SECTION 800 STORM DRAINAGE FACILITIES

SECTION **PAGE**

SECTION 800 STORM DRAINAGE FACILITIES

810.00 STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA

811.00 Scope

Section 800 sets forth the design and technical criteria and specifications for the analysis and design of drainage systems. All subdivision plats, site improvement plans, planned building groups and other proposed construction submitted to the Town for acceptance will be accompanied by a storm drainage analysis. Appropriate drainage system design must be submitted to and accepted by the Town Engineer for each phase of construction. Such analysis and design will conform to the criteria set forth herein. Acceptance of the analysis and design is subject to the following conditions:

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

In either case, the Town Engineer may require a new submittal.

A large portion of the criteria and design aids included in these STANDARDS AND SPECIFICATIONS originated from the Mile High Flood District (MHFD) "Urban Storm Drainage Criteria Manual". For any information not detailed in these specifications, refer to this manual.

812.00 General Provisions

812.01 General Design Criteria

Except where specified here, the procedure, criteria, and standards set forth in the latest revision of the "Urban Storm Drainage Criteria Manual" will be instituted for the analysis of any drainage system. Sound knowledge of current engineering practices and drainage methodology, as well as common sense, will be involved with the analysis of any drainage system.

All development must be in conformance with the current Master Drainage Plan or Outfall System Plan for the drainage basins where the development is located. For areas not included within a Master Drainage Plan or Outfall Systems Plan, onsite historic peak flows shall be calculated using the present land use of the site. For offsite areas draining onto the site, peak flows shall be calculated using the current land use for areas that are fully developed without an existing stormwater detention pond or for areas that are undeveloped that will be required to provide stormwater detention if improved. For offsite areas that are currently developed with an existing stormwater detention pond, the peak detention pond discharge rates shall be used for the peak flows.

Conveyance must be provided downstream of the site to the major drainageway with sufficient capacity to pass the one hundred (100) year storm event. Easements for these conveyance systems must be provided and shown on the drainage plan. If it is not possible to obtain an easement and construct drainage improvements on the downstream property, runoff must be reduced to historic rates and concentrated flows must be spread out to stimulate existing conditions to minimize the potential for erosion.

All major storm floodplain boundaries will be available from the Town Engineer and must be shown on all preliminary and final drainage plans. All pond facilities will be of the detention type. The Town Engineer will approve methods of detention. Retention facilities will only be allowed with the written approval of the Town Engineer.

Construction that will impair surface drainage will not be accepted. The Town reserves the right to issue and enforce more stringent criteria should adverse conditions exist. Designs varying from the criteria will require a variance with written approval by the Town Engineer prior to final acceptance of the plans.

812.02 Design Principals

Natural topographic features will be the basis of location for easements and future runoff calculations. In developed and undeveloped areas, average land slopes may be utilized in runoff computations. Wherever existing drainage patterns and slopes are defined, these will be used. The drainage facilities so designed must be able to handle the design flows with no erosion damage to the system.

Streets will not be used as primary floodways for major storm runoff. The amount of runoff in the streets will not exceed the limits established in Section 815.02 of these STANDARDS AND SPECIFICATIONS.

Stormwater detention facilities and natural drainageways are to be used whenever feasible. Any alteration to natural drainage patterns will not be approved unless a thorough investigation and analysis shows no hazard or liability. The Town Engineer will have final authority over any system design.

The planning and design of the drainage system will not be such as to simply transfer the problem from one location to another or create a more hazardous condition downstream. Provisions will be made in every development in the form of an easement or Right of Way for the 100-year storm to pass through that development, including tributary offsite runoff.

Enhancement of stormwater runoff quality is required for all developments within the Town of Erie through the use of structural or nonstructural Best Management Practices (BMPs). Refer to the Urban Storm Drainage Criteria Manual (Volume 3) for guidance on selection, use and design of BMPs.

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

Irrigation ditches cannot be used as an outfall point for the storm drainage system because of physical limitations. Variances can occur when the capacity of the irrigation ditch is adequate to carry the normal ditch flow plus the storm runoff with adequate freeboard to avoid creating a hazard to those below the ditch. Written approval must be obtained from the ditch owner stating that the owner understands the physical and legal (i.e., liability) consequences of accepting said runoff. However, without major reworking of irrigation ditches to provide major carrying capacity without undue hazard to those downstream or below the ditch, the ditches are almost always totally inadequate for such a use and should not normally be used as an outfall. Moreover, because ditches are normally privately owned, one cannot assume the perpetual

existence or function of a ditch. If a variance is requested to the Town Engineer for use of a ditch as an outfall, it is the design engineer's responsibility to complete all studies and designs deemed necessary by the Town Engineer to support the use of the ditch as well as a secondary drainage design should the ditch cease to exist.

Expressed written approval must be obtained from the managing organization for irrigation ditches being considered for crossing or easements.

813.00 Design Methods

813.01 Initial 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 corresponding to the initial (or ordinary) storm recurring at regular intervals. The other is the major system corresponding to the major (or extraordinary storm), which is unlikely to occur more often than once in 100 or more years. Since the effects and routing of storm waters for the major storm may not be the same as for the initial storm, all storm drainage plans submitted for acceptance will detail two separate systems; one indicating the effects of the initial storm and the other showing the effects of the major storm.

A. *Initial storm provisions:* The objectives of such drainage system planning are to minimize inconvenience, to protect against recurring minor damage, to reduce rising maintenance costs, and to create an orderly drainage system. The initial storm drainage system may include such facilities as curb and gutter, storm sewer, swales, and other open drainageways and detention facilities.

B. *Major storm provisions:* The major storm will be considered the 100-year storm. The objectives of the major storm planning are to eliminate substantial property damage or loss of life and will be as directed and accepted by the Town Engineer. Major drainage systems may include storm sewers, open drainageways and detention facilities. The correlation between the initial and major storm system will be analyzed to insure a well-coordinated drainage system.

813.02 Storm Return Periods

The initial and major storm design return periods will not be less than those found in Table 800-1:

TABLE 800-1
DESIGN STORM RETURN PERIODS

Land Use or Zoning	Design Storm Return Period	
	Initial Storm	Major Storm
Residential	2-year	100-year
Commercial and Business	5-year	100-year
Public Building Areas	5-year	100-year
Parks, Greenbelts, etc.	2-year	100-year

813.03 Runoff Computations, Colorado Urban Hydrograph Procedure (CUHP)

The CUHP method is generally applicable to drainage basins greater than 90 acres. However, the CUHP is required for watershed areas larger than 160-acres. The procedures for the CUHP, as explained in the Urban Storm Drainage Criteria Manual, shall be followed in the preparation of drainage reports and storm drainage facility designs in the Town. The CUHP program requires the input of a design storm, either as a detailed hyetograph or as a 1-hour rainfall depth. The program for the latter using the 2-hour storm distribution recommended in the Urban Storm Drainage Criteria Manual generates a detailed hyetograph distribution. The 1-hour rainfall depths for the Town of Erie are presented in Table 800-2.

Table 800-2
TOWN OF ERIE
ONE-HOUR RAINFALL DEPTH

Design Storm	Rainfall Depth (in.)
2-Year	0.81
5-Year	1.11
10-Year	1.39
25-Year	1.84
50-Year	2.24
100-Year	2.68
500-Year	3.89

The hydrograph from the CUHP program must be routed through any proposed conveyance facility using the Storm Water Management Model (SWMM) or a similar method approved by the Town Engineer.

