DEVELOPMENT PROCESS MANUAL

Chapter 3: Drainage, Flood Control and Erosion

Rio Rancho City of Vision

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Dekker Architecture in Progress

Contents

3. DRAINAGE, FLOOD CONTROL AND EROSION CONTROL

3.1 Introduction

The standards, guidelines and criteria presented herein are provided to facilitate the planning, design, construction and operation of both public and private drainage control, flood control, and erosion control facilities within the community. The criteria are not intended as a substitute for good engineering judgment; imagination and ingenuity are encouraged. The purpose of these criteria is to provide guidance for a majority of design circumstances, however it should be understood that situations will arise in which these criteria are not appropriate or require modification due to unique conditions. Where necessary, coordination between the Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) and the City of Rio Rancho staff is expected and as such, may, in specific cases, require more stringent criteria or allow relaxation of these criteria based on sound engineering practice.

The administration of these standards including interpretation, enforcement, revision, waiver, and variance is hereby delegated to the appropriate representatives from the City of Rio Rancho in conjunction with SSCAFCA.

3.2 References

A. City of Rio Rancho Ordinances and Policies
   i. Rio Rancho Municipal Code, Chapter 152, Flood Hazard Prevention.
   ii. Rio Rancho Municipal Code, Chapter 153, Erosion Control; Storm Drainage.
   iii. Rio Rancho Municipal Code, Chapter 154, Planning and Zoning.
   iv. Rio Rancho Municipal Code, Chapter 155, Subdivision Ordinance.

B. SSCAFCA Manuals and Policies
   i. All SSCAFCA related reference materials can be found at the following link: https://www.sscafca.org/resources/.

3.3 Hydrology

For the purposes of this chapter, all hydrologic modeling completed for the purposes of determining requirements related to drainage, flood control and erosion control for developments larger than 40 acres in the City of Rio Rancho shall follow the guidelines as required by SSCAFCA. Again, consultation with the City of Rio Rancho and SSCAFCA representatives is required to ensure expectations are set at the onset of modeling and analysis pertaining to any development.

3.3.A Considerations

The SSCAFCA Hydrology Criteria Manual sets forth criteria for the design of SSCAFCA constructed facilities and facilities that will ultimately be owned by SSCAFCA but constructed by others. This also includes facilities that require the use of SSCAFCA right-of-way. The City of Rio Rancho leverages this criterion to set forth consistent requirements and policy, however, there may be situations where the City implements additional or altered requirements based on implementation characteristics.

3.3.B Storm Drainage Release Rate

Unless further restricted by downstream or specific infrastructure limitations, the peak discharge permitted from a developed property in the event of a 100-year, 24-hour storm shall be the amount of the historic or pre-developed peak discharge in all watersheds of the City of Rio Rancho. Drainage infrastructure capacity downstream of any given development may govern the allowable discharge. To determine additional constraints on discharge rates, if any, due to downstream infrastructure constraints, coordination with the owner of the downstream infrastructure is required.

3.3.B.I. SYMBOLS AND DEFINITIONS

A_A area in land treatment A

A_B area in land treatment B

A_C area in land treatment C

A_D area in land treatment D

A_T total area in sub-basin

Ac Ft acre feet

C Rational Method coefficient

C_A Rational Method coefficient for treatment A

C_B Rational Method coefficient for treatment B

C_C Rational Method coefficient for treatment C

C_D Rational Method coefficient for treatment D

cfs cubic feet per second

Elev elevation (feet)

Ft feet

hr hour

I Rational Method intensity (inches/hour)

K conveyance factor for SCS Upland Method

mi^2 square mile(s)

n Manning's roughness coefficient

PMF Probable Maximum Flood

1/2PMF one-half of the Probable Maximum Flood

PMP_{15} 15-minute Probable Maximum Precipitation

PMP_{60} 60-minute Probable Maximum Precipitation

PMP_{360} 360-minute Probable Maximum Precipitation

PMP_T Probable Maximum Precipitation at anytime, t

Q_P peak discharge (cfs)

Q_{PA} peak discharge rate (cfs/acre) for treatment A

Q_{PB} peak discharge rate (cfs/acre) for treatment B

Q_{PC} peak discharge rate (cfs/acre) for treatment C

Q_{PD} peak discharge rate (cfs/acre) for treatment D

s slope of subreach in foot per foot

t time in minutes

t_B base time for small watershed hydrograph

T_C time of concentration (hours)

R storage coefficient (hours)

t_p time to peak (hours)

v velocity of flow in watershed (feet/sec)

v_x velocity of flow in watershed subreach

V_{360} runoff volume for 360-minute storm

V_{1440} runoff volume for 1440-minute storm

V_{4days} runoff volume for 4-day storm

V_{10days} runoff volume for 10-day storm

y^x y to the x power

+ addition operator

- subtraction operator

* multiplication operator

/ division operator

√ square root operator

3.3.B.II. DEFINITIONS

100-year Design Storm - means a storm as defined by the Drainage Ordinance and DPM.

ADA – Americans with Disabilities Act.

Amendment - Change to an effective FEMA map resulting in the exclusion of an individual structure or a legally described parcel of undeveloped land that was inadvertently included in the SFHA.

Amenities – Improvements that may enhance the citizens' enjoyment of the outdoors including, but not limited to, trails, viewpoints with benches, wildlife and plant habitat, educational/informational signage, and trailheads.

Applicant - means any Developer seeking to construct drainage facilities under this Procedure.

Base Flood Elevation (BFE) - Elevation of the 100-year (1-percent annual chance) flood, in feet, referenced to the National Geodetic Vertical Datum.

Benefit - means, for the purpose of this Procedure, the provision of a drainage outfall or flood control facility that serves the property.

Benefited Area - means the tracts or parcels of land within a drainage basin benefited by the proposed drainage or flood control facilities.

BMP - Best Management Practice.

Certificate of Completion and Acceptance - means a document issued by the City in a format prescribed in the Development Process Manual which certifies that the public infrastructure improvements required for a development have been satisfactorily completed by the developer and are accepted by the City, for maintenance and public use.

City/County Floodplain Administrator - Public official who is designated by the community to coordinate the community's participation in the National Flood Insurance Program.

Consulting Engineer - means a professional engineer competent in surface water hydrology and hydraulics duly licensed under the laws of the State of New Mexico who is under contract with an Applicant or the City to design drainage facilities.

Cost Allocation - means a cost allocated to new development in order to fund and/or recoup the costs of drainage facilities necessitated by and attributable to the new development.

Cost Allocation Table - means the list or roll of all tracts or parcels of property within the benefited area and the amount to be allocated against each tract or parcel as determined in accordance with this Procedure.

Critical Depth – The depth at which the specific energy of the flow is at a minimum and the Froude number is one.

Critical Facility – Essential infrastructure or buildings whose disruption or damage could cause significant harm, disruption or loss of life and shall include hospitals, schools and other buildings used for emergency shelter, support facilities/utilities for aforementioned facilities, and access routes to the aforementioned facilities.

Critical Slope – The slope at which the normal depth equals the critical depth.

Dams – Storm water retention/detention structures approved and controlled by the Office of the State Engineer.

Depth of Bury – the vertical distance between the top of the utility line and the bottom of the arroyo, whether the utility is in the arroyo or adjacent to the arroyo, at the time of consideration.

Detention Pond – A ponding structure designed with a physical means by which water is released in a controlled manner.

Developer - means any individual, estate, trust, receiver, cooperative association, club, corporation, company, firm, partnership, joint venture, syndicate, political subdivision or other public or private entity engaging in the platting, subdivision, filling, grading, excavating, or construction of structures.

DPM – Development Process Manual.

Drainage Basin - means the land area from which storm water shall drain to an acceptable outfall.

Drainage Facilities - means public facilities used for conducting storm waters to, through and from a drainage basin to the point of final destination, and any related improvements, as defined in the Allocation Plan including, but not limited to, any or all of the following: bridges, pipes, conduits, culverts, crossing structures, arroyos, waterways, inlets, swales, ditches, gulches, channels, temporary or permanent retention and detention areas, water quality features, lateral erosion line and stability measures removal and/or replacement of existing facilities, as well as easements and rights-of-way necessary, to accommodate the same.

Easement Curve – A curve whose degree of curvature is varied either uniformly or according to a definite pattern to give a gradual transition between a tangent and a simple curve which it connects or between two simple curves.

Encroachment - Construction, placement of fill, or similar alteration of topography in the flood plain that reduces the area available to convey flood waters.

Federal Emergency Management Agency (FEMA) - Government Agency that regulates FIRM maps.

Floodway - Channel of a stream or other watercourse, plus any adjacent flood plain areas that must be kept free of encroachment so that the 100-year flood discharge can be conveyed without cumulatively increasing the elevation of the 100-year flood more than zero feet.

Floodway Fringe - Portion of the 100-year flood plain that is not within the floodway and in which development and other forms of encroachment are allowed.

Flood Boundary and Floodway Map (FBFM) - Flood plain management map issued by FEMA that depicts, based on detailed analyses, the boundaries of the 100- and 500-year floods and the limits of the 100-year floodway. Replaced by FIRM.

Flood Insurance Rate Map (FIRM) - Insurance and flood plain management map issued by FEMA that, based on detailed analyses, identifies areas of 100-year flood hazard in a community. Also shown are BFEs, actuarial insurance rate zones, delineations of the 100- and 500-year flood boundaries, and, on some FIRMS, the 100-year floodway. The Flood Insurance Rate Map enables the community to enter the Regulatory Phase of the National Flood Insurance Program.

Floodplain - Any land area susceptible to being inundated by water from any source, or areas adjacent to a watercourse or other body of water that are subject to inundation by flood waters.

Floodplain Development – Any earthwork, storage, or construction activity (permanent or temporary).

Gross Pollutants - litter, vegetation, coarse sediment and floatable debris. For the local Municipal Separate Storm Sewer System (MS4), the gross pollutant treatment size is defined as 1-3/4" and larger.

HDPE – High Density Polyethylene.

High Hazard Structure – A structure whose failure or mis-operation would likely cause loss of human life.

Infrastructure Allocation Drainage Management Plan* or *Allocation Plan - means a comprehensive analysis of the discharge rate volume, frequency, and course of stormwaters within one or more drainage basins or watershed resulting from a new development and used to identify required drainage facilities so that an equitable cost distribution for drainage facilities may be allocated against benefited properties. The Allocation Plan shall be prepared in accordance with this Procedure.

LEE – Lateral Erosion Envelope.

Letter of Map Amendment (LOMA) - Official determination by FEMA that a specific structure or portion of a property is not within a 100-year flood zone; amends the effective FIRM map.

Letter of Map Revision (LOMR) - Official determination by FEMA that revises Base Flood Elevations, flood insurance rate zones, flood boundaries, or floodways as shown on an effective FIRM map.

Mild Slope – The channel slope is less than the critical slope. The normal depth is greater than the critical depth. Flow is subcritical (Froude number less than one) downstream conditions can influence upstream flow.

National Flood Insurance Program (NFIP) - Federal regulatory program under which flood-prone areas are identified and flood insurance is provided to the owners of property in flood-prone areas.

New Development - means the proposed subdivision of land, reconstruction, redevelopment, conversion, structural alteration, relocation or enlargement of any structure; or any proposed use or extension of the use of land affecting drainage within the benefited area, including but not limited to proposed buildings or other structures, site plan requests, grading, paving, filling, or excavation.

Normal Depth – The depth of flow under uniform flow conditions.

NPDES - National Pollutant Discharge Elimination System.

Open Space - means publicly owned or controlled lands set aside for Open Space purposes.

Ponds – Smaller storm water retention/detention structures not approved or controlled by the Office the State Engineer (i.e., containing a storage volume less than 50 acre feet and/or a berm height of less than 25'.

Retention Pond – A ponding structure without a physical means by which water is released in a controlled manner. This includes ponds whose evacuation is dependent upon infiltration and/or evaporation.

Revision - Change to any of the information that is depicted on an effective NFIP map, which is accomplished by a LOMR or by a Physical map revision.

SAS ECZ – Sanitary Sewer Line Erosion Control Zone, the Depth of Scour for the 100-year DEVEX event.

Scour Depth – Cumulative scour depth including consideration of contraction scour and local scour as defined in Sections 3.4 and 3.5 of the Sediment and Erosion Design Guide.

Special Flood Hazard Area (SFHA) - Area inundated by the base (100-year) flood, which carries any of several A or V zone designations.

SSCAFCA – Southern Sandoval County Arroyo Flood Control Authority.

Steep Slope - The channel slope is greater than the critical slope. The normal depth is less than the critical depth. Flow is supercritical (Froude number greater than one) upstream conditions are not affected by downstream conditions.

Stormwater Quality Constituents - dissolved and suspended nutrients, metals, oils, greases, biological agents, etc.

Stormwater Quality Treatment Rate (SWQR) - the peak rate of flow from the water quality storm event.

Stormwater Quality Treatment Volume (SWQV) - the treatment volume from the water quality storm event.

Temporary Drainage Facility - means a nonpermanent drainage control, flood control or erosion control facility constructed as part of a phased project or to serve until such time as a permanent facility is in place, including, but not limited to, desilting ponds, berms, diversions, channels, detention ponds, bank protection and channel stabilization measures.

Water Quality Storm Event - The ninetieth percentile storm event for new development and the eightieth percentile storm for redevelopment using the methodologies specified in EPA publication number 832-R-14-007, or developed for site-specific application using methodology described therein, or based on a site-specific predevelopment hydrology and associated storm event discharge volume specified therein.

Watershed Park – A comprehensive, connected system of joint use amenities along the arroyos in Southern Sandoval County.

Witness Post – A post identifying the location and depth of the utility that will remain in its location through a storm event.

WMP's – Watershed Management Plans.

3.3.C Rational Method

The Rational Method formula is a commonly used, simplified method of estimating peak discharge for small uniform drainage areas. This method is typically used to size drainage structures for the peak discharge of a given return period. Extensions of this method can be used to estimate runoff volume and the shape of the runoff hydrograph to design drainage facilities and / or design a drainage structure that requires routing of the hydrograph through the structure.

The Rational Equation is expressed as follows:

$$Q = CiA \qquad \text{(D-1)}$$

Where:

Q = maximum rate of runoff, in cfs
C = runoff coefficient
i = average rainfall intensity, in inches / hour
A = drainage area, in acres

Assumptions

The following assumptions are inherent when using the Rational Equation:

1. The peak flow occurs when the entire watershed is contributing to the flow.
2. The rainfall intensity is the same over the entire watershed.
3. The rainfall intensity is uniform over a duration equal to the time of concentration.
4. The frequency of the computed peak flow is the same as that of the rainfall intensity (e.g. the 25-year rainfall intensity is assumed to produce the 25-year peak flow).

3.3.C.I. LIMITATIONS

The following limitations shall apply to the Rational Method for use in the City. Drainage areas that do not meet the following conditions will require the use of an appropriate rainfall-runoff method as outlined in Section 3.3.D.

1. The total drainage area cannot exceed 40 acres in size.
2. The land treatment within the contributing watershed must be fairly consistent over the entire drainage area and uniformly distributed throughout the area.
3. The contributing drainage area cannot have drainage structures or other facilities upstream of the point of interest that require flood routing.

3.3.C.II. RUNOFF COEFFICIENTS

Perhaps the most important variable in the Rational Method equation is the runoff coefficient. The runoff coefficient represents the fraction of rainfall that appears as surface runoff from a watershed. Thus, the runoff coefficient is, by default, also a measure of the fraction of rainfall lost to depression storage, infiltration and evaporation with infiltration being the primary loss component. This fraction is largely independent of rainfall intensity or volume from impervious areas. However, for pervious areas, the fraction of runoff varies with rainfall intensity and the accumulated volume of runoff. Therefore, the selection of a runoff coefficient that is appropriate for the storm, soil type, land cover and land use conditions is critical.

Runoff coefficients are based on a characterization of the watershed area into land treatment classifications. Runoff coefficients may be determined following the procedure outlined in the current version of the New Mexico Department of Transportation Drainage Design Manual (NMDOT DDM, Section 403.3).

For watersheds with multiple land treatment types, an area averaged runoff coefficient should be used as input to Equation D-1. The area average can be a simple arithmetic average, as seen in the equation below.

(D-2)

$$C = \frac{A_A C_A + A_B C_B + A_C C_C + A_D C_D}{A_A + A_B + A_C + A_D}$$

3.3.C.III. TIME OF CONCENTRATION

Time of concentration is defined as the time it takes for runoff to travel from the hydraulically most distant part of the watershed to the basin outlet or point of analysis (concentration point). The units for time of concentration are time, in hours. This implies that the time of concentration flow path may not be the longest physical length, but the length that results in the longest time.

Time of concentration is calculated using the SCS Upland Method. The Upland Method is the summation of flow travel time for the series of unique flow characteristics that occur along the overall basin flow path length. The Upland Method travel time equation is:

(D-3)

$$T_C = \sum_{i=1}^{n} \left(\frac{L_i}{36{,}000 \cdot K_i \cdot \sqrt{S_i}} \right)$$

Where:

T_c = Time of concentration, in hours
L_i = Length of each unique surface flow conveyance condition, in feet
K_i = Conveyance factor
S_i = Slope of the flow path, in feet per foot

Table 3.1: Conveyance Factors

K	Conveyance Condition
0.7	Turf, landscaped areas and undisturbed natural areas (sheet flow* only)
1	Bare or disturbed soil areas and paved areas (sheet flow* only)
2	Shallow concentrated flow (paved or unpaved)
3	Street flow, storm sewers and natural channels, and that portion of subbasins (without constructed channels) below the upper 2000 feet for subbasins longer than 2000 feet
4	Constructed channels (for example: riprap, soil, cement, or concrete lined channels)
* Sheet flow is flow over lane surfaces, with flow depths up to 0.1 feet. Sheet flow applies only to the upper 400 feet (maximum) of a subbasin.	

3.3.C.IV. INTENSITY

Rainfall intensity, i, in Equation D-1 is estimated in inches/hour for the specified recurrence interval. The rainfall intensity is uniform over a duration equal to the time of concentration for the drainage area.

For most drainage areas less than or equal to 40 acres in size, it can be assumed that the time of concentration for drainage areas up to 40 acres in size will not exceed 15-minutes. Rainfall intensities corresponding to a 15-minute time of concentration can be found in NOAA Atlas (latest edition), Precipitation - Frequency Atlas of the United States, Volume 1: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah).

3.3.C.V. RUNOFF VOLUME

$$V = C \frac{P}{12} A$$

Runoff volumes for drainage areas less than or equal to 40 acres in size can be estimated using a modified form of the Rational Method Equation. That equation is as follows:

(D-4)

Where:

V = runoff volume, in acre-feet
C = weighted runoff coefficient derived from Equation D-2
P = rainfall depth, in inches
A = drainage area, in acres

Rainfall depths for Equation D-3 can be found in NOAA Atlas (latest edition), Precipitation - Frequency Atlas of the United States, Volume 1: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah). For all other recurrence intervals and / or storm durations, point precipitation depths are to be obtained directly from the National Weather Service through the NOAA 14 Precipitation Frequency Data Server Precipitation values for frequencies up to 1,000 years and duration up to 60 days can be obtained by entering the latitude and longitude of the watershed of interest.

3.3.C.VI. RUNOFF HYDROGRAPH

A runoff hydrograph can be synthesized for drainage areas less than or equal to 40 acres based on the Rational Method. This procedure is to be used where routing of the storm inflow through a drainage structure is desired, such as for the design of a detention basin. The procedure is based on an idealized hydrograph shape, drainage area time of concentration and the Rational Method peak discharge. The shape of the hydrograph is shown in Figure D-1. Equations for deriving the runoff hydrograph shape are as follows:

(D-5)

$$t_B = \left(2.017\frac{C \cdot P \cdot A_T}{Q_P}\right) - \left(0.25\frac{A_D}{A_T}\right)$$

Where:
t_B = time base, in hours
C = runoff coefficient from Equation D-2
P = rainfall depth, in inches from Table 3
Q_P = Rational Method peak discharge, in cfs
A_D = area in land treatment type D, in acres
A_T = drainage area, in acres

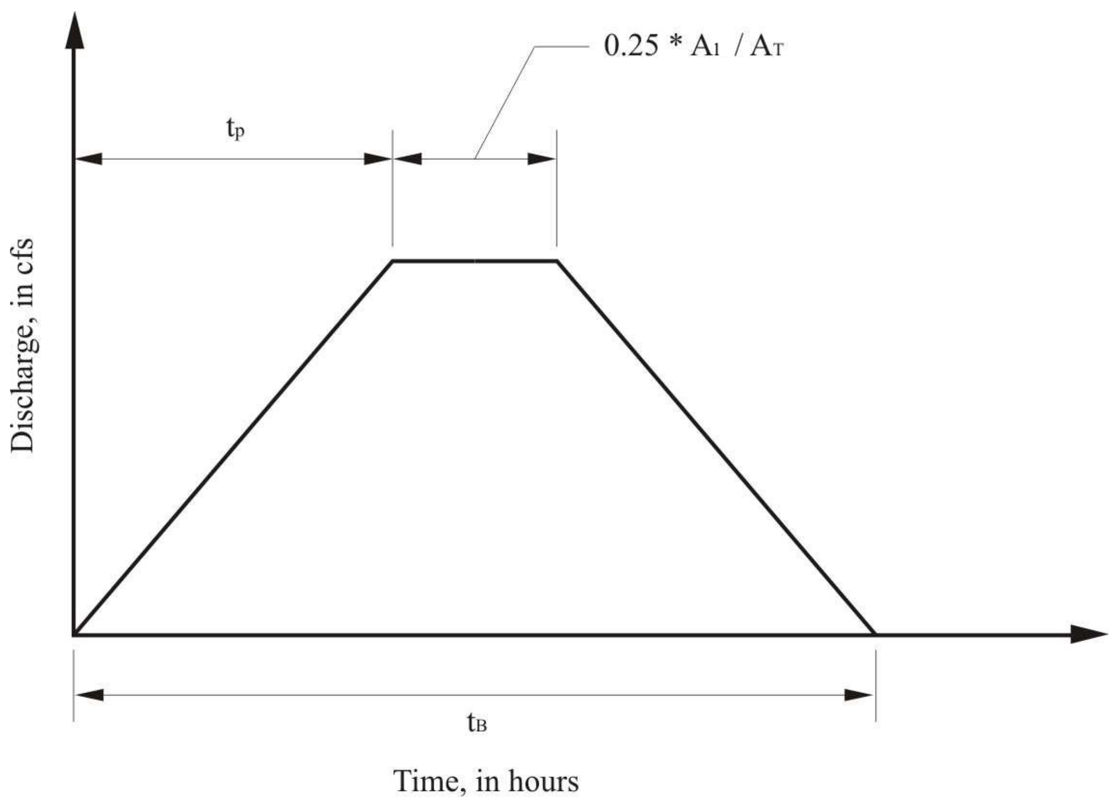
$$t_P = 0.7 \cdot T_C + \frac{1.6 - A_D/A_T}{12}$$

(D-5)

Where:
t_p = time to peak in hours
T_c = time of concentration from Equation D-2, in hours

A_D = area in land treatment type D, in acres
A_T = drainage area, in acres

FIGURE 1. RATIONAL METHOD RUNOFF HYDROGRAPH SHAPE



3.3.D Rainfall-Runoff Modeling: HEC-HMS

Rainfall-runoff modeling for drainage areas greater than 40 acres in size is to be conducted using the U.S. Army Corps of Engineers HEC-HMS software following the procedures outlined in SSCAFCA's Criterial Manual on the SSCAFCA website.

3.3.E Procedure For Probable Maximum Flood

Computation of the Probable Maximum Flood (PMF), or one-half Probable Maximum Flood (½ PMF), is typically required for design of dam spillways in high hazard areas. For flood control dams, the PMF is typically used for design of the emergency spillway. The Office of the State Engineer (OSE) should be contacted regarding specific requirements on the use of the PMF.

- Visit the New Mexico Office of the State Engineer website and contact the Interstate Stream Commission
- Visit the New Mexico Office of the State Engineer website to find the GIS Probable Maximum Precipitation (PMP) Tool Documentation

3.3.E.I. JURISDICTION OF THE OFFICE OF THE STATE ENGINEER (OSE)

The OSE has jurisdiction over the design and construction of non-federal dams that meet OSE's jurisdictional criteria. This authority for the safety of dams is contained primarily within Chapter 72, NMSA 1978. All dams must conform to the OSE criteria as demonstrated by correspondence issued by the OSE and provided to the City Engineer before proceeding to design any project requiring a permit for a dam, the OSE should be contacted to obtain guidance on applicable regulations and design criteria. City review must occur before submittal to OSE to obtain concurrence on determination of PMP. This includes dams intended for sediment, erosion and flood control.

The Manual of Rules and Regulations Governing the Appropriation and Use of the Surface Waters of the State of New Mexico can be found on the State Records Center and Archives website as well as the Summary of New Mexico State Engineer Office Procedure on Design Criteria and Safety of Dams are available from the OSE. Included in the summary is information on the classification of dams, hydrologic evaluation guidelines, probable maximum precipitation (PMP) criteria, and the "Engineering Review Project Check List". Special engineering requirements are required for project design and construction supervision.

The procedures for determination of the PMF must be consistent with the OSE's rules, regulations, procedures and design criteria. The OSE shall make the final determination on the design criteria, safety requirements, alternate specifications/procedures and/or additional requirements.

3.4 Hydraulic Design

3.4 A Weirs and Orifices

3.4.A.I. WEIRS

A weir is a barrier in an open channel, over which water flows. A weir with a sharp upstream corner or edge such that the water springs clear of the crest is a "sharp crested weir". All other weirs are classified as "weirs not sharp crested". Weirs are to be evaluated using the following equation:

$Q = CLH^{3/2}$

Where:

Q = Discharge in cfs

C = Discharge coefficient from Handbook of Hydraulics, King and Brater, 5th Edition (or comparable)

L = Effective length of crest in feet

H = Depth of flow above elevation of crest in feet (approach velocity shall be disregarded in most applications)

Applications

Weirs are generally used as measuring and hydraulic control devices. Emergency spillways in which critical depth occurs and overflow-type roadway crossings of channels are the most common applications of weirs. Channel drop structures and certain storm drain inlets may also be analyzed as weirs. Detail justifying coefficients used must be outlined when selecting weir coefficients in the following cases:

a. Submerged weirs.

b. Broad crested weirs.
c. Weirs with obstructions (i.e., guardrails, piers, etc.).

3.4.A.II. ORIFICES

An orifice is a submerged opening with a closed perimeter through which water flows. Orifices are analyzed using the following equation:

$$Q = CA\sqrt{2gH}$$

Where:

Q = Discharge in cfs
C = Discharge coefficient from Handbook of Hydraulics, King and Brater, 5^{th} Edition (or comparable)
A = Area of opening in square feet
g = 32.2 ft/sec
H = Depth of water measured from the center of the opening

(Approach velocity shall be disregarded in most applications).

Applications

Orifices are generally used as measuring and hydraulic control devices. Orifice hydraulics control the function of many "submerged inlet - free outlet" culverts, primary spillways in detention facilities, manholes in conduit flow, and in storm drain inlets.

