACILITY NUMBER	BASIN AREA (A) Ac (2)	Q _i CFS (3)	IMP % (4)	K Ft (5)	Q _i /A CFS/Ac (6)	Σ Q CFS (7)	Z Ac (8)	S _m Ac-Ft (9)	Q _m CFS (10)
10 - YEAR										
100 - YEAR										

- (1) Facility Number: Designated number of the detention facility being analyzed.
- (2) Basin Area: Area of basin (sub-basin) tributary to the detention facility not including any area tributary to an upstream detention facility
- (3)Q_i: Peak inflow in cfs from the area described in Column 2
- (4) Imp %: Percent imperviousness of the area described in Column 2
- (5) K: $K_{100} = (1.78I - 0.002I^2 - 3.56)/1000$; $K_{10} = (0.95I - 1.9)/1000$
- (6) Q_i/A: Peak inflow (Q_i) in column 3 divided by the area (A) in Column 2
- (7) ΣQ: Peak inflow into detention facility computed by summation of the peak inflow in Column 3 and the maximum release rate in Column 10
- (8) Z: Equivalent inflow area computed by dividing Column 7 by Column 6 (ΣQ/Q_i/A)
- (9) Minimum S_m: Minimum allowed storage volume for the respective detention facility V=KA, where K is from Column 5 and A = Z from Column 8
- (10) Maximum Q_m: Maximum allowed release rate for the respective detention facility Q₁₀ = 0.24Z, Q₁₀₀ = 1.00Z, where Z is from Column 8