813.04 Runoff Computations, Rational Method

The Rational Method will be utilized for sizing storm sewers and for determining runoff magnitude from un-sewered areas. The limit of application of the Rational Method is approximately 160 acres. When the drainage basin exceeds 160 acres, the CUHP method shall be used.
The procedures for the Rational Method, as explained in the Urban Storm Drainage Criteria Manual, shall be followed in the preparation of drainage reports in the Town.

813.05 Runoff Coefficients

Rational method runoff coefficients: The runoff coefficient (C) to be used in conjunction with the Rational Method will be calculated using the percent imperviousness shown in Table 800-3 as explained in the Urban Storm Drainage Criteria Manual.

TABLE 800-3
PERCENT IMPERVIOUS FOR RATIONAL METHOD

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS
Business	
Commercial Areas	95
Neighborhood 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	75
Industrial:	
Light Areas	80
Heavy Areas	90
Parks, Cemeteries	10
Playgrounds	25
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:	
Paved	100
Gravel (Packed)	40
Drives and Walks	90
Roofs	90
Lawns, Sandy Soil	2
Lawns, Clay Soil	2

Note: These Rational Method coefficients may not be valid for large basins.

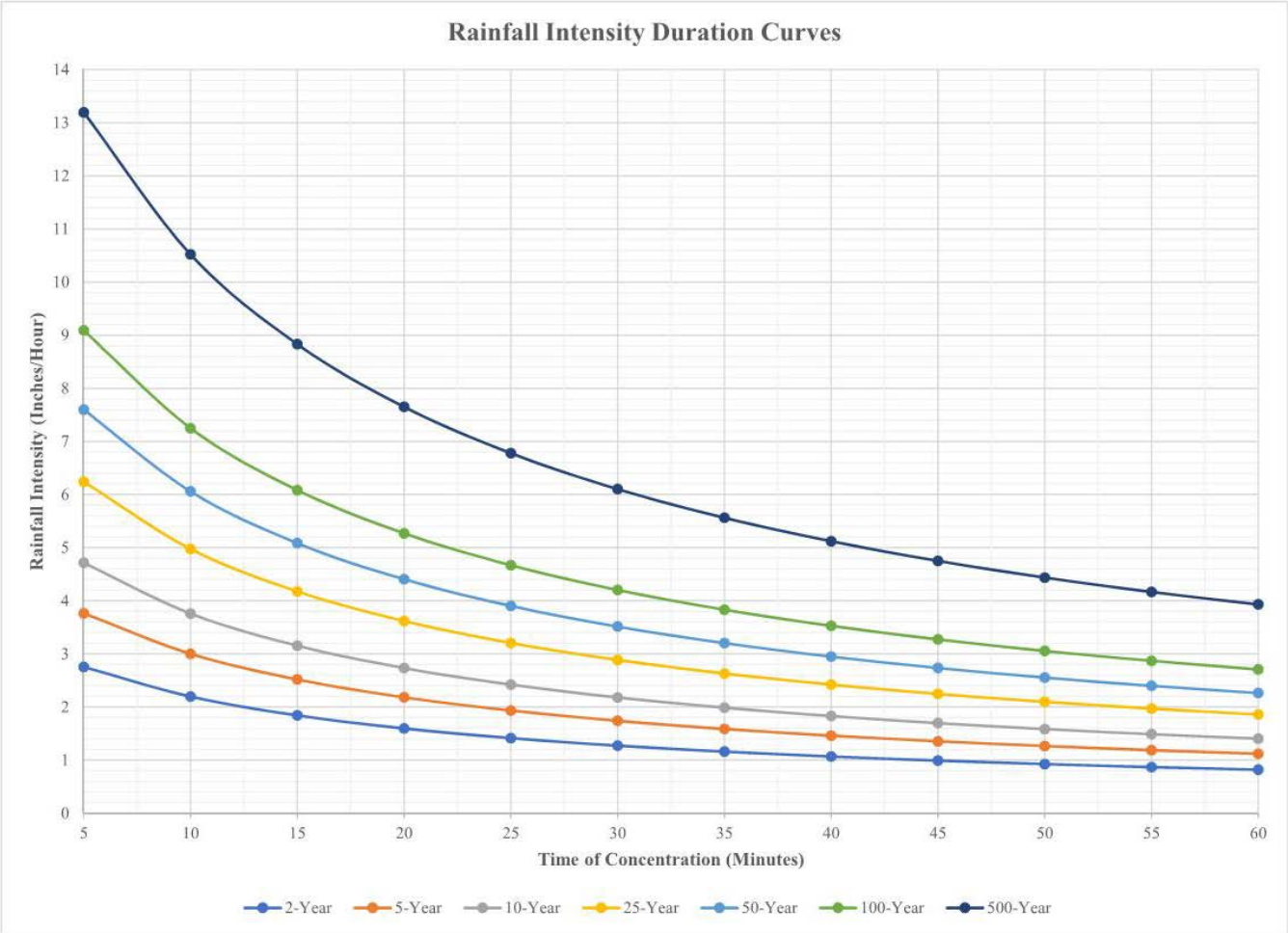
813.06 Rainfall Intensities

The rainfall intensities to be used in the computation of runoff using the Rational Method shall be obtained from the Rainfall Intensity Duration Curves for the Town of Erie, included in these STANDARDS AND SPECIFICATIONS, or can be computed using the following equation.

$$I = \frac{28.5\, P_1}{(10 + T_d)^{0.786}}$$

Where:

I = rainfall intensity (inches per hour)
P_1 = 1-hour point rainfall depth (inches)
T_d = storm duration (minutes)



814.00 Detention

814.01 General

Onsite detention is required for all new development, expansion, and redevelopment. The required minimum detention volume and maximum release rates at these volumes shall be determined in accordance with the procedure and data set forth in these criteria.

For lands where the Town has adopted a Master Drainage Plan or Outfall Systems Plan, detention facilities identified in the Master Drainage Plan or Outfall Systems Plan shall be constructed. For lands where there is no Master Drainage Plan or Outfall Systems Plan, detention is required for all

development as discussed in this section. Detention facilities should be designed using hydrograph and routing methods where possible.

Release rates and volumes, described in Sections 814.08 and 814.09, only apply to detention facilities with tributary drainage areas less than 90 acres. For detention facilities with tributary areas greater than 90 acres, the Full Spectrum Detention method must be used for the design as describes in section 814.12. The Rational Formula-based FAA detention method shall not be used.

Offsite drainage shall be routed around the detention facility or the tributary drainage area must be included in the pond volume and release rate sizing analysis.

More stringent detention volumes and release rates may be required by the Town Engineer to avoid negatively impacting the downstream properties.

Extended Detention Basins with stormwater quality storage as defined in the Urban Storm Drainage Criteria Manual shall typically be provided.

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 tributary drainage area is fully developed). This condition can typically occur for development located adjacent to a major drainageway. If an exemption is granted, a water quality only storage facility must be provided.

Parking lots that serve as detention storage facilities must not have a storage depth of more than 1 foot. Parking lots that serve as detention storage facilities must place notification signs that ponding will occur during a rainfall event. The signs shall be permanent and high quality, meeting both the Town's specifications for traffic signs and the Manual on Uniform Traffic Control Devices (MUTCD). Parking lot detention shall not be used at critical facilities as determined by the Town Engineer. Critical facilities may include, but are not limited to, hospitals, fire stations, police stations, schools, and potential gathering places that may be used in the event of an emergency.