3.4.B Criteria for Hydraulic Design: Closed Conduits

3.4.B.I. GENERAL HYDRAULIC CRITERIA

Closed conduit sections (pipe, box or arch sections) will be designed as flowing full and, whenever possible, under pressure except when the following conditions exist:

1. In some areas of high sediment potential, there is a possibility of stoppage occurring in drains. In situations where sediment may be expected, the City Engineer will use 18% sediment bulking factor for undeveloped conditions and 6% for developed conditions (listed in the SSCAFCA Criteria Manual).

2. In certain situations, open channel sections upstream of the proposed closed conduit may be adversely affected by backwater.

If the proposed conduit is to be designed for pressure conditions, the hydraulic grade line shall not be higher than the ground or street surface or encroach on the same in a reach where interception of surface flow is necessary. However, in those reaches where no surface flow will be intercepted, a hydraulic grade line which encroaches on or is slightly higher than the ground or street surface may be acceptable provided that pressure manholes exist or will be constructed.

3.4.B.II. WATER SURFACE PROFILE CALCULATIONS

3.4.B.II.a. Determination of Control Water Surface Elevation

A conduit to be designed for pressure conditions may discharge into one of the following:

1. A body of water such as a detention reservoir.
2. A natural watercourse or arroyo.
3. An open channel, either improved or unimproved.
4. Another closed conduit.

The controlling water surface elevation at the point of discharge is commonly referred to as the control and, for pressure flow, is generally located at the downstream end of the conduit.

Two general types of controls are possible for a conduit on a mild slope, which is a physical requirement for pressure flow in discharging conduits.

A. Control elevation above the soffit elevation. In such situations, the control must conform to the following criteria:

    1. In the case of a conduit discharging into a detention facility, the control is the 100 -year water surface reservoir elevation.

    2. In the case of a conduit discharging into an open channel, the control is the 100-year design water surface elevation of the channel.

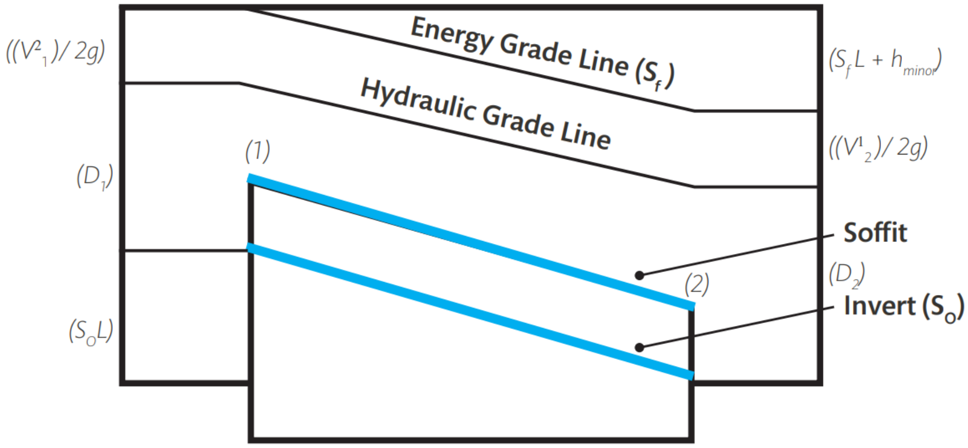
    3. In the case of a conduit discharging into another conduit, the control is the design hydraulic grade line elevation of the outlet conduit immediately upstream of the confluence.

Whenever case (1) or (2) above is used, the possibility of having flow out of manholes or inlets due to discharge elevations at the 100-year level must be investigated and appropriate steps taken to prevent its occurrence.

A. Control elevation at or below the soffit elevation. The control is the soffit elevation at the point of discharge. This condition may occur in any one of the four situations described above in 2a.

B. Instructions for Hydraulic Calculations. Most procedures for calculating hydraulic grade line profiles are based on the Bernoulli equation. This equation can be expressed as follows:

$$\frac{V_1^2}{2g} + D_1 + S_O L = \frac{V_2^1}{2g} + D_2 + S_f L + h_{minor}$$



In which:

D	= Vertical distance from invert to H.G.L
So	= Invert slope
L	= Horizontal projected length of conduit
S_f	= Average friction slope between Sections 1 and 2
V	= Average velocity (g/A)
h_{minor}	= Minor head losses

Minor losses have been included in the Bernoulli equation because of their importance in calculating hydraulic grade line profiles and are assumed to be uniformly distributed in the above figure.

When specific energy (E) is substituted for the quantity $\frac{V^2}{2g} + D$ in the above equation and minor losses are ignored and the result rearranged,

$$L = \frac{E_2 - E_1}{S_O - S_f}$$

The above is a simplification of a more complex equation and is convenient for locating the approximate point where pressure flow may become unsealed.

3.4.B.III. HEAD LOSSES

3.4.B.III.a. Friction Loss

Friction losses for closed conduits carrying storm water, including pump station discharge lines, will be calculated from the Manning equation or a derivation thereof. The Manning equation is commonly expressed as follows:

$$Q = \frac{1.486\, AR^{\frac{2}{3}} S_f^{\frac{1}{2}}}{n}$$

Where:
Q = Discharge, in c.f.s.
n = Roughness coefficient
A = Area of water normal to flow in ft.2
R = Hydraulic radius
S_f = Friction slope

When rearranged into a more useful form:

$$S_f = \left[Q_n/1.486AR^{\frac{2}{3}}\right]^2 = [Q/K]^2$$

Where:

$$K = \frac{1.486\ AR^{\frac{2}{3}}}{n}$$

The loss of head due to friction throughout the length of reach (L) is calculated as follows:

$$h_r = S_r L = [Q/K]^2 L$$

The value of K is dependent upon only two factors: the geometrical shape of the flow cross section as expressed by the quantity ($AR^{2/3}$), and the roughness coefficient (n). The values of n can be found in SSCAFCA's Sediment and Erosion Design Guide. For materials not listed, contact the City Engineer prior to use.

3.4.B.III.b. Transition Loss

Transition losses will be calculated from the equations shown below.

For a Contraction (increasing velocity):

$$H_f = K_e/2(V_2 - V_1)^2/2g$$

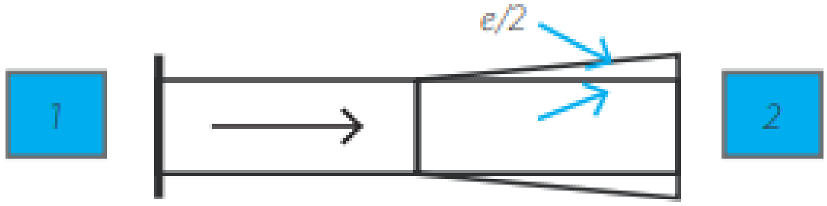
For an Expansion (decreasing velocity):

$$H_f = K_e/2(V_2 - V_1)^2/2g$$

Where:

$$K_e = 3.50(\tan \quad \emptyset/2)^{1.22}$$

These equations are applicable when no change in Q occurs and where the horizontal angle of divergence or convergence (θ /2) between the two sections does not exceed 5 degrees 45 minutes.


e/2
1
2

Deviations from the above criteria must be approved by the City Engineer. When such situations occur, the angle of divergence or convergence (θ/2) may be greater than 5 degrees 45 minutes. However, when it is increased beyond 5 degrees 45 minutes, the above equation will give results for h_t that are too small, and the use of more accurate methods, such as the Gibson method shown Plate 22.3 B-2, will be acceptable.

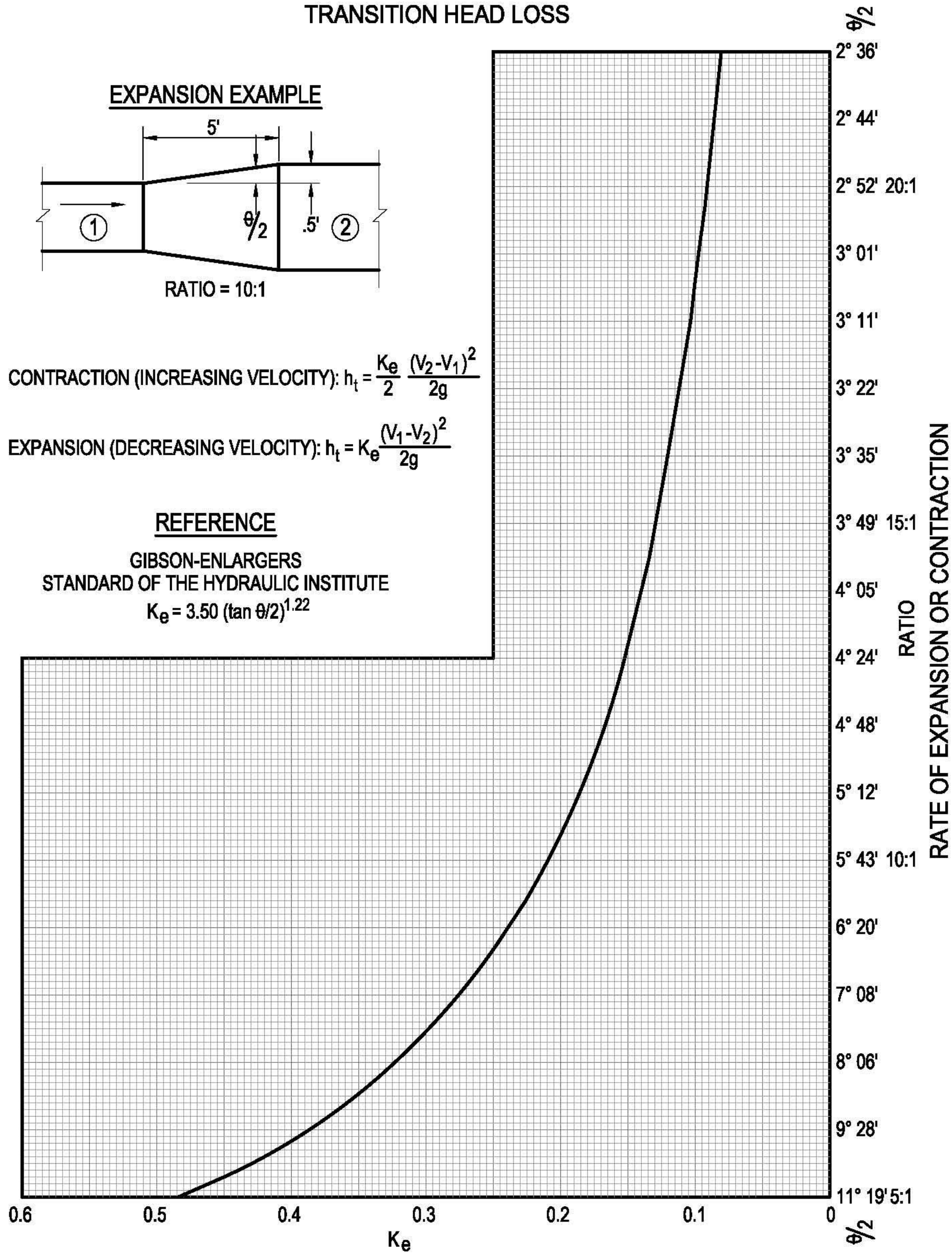
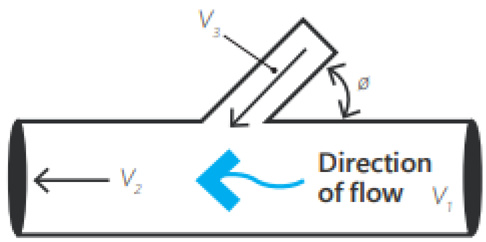


PLATE 22.3 B-2

3.4.B.III.c. Junction Losses

In general, junction losses are calculated by equating pressure plus momentum through the confluences under consideration. This can be done by using either the P + M method or the Thompson equation, both of which are shown in Section 3.4.g. Both methods are applicable in all cases for pressure flow and will give the same results.

For the special case of pressure flow with $A_1 = A_2$ and friction neglected,



Manhole losses will be calculated from the equation shown below. Where a change in pipe size and/or change in Q occurs, the head loss will be calculated in accordance with the preceding equation.

$$H_{mh} = 0.05(V^2/2g)$$

3.4.B.III.d. Bend Loss

Bend losses should be included for all closed conduits, those flowing partially full as well as those flowing full. Bend losses will be calculated from the following equations:

$$H_b = K_b(V^2/2g)$$

Where:

$$K_b = 0.2(\theta/90°)^{0.5}$$

here:

Θ = central angle of bend in degrees

3.4.B.III.e. Exit Loss

Exit loss is the loss when storm drains daylight into a pond or channel, which can be calculated using the following equation:

$$H_{exit} = 0.25(V_2/2g)$$

Angle point losses shall be calculated from the following equation:

$$h_{a\,pt.} = 0.0033\,\theta\left[\frac{V^2}{2_g}\right]$$

In which θ = Deflection angle in degrees, not to exceed 6 degrees without prior approval.

3.4.B.III.f. Special Cases

3.4.B.III.f.i. Transition From Large to Small Conduit

As a general rule, storm drains will be designed with sizes increasing in the downstream direction. However, when studies indicate it may be advisable to decrease the size of a downstream section, the conduit may be decreased in size in accordance with the following limitations:

1. For slopes of .0025 (.25 percent) or less, conduit sizes may be decreased to a minimum diameter of 72 inches. Each reduction is limited to a maximum of 6 inches.
2. For slopes of more than .0025, conduit sizes may be decreased to a minimum diameter of 30 inches. Each reduction is limited to a maximum of 3 inches for pipe 48 inches in diameter or smaller, and to a maximum of 6 inches for pipe larger than 48 inches in diameter. Reductions exceeding the above criteria must have prior City Engineer approval.

In any case the reduction in size must result in a more economical system.

3.4.B.IV. DESIGN REQUIREMENTS FOR MAINTENANCE AND ACCESS

3.4.B.IV.a. Manholes

1. Spacing
   a. Where the proposed conduit is 60” and larger, manholes should be spaced at intervals of approximately 800 feet to 1000 feet. Where the proposed conduit is less than 60 inches in diameter and the horizontal alignment has numerous bends or angle points, the manhole spacing should be reduced to approximately 500 feet.
   b. The spacing requirements shown above apply regardless of design velocities. Deviations from the above criteria are subject to City Engineer approval.
2. Location
   a. Manholes should be located outside of street intersections wherever possible, especially when one or more streets are heavily traveled.
   b. In situations where the proposed conduit is to be aligned both in easement and in street right-of-way, manholes should be located in street right-of-way, wherever possible.
   c. Manholes should be located as close to changes in grade as feasible when the following conditions exist:
      i. When the upstream conduit has a steeper slope than the downstream conduit and the change in grade is greater than 10 percent, sediment tends to deposit at the point where the change in grade occurs.
      ii. When transitioning to a smaller downstream conduit due to an abruptly steeper slope downstream, sediment tends to accumulate at the point of transition.

3. Design

   a. When the design flow in a pipe flowing full has a velocity of 20 f.p.s. or greater, or is supercritical in a partially full pipe, the total horizontal angle of divergence or convergence between the walls of the manhole and its center line should not exceed 5º45'.

3.4.B.IV.b. Pressure Manholes

Pressure manholes should be avoided whenever possible. When unavoidable a pressure manhole shaft and a pressure frame and cover will be installed in a pipe or box storm drain whenever the design water surface is at the ground surface.

3.4.B.IV.c. Special Manholes

Special 36-inch diameter manholes or vehicular access structures will be provided when required. The need for access structures will be determined by the City Engineer during the review of preliminary plans.

3.4.B.IV.d. Deep Manholes

A manhole shaft safety ledge or other structural designs should be considered when the manhole shaft is 20 feet or greater in depth. Installation will be in accordance with City Engineer requirements.

3.4.B.IV.e. Inlets into Main Line Drains

Lateral pipe entering a main line pipe storm drain generally will be connected radially. Lateral pipe entering a main line structure will conform to the following:

1. The invert of lateral pipe 24 inches or less in diameter will be no more than five feet above the invert.
2. The invert of lateral pipe 27 inches or larger in diameter will be no more than 18 inches above the invert, with the exception that storm inlet connector pipe less than 50 feet in length may be no more than five feet above the invert.

Exceptions to the above requirements may be permitted where it can be shown that the cost of bringing laterals into a main line conduit in conformance with the above requirements would be excessive.

3.4.B.IV.f. Minimum Pipe Size

In cases where the conduit may carry significant amounts of sediment, the minimum diameter of main line conduit will be 24 inches.

3.4.B.IV.g. Minimum Slope

The minimum slope for main line conduit will be 0.003 (0.30 percent), unless otherwise approved by the City Engineer. Minimum flow velocity for ¼ full pipe will be 2 f.p.s.

3.4.B.IV.h. Inlet Structures

An inlet structure will be provided for storm drains located in natural channels. The structure should generally consist of a headwall, wingwalls to protect the adjacent banks from erosion, and a paved inlet apron. The apron slope should be limited to a maximum of 2:1. Wall heights should conform to the height of the water upstream of the inlet and be adequate to protect both the fill over the drain and the embankments. Headwall and wingwall fencing and a protection barrier to prevent public entry will be provided.

If trash and debris are prevalent, barriers consisting of vertical 3-inch or 4-inch diameter steel pipe at 24 inches to 36 inches on centers should be embedded in concrete immediately upstream of the inlet apron. Trash rack designs must have City Engineer approval.

3.4.B.IV.i. Outlet Structures

For discharge into SSCAFCA ROW/facilities that will be dedicated to SSCAFCA, please refer to SSCAFCA Criteria Manual and coordinate directly with SSCAFCA staff. For outlet into City maintained channels/ponds, follow the following guidance.

1. Where a storm drain discharges into a detention reservoir, the designer should check with the City Engineer for up-to-date criteria as to location and type of structure to be used.
2. When a storm drain outlets into a natural channel, an outlet structure will be provided which prevents erosion and property damage. Additionally, downstream grade control maybe required to retain channel stability and velocity of flow at the outlet should match as closely as possible with the existing channel velocity. Fencing and a protection barrier will be provided where deemed necessary by the City Engineer.
    a. When the discharge velocity is low, or subcritical, the outlet structure will consist of a headwall, wingwalls, and an apron. The apron may consist of a concrete slab, grouted rock, or well-designed dumped riprap depending on conditions.
    b. When the discharge velocity is high, or supercritical, the designer will, in addition, design bank protection in the vicinity of the outlet and an energy dissipater structure. The City Engineer will furnish, upon request, guidance on types of energy dissipators appropriate for each application.

3.4.B.IV.j. Protection Barriers

A protection barrier is a means of preventing people from entering storm drains. Protection barriers will be provided wherever necessary to prevent unauthorized access to storm drains. In some cases, the barrier may be one of the breakaway types. In other cases, the barrier may be a special design. It will be the designer's responsibility to provide a protection barrier appropriate to each situation and to provide details of such on the construction drawings.

3.4.B.IV.k. Debris Barriers

A debris barrier or deflector is a means of preventing large debris or trash, such as tree limbs, logs, boulders, weeds, and refuse, from entering a storm drain and possibly plugging the conduit. The debris barrier should have openings wide enough to allow as much small debris as possible to pass through and yet narrow enough to protect the smallest conduit in the system downstream of the barrier. One type that has been used effectively in the past is the debris rack. This type of debris barrier is usually formed by a line of posts, such as steel pipe filled with concrete or steel rails, across the line of flow to the inlet. Other examples of barriers are presented in Hydraulic Engineering Circular No. 9, "Debris-Control Structures," published by the United States Department of Commerce, Bureau of Public Roads, which is available upon request from its Office of Engineering and Operations. It will be the designer's responsibility to provide a debris barrier or deflector appropriate to the situation.

3.4.B.IV.I. Debris Basins

Debris basins, check dams and similar structures are a means of preventing mud, boulders and debris held in suspension and carried along by storm runoff from depositing in storm drains. Debris basins constructed upstream of storm drain conduits, usually in canyons, trap such material before it reaches the conduit.

3.4.B.V. OTHER CLOSED CONDUIT CRITERIA

3.4.B.V.a. Angle of Confluence

In general, the angle of confluence between main line and lateral must not exceed 45 degrees and, as an additional requirement, must not exceed 30 degrees under any of the following conditions:

1. Where the peak flow (Q) in the proposed lateral exceeds 10 percent of the main line peak flow.
2. Where the velocity of the peak flow in the proposed lateral is 20 f.p.s. or greater.
3. Where the size of the proposed lateral is 60 inches or greater.
4. Where hydraulic calculations indicate excessive head losses may occur in the main line due to the confluence.

Connector pipe may be joined to main line pipe at angles greater than 45 degrees up to a maximum of 90 degrees provided none of the above conditions exist. If, in any specific situation, one or more of the above conditions does apply, the angle of confluence for connector pipes may not exceed 30 degrees. Connections must not be made to main line pipe which may create conditions of adverse flow in the connector pipes without prior approval from the City Engineer.

The above requirements may be waived only if calculations are submitted to the City Engineer showing that the use of a confluence angle larger than 30 degrees will not unduly increase head losses in the main line.

3.4.B.V.b. Flapgates

Flapgates are discouraged and will only be used on a case by case basis and with approval from the City Engineer.

A flapgate must be installed in all laterals outletting into a main line storm drain whenever the potential water surface level of the main line is higher than the surrounding area drained by the lateral.

The flapgate must be set back from the main line drain so that it will open freely and not interfere with the main line flow. A junction structure will be constructed for this purpose in accordance with City Engineer standards.

3.4.B.V.c. Rubber-Gasketed Pipe

Rubber-gasketed pipe will be used in all storm drain construction unless otherwise approved by the City Engineer.

3.4.B.V.d. Non-Reinforced Concrete Pipe

Non-reinforced concrete pipe may not be used for storm drain applications.

3.4.B.V.e. Junctions

Junctions will only be permitted on mains storm drain lines that are $\geq$42 inches. Junction locations cannot be more that 24' from the downstream manhole. An exception to this requirement may be laterals with slopes of 5% or greater. The City Engineer approval will be required for this exception and all other variances.

PLATE 22.3 B-5 FACTORS FOR CLOSED CONDUITS FLOWING FULL

Manning's Formula:

$$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$K = \frac{Q}{S^{\frac{1}{2}}} = \frac{1.486\, A R^{\frac{2}{3}}}{0.013}$$

For pipe $K = 35.6259 d^{\frac{8}{3}}$

For box $K = 114.3077\ \frac{A^{\frac{5}{3}}}{p^{\frac{2}{3}}}$

$$Q = K s^{\frac{1}{2}}$$

$$s = \frac{Q^2}{K}$$

Where:

Q	= discharge in cfs
S	= friction slope
A	= area of conduit
R	= hydraulic radius of conduit
n	= 0.013
d	= diameter of pipe
“	= height of equivalent box
w	= width of equivalent box
p	= wetted perimeter

PLATE 22.3 B-5							
PIPE & BOX		PIPE		EQUIVALENT BOX			
d		A	K	w		A	K
ft.	in.	sq.ft.		ft.-in.	ft.	sq. ft.	
1.25	15	1.227	64.6				
0.5	18	1.767	105				
0.75	21	2.405	158.4				
2	24	3.142	226.2				
0.25	27	3.976	309.7				
0.5	30	4.909	410.1				
0.75	33	5.939	528.7				
3	36	7.068	666.9				
0.25	39	8.295	825.8				
0.5	42	9.621	1,006				
0.75	45	11.044	1,209				
4	48	12.566	1,436				
0.25	51	14.186	1,688				
0.5	54	15.904	1,967				
0.75	57	17.721	2,272				
5	60	19.635	2,604				
0.25	63	21.648	2,966				
0.5	66	23.758	3,358				
0.75	69	25.967	3,780				
6	72	28.274	4,236				
0.25	75	30.68	4,720				
0.5	78	33.183	5,244				
0.75	81	35.785	5,796				
7	84	38.485	6,388	5'-10"	5.83	40.3	6,357
0.25	87	41.283	7,015				
0.5	90	44.179	7,677	6'-4"	6.33	47	7,780
0.75	93	47.173	8,379				
8	96	50.266	9,120	6'-9"	6.75	53.5	9,256
0.5	102	56.745	10,720	7'-1"	7.08	59.7	10,685
9	108	63.617	12,487	7'-6"	7.5	67	12,452
0.5	114	70.882	14,421	8'-0"	8	75.4	14,598
10	120	78.54	16,538	8'-5"	8.42	83.6	16,726
0.5	126	86.59	18,835	8'-10"	8.83	92.1	19,026
11	132	95.033	21,322	9'-2"	9.17	100.3	21,303
0.5	138	103.879	24,005	9'-7"	9.58	109.5	23,954
12	144	113.098	26,890	10'-0"	10	119.4	26,849

PLATE 22.3 B-6 PARTIALLY FILLED CIRCULAR CONDUIT SECTIONS							
D d	area d^2	wet. per d	hyd.rad d	D d	area d^2	wet. per d	hyd. rad d
0.01	0.0013	0.2003	0.0066	0.51	0.4027	1.5908	0.2531
0.02	0.0037	0.2838	0.0132	0.52	0.4127	1.6108	0.2561
0.03	0.0069	0.3482	0.0197	0.53	0.4227	1.6308	0.2591
0.04	0.0105	0.4027	0.0262	0.54	0.4327	1.6509	0.2620
0.05	0.0147	0.4510	0.0326	0.55	0.4426	1.6710	0.2649
0.06	0.0192	0.4949	0.0389	0.56	0.4526	1.6911	0.2676
0.07	0.0242	0.5355	0.0451	0.57	0.4625	1.7113	0.2703
0.08	0.0294	0.5735	0.0513	0.58	0.4723	1.7315	0.2728
0.09	0.0350	0.6094	0.0574	0.59	0.4822	1.7518	0.2753
0.10	0.0409	0.6435	0.0635	0.60	0.4920	1.7722	0.2776
0.11	0.0470	0.6761	0.0695	0.61	0.5018	1.7926	0.2797
0.12	0.0534	0.7075	0.0754	0.62	0.5115	1.8132	0.2818
0.13	0.0600	0.7377	0.0813	0.63	0.5212	1.8338	0.2839
0.14	0.0668	0.7670	0.0871	0.64	0.5308	1.8546	0.2860
0.15	0.0739	0.7954	0.0929	0.65	0.5404	1.8755	0.2881
0.16	0.0811	0.8230	0.0986	0.66	0.5499	1.8965	0.2899
0.17	0.0885	0.8500	0.1042	0.67	0.5594	1.9177	0.2917
0.18	0.0961	0.8763	0.1097	0.68	0.5687	1.9391	0.2935
0.19	0.1039	0.9020	0.1152	0.69	0.5780	1.9606	0.2950
0.20	0.1118	0.9273	0.1206	0.70	0.5872	1.9823	0.2962
0.21	0.1199	0.9521	0.1259	0.71	0.5964	2.0042	0.2973
0.22	0.1281	0.9764	0.1312	0.72	0.6054	2.0264	0.2984
0.23	0.1365	1.0003	0.1364	0.73	0.6143	2.0488	0.2995
0.24	0.1449	1.0239	0.1416	0.74	0.6231	2.0714	0.3006
0.25	0.1535	1.0472	0.1466	0.75	0.6318	2.0944	0.3017
0.26	0.1623	1.0701	0.1516	0.76	0.6404	2.1176	0.3025
0.27	0.1711	1.0928	0.1566	0.77	0.6489	2.1412	0.3032
0.28	0.1800	1.1152	0.1614	0.78	0.6573	2.1652	0.3037
0.29	0.1890	1.1373	0.1662	0.79	0.6655	2.1895	0.3040
0.30	0.1982	1.1593	0.1709	0.80	0.6736	2.2143	0.3042
0.31	0.2074	1.1810	0.1755	0.81	0.6815	2.2395	0.3044
0.32	0.2167	1.2025	0.1801	0.82	0.6893	2.2653	0.3043
0.33	0.2260	1.2239	0.1848	0.83	0.6969	2.2916	0.3041
0.34	0.2355	1.2451	0.1891	0.84	0.7043	2.3186	.03038
0.35	0.2450	1.2661	0.1935	0.85	0.7115	2.3462	0.3033
0.36	0.2546	1.2870	0.1978	0.86	0.7186	2.3746	0.3026
0.37	0.2642	1.3078	0.2020	0.87	0.7254	2.4038	0.3017
0.38	0.2739	1.3284	0.2061	0.88	0.7320	2.4341	0.3008
0.39	0.2836	1.3490	0.2102	0.89	0.7384	2.4655	0.2996
0.40	0.2934	1.3694	0.2142	0.90	0.7445	2.4981	0.2980
0.41	0.3032	1.3898	0.2181	0.91	0.7504	2.5322	0.2963
0.42	0.3130	1.4101	0.2220	0.92	0.7560	2.5681	0.2944
0.43	0.3229	1.4303	0.2257	0.93	0.7642	2.6061	0.2922
0.44	0.3328	1.4505	0.2294	0.94	0.7662	2.6467	0.2896