814.02 State Engineer's Office

Any dam constructed for the purpose of storing water, with a surface area, volume, and/or dam height as specified in Colorado Revised Statutes 37-87-105, shall require the approval of the plans by the State Engineer's Office. Current legislation may revise these statutes. All detention storage areas shall be designed and constructed in compliance with current state statutes and/or criteria presented herein.

814.03 Grading Requirements

Slopes on earthen embankments shall not be steeper than 4 (horizontal) to 1 (vertical). The geotechnical engineer for the project shall verify slope stability. All earthen slopes shall be covered with topsoil and re-vegetated. For irrigated grassed detention facilities the minimum bottom slope shall be 2% measured perpendicular to the trickle channel. Wet bottom detention facilities shall be reviewed on a case-by-case basis.

When proposed lot grading has three or more lots draining to a shared lot line swale to a roadway, a sidewalk chase drain shall be installed to convey drainage through the sidewalk to the gutter. In areas with detached sidewalk and trees lawns, the sidewalk chase shall continue through the tree lawn and curb to the gutter.

814.04 Freeboard Requirements

The minimum required freeboard for grassed and parking lot detention facilities is one (1) foot above the computed 100-year water surface.

814.05 Trickle Flow Control

All grassed detention ponds shall include a trickle channel.

The base flow shall be carried in a trickle channel. The minimum capacity shall be one (1) percent to three (3) percent of the 100-year flow, but not less than one (1) cfs. Trickle channels may be constructed of concrete or other approved materials to minimize erosion and to facilitate maintenance. Trickle channels that aesthetically blend with the adjacent vegetation and are designed to be stable based on the soil conditions are preferred..

814.06 Outlet Configuration

Refer to the Urban Storm Drainage Criteria Manual for outlet configuration and sizing methods.

814.07 Embankment Protection

Whenever a detention facility uses an embankment to contain water, the embankment shall be protected from catastrophic failure due to overtopping. Overtopping can occur when the pond outlets become obstructed or when a larger than 100-year storm event occurs. Failure protection for the embankment may be provided in the form of a heavy buried riprap layer (Type M or larger) on the entire downstream face of the embankment or a separate stable emergency spillway having a minimum capacity of twice the maximum release rate for the 100-year storm event. For either case, the pond overflow velocity down the face of the embankment must be analyzed and adequate erosion protection must be provided. Structures shall not be permitted in the path of the emergency spillway or overflow. The invert of the emergency spillway should be set equal to or above the 100-year water surface elevation.

814.08 Release Rates

The maximum allowable unit release rates are summarized in Table 800-4. Refer to Urban Storm Drainage Criteria Manual Volume 3 for water quality release rate sizing.

TABLE 800-4
ALLOWABLE RELEASE RATES FOR DETENTION PONDS - CFS/ACRE

	SCS SOIL GROUP*		
CONTROL FREQUENCY	A	B	C & D
2-year	0.02	0.03	0.04
5-year	0.07	0.13	0.17
10-year	0.13	0.23	0.30
25-year	0.24	0.41	0.52
100-year	0.5	0.85	1.00

*SCS soil groups are classified according to their infiltration and transmission rates. The hydrologic soil groups are:

A. - Soils having high infiltration rates even when thoroughly wetted. These consist chiefly of deep, well to excessively drained sands or gravel. These soils have a high rate of water transmission.

B. - Soils having moderate infiltration rates when thoroughly wetted. These consist chiefly of moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C & D. - Soils having slow infiltration rates when thoroughly wetted. These consist chiefly of soils with a layer that impede downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

814.09 Minimum Detention Volume

The minimum required detention volumes should be determined using the following equations (Refer to Urban Storm Drainage Criteria Manual Volume 3 for water quality release rates):

$V = KA$, (Equation 801)

For the 100-year storm event,
$K_{100} = (1.78I-0.002I^2- 3.56)/1000$ (Equation 802)

For the 10-year, storm event,

$K_{10} = (0.95I – 1.90)/1000$ (Equation 803)

Where V = required volume for the 100 or 10-year storm event (acre-feet),
I = Developed basin imperviousness (%)
A = Tributary area (Acres)

814.10 Compensating Detention Procedure

Detention facilities are to be designed using the compensating detention procedure if any runoff is to flow undetained from the subject property. There may be more than one local detention facility onsite. The compensating detention procedure requires that the total release rates from the detained and undetained areas be equal to the allowable release rates from the site. Therefore, the more undetained runoff, the less the allowable detention facility release rates. The maximum limit on the undetained area is 5% or 5 acres, whichever is less.

Minimum Detention Volumes:

For detention facilities with drainage areas less than 90 acres, the minimum detention volumes shall be calculated using the equations in Section 814.09. The area contributing to the undetained runoff shall be included in the minimum detention volume calculation as if this area was draining to the detention facility. For detention facilities that are sized using the Full Spectrum Detention method, only the area tributary to the detention pond shall be included in the pond sizing analysis but using the reduced maximum release rates defined below.

Maximum Release Rates:

The maximum release rates shall be calculated in two steps. First, the allowable release rates from the whole basin (detained and undetained areas) shall be computed using Table 800-4 from Section 814.08. Then the maximum release rates from the detention facility are set equal to the maximum release rates from the whole site minus the runoff rates from the undetained area. Reduced release rates must be determined for all of the storm events analyzed for the pond sizing.

814.11 Sequential Detention Procedure

Unless the CUHP/SWMM method of analysis is used, local detention facilities are to be designed using the "sequential detention procedure" if any storm runoff is detained by two or more detention facilities in sequence before leaving the subject property. The sequential detention method accounts for the inherent decrease in efficiency of two sequential detention facilities versus one facility by considering the released runoff from one facility to be equivalent to runoff from an incremental area tributary to the second facility. Thus, the storage volume of the second facility is increased to accommodate the incremental area runoff. By minimizing the second detention facility's release rate, the volumes of any additional sequential facilities are minimized.

Sequential detention facilities are to be designed using Standard Form SF-11 provided below. The form is divided into two parts: Singular Detention and Sequential Detention. The singular detention part is for listing and computing the parameters associated with a single detention facility. Each facility is analyzed using the "equation detention method" criteria and the "compensating detention procedure" criteria, if required. The sequential detention part of the form evaluates the combined effect of the detention facilities. The results of the second part computations will yield the minimum volume required and the maximum release rates allowed for each detention facility. The description of Standard Form SF-11 is as follows:

Col. 1: **Facility Number**: Designated number of the detention facility being analyzed.

Col. 2: **Basin Area**: Area of basin (sub-basin) tributary to the detention facility not including any area tributary to an upstream detention facility.

Col. 3: **(Q-sub I)**: Peak inflow in cfs from the area described in Column 2.

Col. 4: **IMP %**: Percent imperviousness of the area described in Column 2 to be used in Equations 802 and 803.

Col. 5: **K**: K-factor calculated from Equations 802 and 803 and the percent imperviousness (IMP %) in Column 4.

Col. 6: **(Q-sub I/A)**: Peak inflow (Q-sub I) in Column 3 divided by the area (A) in Column 2.

Col. 7: **ΣQ**: Peak inflow into detention facility computed by summation of the peak inflow in Column 3 and the maximum release rate from the detention facilities just upstream in Column 10.