PLATE 22.3 B-6 PARTIALLY FILLED CIRCULAR CONDUIT SECTIONS							
D d	area d^2	wet. per d	hyd.rad d	D d	area d^2	wet. per d	hyd. rad d
0.45	0.3428	1.4706	0.2331	0.95	0.7707	2.6906	0.2864
0.46	0.3527	1.4907	0.2366	0.96	0.7749	2.7389	0.2830
0.47	0.3627	1.5108	0.2400	0.97	0.7785	2.7934	0.2787
0.48	0.3727	1.5308	0.2434	0.98	0.7816	2.8578	0.2735
0.49	0.3827	1.5508	0.2467	0.99	0.7841	2.9412	0.2665
0.50	0.3927	1.5708	0.2500	1.00	0.7854	3.1416	0.2500

PLATE 22.3 B-7 FACTORS FOR CIRCULAR CONDUITS FLOWING PARTLY FULL

D = depth of water, d = diameter of conduit, K = momentum, C = pressure, F = Velocity Head

Tabulated Values

$(Q/d)^2$ d^3 $(Q/d^2)^2$

D/d	K	C	F	D/d	K	C	F	D/d	K	C	F	D/d	K	C	F
.00	00	.0000	00	.25	.2026	.0157	0.659	.50	.0792	.0833	.1007	.75	.0492	.2121	.0389
.01	23.919	.0000	9188.	.26	.1916	.0173	0.589	.51	.0773	.0873	.0958	.76	.0485	.2185	.0379
.02	8.403	.0000	1134.	.27	.1817	.0190	0.530	.52	.0753	.0914	.0912	.77	.0479	.2249	.0369
.03	4.507	.0001	326.	.28	.1727	.0207	0.479	.53	.0736	.0956	.0869	.78	.0473	.2314	.0359
.04	2.961	.0002	140.9	.29	.1645	.0226	0.435	.54	.0719	.0998	.0829	.79	.0467	.2380	.0351
.05	2.115	.0003	71.9	.30	.1569	.0255	0.395	.55	.0703	.4042	.0793	.80	.0462	.2447	.0342
.06	1.620	.0005	42.1	.31	.1493	.0266	0.361	.56	.0687	.1087	.0758	.81	.0456	.2515	.0334
.07	1.285	.0007	26.5	.32	.1435	.0287	0.331	.57	.0672	.1133	.0726	.82	.0451	.2584	.0327
.08	1.058	.0010	17.97	.33	.1376	.0309	0.304	.58	.0658	.1179	.0696	.83	.0446	.2653	.0320
.09	0.888	.0013	12.68	.34	.1320	.0332	0.280	.59	.0645	.1227	.0668	.84	.0441	.2723	.0313
.10	0.760	.0017	9.28	.35	.1269	.0356	0.259	.60	.0632	.1276	.0641	.85	.0437	.2794	.0.07
.11	0.662	.0021	7.03	.36	.1221	.0381	0.240	.61	.0620	.1326	.0617	.86	.0433	.2865	.0301
.12	0.582	.0026	5.45	.37	.1177	.0407	0.222	.62	.0608	.1376	.0594	.87	.0429	.238	.0295
.13	0.518	.0032	4.31	.38	.1135	.0434	0.207	.63	.0597	.1428	.0572	.88	.0425	.3011	.0290
.14	0.466	.0038	3.48	.39	.1096	.0462	.1931	.64	.0586	.1481	.0551	.89	.0421	.3084	.0285
.15	0.421	.0045	2.84	.40	.1060	. 0491	.1804	.65	.0575	.1534	.0532	.90	.0418	.3158	.0280
.16	0.383	.0053	2.36	.41	.1026	.0520	.1689	.66	.0565	.1589	.0514	.91	.0414	.3222	.0276
.17	0.351	.0064	1.982	.42	.0993	.0551	.1585	.67	.0559	.1644	.0496	.92	.0411	.3308	.0272
.18	0.325	.0070	1.681	.43	.0963	.0583	.1489	.68	.0547	.1700	.0480	.93	.0408	.3384	.0266
.19	0.299	.0080	1.438	.44	.0934	.0616	.1402	.69	.0538	.1758	.0465	.94	.0406	.3460	.0265
.20	0.278	.0091	1.242	.45	.0907	.0650	.1321	.70	.0530	.1816	.0450	.95	.0403	.3537	.0261
.21	0.259	.0103	1.080	.46	.0882	.0684	.1248	.71	.0521	.1875	.0437	.96	.0401	.3615	.0259
.22	0.243	.0115	0.946	.47	.0857	.0720	.1180	.72	.0514	.1935	.0424	.97	.0399	.3692	.0256
.23	0.228	.0128	0.833	.48	.0834	.0757	.1118	.73	.0506	.1996	.0411	.98	.0398	.3770	.0254
.24	0.215	.0143	0.740	.49	.0813	.0795	.1060	.74	.0499	.2058	.0400	.99	.0397	.3848	.0253
												1.00	.0396	.3927	.0252

3.4.C Criteria for Hydraulic Design: Open Channels

For SSCAFCA maintained channels, the designer shall refer to SSCAFCA Criteria Manual, and coordinate review and approval with SSCAFCA staff.

3.4.C.I. GENERAL HYDRAULIC CRITERIA

In general, all open channels should be designed with the tops of the walls or levees at or below the adjacent ground to allow for interception of surface flows. If it is unavoidable to construct the channel without creating a pocket, a means of draining the pocket must be provided on the drawings. All local drainage should be completely controlled. External flows must enter the channel at designated locations and through designated inlets unless specifically authorized by the City Engineer.

In making preliminary layouts for the routing of proposed channels, it is desirable to avoid sharp curvatures, reversed curvatures, and closely-spaced series of curves. If this is unavoidable, the design considerations in Section 3.4.C.V.d below must be followed to reduce super elevations and to eliminate initial and compounded wave disturbances.

It is generally desirable to design a channel for a Froude number of just under 2.0. In areas within the City of Rio Rancho jurisdiction this is not always possible because of steep terrain. If the Froude number exceeds 2.0, any small disturbance to the water surface is amplified in the course of time and the flow tends to proceed as a series of "roll waves". Reference is made to Section 3.4.C.V.d. for criteria when designing a channel with a Froude number that exceeds 2.0.

In the design of a channel, if the depth is found to produce a Froude number between 0.7 and 1.3 for any significant length of reach, the shape or slope of the channel should be altered to secure a stable flow condition. All analyses should be performed for the 10-year and 100-year design discharges.

3.4.C.II. WATER SURFACE PROFILE CALCULATIONS

3.4.C.II.a. General

Water surface profile calculations must be calculated using the Bernoulli energy equation (see Section 3.4.B.II) combined with the momentum equation for analyzing confluences and functions. For use in expediting such calculations, computer programs are available from many sources, such as the U.S. Army Corps of Engineers and from industry accepted commercial software.

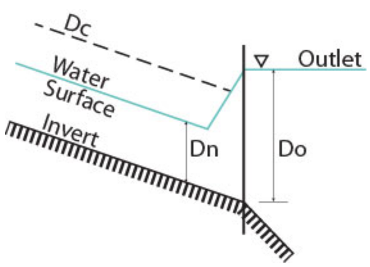
3.4.C.II.b. Determination of Controlling Water Surface Elevation

The following are general control points for the calculation of the water surface profile:

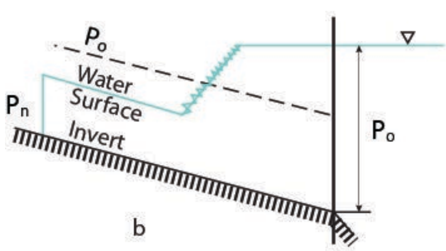
1. Where the channel slope changes from mild to steep or critical, the depth at the grade break is critical depth. We are defining mild slope as less than critical. Steep slope produces supercritical flow.
2. Where the channel slope changes from critical to steep, the depth at the grade break is critical depth.
3. Where a discharging or outletting channel or conduit is on a mild slope, the water surface is generally controlled by the outlet.

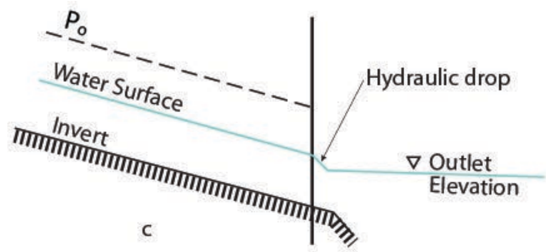
4. When a channel on a steep slope discharges into a facility that has a water surface depth greater than the normal depth of the channel, calculate pressure plus momentum for normal depth and compare it to the pressure plus momentum for the water surface depth at the outlet according to the equation, $P_n + M_n \sim P_o + M_o$.

    a. If $P_n+M_n > P_o+M_o$, this indicates upstream control with a hydraulic jump at the outlet.



    b. If Pn + Mn < Po + Mo, this indicates outlet control with a hydraulic jump probably occurring upstream.





    c. Where the water surface of the outlet is below the water surface in the channel or conduit, control is upstream and the outflow will have the form of a hydraulic drop.

When there is a series of control points, the one located farthest upstream is used as a starting point for water surface calculation.

3.4.C.II.c. Direction of Calculation

Calculations proceed upstream when the depth of flow is greater than critical depth and proceed downstream when the depth of flow is less than critical depth.

3.4.C.III. HEAD LOSSES

3.4.C.III.a. Friction Loss

Friction losses or open channels shall be calculated by an accepted form of the Manning equation. The Manning equation is commonly expressed as follows:

$$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S_f^{\frac{1}{2}}$$

In which:

Q = flow rate, in cfs
n = roughness coefficient
A = area of water normal to flow, in ft.
R = Hydraulic radius
Sf = Friction slope

When arranged into a more useful form,

$$S_f = \frac{2gn^2}{2.21}\left[\frac{V^2}{2_g}/R^{\frac{4}{3}}\right]$$

The loss of head due to friction throughout the length of reach involved (L) is calculated by:

$$h_f = S_f\ L$$

Refer to the appendix for values of "n" for different materials and corresponding values of

$$\frac{2gn^2}{2.21}$$

3.4.C.III.b. Junction Loss

Junction losses will be evaluated by the pressure plus momentum equation and must conform to closed conduit angle of confluence criteria, Section 3.4.B.V.

3.4.C.IV. CHANNEL INLETS

3.4.C.IV.a. Side Channels

Flow rates of 25% or more of the main channel flow must be introduced to the main channel by a side channel hydraulically similar to the main channel. Piping systems can be used to introduce side flows, if justification is provided satisfactory to the City. The centerline radius of the side channel may not be less than the quantity (QV/l00) in feet.

Velocity and depth of the flows in the side channel when introduced into the main channel must be matched to within 1 foot of velocity head and to within 20% of the flow depth for both the 10-year and l00-year design discharges and the four combinations of side inlet and main channel flows which result. Energy and momentum balance type calculations must be provided to support all designs involving side channels.

3.4.C.IV.b. Surface Inlets

When the main channel is relatively narrow and when the peak discharge of side inflow is in the range between 3 and 6 percent of the main channel discharge, high waves are usually produced by the side inflow and are reflected downstream for a long distance, thus requiring additional wall height to preclude overtopping of the channel walls. This condition is amplified when the side inflow is at a greater velocity than the main channel. To eliminate these wave disturbances, the Los Angeles District of the Corps of Engineers has developed a side channel spillway inlet. The City may require this type of structure when outletting into one of their facilities, and its use should be considered for city channels if high waves above the normal water surface cannot be tolerated. See Subsection 3.4.C.IV.d below titled "Transitions" for the Corp's procedure and criteria.

Surface-type inlets shall be constructed of concrete having a minimum thickness of 7 inches and shall be reinforced with the same steel as 7” concrete lining. The upstream end of the surface inlet shall be provided with a concrete cutoff wall having a minimum depth of three feet and the downstream end of the inlet shall be connected to the channel lining by an isolation joint. Side slopes of a surface inlet shall be constructed at slopes no greater than l vertical to 10 horizontal to allow vehicular passage across the inlet where a service road is required.

Drainage ditches or swales immediately upstream of a surface inlet shall be provided with erosion protection consisting of concrete lining, rock riprap or other non-erosive material as directed by City Engineer.

Surface inlets shall enter the channel at a maximum of 90° to the channel centerline, i.e., they may not point upstream.

3.4.C.IV.c. Direct Pipe to Channel

Additionally, pipe and box culvert inlets to channels shall be isolated by expansion joints. Continuously reinforced channels shall be designed to accommodate any extra stress resulting from these discontinuities. Corps of Engineers EM 1110-2-1061. Section 4-4. Open Channel Junction, h. Box and Pipe Culvert Inlets, has additional design criteria.

3.4.C.IV.d. Transitions

3.4.C.IV.d.i. Subcritical Flow

For subcritical velocities less than 12 f.p.s., the angle of convergence or divergence between the center line of the channel and the wall must not exceed 12° 30'. The length of the transition (L) is determined from the following equation:

$$L > 2.5\,\Delta B$$

For subcritical velocities equal to or greater than 12 f.p.s., the angle of convergence or divergence between the center line of the channel and the wall must not exceed 5° 45'. The length (L) is determined from the following equation:

$$L > 5.0\,\Delta B$$

Head losses for transitions with converging walls in subcritical flow conditions can be determined by using either the P + M method or the Thompson equation, both of which are shown in Section 3.4.G.IV. For transitions, both methods are applicable in all cases and will give the same results.

3.4.C.IV.d.ii. Supercritical Flow

3.4.C.IV.d.ii.1. Divergent Walls

The angle of divergence between the center line of the channel and the wall must not exceed 5° 45' or $\tan^{-1}$ F/3 whichever is smaller. The length of the transition (L) is the longest length determined from the following equations:

$$L \geq 5.0\,\Delta B$$

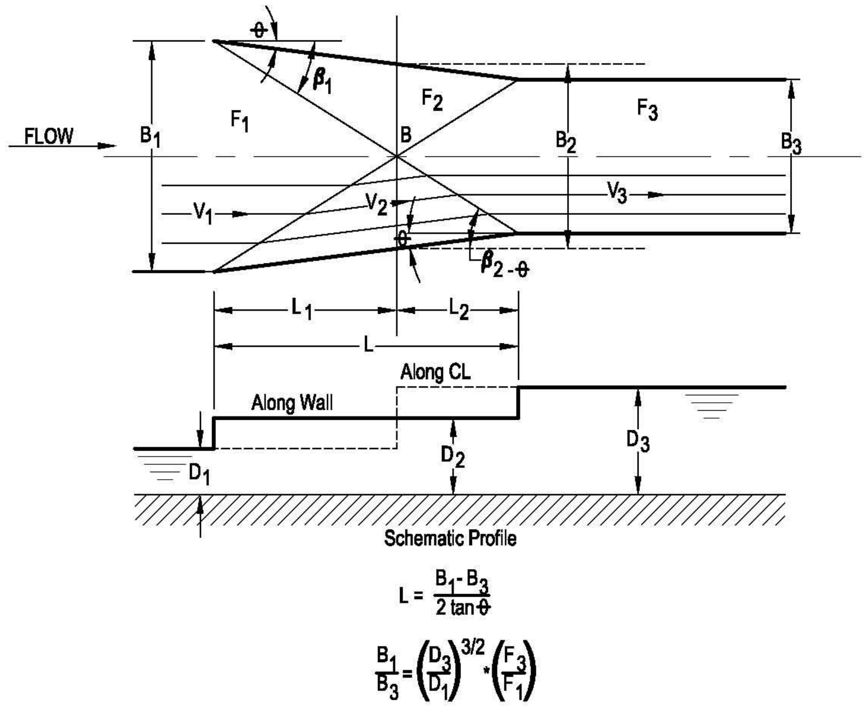
$$L \geq 1.5\,\Delta BF$$

Where:
F = Upstream Fourde number based on depth of flow
ΔB = The difference in channel width at the water surface

Convergent Walls

Convergent walls > 5 degrees - 45 degrees shall only be used at the discretion of the City and based on an approved oblique wave analysis.

Converging walls should be avoided when designing channels in supercritical flow; however, if this is impractical, the converging transition will be designed to minimize wave action. The walls of the transition should be straight lines.



CONVERGENT WALL SCHEMATIC

With the initial Froude number and the contraction ratio fixed, and with the continuity equation giving trial curves can produce the geometry of the construction suggested above. The curves represent the equation:

$$\frac{B_1}{B_3} = \left(\frac{D_3}{D^1}\right)^{\frac{3}{2}} = \frac{F_3}{F^1}$$

Refer to Plate 22.3 C-1.

3.4.C.IV.d.iii. Transitions Between Channel Treatment Types

3.4.C.IV.d.iii.1. Earth Channel to Concrete Lining Transition

The mouth of the transition should match the earth channel section as closely as practicable. Wing dikes and/or other structures must be provided to positively direct all flows to the transition entrance and protect the channel entrance from being flanked.

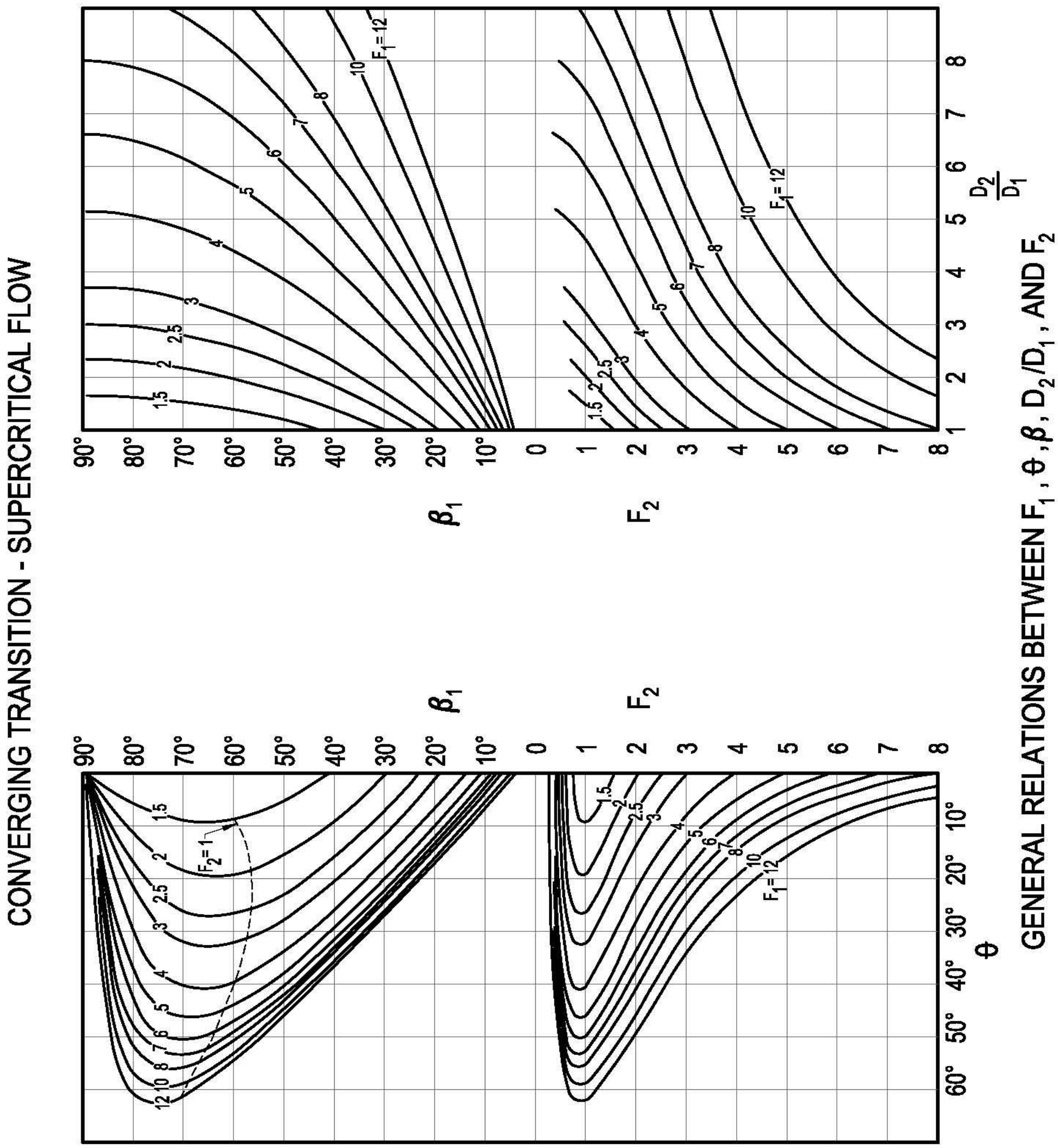

CONVERGING TRANSITION - SUPERCRITICAL FLOW
GENERAL RELATIONS BETWEEN F_1, θ, β, D_2/D_1, AND F_2
β_1
F_2
θ
$\frac{D_2}{D_1}$
$F_2 = 1$
$F_1 = 12$

PLATE 22.3 C-1

The upstream end of the concrete lined transition will be provided with a cutoff wall having a depth of 1.5 times the design flow depth but at least 3.0 feet and extending the full width of the concrete section. Erosion protection directly upstream of the concrete transition consisting of grouted or dumped rock riprap at least 12 feet in length and extending full width of the channel section must be provided. Grouted riprap must be at least 12 inches thick. Dumped riprap must be properly sized, graded and protected with gravel filter blankets.

The maximum allowable rate of bottom width transition is 1 to 7.5. Grout, dumped, or wire-tied material may also be used if approved on a case-by-case basis by the City Engineer. Grouted and wire-tied material require gravel filters as well.

3.4.C.IV.d.iii.2. Concrete Lining to Earth Channel Transition

The transition from concrete lined channels to earth channels will include an energy dissipator as necessary to release the designed flows to the earth channel at a relatively non-erosive condition and downstream grade control in the natural channel, as needed to prevent channel instability.

Since energy dissipator structures are dependent on individual site and hydraulic conditions, detailed criteria for their design has been purposely excluded and only minimum requirements are included herein for the concrete to earth channel transition.

On this basis, the following minimum standards govern the design of concrete to earth channel transitions:

► Maximum rate of bottom width transitions:

Water Velocity	
0-15 f.p.s.	1:10
16-30 f.p.s.	1:15
31-40 f.p.s.	1:20

► The downstream end of the concrete transition structure will be provided with a cutoff wall having a minimum depth of 6 feet and extending the full width of the concrete section or as recommended by the engineer and accepted by the City Engineer.

► Directly downstream of the concrete transition structure erosion protection consisting of rough, exposed surface, grouted rock riprap and extending full width of the channel section shall be provided. The grouted rock riprap should be a minimum of 12 inches thick. Grout, dumped, or wire-tied material may also be used if approved on a case-by-case basis by the City Engineer. Grouted and wire-tied material require gravel filters as well. The length of riprap shall be determined by engineering analysis.

3.4.C.V. PIERS

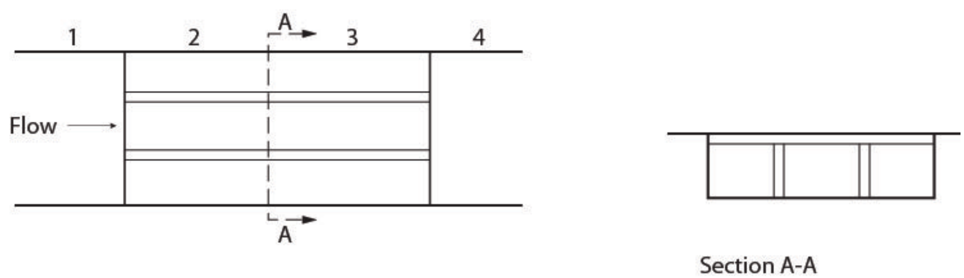
3.4.C.V.a. General

The effect of piers on open channel design must be considered at bridge crossings and where an open channel or box conduit not flowing full discharges into a length of multi-barreled box. This effect is especially important when flow is supercritical and when transported debris impinges on the piers.

The total pier width includes an added width for design purposes to account for debris. Inasmuch as the debris width to be used in design will vary with each particular situation, the City Engineer will be contacted during the preliminary design stages of a project for a determination of the appropriate width. Streamline piers should be used when heavy debris flow is anticipated.

The water surface elevations at the upstream end of the piers is determined by equating pressure plus momentum. The water surface profile within the pier reach is determined by the Bernoulli equation. The water surface elevations at the downstream end of the piers may be determined by applying either the pressure plus momentum equation or the Bernoulli equation.

3.4.C.V.a.i. Pressure plus Momentum (P + M) Equation as Applied to Bridge Piers



$$P_1 = M_1 \frac{A_g}{A_1} - P_p = P_2 + M_g$$

Where:
P_1 = Hydrostatic pressure in unobstructed channel
M_1 = Kinetic momentum in unobstructed channel

Where:
A_1 = Area of unobstructed channel
A_2 = A1 - Kp Ap = Area of water within bridge
P_2 = Hydrostatic pressure within bridge based on net flow area
M_2 = Kinetic momentum within bridge based on net flow area
P_p = Kp Ap Yp = Hydrostatic pressure of bridge pier
A_p = Area of piers
Y_p = Centroidal moment arm of A_p about the hydraulic grade at the section
K_p = Pier factor
K_p = 1.0 for square-nosed piers
K_p = 2/3 for round-nosed piers

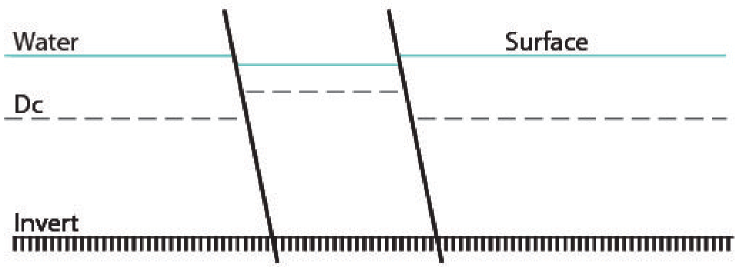
(Subscripts indicate the applicable section)

Plate 22.3 C-2 is a graphical representation of the method presented above. Plate 22.3 C-3 and 22.3 C-4 are a graphical solution of the above P + M equation.

3.4.C.V.b. Analysis

For subcritical or critical flow, the following cases, numbers 1 or 2, generally apply.

1. If the depth which balances the P + M equation at the downstream end is equal to or above D_C within the piers, continue the water surface calculations to the upstream face of the bridge piers. Calculate the depth upstream of the piers by equating pressure plus momentum.



BRIDGE PIER LOSSES BY THE MOMENTUM METHOD

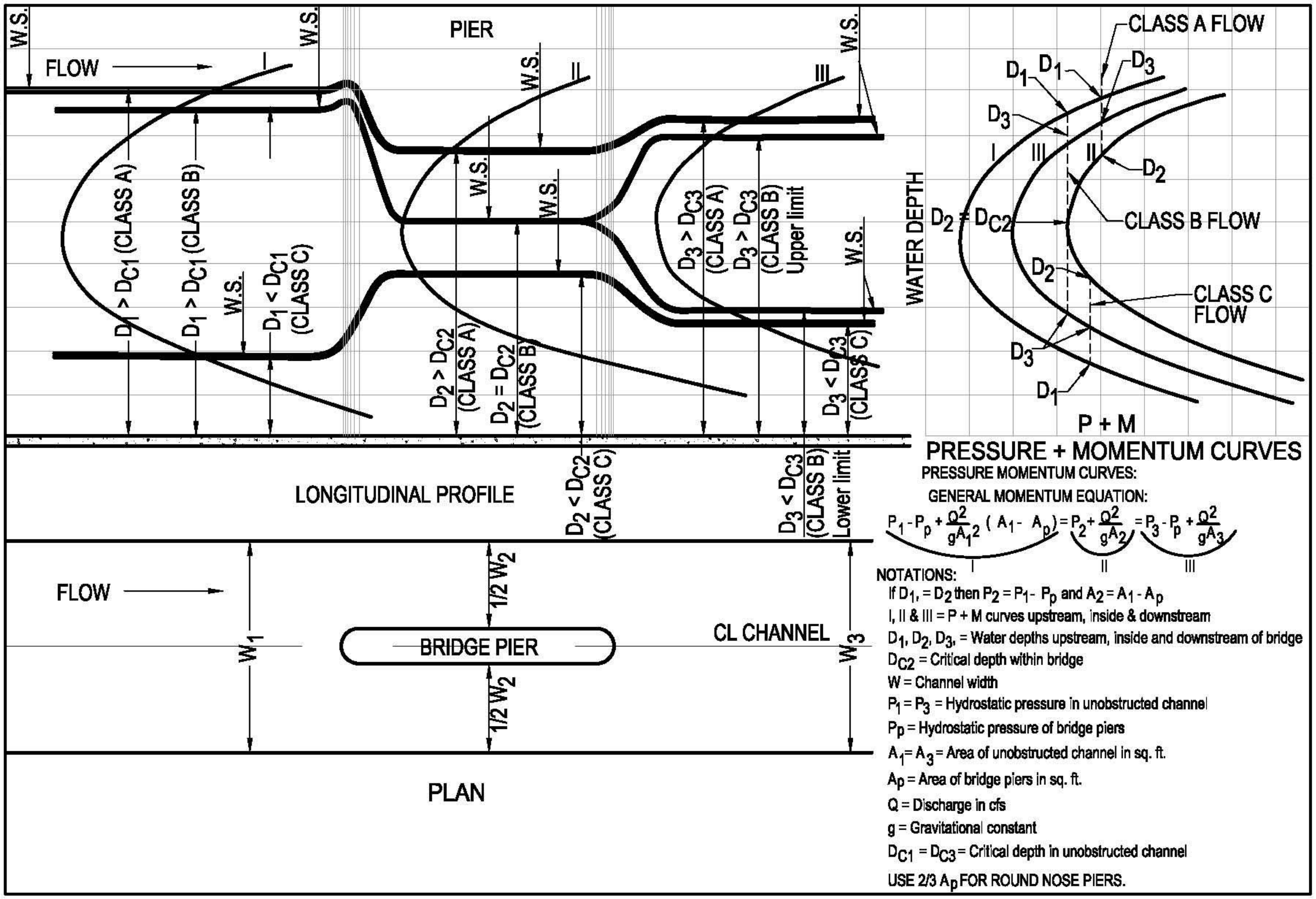
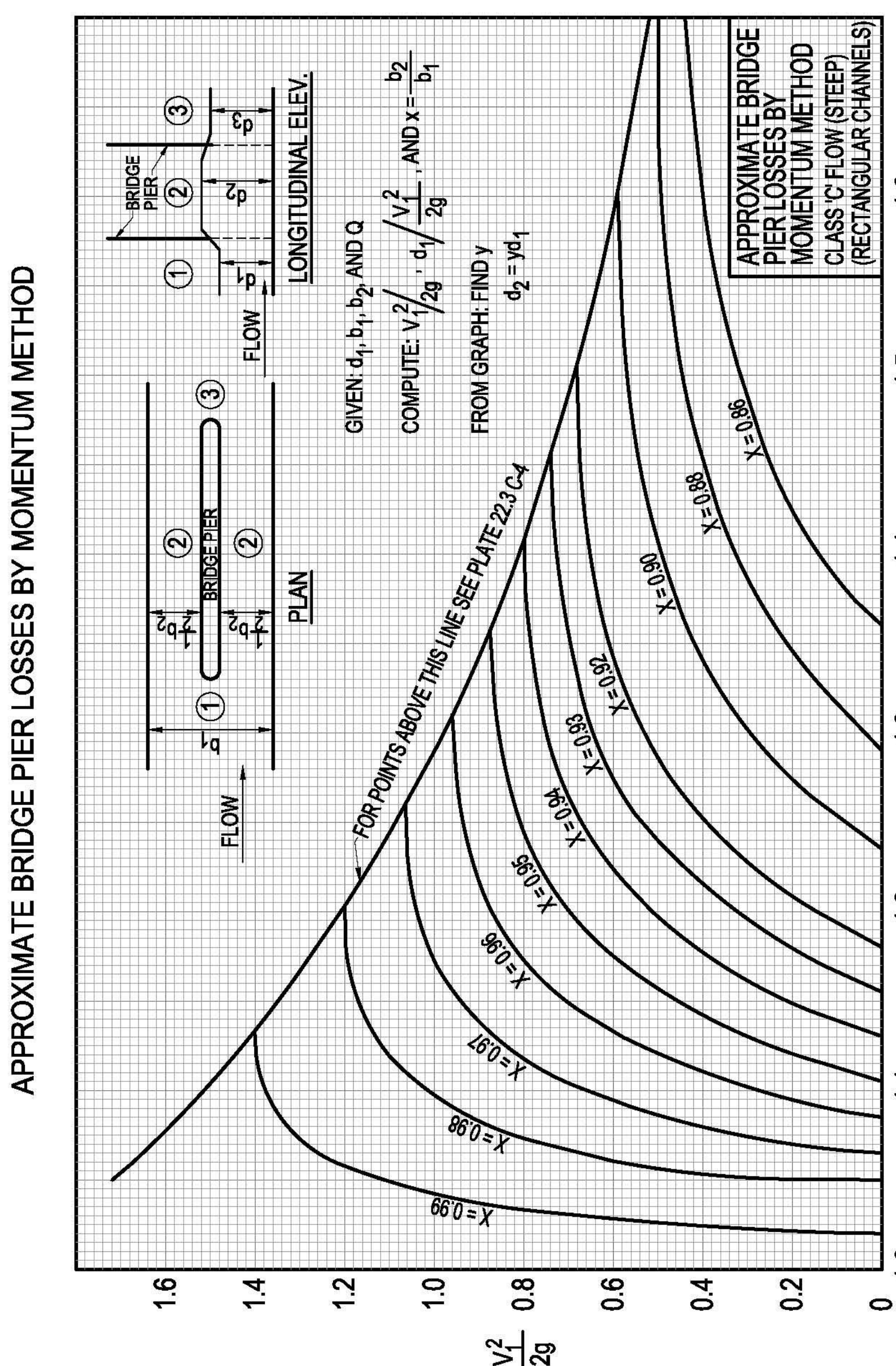


PLATE 22.3 C-2



APPROXIMATE BRIDGE PIER LOSSES BY MOMENTUM METHOD
FLOW
BRIDGE PIER
b1
b2/2
PLAN
BRIDGE PIER
d1
d2
d3
LONGITUDINAL ELEV.
GIVEN: d1, b1, b2, AND Q
COMPUTE: V1²/2g, d1/(V1²/2g), AND x = b2/b1
FROM GRAPH: FIND y
d2 = yd1
FOR POINTS ABOVE THIS LINE SEE PLATE 22.3 C-4
X = 0.99
X = 0.98
X = 0.97
X = 0.96
X = 0.95
X = 0.94
X = 0.93
X = 0.92
X = 0.90
X = 0.88
X = 0.86
APPROXIMATE BRIDGE PIER LOSSES BY MOMENTUM METHOD
CLASS 'C' FLOW (STEEP)
(RECTANGULAR CHANNELS)
y = d2/d1
d1/(V1²/2g)
1.0
1.1
1.2
1.3
1.4
1.5
1.6
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6

PLATE 22.3 C-3

APPROXIMATE BRIDGE PIER LOSSES BY MOMENTUM METHOD

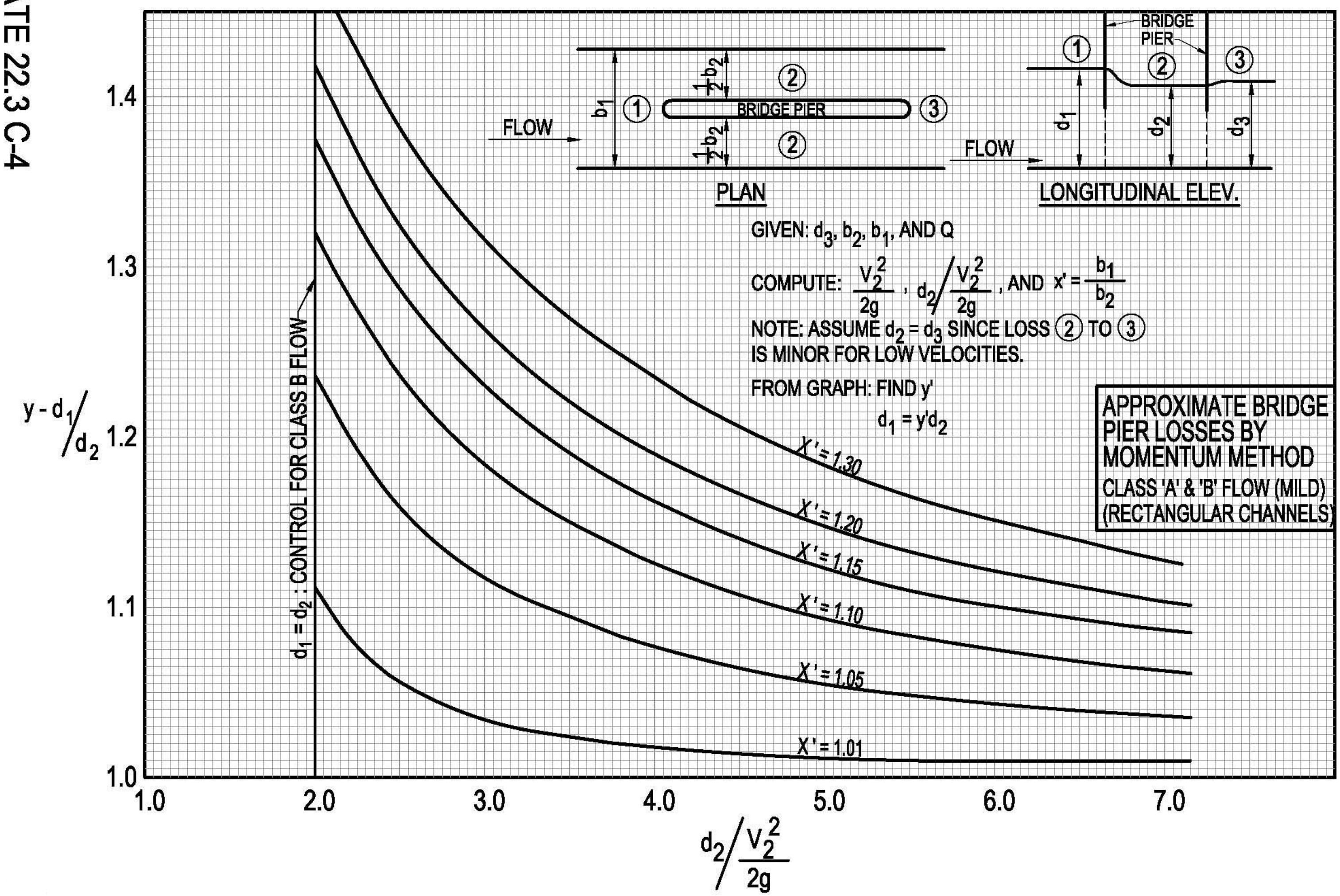
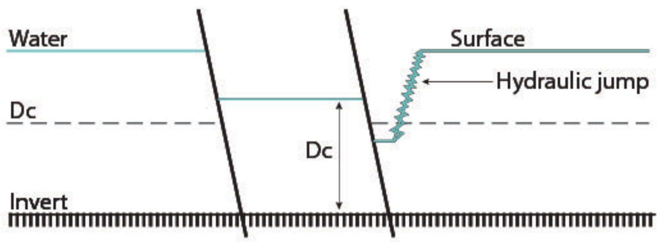


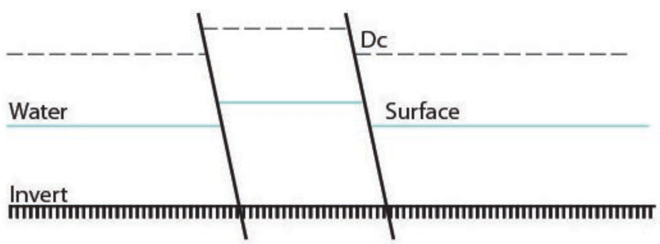
PLATE 22.3 C-4

2. If at the downstream end of the piers no depth can be found to balance the P + M equation, assume critical depth within the pier and calculate the water surface just downstream from the end of the pier. Calculate P + M for this depth and its sequence depth. If the upper sequence depth provides a greater sum (P + M), a hydraulic jump occurs at the downstream end of the pier. If the lower sequent depth results in a greater sum (P + M) the hydraulic jump occurs some distance downstream from the pier. Within the pier, calculate the water surface to the upstream face and then calculate the depth just upstream of the face of the pier using the P + M equation.

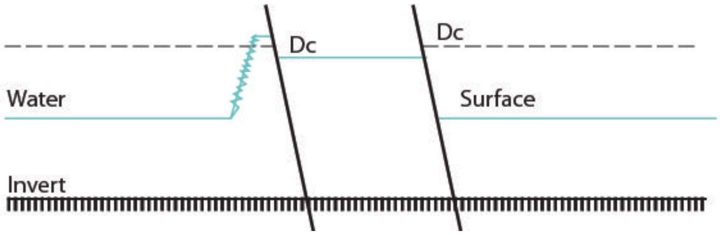


For supercritical flow the following cases, numbers 3 or 4, generally apply.

3. If the depth calculated by the P + M equation just inside the upstream face of the pier is equal to or below critical depth continue the water surface to the downstream end of the pier and then calculate the depth just outside the pier by either the P + M equation or the Bernoulli equation.



4. If, at the upstream end of the pier, no depth can be found to balance the P + M equation, calculate P + M for the depth of flow just outside the upstream end of the pier and its sequent depth. If the lower stage results in the greater sum (P + M), this indicates a hydraulic jump at the upstream face of the pier. If the upper stage results in the greater sum (P + M), this indicates a hydraulic jump some distance upstream from the pier. Assume critical depth just inside the upstream pier face and continue the water surface to the downstream end of the pier, and then calculate the depth just outside the pier by either the P + M equation or the Bernoulli equation.



3.4.C.V.c. Curving Alignments

3.4.C.V.c.i. Superelevation

Superelevation is the maximum rise in water surface at the outer wall above the mean depth of flow in an equivalent straight reach, caused by centrifugal force in a curving alignment.

1. Rectangular Channels

For subcritical velocity, or for supercritical velocity where a stable transverse slope has been attained by an upstream easement curve, the superelevation (s) can be calculated from the following equation:

$$S = \frac{V^2 b}{2gr}$$

For supercritical velocity in the absence of an upstream easement curve, the superelevation (S) is given by the following equation:

$$S = \frac{V^2 b}{gr}$$

Where:

V = Velocity of the flow cross section, in f.p.s.
b = Width of the channel, in ft.
g = Acceleration due to gravity
r = Radius of channel center line curve, in ft.
X = Distance from the start of the circular curve to the point of the first S in ft.
D = Depth of flow for an equivalent straight reach
B = Wave front angle

$$x = \frac{3.14bV}{\sqrt{12gD}} = \frac{.16bV}{\sqrt{D}} = \frac{0.908b}{\sin B}$$

$$\sin B = \frac{\sqrt{g^D}}{V} = \frac{1}{F}$$

"S" will not be uniform around the bend but will have maximum and minimum zones which persist for a considerable distance into the downstream tangent.

2. Trapezoidal Channels

For subcritical velocity, the superelevation (S) can be calculated from the following equation:

$$S = \frac{1.15V^2(b + 2zD)}{2gr}$$

Where:
z = Cotangent of bank slope
b = Channel bottom width, in ft.

For supercritical velocity, curving alignments shall have easement curves with a superelevation (S) given by the following equation:

$$S = \frac{1.13V^2(b + 2zD)}{2gr}$$

3. Unlined Channels

Unlined channels will be considered trapezoidal insofar as superelevation calculations are concerned. However, this does not apply to calculations of stream or channel cross-sectional areas.

3.4.C.V.d. Freeboard:

Freeboard is the additional wall height applied to a calculated water surface. This criteria can be superseded by other government regulations/requirements.

1. Rectangular Channels will not be used except with City Engineer's approval
2. Trapezoidal Channels and Associated Types

    Adequate channel freeboard above the designed water surface must be provided and will not be less than the amount determined by the following:

    a. For flow rates of less than 100 c.f.s. and average flow velocity of less than 35 f.p.s.:

$$Freeboard(Feet) = 1.0 + 0.025\, Vd^{\frac{1}{3}}$$

    b. For flow rates of 100 c.f.s. or greater and average flow velocity of 35 f.p.s. or greater:

$$Freeboard(Feet) = 0.7\left(2.0 + 0.025\, Vd^{\frac{1}{3}}\right)$$

Freeboard will be in addition to any superelevation of the water surface, standing waves and/or other water surface disturbances. When the total expected height of disturbances is less than 0.5 feet, disregard their contribution.

Unlined portions of the drainage way may not be considered as freeboard unless specifically approved by the City Engineer.

For supercritical flow where the specific energy is equal to or less than 1.2 of the specific energy at D_c, the wall height will be equal to the sequent depth, but not less than-the heights required above. This condition should be avoided.

3. Roll Waves

Roll waves are intermittent surges on steep slopes that will occur when the Froude Number (F) is greater than 2.0 and the channel invert slope (S_0) is greater than the quotient, twelve divided by the Reynolds Number. When they do occur, it is important to know the maximum wave height at all points along the channel so that appropriate wall heights may be determined based on the experimental results of roll waves as identified by Richard R. Brock, so that the maximum wave height can be estimated.

For details, see "Development of Roll Waves in Open Channels", Report No. KH-R-16, California Institute of Technology, July 1967. Refer also to Plates 22.3 C-5, 22.3 C-6, 22.3 C-7.

3.4.C.V.e. Criteria

3.4.C.V.e.i. Unlined Channels

After full consideration has been given to the soil type, velocity of flow, desired life of the channel, economics, availability of materials, maintenance and any other pertinent factors, an unlined earth channel may be approved for use.

Generally, its use is acceptable where erosion is not a factor and where mean velocity does not exceed 3 f.p.s. Old and well-seasoned channels will stand higher velocities than new ones; and with other conditions the same, deeper channels will convey water at a higher non-erodible velocity than shallower ones.

Maximum side slopes are determined pursuant to an analysis of soil reports. However, in general, slopes should be 6:1 or flatter with erosion protection measures. Provide a buffer for the LEE.

3.4.C.V.e.ii. Composite Linings

In case part of the channel cross section is unlined or the linings are composed of different materials, a weighted coefficient must be determined using the roughness factors for the materials as given in SSCAFCA's Sediment and Erosion Design Guide. If the lining materials are represented by the subscripts "a", "b" and "c", and the wetted perimeters by "P", the weighted value of "n" for the composite section is given by the following equation:

$$n = \frac{\left[P_a n_a^{\frac{3}{2}} + P_b n_b^{\frac{3}{2}} + P_c n_c^{\frac{3}{2}}\right]^{\frac{2}{3}}}{P}$$

ROLL WAVES

Maximum Wave Height

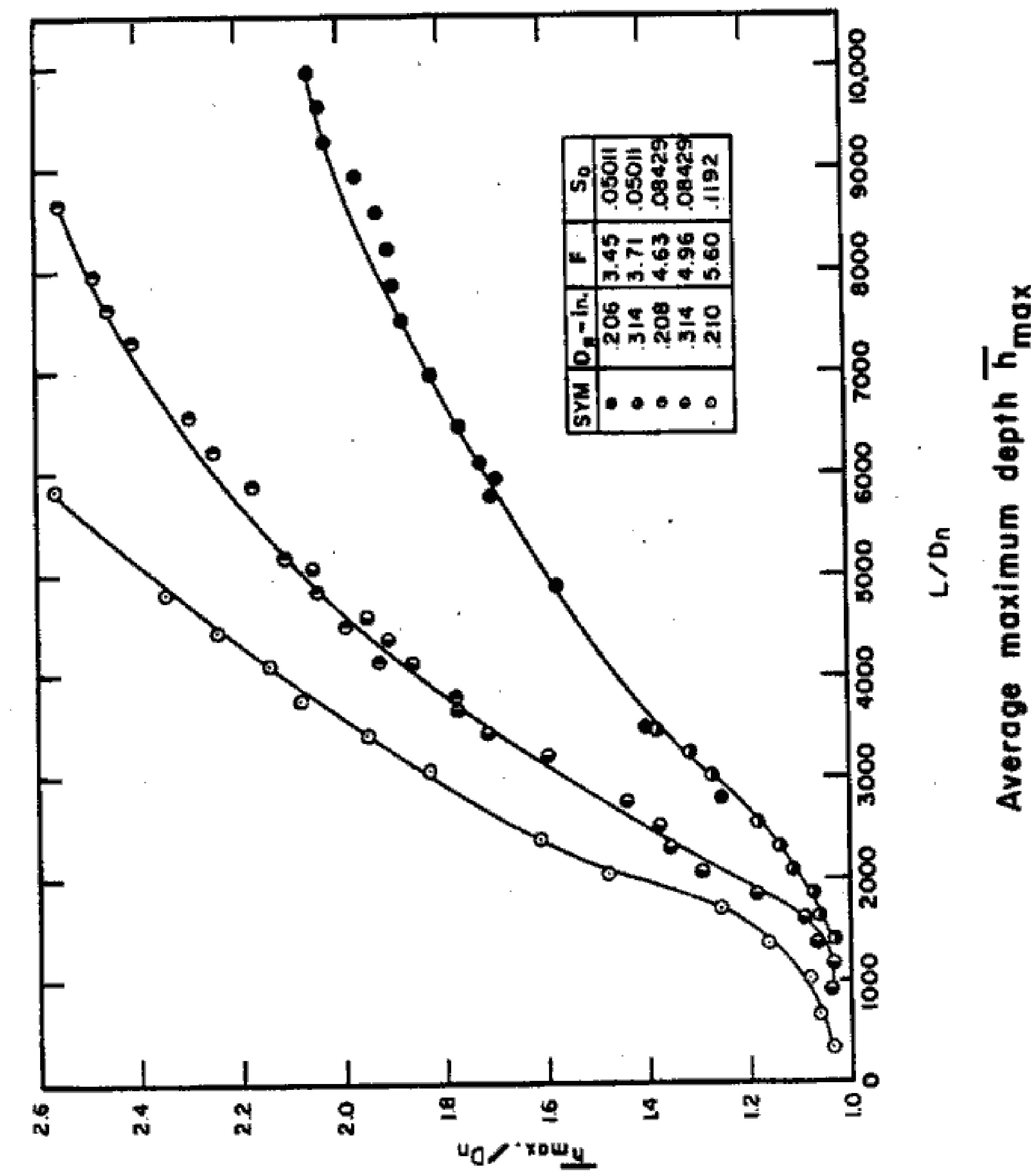
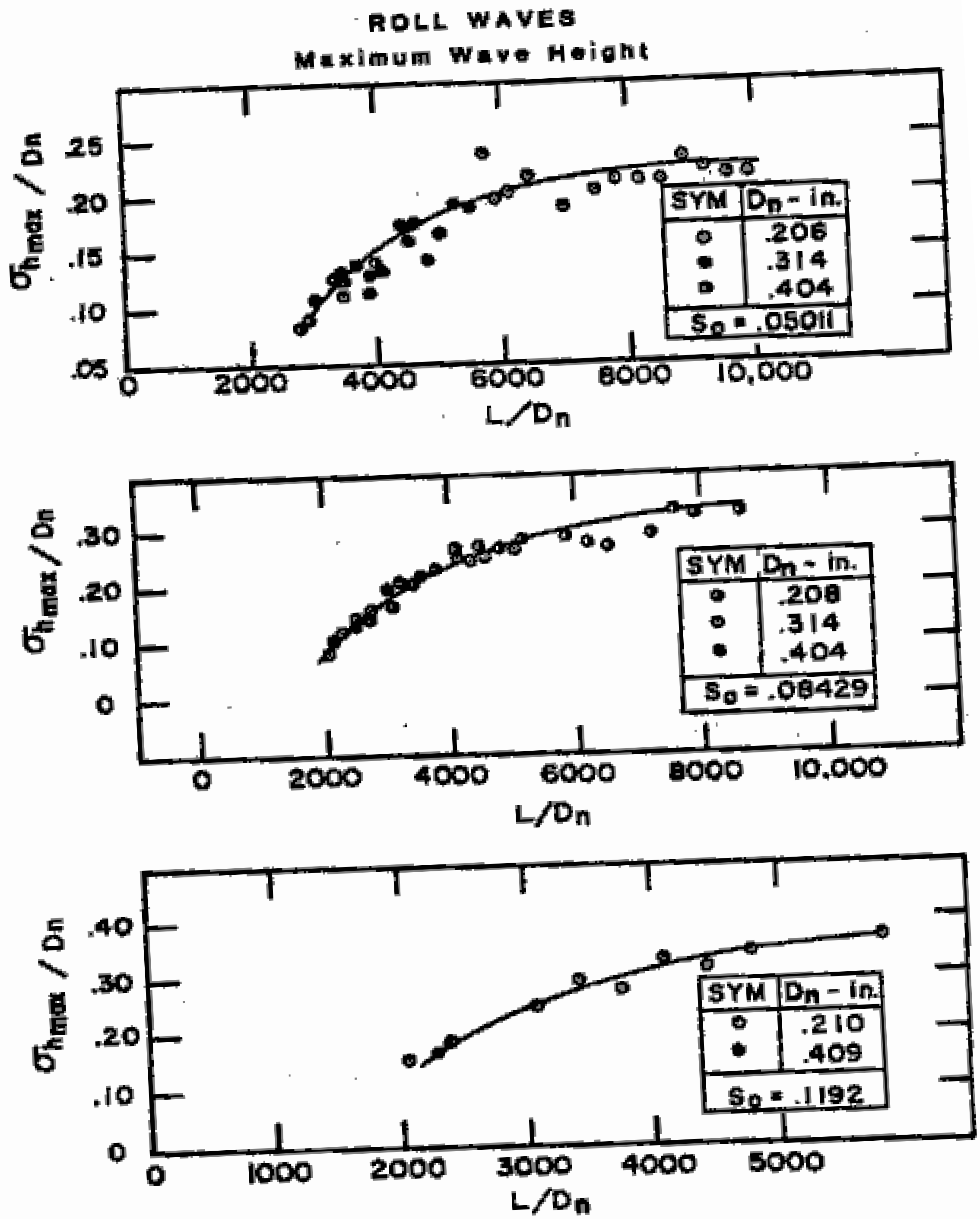


PLATE 22.3 C-5



Standard deviation of the maximum depth, $\sigma_{h_{max}}$.