Col. 8: **Z**: Equivalent inflow area computed by dividing Column 7 by Column 6 ($\Sigma Q/(Q_I/A)$).

Col. 9: **Minimum S-sub m**: Minimum allowed storage volume for the respective detention facility computed using Equation 801 and the parameters in Column 5 (K-factor) and Column 8 (Z = A).

Col. 10: **Maximum Q-sub m**: Maximum allowed release rate for the respective detention facility computed using the values in Table 800-4 and the Z parameter in Column 8.

STANDARD FORM SF-11
SEQUENTIAL DETENTION CALCULATION

SUBDIVISION _____

CALCULATED BY _____ DATE _____

10-YEAR

	SINGULAR DETENTION					SEQUENTIAL DETENTION			
FACILITY NUMBER	BASIN AREA (A)	Qi	IMP	K	Qi / A	Σ Q	Z	Sm	Qm
	Ac	CFS	%	Ft	CFS/Ac	CFS	Ac	Ac-Ft	CFS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)

100-YEAR

	SINGULAR DETENTION					SEQUENTIAL DETENTION			
FACILITY NUMBER	BASIN AREA (A)	Qi	IMP	K	Qi / A	Σ Q	Z	Sm	Qm
	Ac	CFS	%	Ft	CFS/Ac	CFS	Ac	Ac-Ft	CFS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)

$\Sigma Q = Q_i$ + Previous Q_m

$Z = \Sigma Q/(Q_i/A)$

$S_m = KZ$

Town of Erie Section 800
Construction Standards and Specifications
Storm Drainage Facilities

814.12 Simplified Full-Spectrum Detention Sizing

Refer to the Urban Storm Drainage Criteria Manual for Full-Spectrum Detention Sizing. For detention facilities with tributary drainage areas less than 10 acres, the Simplified Equations for sizing may be used. The UD-Detention workbook or CUHP/SWMM Hydrograph Routing method can be used for sizing ponds with tributary areas of all quantities. For multiple detention facilities in parallel or in series, the CUHP/SWMM Hygrograph Routing method must be used.

815.00 Design Standards

815.01 Open Channels

Except as modified herein, open channels will be designed for the 100-year frequency storm and will conform to the criteria set forth in the Urban Storm Drainage Criteria Manual. However, the channel design will also be analyzed with respect to initial storm runoff and its effect made known. Whenever practical, the channel should have slow flow characteristics, be wide and shallow, and be natural in its appearance and functioning.

Where appropriate or required by the Town Engineer, such as for major drainageways, natural stream corridors shall be preserved and stabilized or naturalized channels shall be created in accordance with the Urban Storm Drainage Criteria Manual, Chapter 8 Open Channels.

Channels shall be designed in such a manner that critical depth and super-critical flows are avoided. Capacities for small channels may be computed from Manning's Formula for uniform flow, except at crossings and transitions where backwater effects will need to be accounted for and the Town Engineer may require the channel capacity be calculated using different methods.

The channel cross section may be almost any type suitable to the location. However, the limitations for design for the major storm and initial storm design flows shall include:

A. The channel and overbank areas shall have adequate capacity for the 100-year storm runoff.
B. Side slopes: Side slopes will be as flat as practical. Side slopes of 4:1 will be considered a normal minimum. Under special conditions, slopes of 3:1 may be utilized with written approval of the Town Engineer. However, a slope of no steeper than 4:1 is the practical limit for mowing equipment.
C. Depth: The maximum design depth of flow for the major storm shall be limited to five (5) feet, not including freeboard. Any design variation exceeding the maximum depth of flow must be submitted in writing for approval by the Town Engineer. Critical depths and velocities will be investigated for both the major and initial storm runoffs and these values made available to the Town Engineer.
D. Freeboard: Except where localized overflow in certain areas is desirable for additional ponding benefits or other reasons, the minimum allowable freeboard will be one (1) foot
E. Bottom width: The bottom width should 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 will have slopes of 0.2% to

0.6%. Where the natural topography is steeper than desirable, drops may have to be utilized.

G. Curvature: The centerline curvature will not have a radius less than twice the design flow top width, but not less than one hundred (100) feet.

H. Trickle channels: Trickle channels to carry low flows will be required for all new channels. The capacity of a trickle channel will be approximately 2.0% of the major design flow. Where 2.0% of the major design flow exceeds 90 cfs, a low flow channel will be required. Low flow channels shall be in accordance with the MHFD Urban Storm Drainage Criteria Manual.

I. Design velocity: The maximum velocity for the major storm design runoff will 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.

J. Erosion: All channels will be designed with the proper and adequate erosion control features.

K. Grass lining: The grass lining for channels shall be in accordance with the MHFD Urban Storm Drainage Criteria Manual.

L. Water surface profile: A water surface profile for the major storm runoff will be computed for all channels and clearly shown on the final drawings submitted for acceptance. Computations of the water surface profile will utilize standard backwater methods such as HEC-RAS taking 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 final design plan.

M. Roughness coefficient (n): The value of the roughness coefficient (n) to be used in Manning's Formula, HEC-RAS, and for any other hydraulic calculation will not be less than those listed in Table 800-5:

N. 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 will not be permitted. Minimum velocities for all channels will not be less than two (2) feet per second for the initial storm runoff.

TABLE 800-5
MINIMUM VALUES OF ROUGHNESS COEFFICIENT (n)

Type of Channel and Description Closed Conduits:			Minimum
	Closed Conduits:		
		Concrete pipe and box culvert (new)	0.013
		Concrete pipe and box culvert (old)	0.015
		PVC pipe	0.011
		CMP pipe	0.024
		HDPE pipe	0.010
	Channels and Swales:		
		Grass-lined (native grasses)	0.035
		Grass-lined (turfgrass sod)	0.030
		Riprap-lined	0.042
		Concrete trickle channel	0.013
	Major Drainageways:		
		Natural channel preservation	See USDCM
		Naturalized channel	See USDCM
		Wetlands channel	See USDCM
	Streets:		
		Asphalt street with concrete gutter	0.016
		Concrete street and gutter	0.013
		Concrete pavement and crosspans	0.013

815.02 Street Flow Capacities

Except as modified herein, the criteria set forth in the Urban Storm Drainage Criteria Manual will be used in analyzing and approving the adequacy of streets as a function of the drainage system. The Street Classifications for Drainage Purposes are listed in Table 800-6.

Table 800-6

STREET CLASSIFICATION FOR DRAINAGE PURPOSES

Street Classification	Function	Speed/Number of Lanes	Signalization at Intersections	Street Parking
Local	Provide access to residential and industrial areas	Low speed with 2 moving lanes	Stop signs	One or both sides of the street
Collector	Collect and convey traffic between local and arterial streets	Low to moderate speed with 2 or 4 moving lanes	Stop signs or traffic signals	One or both sides of the street
Arterial	Function as primary through traffic conduits in urban areas	Moderate to high speeds with 4 to 6 lanes	Traffic signals (controlled access)	Usually prohibited
Freeway	Provide rapid and efficient transport over long distances	High speed travel with 4 lanes or more	Cloverleaves, access ramps (limited access)	Always prohibited

Both the initial storm runoff and major storm runoff must be considered, and calculations showing such runoff at critical sections will be submitted. The following criteria will apply in the determination of allowable street flow capacities:

A. Street, curb/gutter, walks, crosspans and curb cuts shall conform to all applicable Sections of these STANDARDS AND SPECIFICATIONS.