PLATE 22.3 C-6

ROLL WAVES

Maximum Wave Height

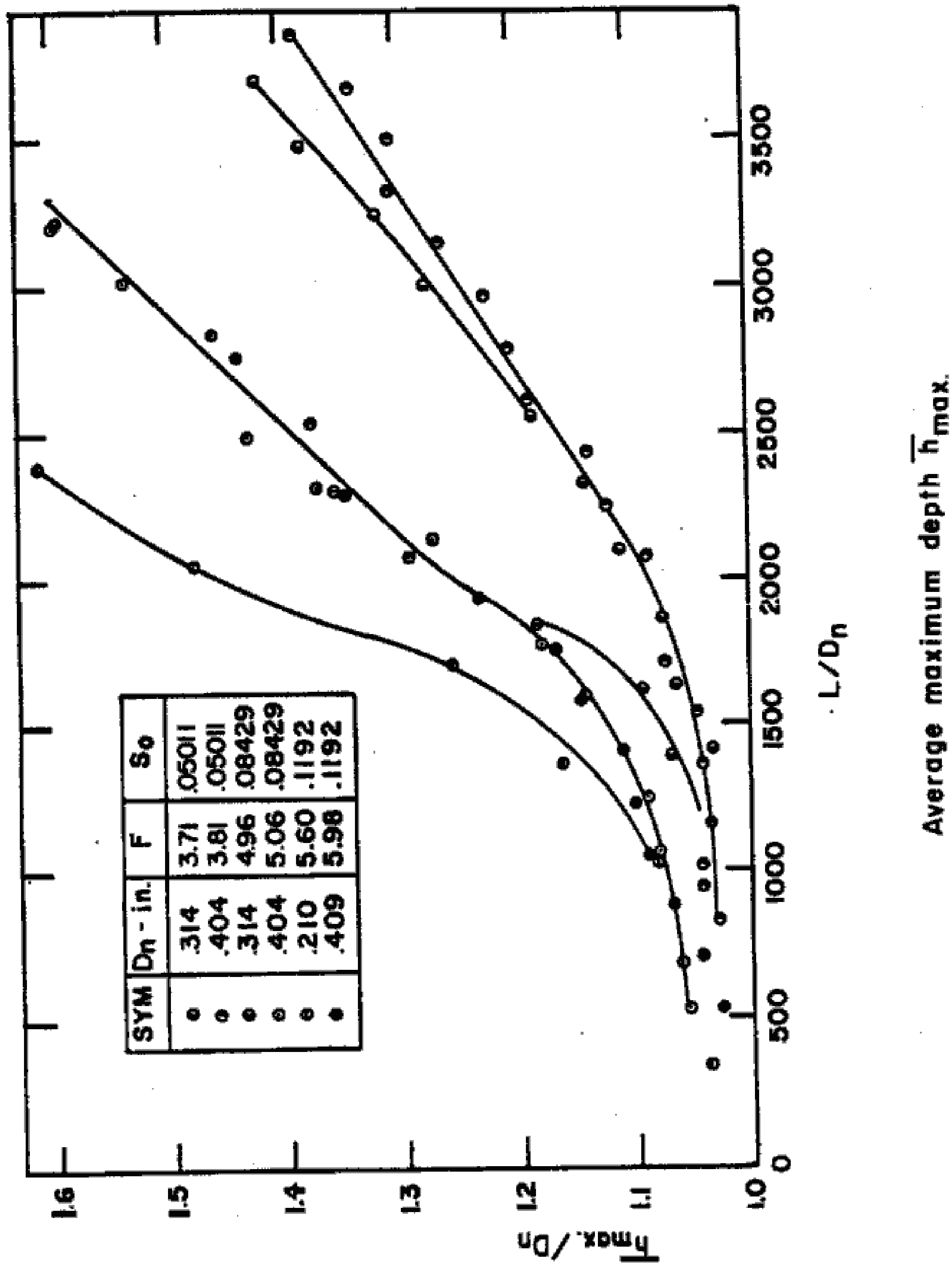


PLATE 22.3 C-7

3.4.C.V.e.iii. Maximum Sidewall Slopes (Freeboard Area)

The following sidewall slopes are generally the maximum values used for channels on at least one side of the concrete lined channel.

Lining Material	Maximum Slope
Soil Cement	2:1
Portland Cement Concrete	Vertical (Trapezoidal 2:1)
Grouted Rock Rip-Rap	2:1
Dumped Rock Rip-Rap	2:1
Earth Lined	6:1
Grass Lined (sodded)	6:1
Gravel Mulch	6:1

3.4.C.V.e.iv. Channel Maintenance and Access Road

A maintenance and access road having a minimum of 12 feet top width shall be provided on both sides of improved channels. The roads should be sloped away from the channel, and roadway runoff carried in a controlled manner to the channel. In some cases the City Engineer may require additional width. Channel maintenance and access roads shall be surfaced with gravel base course. The thickness of said base course shall be 6 inches. Maintenance access roads may also be paved if they are to be included as a quality of life feature for usage by the general public.

Turnouts will be provided at no more than ½ mile intervals and turnarounds must be provided at all access road dead ends.

Ingress and egress from public right-of-way and/or easements to the channel maintenance and access roads must be provided.

3.4.C.V.e.v. Channel Access Ramps

Channel access ramps for vehicular use will be provided as necessary for complete access to the channel throughout its entire length with the maximum length of channel between ramps being one-half mile.

Ramps shall be constructed of 8" thick reinforced concrete and will not have slopes greater than 10% and ramps shall not enter the channel at angles greater than 15% from a line parallel to the channel centerline.

Ramps may be constructed on one side of the channel and must be approved by the City. The maintenance and access road on the “ramp” side shall be offset around the ramp to provide for continuity of the road full length of the channel.

The downhill direction of the ramp should be oriented downstream.

3.4.C.V.e.vi. Street Crossings

Street crossing or other drainage structures over the concrete lined channel should be of the all weather type, i.e., bridges or concrete box culverts. Crossing structures should conform to the channel shape in order that they disturb the flow as little as possible.

It is preferred that the channel section be continuous through crossing structures. However, when this is not practicable, hydraulic disturbance shall be minimized, and crossing structures should be suitably isolated from the channel lining with appropriate joints.

Street crossing structures shall be capable of passing the l00 year frequency design storm flow.

Channel lining transitions at bridges and box culverts should conform to the provisions for transitions hereinafter provided. Drainage structures having a minimum clear height of 8 feet and being of sufficient width to pass maintenance vehicles may result in minimizing the number of required channel access ramps. Unless otherwise specifically authorized by the City Engineer, all crossing structures must have at least 8.0 feet of clear height.

3.4.C.V.e.vii. Subdrainage

Concrete lined channels to be constructed in areas where the ground water table is greater than two feet below the channel invert, weep holes or other subdrainage systems are not required.

Areas where the ground water table is within two feet or less of the channel bottom, there shall be provided, special subdrainage systems as necessary to relieve water pressures from behind the channel lining.

3.4.D Storm Inlets

3.4.D.I. DESIGN FLOW (Q)

The Design Q for storm inlet design should be determined based on the following procedures.

1. Outline the drainage basin on a map with an appropriate scale.
2. Outline the drainage area contribution to each proposed storm inlet, designating this area with the corresponding subarea number and with a letter (2A, 2B, 2C, etc.). Drainage areas should be differentiated by color or line type.
3. Calculate the tributary area in acres for each storm inlet or battery of storm inlets.
4. Assuming satisfactory drainage area relationships, the storm inlet design Q will be calculated as follows:

(a) $$Q_{DES} = \frac{Q_P A}{A_T}$$

Where:
A = Area in acres tributary to storm inlet
A_T = Total area in acres of the appropriate subarea

Q_P = Peak Q from appropriate subarea, in c.f.s.

In cases where the main line design Q's are reduced because of a restricted outlet, the storm inlet design Q's must be reduced by the same percentage.

If, during the design of a project, it is determined that the proposed storm inlet interception points will change the interception points assumed in the main line hydrology, then the main line Q's should be adjusted accordingly.

3.4.D.II. REQUIRED DATA AND CALCULATIONS

3.4.D.II.a. Street Flow Carrying Capacity

Submitted data should include complete cross sections between property lines of streets at the proposed storm inlet and of any streets which control the flow of water to the pertinent locations. Street cross sections should indicate the following:

1. Dimensions from the street center line to the top of curb and property line.
2. Gutter slope upstream of each storm inlet.
3. Elevations for the top of curb, flow line, property line and street crown at each storm inlet center line.
4. Curb batter.

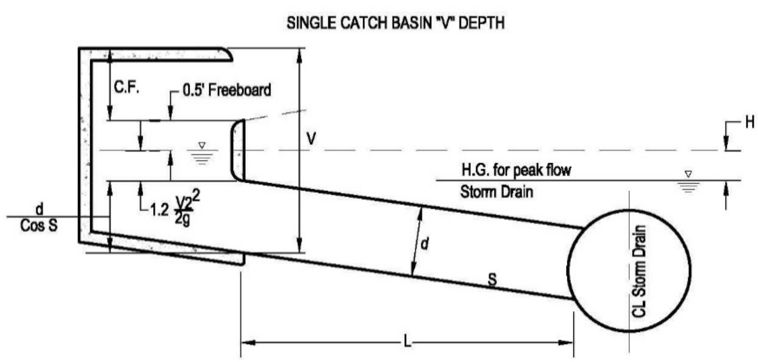
Please refer to Plates 22.3 D-1 to 22.3 D-4 inclusive, for nomographs giving street capacities for some typical street sections.

3.4.D.II.b. Storm Inlet Size and Type

Size and type of storm inlet should be determined by physical requirements and by inlet flow capacities given in Plates 22.3 D-5 to 22.3 D-7, inclusive. Criteria used, if other than those recommended in this section, must be cited and accompanied by appropriate calculations.

3.4.D.II.c. Connector Pipe and "V" Depth Calculation

(1) Single Storm Inlet



STREET CAPACITY

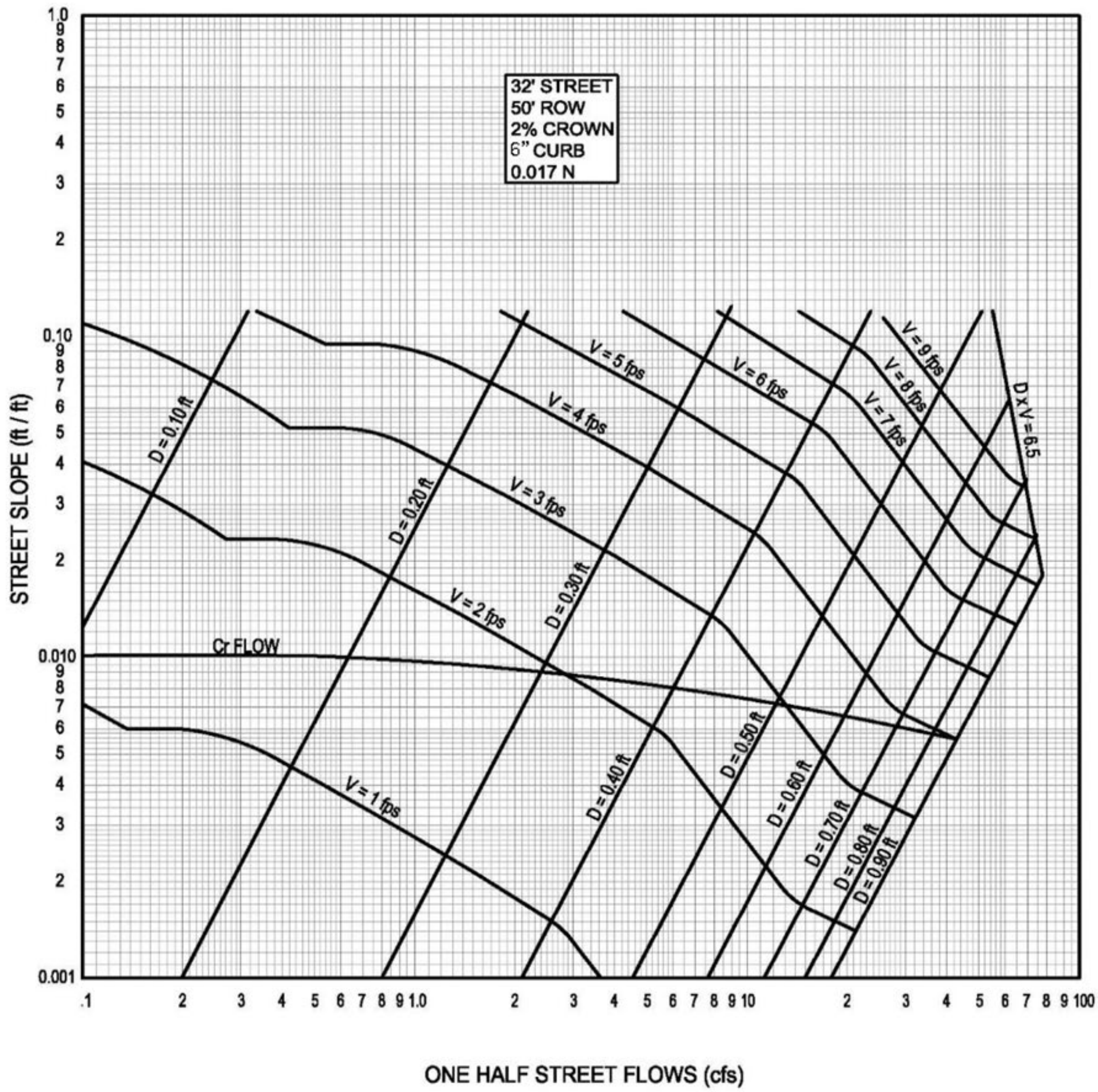


PLATE 22.3 D-2

STREET CAPACITY

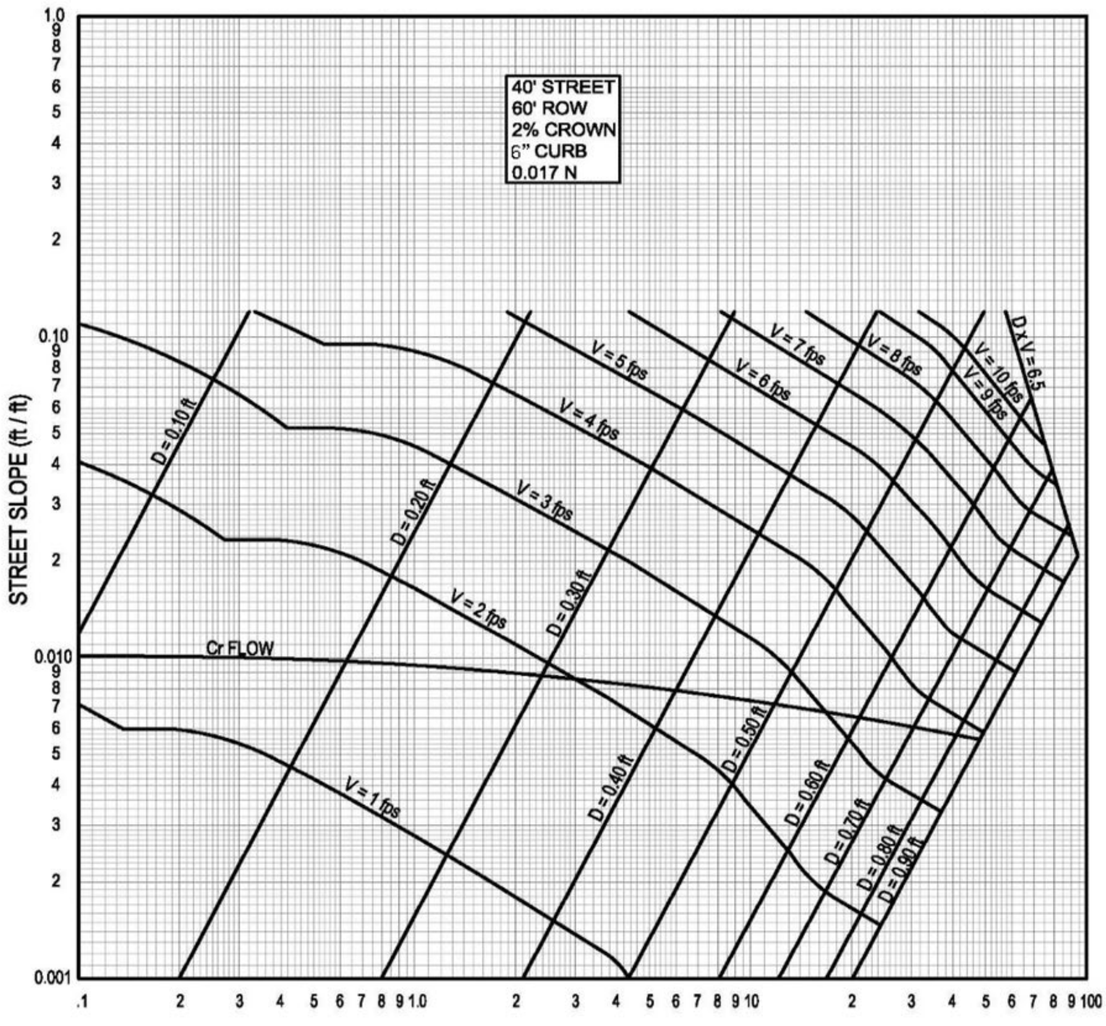


PLATE 22.3 D-3

STREET CAPACITY

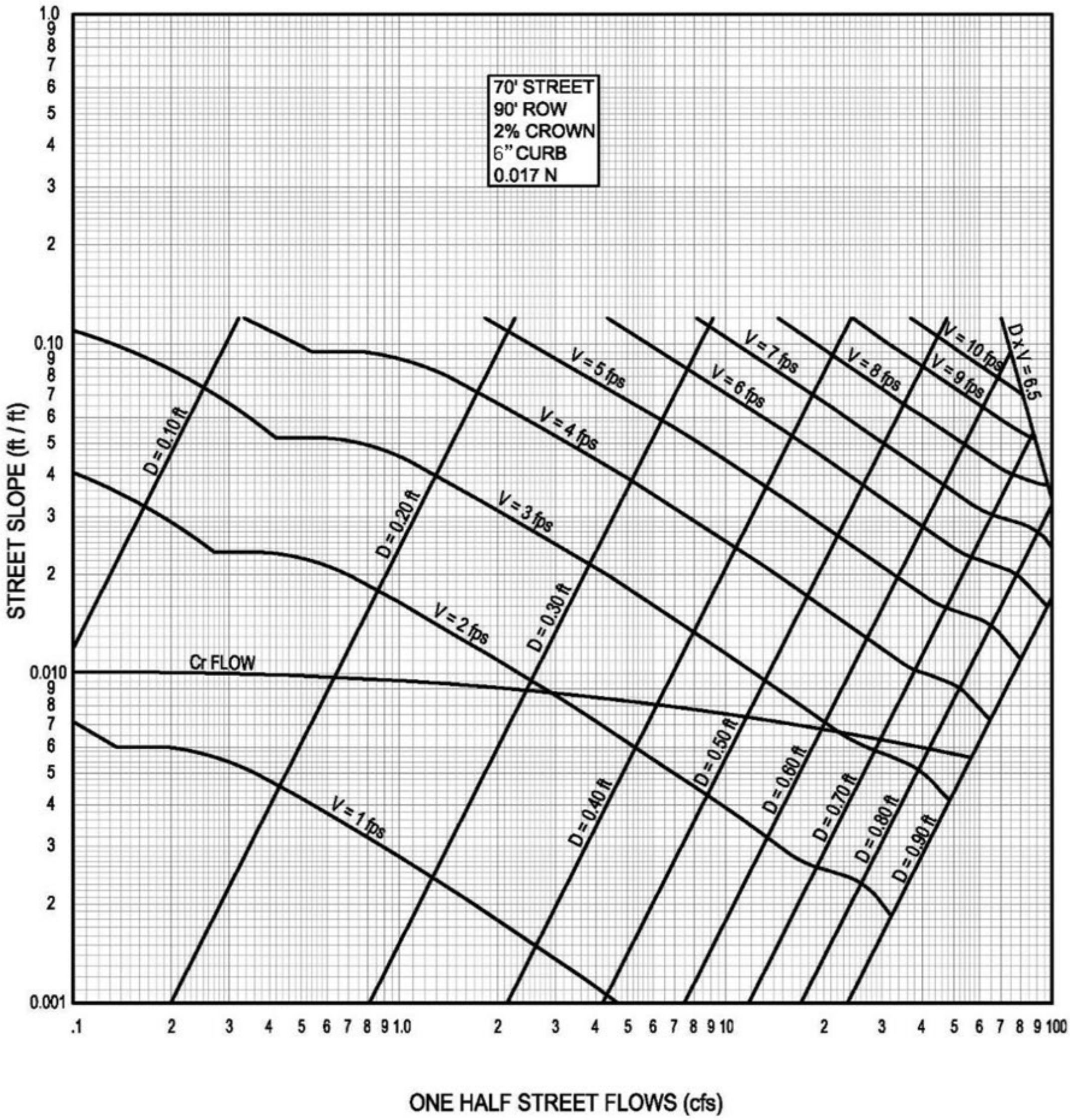


PLATE 22.3 D-4

GRATING CAPACITIES FOR TYPE "A", "C" AND "D"

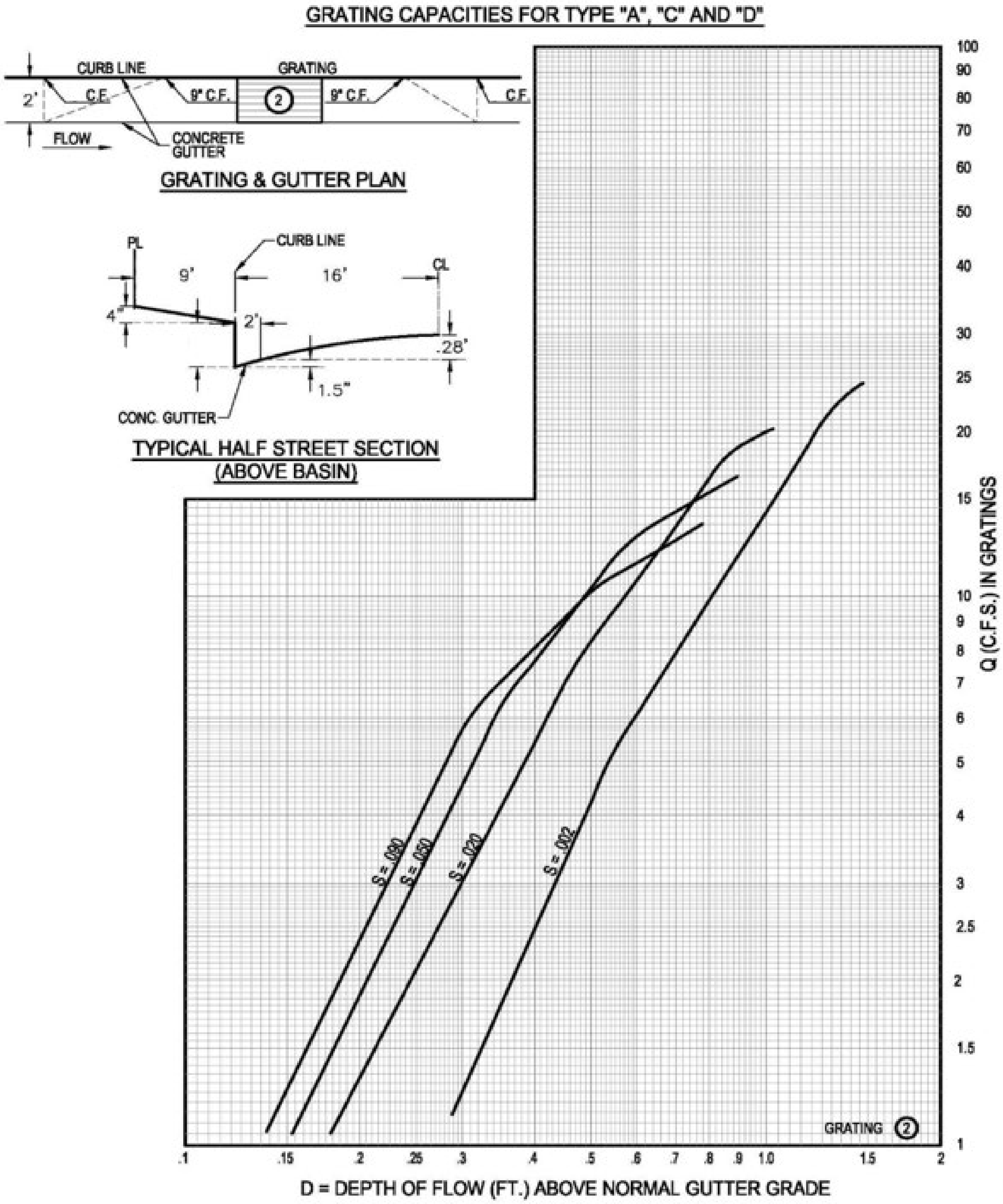


PLATE 22.3 D-5

GRATING CAPACITIES FOR TYPE DOUBLE “C” AND “D”

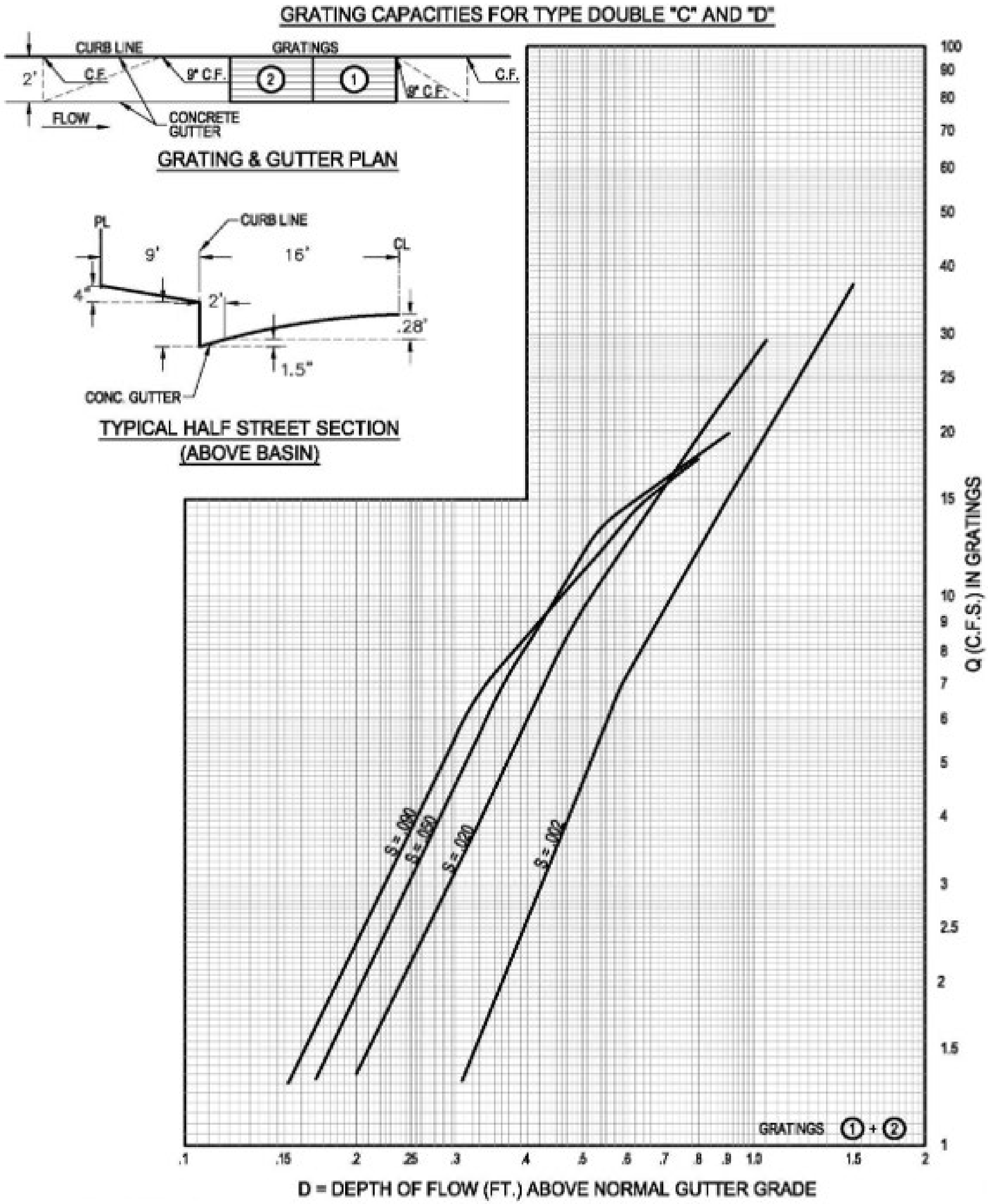


PLATE 22.3 D-6

GRATING CAPACITIES FOR TYPE "B"

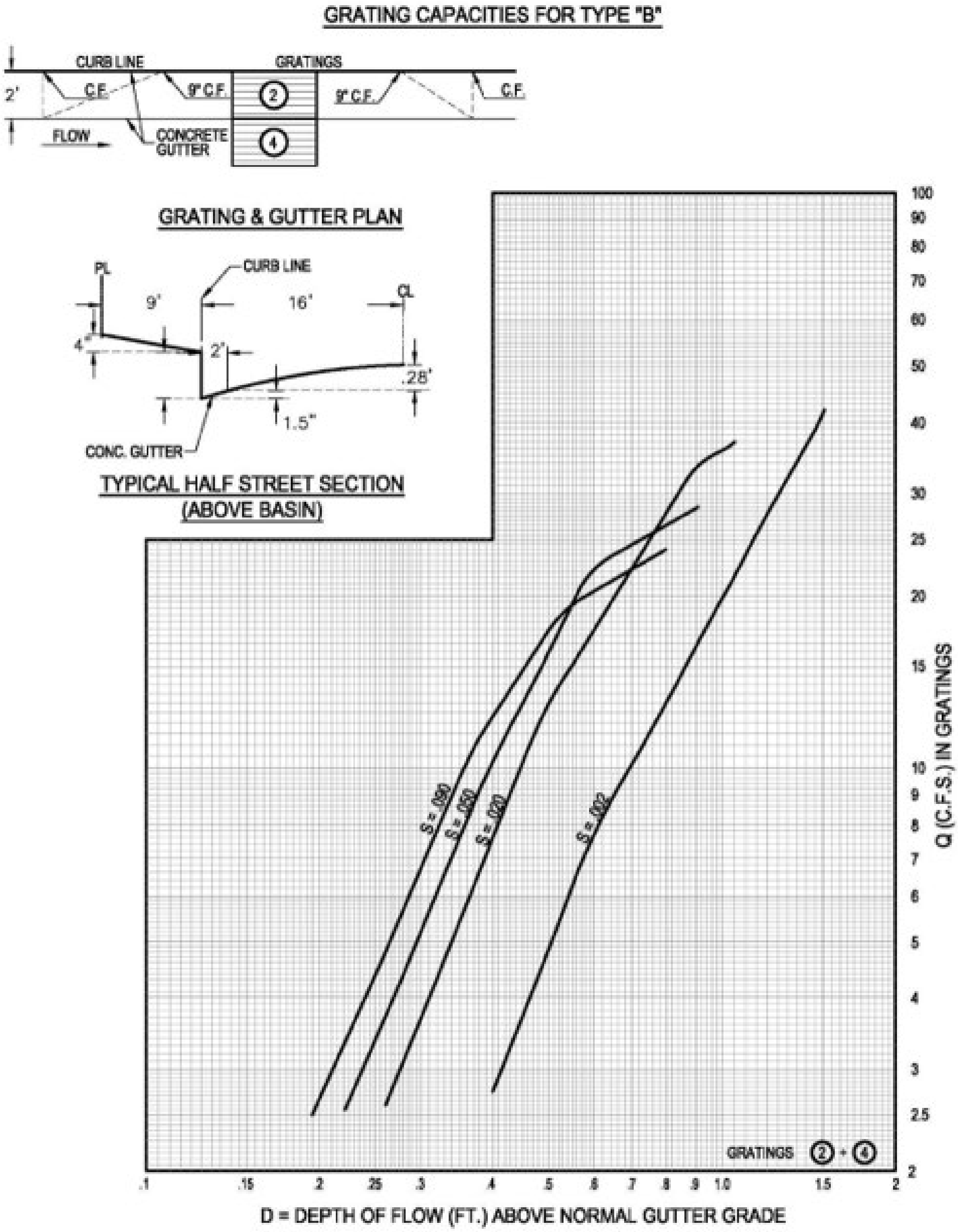


PLATE 22.3 D-7

Given the available head (H), the required connector pipe size can be determined from culvert equations, such as those given in King & Brater, Handbook of Hydraulics, Section Four, 5th Edition. Plate 22.3 D-8 can be used for a nomographic solution of a culvert equation for culverts flowing full.

The minimum storm inlet "V" depth should be determined as follows:

$$V = C.F. + 0.5 + 1.2\frac{V^2}{2g} + \frac{d}{\cos S}$$

Where:

V = Depth of the storm inlet , or "V" depth, measured in feet from the invert of the connector pipe to the top of the curb.

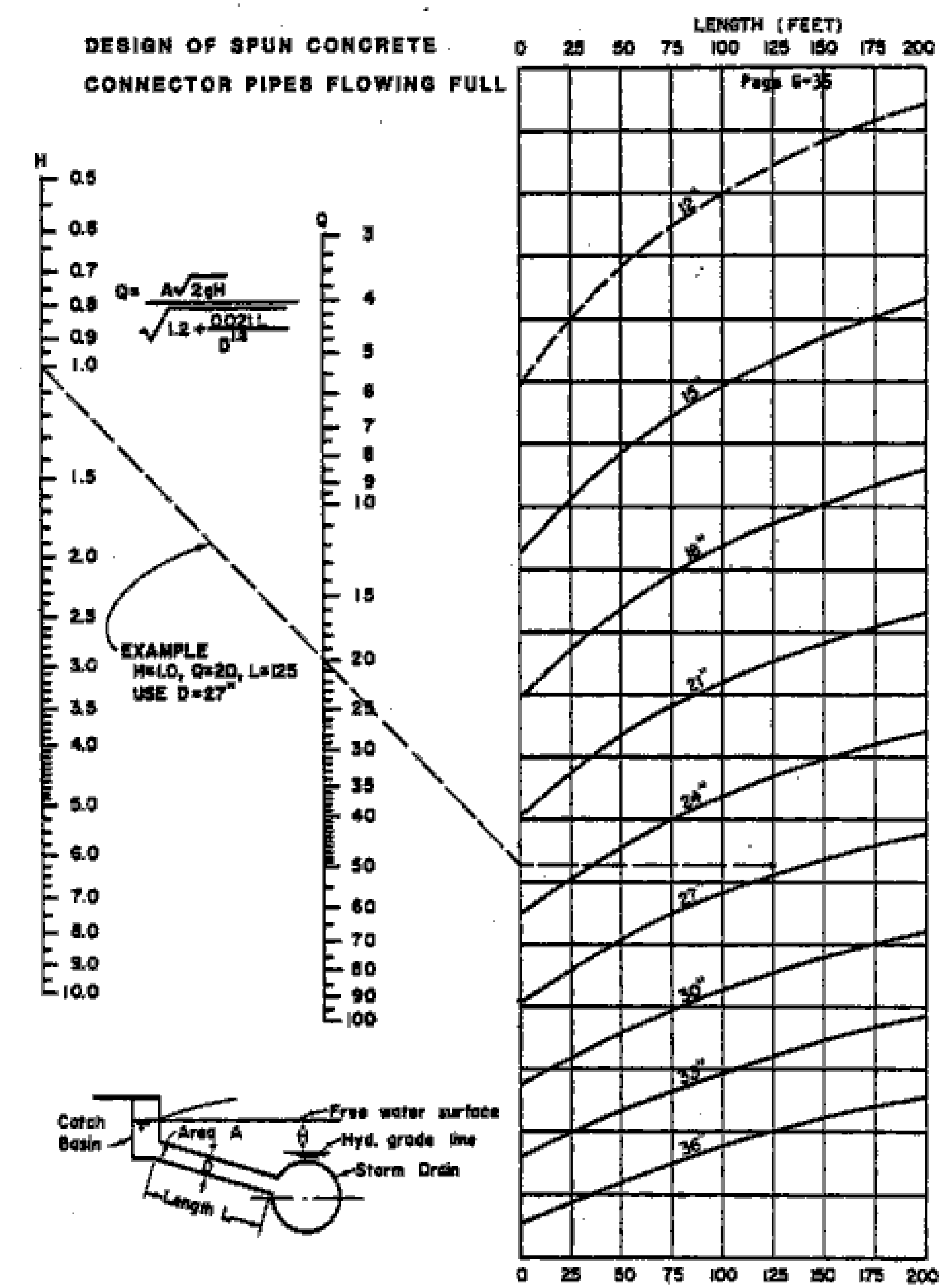
C.F = Vertical dimension of the curb face at the storm inlet opening, in feet.
V = Average velocity of flow in the connector pipe, in feet per second, assuming a full pipe section.
d = Diameter of connector pipe, in feet.
S = Slope of connector pipe.

The term $1.2(V^2/2g)$ includes an entrance loss of .2 of the velocity head.

Assuming a curb face at the storm inlet opening of 10 inches, which is the value normally used, and Cos S = 1, the above equation may be simplified to the following:

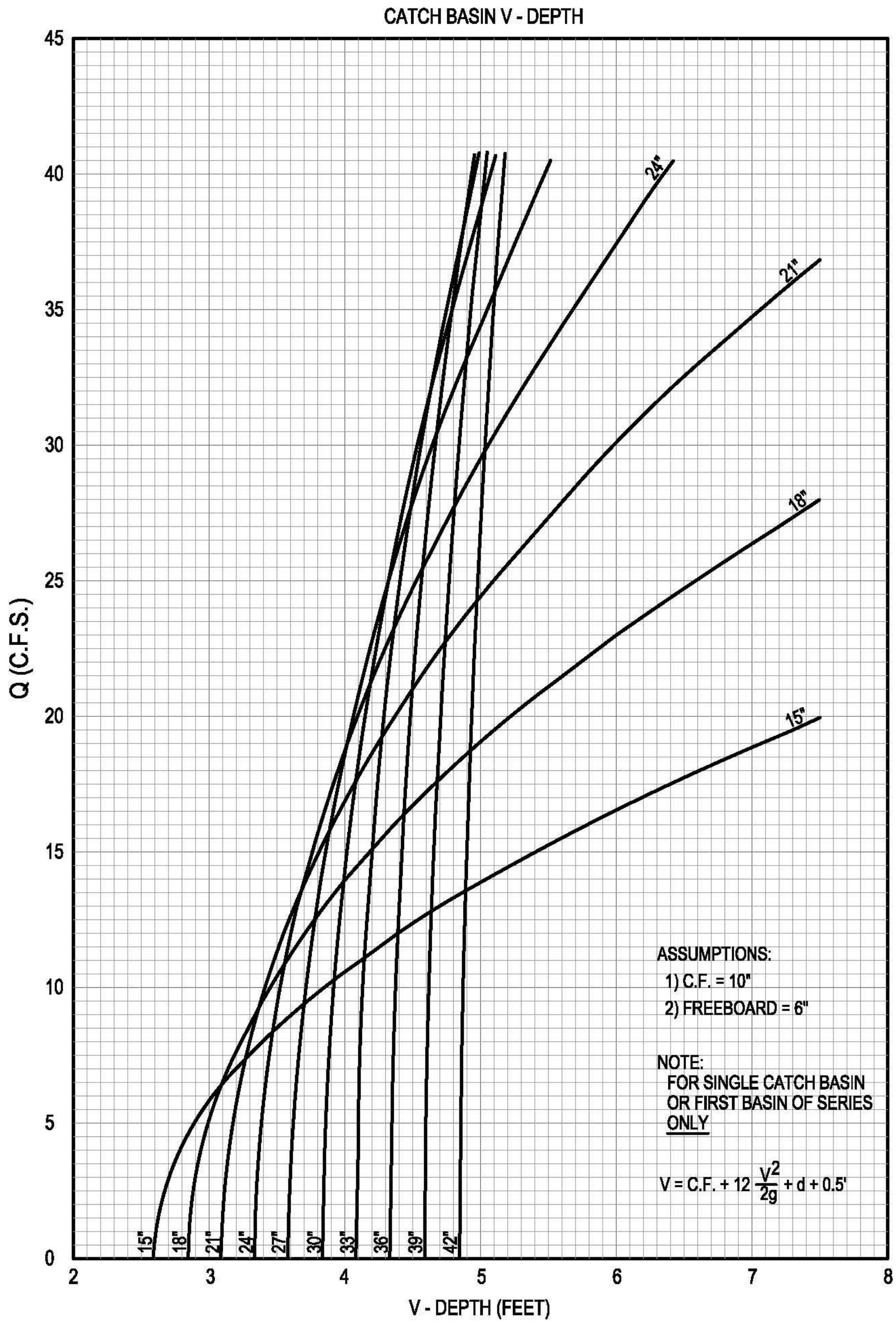
$$V = 1.33 + 1.2\frac{V^2}{2g} + d$$

Please refer to Plate 22.3 D-9 for a graphical solution to the above equation for curb faces of 10 inches.



DESIGN OF SPUN CONCRETE
CONNECTOR PIPES FLOWING FULL
LENGTH (FEET)
0 25 50 75 100 125 150 175 200
H
Q
$Q = \frac{A\sqrt{2gH}}{\sqrt{1.2 + \frac{0.021L}{D^{1.3}}}}$
EXAMPLE
H=1.0, Q=20, L=125
USE D=27"
12" 15" 18" 21" 24" 27" 30" 33" 36"
Catch Basin
Area A
Free water surface
Hyd. grade line
Storm Drain
Length L

PLATE 22.3 D-8



CATCH BASIN V - DEPTH
Q (C.F.S.)
V - DEPTH (FEET)
45
40
35
30
25
20
15
10
5
0
2
3
4
5
6
7
8
24"
21"
18"
15"
15"
18"
21"
24"
27"
30"
33"
36"
39"
42"
ASSUMPTIONS:
1) C.F. = 10"
2) FREEBOARD = 6"
NOTE:
FOR SINGLE CATCH BASIN
OR FIRST BASIN OF SERIES
ONLY
V = C.F. + 12 V2/2g + d + 0.5'

PLATE 22.3 D-9

STORM INLET **CALCULATION SHEET**

Sht ________ of ________

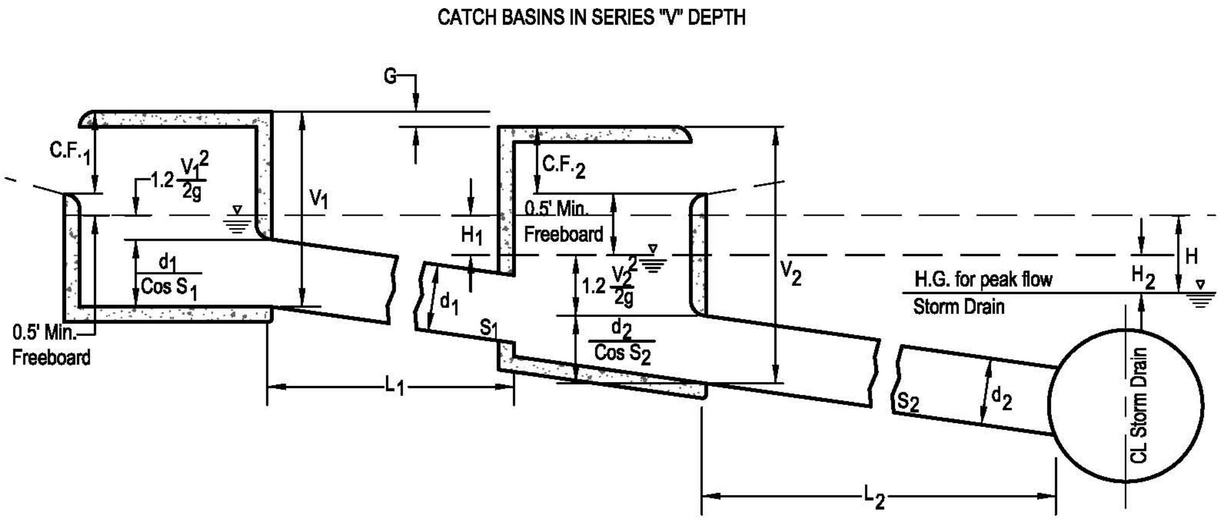
PROJECT ____________________ CALCULATED BY ____________________

DESIGN FREQUENCY ____________________ DATE ____________________

FLOW DIAGRAM (Indicate street slopes)	Sym.	Drain Area	Q		Cap of 1/2 Street	Gutter "d"	C.B.		Connector Pipe			V Depth
			Total	Inter.			No.	Size	Head	L	Dia	

PLATE 22.3 D-10

d. Storm Inlets in Series



Select a connector pipe size for each storm inlet, and determine the related head loss (H_1, H_2) by means of a culvert equation, or by Plate 22.3 D-9 . The sum of head losses in the series should not exceed the available head, i.e.,

$$H_1 + H_2 + \cdots \ldots \ldots \ldots . + H_n \leq H$$

The minimum storm inlet "V" depths are determined in the following manner:

(1) The first storm inlet "V" depth is calculated as for a single storm inlet:

$$V_1 = 1.33 + 1.2\frac{V_1^2}{2g} + d_1$$

(2) The second storm inlet "V" depth is determined as follows:

$$V_2 = C.F._1 + 0.5 + H_1 + 1.2\frac{V_2^2}{2g} + \frac{d_2}{\cos S_2} - G$$

Assuming again that C.F. = 0.83 and Cos S_2 = 1,

$$V_2 = 1.33 + H_1 + 1.2\frac{V_2^2}{2g} + d_2 - G$$

(3) The freeboard provided for the second storm inlet generally should not be less than 0.5 feet and shall be checked as follows:

$$FB_2 = V_2 - \frac{d_2}{\cos \quad S_2} - 1.2\frac{V_2^2}{2g} - C.F._2$$

If C.F.$_2$ = 0.83 and Cos S$_2$ = 1,

$$FB_2 = V_2 - d_2 - 1.2\frac{V_2^2}{2g} - 0.83$$

Where especially "tight" conditions prevail, the 0.5 feet freeboard requirement referred to above may be omitted. In such cases the difference between the gutter elevation and the hydraulic grade line elevation of the main line will be accepted as the available head.

(4) Connector pipes between storm inlets in series are be checked for adverse slope by the following relationship:

$$V_2 - 0.5 > V_1 - G$$

The figure of 0.5 shown above is the standard 6-inch cross slope of the storm inlet floors.

3.4.D.II.d. Other Criteria

3.4.D.II.d.i. General

1. Existing drainage systems which are not required to carry any portion of the design Q of a proposed system may be designated to be abandoned in place upon completion of the proposed drain. Such existing drainage systems should not be sealed or removed before completion of the proposed system, if needed to carry off storm water during the construction period. It is the designer's responsibility to ascertain the necessity of maintaining existing drainage systems in place.
    a. Existing street or sidewalk culverts may be designated to have the interfering portions removed and the inlets sealed, or the culverts may be kept in operation and connected to the storm drain or to the back of a proposed storm inlet. If the culvert is to be connected, a structural detail should be provided. Refer to the City Engineer for instructions.
    b. Existing street or sidewalk culverts that do not interfere with construction should be maintained in place.
2. Storm inlets will be located within street rights-of-way unless otherwise approved by the City Engineer. All storm inlets which must be located outside street right-of way lines in order to intercept storm waters under existing conditions are considered "must" storm inlets. Right-of-way or an easement for such storm inlets must be acquired. Storm inlets may be located outside dedicated streets to accommodate future street widenings and should be designed to intercept storm water under existing conditions.
    a. Storm inlets to be constructed off the paved portion of the roadway but within the street right-of way lines must be made operable by grading the roadway to permit storm water to flow to the basin.

Street remodeling of this nature will be performed during construction.

3. If a project is to have one or more cutoff points in phased construction, each cutoff point should have a battery of storm inlets at the upstream terminus sufficient to collect the flow carrying capacity of the storm drain at that point. Each battery of storm inlets should be designed with sufficient data regarding types and sizes of storm inlets, connector pipe sizes and D-loads, "V" depths, local depressions, and whatever other information may be necessary to construct the system.

4. Sump designs for storm inlets should normally be limited to local streets and only those situations where terrain or grading considerations warrant their use. When specifying a sump storm inlet(s) the designer shall ensure that surrounding properties are protected from the occurrence of system clogging by demonstrating that one of the following emergency backup conditions exist:

   a. The design storm peak flow rate will release to either a public R.O.W. or public easement without rising above any adjacent structure pad elevations; or

   b. Sufficient storage is available within a combination of public R.O.W., public easement, and non-structurally occupied private properties to hold 100% of the design event volume, without inflicting damage to structures, until such time as the underground system can be unclogged.

When relying on public easements across private property to achieve either objective, the easement language creating the encumbrance shall specify that said easement is a surface flowage easement and no structural improvements which would interfere with conveyance or storage of water shall be allowed. Any surface modification within the flowage easement will require an encroachment agreement from the City.

3.4.D.II.d.ii. Storm Inlets

The selection of type, number, and spacing of storm inlets should be based on Plates 22.3 D-l through 22.3 D-7 and the following instructions. Be aware that the City of Rio Rancho standard street curb heights are 6"and this may require design and construction adjustments.

City standard storm inlets "Type A, B and C" are combination inlet(s) with both curb opening and grating. Storm inlet "Type D" is a grating only inlet. Basin gratings tend to accumulate debris and clog. The curb opening both limits debris accumulation and offsets lost capacity due to clogging of the grating. Except for certain valley applications, combination basins should be used. Due to main line clogging, grating only basins should be used in valley applications where main line pipe diameters are 24" or less or where quarter full pipe velocities are less than 2.5 f.p.s.

"Type A" storm inlets should be used for single inlet applications and as the first inlet in a battery of inlets. The "Type A" basin performs the function of sweeping debris off the street upstream of the grating and minimizing clogging. "Type A" inlets are used with standard curb and gutter.

"Type B" storm inlets are generally placed downstream of and/or in conjunction with "Type A" storm inlets on streets other than arterials and collectors. This type storm inlet has potential to collect substantial runoff when the grating is clean. If "Type B" basins are used alone, without a "Type A" within 150 feet upstream, the capacity shown in Plate 22.3 D-7 should be reduced 15% due to clogging. "Type B" storm inlets are used with standard curb and gutter.

"Type C" storm inlets are generally placed downstream of and/or in conjunction with "Type A" storm inlets. If "Type C" storm inlets are used without a "Type A" within 150 feet upstream, the capacity shown in Plates 22.3 D-5 and 22.3 D-6 should be reduced 15% for clogging. "Type C" storm inlets are used with standard curb and gutter.

"Type D" storm inlets are generally used on streets with slope greater than 5%, in driveways and in certain valley areas as described above. "Type D" storm inlets can be used with either standard curb and gutter or with mountable curb.

The number of storm inlets to be connected in series should not exceed two. If the connection of more than two storm inlets in series is unavoidable, consideration should be given to designing a lateral drain.

3.4.D.II.d.iii. Connector Pipe

1. The minimum diameter of connector pipe is 18 inches.
2. The horizontal alignment of connector pipes must not contain angle points or bends, unless approved by the City Engineer.
3. Connections at manholes or junction structures are preferred.
4. The storm inlet spacing shall be a minimum of 25 feet between curb transitions.
5. Storm inlet connector pipes shall outlet at the downstream end of the storm inlets, unless prevented by field conditions. Downstream, in this paragraph, refers to the directions of the gutter slope at the storm inlet in question.
6. Where feasible, connector pipes should be located so as to avoid, as much as possible, cutting into existing cross gutters and spandrels.
7. The conversions of type A's, B's or C's to D's storm inlets will not be permitted. If the storm inlet is in conflict with a driveway, the storm inlet will be removed and replaced with another inlet outside of the driveway. To avoid conflicts with driveways, the engineer should identify the proposed driveways on the grading plan when storm inlets front the lots.