B. In relation to street capacity for initial storm, pavement encroachment for the initial design storm shall not exceed the limitations set forth in Table 800-7:

TABLE 800-7
ALLOWABLE PAVEMENT ENCROACHMENT AND DEPTH OF FLOW FOR INITIAL STORM RUNOFF

Street Classification	Maximum Encroachment*
Local	No curb overtopping; flow may spread to crown of street.
Collector	No curb overtopping; flow spread must leave the equivalent of one 10-foot driving lane clear of water.
Arterials	No curb overtopping; flow spread must leave the equivalent of two 10-foot driving lanes clear of water - one lane in each direction.
Freeways	No encroachment is allowed on any traffic lane.

* Where no curbing exists, encroachment will not extend past property lines.

The storm sewer system will commence at the point where the maximum allowable encroachment occurs.

C. In relation to street capacity for major storm, the allowable depth of flow and inundated area for the major design storm will not exceed the limitations set forth in Table 800-8:

TABLE 800-8
ALLOWABLE DEPTH OF FLOW AND INUNDATED AREA FOR MAJOR STORM RUNOFF

Street Classification	Allowable Depth and Inundated Areas
Local & Collector	Residential dwellings and public, commercial, and industrial buildings shall be no less than 12 inches above the 100-year flood at the ground line or lowest water entry of the building. The depth of water over the gutter flow line must not exceed 12 inches.
Arterial & Freeway	Residential dwellings and public, commercial, and industrial buildings must be no less than 12 inches above the 100-year flood at the ground line or lowest water entry of the building. The depth of water must not exceed the street crown to allow operation of emergency vehicles. The depth of water over gutter flow line must not exceed twelve (12).inches

D. Cross street flow: Cross street flow will occur by one of the following methods. One method is runoff which has been flowing in a gutter and then flows across the street to the opposite gutter or inlet. The second case is flow from some external source, such as a drainageway or conduit, which will flow across the crown of the street when the conduit capacity is exceeded. Allowable Cross Street Flow is set forth in Table 800 –9.

TABLE 800-9
ALLOWABLE CROSS STREET FLOW

Street Classification	Initial Storm Flow	Major Storm Flow
Local	6 inches of depth in crosspan.	12 inches of depth above gutter flow line.
Collector	Where cross-pans allowed, depth of flow must not exceed 6 inches.	12 inches of depth above gutter flow line.
Arterial/Freeway	None.	No cross flow.

815.03 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 Urban Storm Drainage Criteria Manual. Both the initial and major storm events shall be considered to size the storm sewer system. Storm sewers and inlets shall be of sufficient capacity to adequately carry the expected runoff from the initial design storm, minimum. There are conditions when the storm sewer system needs to be sized to convey flows greater than the initial design storm (and as much as the major storm event). The storm sewer system and subsequent storm inlets will commence at all locations where the allowable street capacity is exceeded or wherever ponding of water is likely to occur. No bubblers will be allowed. The minimum allowable pipe size to be used in storm sewers and laterals will be as listed in Table 800-10:

TABLE 800-10
MINIMUM ALLOWABLE PIPE SIZE

Type of Conduit	Min. Inside Pipe Dia.
Main Trunk Sewer	18"
Short Laterals	15"

Arch pipes will be allowed where design conditions dictate, provided that the minimum cross-sectional areas will not be less than the equivalent pipe size specified above. All storm sewer conduits shall be of sufficient structural strength to withstand an H-20 design load.

The maximum allowable distance between manholes or other suitable appurtenances for cleanouts shall not exceed those listed in Table 800-11:

TABLE 800-11
MAXIMUM ALLOWABLE MANHOLE SPACING

Inside Diameter or Minimum Head Room	Maximum Allowable Distance Between Manholes & Cleanouts
18” - 36"	400 feet
42" - 60"	500 feet
60" & Larger	750 feet

The capacities of conduits will be computed using the criteria set forth in the Urban Storm Drainage Manual, including a hydraulic grade line (HGL) analysis, for both the initial and major storm events. Friction, lateral, bend, exit and entrance losses shall be included in the design. The storm sewer design shall include tailwater conditions. The value of the roughness coefficient (n) to be used will not be less than those specified in Section 815.01(l), Table 800-5 of these STANDARDS AND SPECIFICATIONS. The average flow velocity for the initial storm event shall not be less than two (2) feet per second and the maximum velocity for all storm events shall not exceed 18 feet per second. The HGL for the major storm event peak flow shall be at least 1 foot below the elevation of manhole covers, inlet grates, and the flowline at inlet curb openings. For storm sewer systems designed for the initial storm event, additional runoff can be intercepted by inlets during major storm events due to greater depths of flow in the streets. Surcharge created by conveyance of the additional runoff must be analyzed and the HGL must meet the maximum limit as described above for the major storm event.

Allowable storm inlets will be curb opening inlets, type "R" or combination curb/grate inlets, type “13”, similar and equal to the Town's Standard Storm Water Inlets or as approved by the Town Engineer. Inlets will be utilized at all points where ponding or sump conditions exist. Refer to the Standard Drawings for details.

The allowable capacity and spacing of storm inlets shall be analyzed using the criteria set forth in the Urban Storm Drainage Criteria Manual. Reduction factors are applied to the theoretical inlet capacity to determine the allowable capacity. These reduction factors compensate for debris plugging, pavement overlaying, variations in design assumptions or other factors that decrease inlet capacities. Other methods, such as nomographs, may be used to design inlets as long as appropriate reduction factors are applied. The Town Engineer must approve other design methods.

The size of outlet pipes from storm water inlets shall be based on providing at least 1 foot of freeboard from the gutter flowline to the hydraulic inlet control depth for the outlet pipe or the storm sewer hydraulic grade line at the inlet, whichever is higher.

At sump inlets, an emergency overflow channel designed to convey the major storm runoff must be provided in case the inlet becomes clogged. The emergency overflow channel shall be contained within a drainage tract or easement. If the sump inlet is designed to intercept the major storm event, the emergency overflow channel does not need to meet maximum velocity requirements. If the sump inlet is not designed to intercept the major storm event, the emergency overflow channel must meet the requirements in Section 815.01 Open Channels of these STANDARDS and SPECIFICATIONS.

Computations for storm sewer design and storm inlet designs shall be submitted on forms similar to those included in these specifications for acceptance, or computer model or spreadsheet generated results tables. Adequate details of the proposed storm sewer system, including plan and profile, details of inlets, manholes and other appurtenances shall be included in the overall drainage plan submitted for acceptance.

The storm sewer outlet shall be protected for the major storm event. The protection shall be designed as set forth in the Urban Storm Drainage Criteria Manual.

815.03.01 Nuisance Flows

The locations of inlets is important to address the effect of nuisance flows and avoid icing. Nuisance flows are urban runoff flows that are typically most notable during dry weather and come from sources such as over-irrigation, snowmelt, and excessive sump pump discharge. Nuisance flows can cause problems in both warm and cold weather months. Problems include algae growth and ice. While it is possible to minimize nuisance conditions through design, irrigation practices in the summer and snow and ice removal in the winter make it very difficult to eliminate nuisance flows entirely. Because these practices are somewhat controlled by residents and businesses, homeowner's associations and business associations should plan for maintenance on private roadways and parking areas to address nuisance flow conditions, particularly in the winter when ice accumulation can impede the ability of the drainage system to serve its purpose. Design engineers should work with property owners and development teams to implement a storm drainage design that minimizes the impact of nuisance flows to the greatest degree possible.

Because of many of the issues related to nuisance flows are beyond the control of the Town, identifying problem areas and incorporating maintenance objectives shall be considered as part of the planning and design process to minimizing nuisance conditions. For new development projects, inlet placement should take in to reasonable consideration interception of runoff prior to accumulation at a design point with increased chance of freezing, avoidance of heavily shaded areas, and increased inlet capacity at strategic locations.

Discharge from foundations drains, private lot storm drainage pipes, and sump pumps must comply with applicable State and Local requirements. Down spout and sump pump discharges shall be directed to swales, lawns, and gardens (keeping away from foundation backfill zones and walkways) where water can infiltrate. Discharge from sump pumps may be tied to the Town's stormwater system upon approval from the Town Engineer but may not discharge directly to a street surface. All tie-in points shall be installed at approved locations such as at a manhole or an inlet. No direct tie-in to a storm drain pipe shall be allowed. Sump pump discharge flows can only be released into a stormwater conveyance system specifically designed and accepted by the Town to receive such flows.

Control of nuisance waters including but not limited to flows over sidewalks, algae growth on sidewalks, and ice accumulation on sidewalks and driveways is strictly the responsibility of the property owner of the adjoining lot. The Town will make reasonable efforts to minimize the occurrence of such nuisances through its review and inspection authorities, but if such nuisances do occur, the Town is not responsible or obligated to correct or require any other party to correct such a problem.

815.04 Culverts

Culvert capacities shall be at least equal to the capacities of culverts designed in accordance with the procedures outlined in the Urban Drainage Storm Criteria Manual. Culverts may be of any shape and construction required by existing topographic features, provided, however, the size, shape, location, and type of construction of culverts shall be subject to acceptance by the Town Engineer.

Culverts installed under local and collector streets shall be designed to pass at least the 10-year storm event. Culverts installed under arterials shall pass at least the 100-year storm event.

Culverts under principal arterials shall have sufficient capacity to pass all of the runoff from the major storm considering a minimum of twenty percent (20%) of the inlet plugged. Higher percentages may be required based on site-specific considerations.

Overtopping of culvert installations due to plugging must be analyzed for the 100-year storm event. The overtopping depth due to plugging must be less than one foot.

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

A. The culvert, including inlet and outlet structures, will properly take care of water, bed load and debris at all stages of flow.

B. Inlets: 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 will not be acceptable. For large structures, provisions shall be made to resist possible structural failure due to hydrostatic uplift forces.

C. Outlets: Culvert outlets shall be designed to avoid sedimentation, undermining of culvert, or erosion of downstream channels. Outlets shall be provided with either flare-end sections or headwalls, with wingwalls and riprap or grouted boulders. Projecting outlets will not be acceptable. Outlet protection shall be designed according to the Urban Storm Drainage Criteria Manual or a method acceptable to the Town Engineer.

D. Slopes: Culvert slopes shall be such that neither silting nor excessive velocities nor scour occur.

E. Excessive ponding above culvert entrances will 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 inundate existing or future utilities and structures.

F. Tailwater: The height of tailwater at the outlet shall be considered by the culvert outlet control analysis and will be subject to acceptance by the Town Engineer.

G. Hydraulic Design: Culverts shall be analyzed to determine whether discharge is controlled by inlet or outlet conditions for both the initial storm discharge and the major storm discharge. The value of the roughness coefficient (n) used shall not be less than those specified in Section 815.01, Table 800-5 of these STANDARDS AND SPECIFICATIONS. Computations for selected culvert sizes shall be submitted for approval on forms similar to those included in these specifications, or computer model or spreadsheet generated results tables.

H. Minimum Allowable Size: The required size of the culvert shall be based on adequate hydraulic design analysis. In no case shall approval be made for round culverts with less than an eighteen (18) inch inside diameter.

I. Multiple Culvert Installations: Where physical conditions dictate, multiple culvert installations will be acceptable, subject to approval by the Town Engineer. Headwalls shall be used with multiple culvert installations. The minimum size of any culvert shall not be less than the requirements set forth in Section 815.03, Table 800-10 of these STANDARDS AND SPECIFICATIONS.

J. Structural Design: The structural design of culverts shall conform to those methods and criteria recommended by the manufacturer of a specific type of culvert for the specified embankment conditions. Where appropriate, the applicable provisions of Section 815.02 of these STANDARDS AND SPECIFICATIONS will also apply to the design of culverts.

820.00 GENERAL PROVISIONS

821.00 General

All storm drainage construction in the Town rights-of-way shall be accomplished in accordance with these STANDARDS AND SPECIFICATIONS, and these standards will cover not only new storm drainage construction but also repairs and maintenance of the existing facilities within the Town.

822.00 Accepted Plans

All storm drainage construction shall be done in accordance with engineered construction plans for the work, prepared under the direction of a Registered Professional Engineer licensed to practice in Colorado. Plans will conform to the Town's Design Criteria and must be accepted by the Town Engineer. Storm drainage plans will include an Area Grading Plan and an Erosion Control plan as defined in Section 161.00 of these STANDARDS AND SPECIFICATIONS.

Where work is to be done on an irrigation ditch, the written approval of the ditch owner is required prior to acceptance by the Town Engineer.

823.00 Permits Required

The Town Engineer will require a public improvement permit and may require a Stormwater Quality permit. Refer to Section 150.00, Permits and Inspections, of these STANDARDS AND SPECIFICATIONS for additional requirements.

824.00 Maintenance of Traffic

Maintenance of traffic shall comply with Section 623.00, Maintenance of Traffic, of these STANDARDS AND SPECIFICATIONS.

830.00 EROSION CONTROL

831.00 General

Erosion and sedimentation are natural processes, the intensity of which are 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 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.

832.00 Requirements

Control measures shall be designed in conformance with Urban Storm Drainage Criteria Manual. All land-disturbing activities within the Town of Erie shall be in compliance with applicable Colorado Discharge Permit System (CDPS) and Colorado Air Pollution Control Division regulations to protect stormwater.

833.00 Submittal

A discussion summarizing erosion control methods shall be submitted as part of the preliminary and final drainage reports as required in Section 162.00 of these STANDARDS AND SPECIFICATIONS. A detailed Erosion Control Plan must accompany the Area Grading Plan and approved Drainage Plan as required in Section 161.03 of these STANDARDS AND SPECIFICATIONS. The Erosion Control Plan must be submitted to, and accepted by the Town of Erie Planning and Development Department prior to receiving a Stormwater Quality Permit.

834.00 Erosion Control Measures

Detailed control measures must be provided to protect the following:

A. Inlets and culverts
B. Drainageways
C. Streams or other water bodies that are immediately adjacent to land disturbed by construction activity.
D. Cut and fill areas where exposed soil exists.
E. Properties and improved streets adjacent to construction activity.
F. Other as required by the Town Engineer.

Initial control measures such as sediment traps, inlet protection or silt fences must be installed in accordance with the accepted Erosion Control Plan prior to any disturbance on site. Control measures shall be kept in good repair and fully functional until the erosion potential from the site no longer exists. Permanent stabilization measures (sod, seed, mulching, etc.) will be in place prior to the request for a Certificate of Occupancy.

A water truck shall be kept on-site at all times during land disturbing activities to control wind erosion and dust.