3.4.E Street Hydraulics

1. A secondary use of the street network is the conveyance of storm runoff. This secondary use must always be subsidiary to the primary function of streets which is the safe conveyance of people and vehicles. The goals of street hydraulic design are therefore:
    a. To provide an economical means of transporting storm runoff.
    b. To ensure that the safety and convenience of the public are preserved.
    c. To prevent storm runoff, once collected by the street system, from leaving the street right-of-way except at specially designated locations.
2. Street hydraulic design critical are as follows:
    a. Manning's roughness coefficient is 0.017.

b. Conjugate and/or sequent depth in the event of the 100-year design discharge may not exceed curb height and shall be contained within the street right-of-way.

c. Flow depths in the event of the 10-year design discharge may not exceed 0.33 feet at the curb line in any collector or arterial street. One lane free of flowing or standing water in each traffic direction must be preserved on arterial streets.

d. The product of depth times velocity shall not exceed 6.5 in any location in any street in the event of a 10-year design storm (with velocity calculated as the average velocity measured in feet per second and depth measured at the gutter flowline in feet).

e. The energy grade line of the street flow must be contained within the street right-of-way.

3. For streets with more than two driving lanes in each direction:

   a. The product of depth times velocity may not exceed 6.5 at any location in any street in the event of a 10-year design storm (with velocity calculated as the average velocity measured in feet per second and depth measured at the gutter flowline in feet).

   b. Inverted crown streets are prohibited unless prior authorization provided to and approved by the City.

   c. The assumption of equal flow distribution between gutters on undivided streets and between street sections on divided streets is only valid where its validity can be demonstrated.

4. Plates 22.3 D-1 through 22.3 D-4 may be used where applicable in the hydraulic design of streets. T-intersections, radical slope changes and intersections are potential locations for hydraulic jumps when upstream slopes are steeper than critical slope.

   a. When conditions indicate that a hydraulic jump or that the effects of superelevation will allow runoff to exceed street hydraulic design criteria, provisions must be made for treatment of the problem. The warping of street sections and the construction of deflector walls for these purposes is prohibited unless specifically authorized by the City Engineer.

5. Intersections and other radical changes in street cross section and slope require special consideration whenever the flow depth/street slope relationship results in flows occurring in the supercritical flow regime. The critical slope line shown on the street rating curves is used to determine on which side of critical depth the flow occurs and if slope or cross section changes will allow the flow to cross through critical depth from supercritical.

6. If flow is likely to cross into the subcritical flow range, then Plate22.3 E-1, "Tail Water vs. Froude Number" is used to determine the height and Plate 22.3 E-2, "Length of Jump vs. Froude Number" figure is used to determine jump length. The height of jump should not exceed curb height and shall be contained within the street right-of-way.

TAIL WATER DEPTH VS. D_1

HYDRAULIC DESIGN OF STILLING BASINS AND ENERGY DISSIPATORS

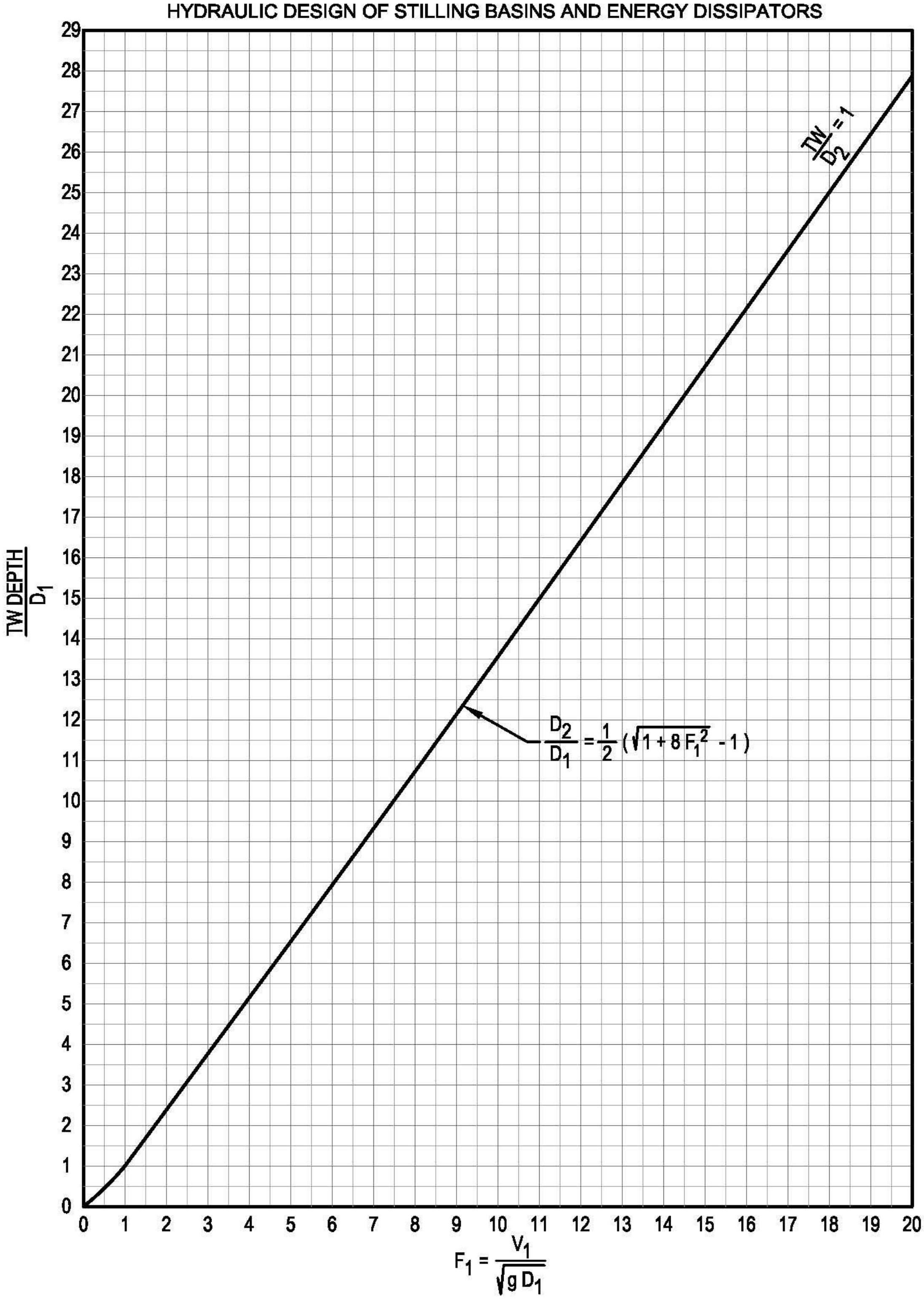


FIGURE5. - RATIO OF TAIL WATER DEPTH TO D_1 (BASIN I)

PLATE 22.3 E-1

LENGTH OF JUMP IN TERMS OF D_1

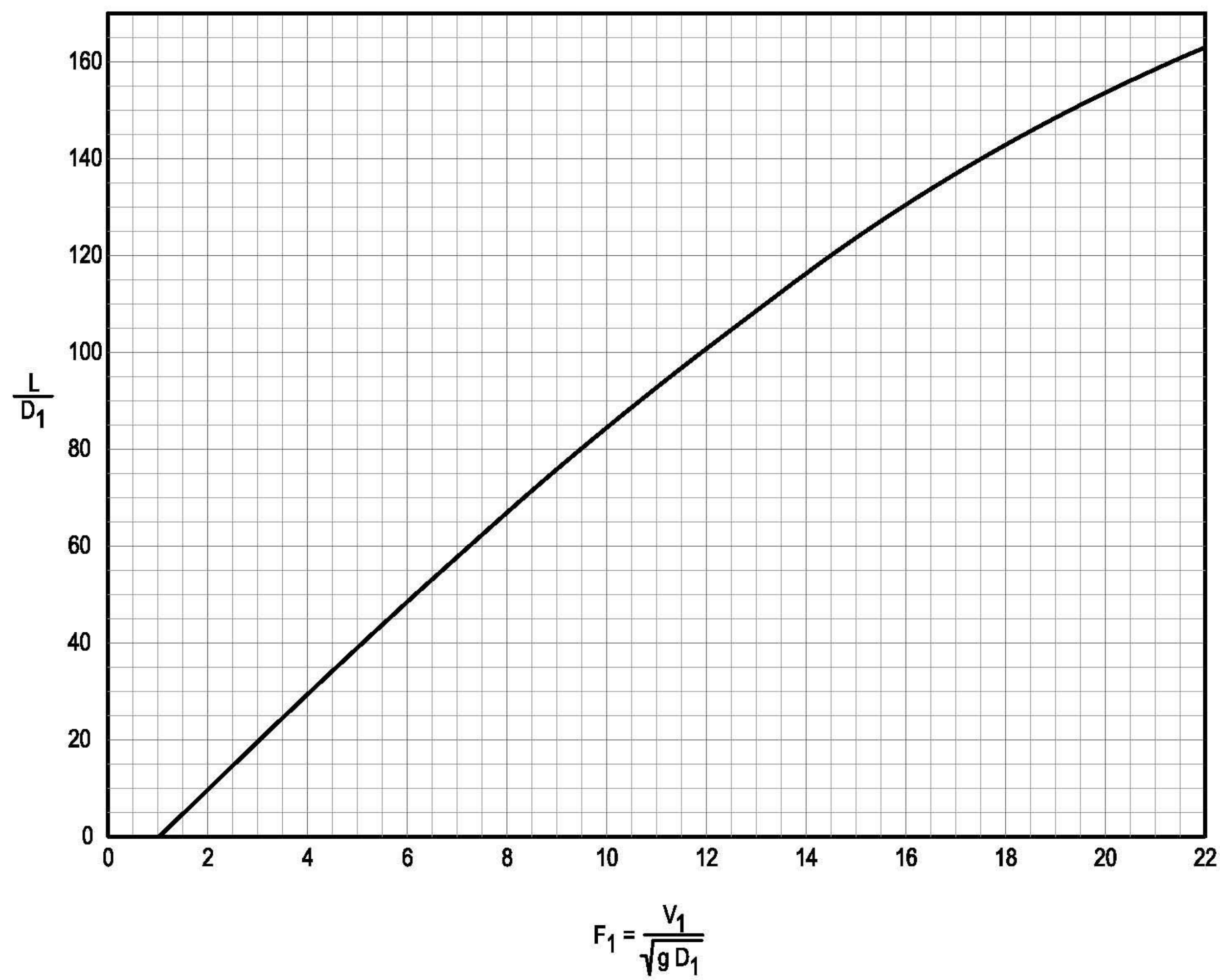


FIGURE 6. - LENGTH OF JUMP IN TERMS OF D_1 (BASIN I)

PLATE 22.3 E-2

3.4.F Berms and Levees

All levees and berms constructed for drainage or flood control purposes, and which are required to contain or convey 50 cfs or more in the event of the 100 year design discharge must conform to the following guidelines:

1. Cross Section
   a. Unarmored faces of berms and levees must have side slopes not steeper than 6:1 (horizontal to vertical).
   b. Rock graveled faces of berms and levees must have side slopes not steeper than 3:1 (horizontal to vertical).
   c. Concrete faced berms and levees will have side slopes of 2:1 (horizontal to vertical).
   d. Berms and levees less than 4.0 feet in height must have a minimum top width of 8.0 feet.
   e. Berms and levees 4.0 feet high and greater must have a minimum top width of 12.0 feet.
   f. All berms and levees must be provided with a structural keyway with bottom width equal to the top width and depth equal to at least one half the height, but not less than 3.0 feet and side slopes not steeper than 2:1 (horizontal to vertical).
2. Certification
   a. All levees and berms shall be inspected during construction and certified by a New Mexico Professional Engineer as to their substantial compliance to the plans and specifications. Certified as-built drawings, accompanied by daily inspection reports, shall also be provided.
3. Berm or Levee
   a. Any berm or levee whose purpose is to divert or convey runoff in a major arroyo shall be specially designed on a case-by-case basis and shall meet or exceed the guidelines listed herein.
4. Freeboard
   a. Berms and levees must be provided with freeboard for the 100-year design flow based on the following guidelines:
      i. For flow depths less than 3.0 feet and not involving a major arroyo; minimum freeboard is 2.0 feet.
      ii. For flow depths 3.0 feet and greater and, involving a major arroyo; minimum freeboard is 3.0 feet.
      iii. If the berm or levee structure is necessary to protect existing property or structures from a FEMA flood plain, FEMA criterion must be complied with in the design and construction of the structure.

5. Bank Protection

   a. All berms and levees expected to convey or divert 50 cfs or more in the event of the 100-year design discharge must be provided with bank protection according to the following guidelines:

      i. Bank protection must be provided wherever design velocities exceed 3 feet/sec.

      ii. Bank protection must be provided on the outside of curves from the beginning of curvature, through the curve and for a distance equal to 5 times the flow velocity in feet downstream from the point of tangency.

      iii. When required, bank protection must be provided to two feet above the design flow depth plus additional depth as required (e.g. superelevation, waves at confluences, hydraulic jumps, etc.).

      iv. Bank protection must extend downward on a projection of the bank slope, to a minimum depth equal to 1.5 times the design flow depth but never less than 3.0 feet. Bank protection for major arroyos shall be accompanied by a City Engineer approved sediment transport analysis.

         NOTE: Berms, dams, levees, and diversions of certain magnitudes and nature may fall within the jurisdiction of the Office of the State Engineer. The design professional is expected to be aware of and comply with regulations promulgated by that jurisdiction.

3.4.G Miscellaneous Hydraulic Calculations

3.4.G.I. HYDRAULIC JUMP

1. Location

   a. If the water surface from a downstream control is computed until critical depth is reached, and similarly the water surface from an upstream control is computed until critical depth is reached, a hydraulic jump will occur between these controls and the top of the jump will be located at the point where pressure plus momentum, calculated for upper and lower stages, are equal.

2. Length

   a. The length of a jump is defined as the distance between the point where roller turbulence begins and water becomes white and foamy due to air entrainment, and the point downstream where no return flow is observable.

      1. For rectangular channels, the length of jump (L) for the range of Froude Numbers between two and twenty, based on flow depth, is given by the following equation:

$$L = 6.9(D_2 - D_1)$$

Where D1 and D2 are the sequent depths.

2. For trapezoidal channels, the length of jump (L) is given by the following equation:

$$L = 5D_2\left(1 + 4\sqrt{\frac{t_2 - t_1}{t_1}}\right)$$

Where:
t_1 = width of water before jump
t_2 = width of water after jump

Side Slope	$L/(D_2-D_1)$
2:1	44.2
1:1	33.5
1/2:1	22.9
Vertical	6.9

3.4.G.II. TRASHRACK HEAD LOSS

The head loss through a trash rack is commonly determined from the following equation:

$$h_{TR} = K_{TR}(V_n/2g)$$

$$K_{TR} = 1.45 - 0.45\left(A_n/A_g\right) - \left(A_n/A_g\right)^2$$

Where:
K_{TR} = Trashrack coefficient
A_n = Net area through bars, in ft.^{2}
A_g = Gross area of trash rack and supports (water area without trash rack in place), in ft.^{2}
V_n = Average velocity through the rack openings (A/A_n), f.p.s.

For maximum head loss, assume that the rack is clogged, thereby reducing the value of A_n by 50%.

3.4.G.III. SIDE CHANNEL WEIRS

The Los Angeles District Corps of Engineers, as mentioned in Section 3.4.V.IV., has developed a side channel spillway inlet. The City may require this type of structure for drains outletting into their facilities. The Corps' procedure for designing a side channel spillway is as follows:

1. Set the top of that part of the main channel wall at the location of the proposed spillway about 6 inches above the computed water surface level in the main channel.

2. Determine the length of spillway (L) required to discharge the design inflow of the side inlet by the following equation, in which the maximum value of H is not greater than one and one-half feet.

$$L = \frac{Q}{CH^{\frac{3}{2}}}$$

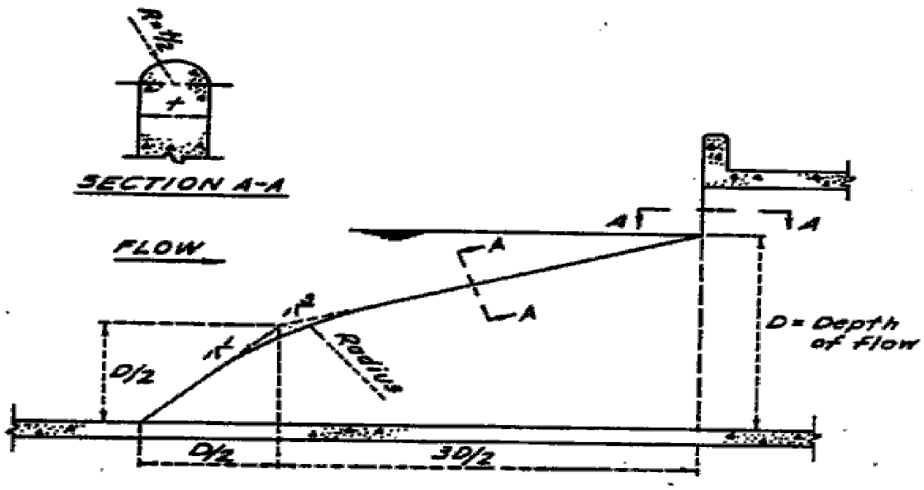
Where:
Q = discharge of side inlet, in c.f.s.
C = weir coefficient
H = depth of water over the crest of the side inlet in feet

3. Determine the depth of flow in the approach side channel at the upstream end of the spillway.
4. Set the side channel invert elevation at the upstream end of the spillway at an elevation below the spillway crest a distance equal to the water depth as determined in 3., above, minus the assumed head on the spillway.
5. Set the side channel invert slope equal to the spillway and the main channel water-surface slopes.
6. By trial, determine the width of the side channel required to maintain a constant depth of flow at several points downstream from the upstream end of the spillway. The discharge at each of these points is assumed to be the difference between the initial discharge less the amount spilled over that part of the spillway as computed by CLH3/2, in which C is 3.087 and H is equal to the critical depth over the crest (neglecting the velocity of approach).
7. Plot the widths thus determined for the side channel on the channel plan and approximate a straight or curved line through them to locate the point of intersection of this line and the main channel wall.
8. If the length between the assumed point at the upstream end of the spillway and this intersection point is equal to the length determined in b., above, the angle at the intersection indicates the required convergence for the side channel.
9. From the final layout determine the width and recompute the water surface in the side channel for the final design. The discharge over each portion of the spillway is calculated by using the average head between the two sections considered.

3.4.G.IV. PIER EXTENSIONS

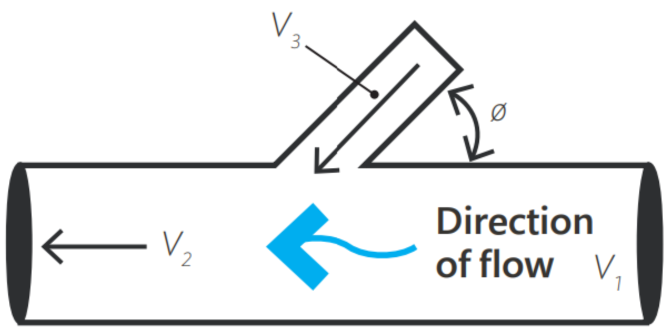
Pier extensions of a streamlined nature should be used when heavy debris flow is anticipated.

In supercritical flow the addition of a specified width to account for the assumed amount of debris may result in impractical and costly structures. In lieu of assuming additional pier width for debris, the use of streamline pier extensions should be investigated. Unless an unusual quantity of debris is anticipated, it can be assumed that the major portion of the debris will not cling to the pier extension. Pier extensions should be designed using the criteria indicated in the figure below.



THOMPSON EQUATION

The Thompson Equation for junctions is described by the following:



Where:

y = difference in hydraulic gradient for the two end sections, in feet,

A_{avg} = average area, in feet2 = 1/6 (A1 + 4Am + A2) or,

A_m = mean area of flow, in feet2

The above equation is applicable only to prismoidal and circular conduits or channels. The friction force may be considered negligible or can be calculated and taken into account. It is recommended that the Thompson equation not be used when an open channel changes side slope going through a junction.

For details of the above method, refer to Office Standard No. 115, Hydraulic Analysis of Junctions, 1968 edition, Storm Drain Design Division, Bureau of Engineering, City of Los Angeles.

In the following compilations:

1. "w", the unit weight of water, has been omitted since it appears in all terms.
2. The assumptions are made that the cosines of the invert slopes equal unity and that the tangents and sines of the friction slopes are equal.

The general equilibrium equation for all cases is:

$$P_2 + M_2 = P_1 + M_1 + M_3 \cos\ + P_i + P_w - P_f$$

Where:

P_1 = hydrostatic pressure on section 1
P_2 = hydrostatic pressure on section 2
P_i = horizontal component of hydrostatic pressure on invert
P_w = axial component of hydrostatic pressure on walls
P_f = retardation force of friction (S_1 and S_2 are friction slopes - see Kings Hdbk.)
M_1 = momentum of moving mass of water entering junction at section 1
M_2 = momentum of moving mass of water leaving junction of section 2
M = axial component of momentum of the moving mass of water entering the junction at section 3
P = $A\bar{y}$
$\bar{y}$ = distance to centroid from water surface
M = $\frac{Q^2}{s^A}$

3. Determination of Spillway Channel Widths

Using the spillway length determined above, the overflow spillway is laid out (see Plate 22.8 B-3) using widths determined by trial. Upon completing the layout, the spillway widths at 20-foot intervals are taken from the drawing and the outflow is checked.

See computation on Plate 22.8 B-3.

(Note all trials necessary to obtain the desired widths are not shown on the sample problem.)

3.4.G.IV.a.i.1. TYPICAL SIDE CHANNEL SPILLWAY INLET

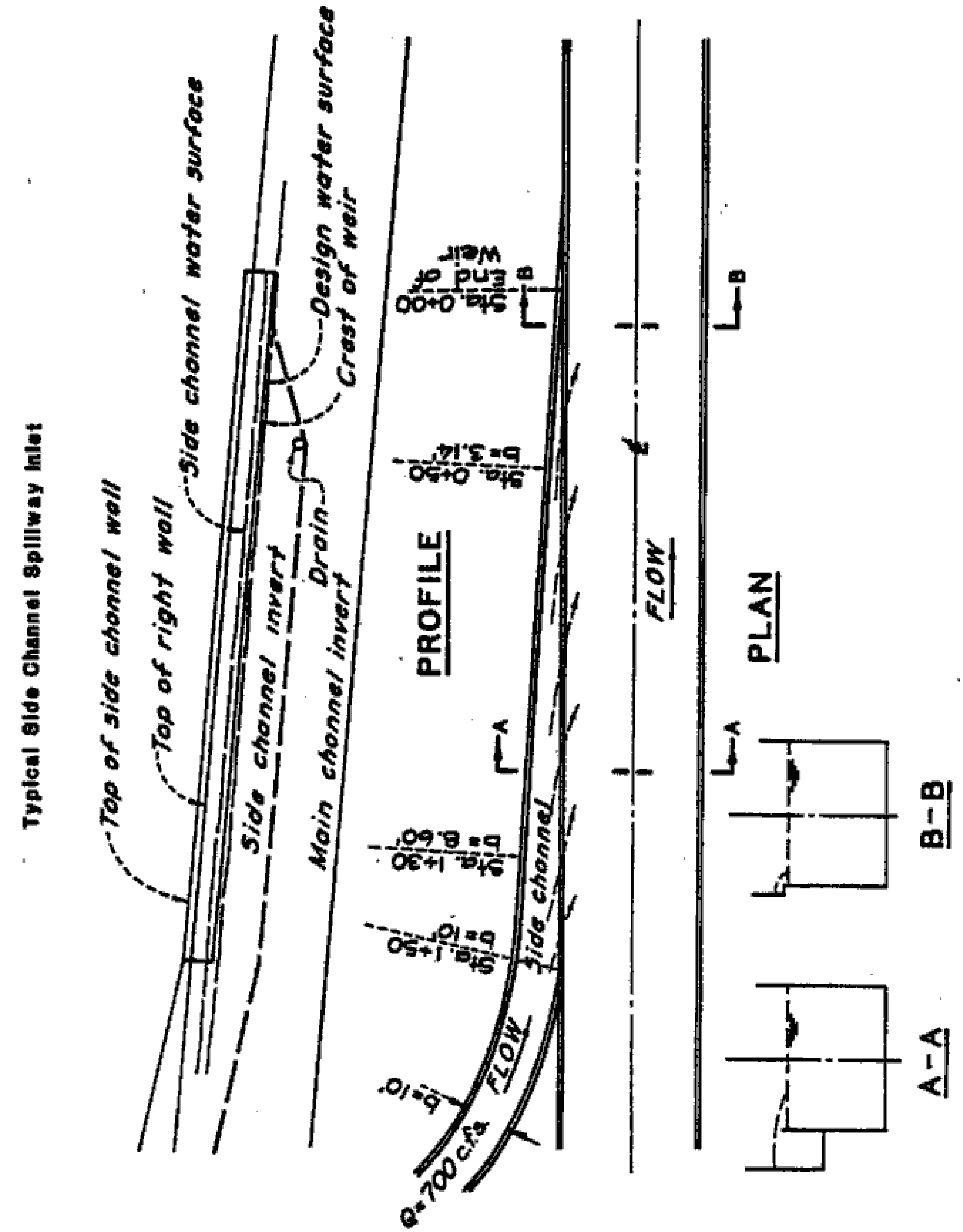


PLATE 22.8 B-3

SIDE CHANNEL SPILLWAY INLET CALCULATION SHEET

Q = 700 n = .014 S_o = INVERT SLOPE $S_f = \left(\frac{Q_a n}{1.486 A R^{2/3}}\right)^2$ d = DEPTH OF FLOW IN SIDE CHANNEL E.S. = $d + \frac{V^2}{2g}$ $\Delta E = \Delta L (S_o - S_f)$ H_w = HEAD ON WEIR

PROJECT SAMPLE PROBLEM
CALCULATED BY ___ DATE ___

STATION	SECTION	d	A	$\frac{V^2}{2g}$	E.S.	W.P.	$R^{4/3}$	S_f	S_o	$S_o - S_f$	ΔL	ΔE	CHECK E.S.	H_w	FLOW OUT $Q_f = C \Delta L H_w^{3/2}$	DESIRED Q_d	$Q_d \pm$	ACTUAL Q_a
									.0909									
1+80	b=10'	3.12	31.2	7.80	10.92	16.24		.01006					10.92	—	—	700		
1+50	b=10', 1.65'	3.12	31.2	7.80	10.92	14.74	1.65	.00644					10.92	1.30	—	700	—	700
								.01707	.01656	-.00051	20	-.01		1.30	114			
1+30	b=8.6', 1.62'	3.12	26.83	7.78	10.90	12.34	1.30	.0177					10.91			600	+14	586
								.01401	.01656	-.00255	20	-.05		1.43	106			
1+10	b=7.14', 1.49'	3.03	21.60	7.80	10.83	11.01	2.50	.01850					10.85			486	+6	480
								.00891	.01656	-.00035	20	-.01		1.30	92			
0+90	b=5.74', 1.42'	2.92	16.05	7.92	10.85	10.38	1.30	.00550					10.94			380	-8	388
								.00830	.01656	-.00874	20	-.18		1.28	90			
0+70	b=4.0', 1.41'	2.90	12.06	7.75	10.85	8.97	1.28	.02790					10.86			288	-10	298
								.03043	.01656	-.01348	20	-.30		1.27	89			
0+50	b=2.94', 1.42'	2.88	8.96	7.46	10.35	7.89	1.12	.0338					10.38			198	-11	209
									-.01040					1.27	221			
0+00	END OF WEIR															0	—	0