835.00 Erosion Control Structures

Erosion and sediment control measures should be obtained from the Urban Storm Drainage Criteria Manual or selected, designed, and adequately sized in accordance with good engineering hydrologic, and pollution control practices.

840.00 STORM DRAINAGE CONSTRUCTION

841.00 Site Work and Earthwork

841.01 General

Site work and earthwork shall be performed in accordance with Section 300.00, Site Work and Earthwork, of these STANDARDS AND SPECIFICATIONS.

841.02 Trenching, Backfilling and Compacting

Trenching, backfilling and compacting shall be performed in accordance with Section 350.00, Trenching, Backfilling and Compacting, of these STANDARDS AND SPECIFICATIONS.

841.03 Preservation of Monuments

Refer to Section 141.00, Protection of Public and Utility Interests, of these STANDARDS AND SPECIFICATIONS.

842.00 Materials

842.01 Pipe

Reinforced concrete pipe (RCP): shall be manufactured in accordance with ASTM C-76. All applicable portions of Section 706, Concrete and Clay Pipe, of the CDOT Standard Specifications for Road and Bridge Construction shall apply. Rubber gasket joints shall be in accordance with ASTM C443.

Polyvinyl Chloride Pipe (PVC): shall be manufactured in accordance with ASTM F794. All applicable portions of Section 712.13, Plastic Pipe, of the CDOT Standard Specifications for Road and Construction shall apply. Use of PVC within the right-of-way is not allowed.

Corrugated metal pipe (CMP): shall be fabricated in accordance with all applicable portions of Section 707, Metal Pipe, of the CDOT Standard Specifications for Road and Bridge Construction.
Use of CMP within the right-of-way is not allowed.

High-density polyethylene pipe (HDPE): shall be manufactured in accordance with ASTM D3350, ASTM D4976, ASTM F667, ASTM F894, ASTM F2306, and ASTM F2562. Requirements for test methods, dimensions and markings shall comply with AASHTO Designation M-294. Use of HDPE within the right-of-way is not allowed.

Couplings shall be corrugated to match the pipe corrugations (to be fabricated by the pipe manufacturer) and the width shall not be less than one-half (1/2) the nominal diameter of the pipe. Split couplings shall be manufactured to engage an equal number of corrugations on each side of the pipe joint. Where required by the Town Engineer, a mastic type gasket will be utilized. A manufacturer's certification that the product was manufactured, tested and supplied in accordance with this specification shall be furnished upon request of the Town Engineer.

Pipe class designation or gauge shall be as shown on the accepted plans or as designated by the Town Engineer for each individual project. Pipe material shall be chosen based on strength and soil conditions. At no time shall high-density polyethylene pipe (HDPE) be allowed under roadways.

All pipe shall be inspected by the Town Engineer to allow for rejection of pipe that fails to conform to the requirements of these STANDARDS AND SPECIFICATIONS. Defects will be marked so as not to disfigure the rejected pipe. Rejected pipe will be removed from the job site within 24 hours.

At all locations where corrugated metal pipe (CMP) is to be installed, a corrosion resistance level test shall be performed and a test report submitted to the Town Engineer for acceptance. The test will classify the soil and water to one of the Corrosion Resistance (CR) Levels shown in Table 800-14.

TABLE 800-14
GUIDELINES FOR SELECTION OF CORROSION RESISTANCE (CR) LEVELS

CR Level	Sulfate (SO_4) % max.	Chloride (Cl) % max.	pH	Sulfate (SO_4) ppm* max.	Chloride (Cl) ppm max.	pH
CR 0**	0.05	0.05	6.0 - 8.5	250	250	6.0 - 8.5
CR 1	0.15	0.15	6.0 - 8.5	250	250	6.0 - 8.5
CR 2	0.05	0.05	6.0 - 8.5	500	500	6.0 - 8.5
CR 3	0.15	0.15	6.0 - 8.5	500	500	6.0 - 8.5
CR 4	0.50	1.00	5.0 - 9.0	1000	1000	5.0 - 9.0
CR 5	1.00	1.50	5.0 - 9.0	2000	2000	5.0 - 9.0
CR 6	1.00	1.50	5.0 or 9.0	2000	2000	5.0 or 9.0

* ppm = parts per million
**No special corrosion protection recommended when values are within these limits.

842.01.01 Electronic Marker System

All storm sewer pipe shall be installed with electronic markers at a maximum spacing of one marker for every 50 lineal feet of pipe. These markers shall be green in color and as manufactured by 3M. Full range markers shall be used up to a maximum depth of 8 feet. If the storm pipe is to be installed at a depth greater than 8 feet, a marker shall be placed in the trench at a depth of 8 feet aligned with the pipe centerline. The markers shall be tested to verify acceptable function at time of Initial Acceptance.

842.02 Pipe Joints

Pipe joints shall be constructed as designated on the accepted construction plans or as otherwise accepted by the Town Engineer. Rubber gasket joints for concrete pipe will conform to ASTM C-443. Corrugated metal pipe joints will be installed according to pipe manufacturer's recommendations. Cement mortar joints will 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 will be discarded and a new batch prepared.

842.03 Manholes, Inlets and Sidewalk Chases

Manholes and inlets may be constructed of cast-in-place or precast concrete. Manhole materials shall comply with all applicable portions of Section 732.04, Manhole Materials, of these STANDARDS AND SPECIFICATIONS.

Inlets shall conform to the Standard Drawings and to applicable Colorado Department of Transportation "M" Standards. All lids for inlets shall have the words “No Dumping – Drains to River” and “Storm Sewer”.

Sidewalk chase drains are allowed and shall conform to the standard drawings.

842.04 Manhole Base Slabs & Base Beams

Refer to Section 732.05, Manhole Base Slabs and Base Beams, of these STANDARDS AND SPECIFICATIONS.

842.05 Concrete

Concrete shall conform to Section 400.00, Concrete Work, of these STANDARDS AND SPECIFICATIONS, for Portland cement concrete work. Type II cement will be used. Concrete encasement of pipe will conform to the details shown on the accepted plans.

842.06 Cast Iron Fittings

Refer to Section 732.07, Cast Iron Fittings, of these STANDARDS AND SPECIFICATIONS.

842.07 Bedding Material

Bedding for storm sewer mains shall meet the gradation of CDOT “No.67 Coarse Aggregate” as specified in Section 703.02 in the latest edition of the CDOT “Standard Specifications for Road and Bridge Construction”. Reference the Storm Sewer Trench Detail for further detail. All applicable portions of Section 352.00, Bedding for Pipelines and Service Lines, of these STANDARDS AND SPECIFICATIONS, shall apply.

842.08 Riprap and Filter Cloth

Riprap and filter cloth shall be installed at those locations noted on the accepted plans, or in locations designated by the Town Engineer. Riprap and bedding shall meet the standards set forth in the Urban Storm Drainage Criteria Manual.

842.08.01 Riprap

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 single stone shall be less than one-third (1/3) its length and rounded stone will not be accepted except when used for mixing void-filled riprap per the USDCM requirements. The rock shall sustain abrasion test (Los Angeles machine - ASTM C0535-69) and shall sustain a loss of not more than ten percent (10%) 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 in Table 800-14.

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

TABLE 800-14
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 rock size
** Bury Types VL and L with native topsoil and re-vegetate to protect from vandalism.

842.08.02 Filter Cloth

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:

A.	Weight	3.9 oz/yd	ASTM D1910
B.	Thickness	15 mils	ASTM D1777
C.	Grab Strength	130 lbs	ASTM D1682
D.	Elongation Break	60%	ASTM D1682
E.	Mullen Burst Strength	140 psi	ASTM D3786
F.	Puncture Strength	40 lb	ASTM D751
G.	Trapezoid Tear Strength	60 lb	ASTM D751
H.	Equivalent Opening Size	70-100 U.S. Sieve	CW 02215

842.08.03 Filter Material

The filter material that shall be placed on top of the filter cloth (at specified thickness) prior to placement of the riprap shall meet the requirements of "Stabilization Material" as defined in Section 340.01, Definitions, of these STANDARDS AND SPECIFICATIONS.

When requested by the Town Engineer, the Contractor shall furnish copies of tests from a certified and acceptable testing laboratory for the following:

A. Gradation and soundness of rock for riprap and boulders
B. Gradation of filter material
C. Strength and characteristic tests for filter cloth

843.00 Installation

Refer to Section 733.01, General, of these STANDARDS AND SPECIFICATIONS.

843.01 Alignment and Grade

Refer to Section 733.02, Alignment and Grade, of these STANDARDS AND SPECIFICATIONS.

843.02 Protection of Existing Underground Utilities

Refer to Section 733.03, Protection of Existing Underground Utilities, of these STANDARDS AND SPECIFICATIONS.

843.03 Wet Trench

Refer to Section 351.00, Trench Excavation for Pipelines and Service Lines, of these STANDARDS AND SPECIFICATIONS.

843.04 Handling Pipe and Fittings

Refer to Section 733.05, Handling Pipe and Fittings, of these STANDARDS AND SPECIFICATIONS.

843.05 Sewer Pipe Installation

Refer to Section 733.06, Sewer Pipe Installation, of these STANDARDS AND SPECIFICATIONS.

843.06 Connections to Existing Manholes

Refer to Section 733.07, Connections to Existing Manholes, of these STANDARDS AND SPECIFICATIONS.

843.07 Construction of Manholes, Inlets and Sidewalk Chases

Manholes and inlets shall be constructed in accordance with applicable portions of Section 733.08, Construction of Manholes, of these STANDARDS AND SPECIFICATIONS. Refer to the Standard Drawings for manhole details, inlet details, and for sidewalk chase details. Inlets shall be per CDOT Construction Details or accepted by the Town of Erie.

843.08 Construction of Open Channels and Special Structures

All work will conform to details shown on the accepted plans and whatever additional specifications are required. Construction will be accurately done to line and grade according to construction stakes as required by Section 733.02 of these STANDARDS AND SPECIFICATIONS.

When required, sidewalk chases will be constructed as detailed on the Standard Drawings.

843.09 Riprap and Filter Cloth

Excavation for riprap shall conform to all applicable portions of Section 300.00, Site Work and Earthwork, of these STANDARDS AND SPECIFICATIONS.

The Contractor shall complete the excavation in accordance with the accepted plans or as directed by the Town Engineer, then he shall place the filter cloth over the graded areas loosely enough so that any protrusions from underneath or applied bands to the cloth will not cause stretching of the cloth beyond elastic limits.

The outer edge of the filter cloth shall be folded vertically upward at the trench. All overlapping joints shall be a minimum of two (2) feet wide, with the upstream section overlapping the downstream portion. The overlapping joints shall be secured with staples at each edge of the adjoining sections of cloth, and spaced at two (2) foot intervals. The Contractor, at his expense, in accordance with the manufacturer's recommendations, shall repair any holes, rips or other damage to the filter cloth.

Stabilization material, as described in Section 340.01, Definitions, of these STANDARDS AND SPECIFICATIONS, shall be placed on top of the filter cloth (where filter cloth is used) to a thickness of six (6) inches. The material shall be placed using equipment, which will 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 screeded to give a finished surface, which is within one- (1) inch of the specified thickness.

Riprap shall be placed to conform to the details shown on the accepted 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, so 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 by more than one-quarter (1/4) foot per foot of depth. The material may be machine placed with sufficient handwork to accomplish the requirements noted herein.

Where boulders are to be grouted, the boulders shall be laid with care to prevent earth and sand from filling the gaps between boulders. Grout must be removed from exposed rock for aesthetic purposes.

Gaps shall be filled with grout and mechanical vibrators shall be used to insure all voids are filled. The surface shall be trowel finished. Concrete for the grout shall be an approved batch meeting the following requirements:

a. All grout shall have a minimum 28-day compressive strength equal to 3,200 psi.
b. One cubic yard of grout shall contain a minimum of six (6) sacks of Type II Portland cement.
c. A maximum of 25% Type F Fly Ash may be substituted for the Portland cement.
d. Aggregate for the grout shall consist of 70% natural sand (fines) and 30% 3/8-inch rock (coarse).
e. Slump shall be four (4) inches to six (6) inches.
f. Air entrainment shall be 5.5% - 7.5%.
g. Grout shall contain one and one-half (1-1/2) pounds of Fibermesh, or approved equivalent, per cubic yard of grout.
h. Color Additive in required amounts shall be used when so specified by contract.

Except when approved in writing by the Town Engineer, the Contractor shall not be permitted to grout boulders when the air temperature away from artificial heat falls below thirty-two degrees Fahrenheit (32°F), and there is frost in the subgrade. When grouting is permitted during cold weather, the temperature of the mix shall not be less than fifty degrees Fahrenheit (50°F) at the time of placing. During hot weather conditions, the temperature of the mix shall not be more than ninety degrees Fahrenheit (90°F) at the time of placing The Contractor shall not place filter cloth, stabilization material, or boulders on frozen ground. Blankets and heaters must be used to maintain a temperature between fifty degrees Fahrenheit (50°F) and seventy degrees Fahrenheit (70°F) for the required curing period. Concrete shall not be placed against forms exposed to heating unless the temperature of the forms is first cooled to less than or equal to ninety degrees Fahrenheit (≤90°F).

843.10 Inspections

Initial Acceptance: Prior to initial acceptance the Contractor, at the Contractor's expense, will jet-vac the storm sewer and have the lines inspected with TV video equipment (a copy of the video tape and written report must be supplied to the Town). If, after visual inspection of the storm sewer system and video, the Town Engineer suspects that there is a problem, he may require that further tests shall be completed by the Contractor at the Contractor's expense. Should any inadequacies be found, the Contractor shall make repairs deemed necessary to correct the problem.

Final Acceptance: Prior to final acceptance the Contractor, at the Contractor's expense, will jet-vac the storm sewer and have the lines inspected with TV video equipment (a copy of the video tape and written report must be supplied to the Town). If, after visual inspection of the storm sewer system and video, the Town Engineer suspects that there is a problem, he may require that further tests shall be completed by the Contractor at the Contractor's expense. Should any inadequacies be found, the Contractor shall make repairs deemed necessary to correct the problem.

850.00 TRENCHING, BACKFILLING AND COMPACTING

Refer to Section 350.00, Trenching Backfilling and Compacting, of these STANDARDS AND SPECIFICATIONS.

860.00 RESTORATION AND CLEANUP

Refer to Section 360.00, Restoration and Cleanup, of these STANDARDS AND SPECIFICATIONS.

870.00 GRADING AND EXCAVATION

Refer to Section 330.00, Site Preparation, of these STANDARDS AND SPECIFICATIONS.