$Q = (3.087)(50)(1.27)^{3/2}$ (→ 221)

Q_f = FLOW OUT OF SIDE CHANNEL
Q_d = DESIRED FLOW IN SIDE CHANNEL
$Q_±$ = DIFFERENCE BETWEEN ACTUAL AND DESIRED FLOW IN SIDE CHANNEL
Q_a = ACTUAL FLOW IN SIDE CHANNEL

PLATE 22.8 B-4

SIDE CHANNEL SPILLWAY INLET CALCULATION SHEET

Q = 700 n = .014 S_o = INVERT SLOPE $S_f = \left(\frac{Q_n}{1.486AR^{2/3}}\right)^2$ d = DEPTH OF FLOW IN SIDE CHANNEL E.G. = $d + \frac{V^2}{2g}$ ΔE = ΔL ($S_o - S_f$) H_w = HEAD ON WEIR

PROJECT SAMPLE PROBLEM CALCULATED BY GJP DATE 6-1-73

STATION	SECTION	d	A	$\frac{V^2}{2g}$	E.G.	W.P.	$R^{4/3}$	S_f	S_o	$S_o - S_f$	ΔL	ΔE	CHECK E.G.	H_w	FLOW OUT $Q_1 = CΔLH_w^{3/2}$	DESIRED Q_2	Q_3 ±	ACTUAL Q_4
									.0000									
1+70	b=10'	3.12	31.2	7.90	11.02	16.24		.01000										
													10.92	—	—	700		
1+50	b=10', 1.00'	3.12	31.2	7.90	11.02	16.74	1.85	.01046										
													10.92	1.50	—	700	—	700
								.01707	.01500	−.00051	20	−.01		1.50	114			
1+30	b=9.0', 1.00'	3.12	28.08	7.70	10.80	15.24	1.50	.0177										
													10.91			600	+14	586
								.01461	.01636	−.00255	20	−.05		1.43	106			
1+10	b=7.16', 1.00'	3.00	21.00	7.00	10.83	11.81	2.30	.01632										
													10.83			400	+6	400
								.01691	.01536	−.00635	20	−.01		1.30	92			
0+90	b=5.36', 1.00'	2.92	15.60	7.83	10.85	10.36	1.37	.02350										
													10.84			300	−8	300
								.02030	.01636	−.00674	20	−.10		1.50	90			
0+70	b=4.0', 1.00'	2.80	12.80	7.73	10.53	8.97	1.50	.02710										
													10.66			200	−10	190
								.03046	.01656	−.01390	20	−.36		1.37	87			
0+50	b=2.0', 1.00'	2.35	3.08	7.46	10.38	7.85	1.13	.0358										
													10.38			199	−11	202
									−.01340					1.27	281			
0+30	END OF WEIR																	
										Q=(3.087)(30)(1.27)$^{3/2}$						0	—	0

Q_1 = FLOW OUT OF SIDE CHANNEL
Q_2 = DESIRED FLOW IN SIDE CHANNEL
Q_3 = DIFFERENCE BETWEEN ACTUAL AND DESIRED FLOW IN SIDE CHANNEL
Q_4 = ACTUAL FLOW IN SIDE CHANNEL

PLATE 22.8 B-5

n	$\frac{2gn^2}{2.21}$
.012	.00420
.013	.00492
.014	.00571
.015	.00656
.016	.00746

n	$\frac{2gn^2}{2.21}$
.020	.01166
.022	.01410
.025	.01821
.030	.02623
.035	.03570

WATER SURFACE COMPUTATION SHEET

Project____________________

Reach____________________

$S_f = \left[\frac{2gn^2}{2.21}\right] \frac{H_v}{R^{4/3}}$ or $\left[\frac{1}{K'}\right]^2 X^2$, S=Channel Slope, $E = D + H_v$

$H_v = \frac{V^2}{2g}$, $L = \frac{\Delta E}{S - S_{f_{av.}}}$

$X = \frac{Qn}{b^{8/3}} = \frac{Qn}{d^{8/3}}$ n=______ $\Delta E = L(S - S_{f_{av}})$

Sheet_____of_____

Calc._____Date_____

Check_____Date_____

Ref.__________

Station (L)	Invert Elev.	D	W.S. Elev.	Q	Section	Area	V	H_v (ΔH_v)	E.G. Elev.	w.p. D/b	R (1/K')²	$R^{4/3}$ X^2	S_f ($S_{f_{av.}}$)	S	$S - S_{f_{av.}}$	E (ΔE)	h_f	h_l	E.G. Elev.

PLATE 22.8 B-6

3.4.G.IV.a.i.5. SIDE CHANNEL SPILLWAY INLET CALCULATION SHEET

SIDE CHANNEL SPILLWAY INLET CALCULATION SHEET

$Q =$ ______ $n =$ ______

$S_o =$ INVERT SLOPE $S_f = \left(\frac{Q_s n}{1.486 A R^{2/3}}\right)^2$ $d =$ DEPTH OF FLOW IN SIDE CHANNEL $E.G. = d + \frac{V^2}{2g}$ $\Delta E = \Delta L\,(S_o - S_f)$ $H_w =$ HEAD ON WEIR

PROJECT ______
CACULATED BY ______ DATE ______

STATION	SECTION	d	A	$\frac{V^2}{2g}$	E.G.	W.P.	$R^{2/3}$	S_f	S_o	$S_o - S_f$	ΔL	ΔE	CHECK E.G.	H_w	FLOW OUT $Q = C\,\Delta L\,H_w^{3/2}$	DESIRED Q_d	$Q_s \pm$	ACTUAL Q_a

$Q_o =$ FLOW OUT OF SIDE CHANNEL
$Q_d =$ DESIRED FLOW IN SIDE CHANNEL
$Q_s =$ DIFFERENCE BETWEEN ACTUAL AND DESIRED FLOW IN SIDE CHANNEL
$Q_a =$ ACTUAL FLOW IN SIDE CHANNEL

PLATE 22.8 B-7

3.4.H Sediment Transport and Channel Stability

Moving water has the ability to transport sediment. The amount of sediment per unit of water that can be transported is related to flow depth, velocity, temperature, vertical and horizontal channel alignment, the amount of sediment available, the size and density of the sediment available and many other minor but sometimes important parameters. A channel's stability can be defined in terms of its ability to function properly during flood event without serious aggradation and/or degradation and that its continued operation can be relied upon without extraordinary maintenance and repairs. While channel stability problems are largely associated with earth and flexibly lined channels, concrete lined, supercritical channels are not immune. Any time a downstream channel reach has a lower sediment capacity than some upstream reach, there is a potential for sediment accumulation. The following worksheets can be used to make qualitative determinations with regard to channel stability.

Detailed qualitative analyses must be performed for any design requiring construction in a major arroyo.

3.4.H.I. CHANNEL STABILITY WORK SHEET INSTRUCTIONS

A stable earth-lined channel is defined for the purposes of design as one in which neither degradation or aggradation is occurring at such a rate that it causes a continuous and serious maintenance problem. Channel degradation can cause extensive damage to bridges and other crossing structures due to the undermining of their foundations. Channel aggradation on the other hand results in reduced channel and crossing structure capacities and, therefore, in increased frequency of flooding.

3.4.H.I.a. CHANNEL STABILITY WORK SHEET – A

The Proposed Development or Land Use Change Will Affect:	In the Following Way:		
	No Change	Increase	Decrease
Flow Rates			
Flow Velocities			
Flow Frequencies			
Flow Duration			
Flow Depth			
Sediment Reaching			
the Channel			
Sediment Particle Size			
Streambed Material Size			
Channel Vegetation			

3.4.H.I.b. CHANNEL STABILITY WORK SHEET – B

An Increase or Decrease In:	Will Have the Following Effect in the Channel	
	Increase	Decrease
Flow Rate…………………………………	Degradation	Aggradation
Flow…………………………………………	Degradation	Aggradation
Flow Frequency…………………………	Degradation	Aggradation
Flow Duration……………………………	Degradation	Aggradation
Flow Depth……………………………….	Degradation	Aggradation
Sediment Reaching the Channel ….	Degradation	Aggradation
Sediment Particle Size…………………	Degradation	Aggradation
Streambed Material Size …………….	Degradation	Aggradation
Channel Vegetation ……………………	Degradation	Aggradation

3.4.H.II. CHANNELS

1. Earthwork
   a. The following shall be compacted to at least 95% of maximum density as determined by ASTM D-1557 (modified Proctor):
      i. The 12 inches of subgrade immediately beneath concrete lining (both channel bottom and side slopes).
      ii. Top 12 inches of maintenance road. (either as subgrade or finished roadway if unsurfaced).
      iii. Top 12 inches of earth surface within 10 feet of concrete channel lip. It is particularly important to compact earth immediately adjacent to concrete lip. This area is sometimes overlooked when forms are removed.
      iv. All fill material.
2. Concrete
   a. All concrete channels shall be continuously reinforced.
   b. All exposed concrete drainage structures shall be tinted with San Diego Buff or a color approved by the City Engineer.
   c. Materials
      i. Cement type: ILA or I-IILA
      ii. Minimum cement content: 5.5 sacks/c.y.
      iii. Maximum water-cement ratio: 0.53 (6 gals. per sack)

iv. Maximum aggregate size: 1 ½ inches

v. Air content range: 4-7%

vi. Maximum slump: 3 inches

vii. Minimum compressive strength (fc): 3500 psi @ 28 days

viii. Class F Fly ash meeting the requirements of ASTM C618 shall be proportioned in the mix at a 1:4 ratio of fly ash to cement weight.

ix. Steel reinforcement shall be a minimum of grade 60 deformed bars. Wire mesh shall not be used, however welded wire mats are allowed.

d. Lining Section

i. Where appropriate, the City supports maintaining unlined channel bottoms as much as possible (in coordination with SSCAFCA Resolution 2022-05). When required, concrete lined channels must follow the following criteria.

(1) Bottom width - 10 feet minimum.

(2) Side Slopes - 1 vertical to 2 horizontal slope, or flatter.

(3) Concrete lining thickness.

(a) All concrete lining shall have a minimum thickness of 8 inches.
(b) The lining shall be thickened to 10 inches on the channel bottom and lower 18 inches of the side slope when design velocity exceeds 25 feet per second. This will provide an additional top two inches of sacrificial concrete. Steel placement shall be based upon the standard 8" thickness as measured from the bottom of the concrete lining.

(4) Concrete Finish

(a) The surface of the concrete lining shall be provided with a tined finish. Pneumatically applied "shotcrete" is an acceptable concrete lining alternative and does not require a tinned finish, but it must be preapproved by the City. Precautions shall be taken to guard against excessive working or wetting of finish.

(5) Concrete Curing

(a) All concrete shall be cured by the application of liquid membrane-forming curing compound (white pigmented) immediately upon completion of the concrete finish.

(6) Steps

(a) Ladder-type steps shall be installed at locations suitable for rescue operations along the channel but not farther than 700 ft. apart on both sides of the channel. Bottom rung shall be placed approximately 12 inches vertically above channel invert.

e. Joints

i. Insofar as feasible, channels shall be continuously reinforced without transverse joints. However, expansion joints may be installed where new concrete lining is connected to a rigid structure or to existing concrete lining which is not continuously reinforced.

ii. The preferred design avoids longitudinal joints. However, if included, longitudinal joints should be on side slope at least one foot vertically above channel invert.

iii. All joints shall be designed to prevent differential displacement and shall be watertight.

iv. joints are required at the end of a day's run, where lining thickness changes.

f. Reinforcing Steel for Continuously Reinforced Channels.

i. Ratio of longitudinal steel area to concrete area not including additional thickness of sacrificial concrete.

$$A_{s\,long} \;/\; A_{c\,long.} \geq .005$$

(a)

ii. Ratio of transverse steel area to concrete area not including additional thickness of sacrificial concrete.

$$A_{s\,transv.} \;/\; A_{c\,transv.} \geq .0025$$

Note: In (a) and (b) above As = crossectional area of steel in the direction indicated; Ac = crossectional area of concrete in the direction indicated. Longitudinal = long.; transverse = transv.

ii. Steel Placement: Temperature and shrinkage steel shall be placed so as to be in the top of the middle third of the slab, but at least 3" from the bottom of the slab. Longitudinal steel shall be on tip of the transverse steel. (NOTE: Inspectors must insure this requirement is not violated by contractors during pouring operations.)

3.4.H.III. EARTHWORK FOR LEVEES AND BERMS

All earthfill berms and levees shall be constructed of high-quality fill material free of debris, organic matter, frozen matter and stone larger than 6 inches in any dimension. The key trench shall be scarified to a depth of 6 inches to ensure bonding with the fill material. Lifts shall not exceed 12 inches of loose material before compaction. The material in each lift shall contain optimum moisture content (-1% to +3%) and shall be compacted to at least 90% and not more than 95% of maximum density as determined by ASTM D 1557 or as recommended by a geotechnical engineer and accepted by the City Engineer. Proper bonding between lifts shall be guaranteed by scarifying each lift after compaction to a depth of at least 3 inches.

Levees and berms intended to provide flood protection for properties and structures shall comply with all FEMA requirements for removal from a 100-year floodplain. A minimum 3' freeboard above the high-water elevation is required on all levees and berms.

3.5 Channel Treatment Selection Guidelines

3.5.A General

The selection of a treatment type or of a combination of treatment types for a channel within the City area should be based on an assessment of the needs of the community as they relate to:

- System Failure.
- Safety.
- Safety System Impacts.
- Adjacent Treatment Types.
- Operation and Maintenance.
- Initial Costs and Life Expectancy.
- Costs Including ROW.
- Joint use Possibilities.
- Water Quality Impacts.

These items are briefly described below:

3.5.B Flood Control

The magnitude of the flood control requirements and the consequences of a system failure should be considered foremost in the treatment selection process.

3.5.C Drainage

The existing and future land uses, the specific on- and off-site drainage treatments, and watershed topography should each be evaluated in terms of their impacts on the channel system. The unmitigated hydrologic effects of urbanization generally include higher peak runoff rates from smaller, more frequent storms, cleaner runoff (with respect to sediment), and increased annual runoff volumes.

3.5.D Maintenance

The selection of a channel treatment type should include analyses of both short- and long-term maintenance. While maintenance efforts will vary between treatment types, all facilities should be able to function through one runoff event with no maintenance, through one flood season with very little maintenance and from season to season with regular, but minimal maintenance requirements.

3.5.E Rights-of-Way and Easements

The cost of land and the availability of rights-of-way or easements should be considered in the channel treatment selection process. Rights-of-way and easements should be appropriately located, aligned and sized for the particular treatment type. Some treatment types may require significant construction easements, but much smaller permanent rights-of-way or easements. The likelihood of replacement or reconstruction should be considered when channel treatment selection is balanced against the configuration of permanent rights-of-way and easements.

3.5.F Safety

The selection of a channel treatment type should be based on any special safety considerations dictated by adjacent or nearby land uses. Whenever a required channel treatment is not compatible with adjacent land uses, adequate safety hazard mitigation measures should be incorporated into the design and construction of the facilities. Channels with vertical walls of 30 inches or greater will require a barrier or fence. Minimum fence or barrier height shall be 42 inches.

3.5.G Upstream and Downstream Channel Treatments

The treatment selection process for each channel reach should include an analysis of the impacts of existing and planned upstream and downstream treatment types on a proposed treatment type and, in turn, the effects of the proposed treatment on existing and planned upstream and downstream treatments.

3.5.H Initial Cost and Life Expectancy

The initial construction costs of various channel treatment types are and will always be one of the more heavily weighted factors in the selection process. However, when viewed on a larger scale, maintenance and replacement costs can be more important to the total costs of providing adequate levels of protection over time, and therefore must be considered in the planning, design and construction of channel treatment measures.

3.5.I Joint Use Possibilities

The opportunities for including other uses such as transportation and utility corridors, open space or recreation in the design should be considered when selecting a treatment type and when establishing rights-of-way and easements. The inclusion of any other uses must be self-supporting financially and in no way impair or delay the implementation of the drainage and flood control function of the facilities. Operations and Maintenance of these joint use facilities must also be considered. SSCAFCA will only operate and maintain regional drainage and flood control facilities in accordance with their current policies.

3.6 Design Grading and Erosion Control

3.6.A Slope Criteria

Earthen slopes shall confirm to the following:

Maximum slope should not be steeper than 6:1 (horizontal to vertical) unless protected from erosion and slope failure through City Engineer approved means.

3.6.B Grading near the Property Line

Particular attention must be given to grading (either cut or fill) near property lines. Care should be taken to ensure that existing foundations, retaining walls, stable slopes or other structures are not endangered and that the adjacent property is not or will not be damaged, or its use constrained due to grading at or near the property line. Grading must accommodate runoff onto the site and ensure discharge to the historic drainage location at or below the historic flow rates, unless an alternative is approved by the City Engineer in writing.

3.6.C Grading In and Adjacent to Major Facilities

No grading, excavation, or fill may take place in or adjacent to any watercourse defined as a major facility without express written approval from the City Engineer. Construction activities within major facilities shall provide for the safe passage of the 100-year design flow especially during the months of June, July, August and September. Construction activities in arroyos shall provide procedures and install systems that ensure the safety of the public and personnel from runoff events. Particular attention shall be given to potential runoff from flash floods occurring upstream of the facility.

3.6.D Floodplain Development

No floodplain development will be permitted within a FEMA Special Flood Hazard Area (A or V zone designations) without an approved drainage report and financial guarantees for the permanent improvements. Development of critical facilities within a FEMA recognized 500 year floodplain must be designed and constructed in such a manner as to protect the critical facility from a 500 year event.

3.6.E Violations as to Construction Or Site Alteration

No grading or other alteration of a site shall take place:

1. Prior to approval of an infrastructure list/preliminary plat, building permit or development plan by the City, if the grading or site alteration is related to a proposed subdivision.
2. Prior to approval of a drainage plan or report, or a determination by the City Engineer/ that no such plan or report is required.
3. Contrary to the provisions of a drainage plan or drainage report or to the specifications of a preliminary or final plat, approved under the provisions of this section.
4. Prior to the submittal of a construction schedule for the proposed drainage infrastructure improvements/grading.
5. Prior to the issuance of any permits required pursuant to this section.
6. Prior to submittal of financial guarantees required by the City.
7. Prior to:
    a. Submittals and review of Storm Water Pollution Prevention Plan
    b. Filing and activation of Environmental Protection Agency Notice of Intent
    c. Installation of Best Management Practices per Storm Water Pollution Prevention Plan

d. USACE 404 permit approval, if required.

3.6.F Erosion and Stormwater Pollution Control

All grading within the City of Rio Rancho must be performed in a manner which prevents the movement of significant and damaging amounts of sediment onto adjacent property and public facilities by both water and wind, and minimizes the impacts to stormwater runoff quality. Every project involving the grading of more than 1.0 acre or the importation or excavation of more than 500 cubic yards of soil must be accompanied by an erosion control plan accepted by the City Engineer. All grading shall conform with EPA Stormwater Regulations. See Chapter 2.10.Q for detailed information on the Stormwater Pollution Prevention Plan. All required stormwater pollution improvements/drainage infrastructures must be constructed at the start of the project.

1. Construction Phase:

It is the responsibility of the contractor to implement the erosion and stormwater pollution control plans during the construction phase. Repair of damaged facilities and clean-up of sediment accumulations on adjacent property and in public facilities is the responsibility of the contractor. Failure to do so promptly may result in a "stop-work order" being issued that will remain in force until repair and clean-up is completed to City Engineer satisfaction. All exposed earth surfaces must be protected from wind and water erosion prior to final acceptance of any project. The continued maintenance of these protective measures is the responsibility of the owner or his assigns. Penalties will be assessed for graded sites left inactive for fourteen (14) days or more as provided for in the City's Drainage Ordinance.

2. Phased Construction:

Areas graded in conjunction with phased projects, but not left in their permanent condition must be protected during the interim from wind and water erosion and must not increase stormwater pollution from the existing pre-project conditions per City policies.

3.6.G Means of Erosion Control

There are numerous mechanical and vegetative methods for preventing soil erosion. The U.S. Environmental Protection Agency Publication EPA-R2-72-OIS Guidelines for Erosion and Sediment Control Planning and Implementation, New Mexico Department of Transportation Manual and the local U.S.D.A. Natural Resource Conservation Service Office can provide numerous, inexpensive and effective erosion management techniques.

1. The soils in the City's jurisdiction are highly erosive requiring special attention during the design, construction and post construction phases of development.
2. Methodology
    a. The SSCAFCA Erosion and Sediment Design Guide will be the basis for analysis and evaluation of erosion control, sediment transport, sediment deposition and related issues.
3. Erosion and Sediment Generation

   a. Erosion, both on-site, off-site and from natural arroyos and channels shall be considered and incorporated in the analysis, evaluation and design of site development. The volume of sediment in the off-site flow, determined from the sediment bulking factors as defined in the hydrologic analysis procedures in section 3.4, will be the minimum volume of sediment generation considered in evaluating downstream capacity.

4. Sediment Transport

   a. Sediment generation, transport and deposition shall be considered in the drainage and flood control system analysis and design and in determining downstream capacity.

3.6.H Pond/Dam Design

1. Detention Ponds: Detention ponds shall not be constructed in public street rights-of-way. Discharge from the detention pond(s) shall be conveyed to public infrastructure capable of containing the release. Such infrastructure may be streets and channels. The means of conveyance to the public infrastructure shall be approved by the City. If flows may be conveyed by pipes smaller than 24" then 24" pipe shall be used with an appropriately sized orifice plate. Detention ponds shall be sized to provide a storage capacity for the 100 year 24 hour storm plus 1 foot of freeboard and to empty within 24 hours. Percolation and evaporation may only be considered if supported by calculations and data for the specific location of the pond. Regional soil data will not be accepted.

2. Retention Ponds: Retention ponds are not generally allowed. Retention ponds must be approved by the City Engineer. If retention ponds are approved by the City Engineer they shall not be constructed in public street rights-of-way. Retention ponds shall be sized to provide storage capacity for twice the volume of the 100 year 24 hour storm plus 1 foot of freeboard. A maintenance plan shall be provided to and approved by the City Engineer. The plan shall contain at a minimum:

   a. Treatment procedures for water that remains in the pond for more than 24 hours.

   b. Names and telephone numbers for contacts responsible for the treatment and maintenance of the pond.

   c. Time frame for the existence of the retention pond.

3. At the City Engineers discretion, retention ponds may be required to have a maintenance financial guarantee.

4. Individual on Lot Ponds: Individual on lot ponds are not allowed in "planned subdivisions" even if such planned subdivisions are using existing (premature) platting. For the purpose of this ordinance a planned subdivision is defined to mean: Any area of land within the jurisdiction of the City that has either previously been divided or will be divided in accordance with an approved plan. For previously divided land it shall either be owned by a single entity or advertised or sold under a common promotional plan. NMSA 1978 (Supp. 1981) section 47-6-2(K).

5. Access: Access into a facility shall be opposite the outlet if possible with a minimum width of 12 feet. Maximum access slope shall be 10:1 or flatter. Standard design tube or pipe gates shall be installed to restrict vehicle access. Gates shall be set back 50 feet from arterial or collector streets so equipment does not have to park in the street.

6. Spillways: Principal spillways shall be designed, at a minimum, for the 100 year fully developed condition and shall always be provided, be erosion resistant, and discharge to a public right-of-way, drainage easement and/or historic flow path.
   a. Emergency spillways for ponds shall be designed, at a minimum, for the 500-year storm event for fully developed conditions and discharge to a public right-of-way, drainage easement and/or historic flow path.
   b. Emergency spillways for dams shall be designed, at a minimum, to meet the Office of the State Engineer criteria and discharge to a public right-of-way, drainage easement and/or historic flow path.
7. Outlets:
   a. Facility outlets shall always be gravity flow whenever feasible and located in a corner or accessible edge of facility, opposite of facility access point if possible. Outlet pipe shall be a minimum of 24 inches in diameter with a slope such that when flowing at ¼ full, velocity is 2 fps or greater.
   b. The outlet will be surrounded by a stabilized grade pad appropriately sized for maintenance with a minimum of 6 feet of stabilized grade in all directions.
   c. To protect downstream properties, outlets may be sized to restrict flows below historic or existing conditions at the sole discretion of the City Engineer.
8. Pond Bottoms:
   a. Facility bottoms shall be designed to convey nuisance flows from the inlet to a storm water pollution prevention feature (such as a pervious bottom area for infiltration) prior to discharging to the outlet. Ease of maintenance shall be a consideration in all dams/detention basins. A feature such as a low flow channel having minimum dimensions of 3' wide by 8" thick, structurally reinforced concrete with a 1" invert shall be considered to allow maintenance crews a non-saturated, hardened surface to perform maintenance and provide a grade check in the bottom of the basin. Special care should be given to ensure that the channel is not under-cut. Each dam/detention basin should be evaluated with regard to such features as ease of maintenance, water quality, desirability of vegetation and habitat, effect on neighborhoods (odors, mosquitoes, vectors), stability/safety of the foundation and embankment, well wash water and possible recharge.
   b. The minimum pond bottom slope is 0.5%, both cross slope and longitudinally.
9. Side Slope and Bottom Treatments:
   a. Vegetation will be accepted if seeded per the New Mexico APWA Standard Specifications for Public Works Construction, most recent edition.
   b. Side slopes shall be treated with gravel mulch per New Mexico APWA Standards Specifications for Public Works Construction, most recent edition.
   c. A geotechnical investigation and report will be required.
10. Minimum Pond Size: In order for a pond to be publicly maintained by the City, it must be a minimum of two (2) acre-feet.

11. Fencing: Detention ponds will require five (5) strand barbless wire fencing with wooden posts in accordance with the City Standard Details.

12. Drainage: All detention ponds must be evacuated in twenty-four (24) hours or less, unless discharge is limited by downstream constraints. In any event, all ponds shall be evacuated within 96 hours unless approvals are received from both the City and the Office of the State Engineer. Ponds that take more than six (6) hours to drain will be designed for a design storm equal to or exceeding the evacuation time. No percolation credit for volume reduction will be given.

13. Signage: All ponds shall have a sign fixed to the fence, in the vicinity of the access gate and visible to the public, that designates the name of the facility and the agency or organization responsible for maintaining the pond. The sign location and sign face shall be included in the infrastructure plans.

14. Freeboard: All ponds shall have a minimum of one (1') foot of freeboard above the 100-year, 24-hour period.

15. In-Pond Sediment Storage: An evaluation shall be performed to ensure sufficient in pond storage of sediment deposited during a 100-year event will not affect the functional capability of the structure.

16. Sediment Stock Pile and Transport Provision: An evaluation shall be performed to how sediment and debris shall be removed from the facility and transported offsite.

3.6.I Temporary Ponds

1. Interim or temporary facilities shall be protected by a covenant. These covenants may cover a tract of land larger than needed for the final permanent facility in lieu of financial guarantees.

2. An emergency spillway must be provided that will safely convey the 100 year design flow entering the pond.

3. Temporary ponding may be allowed if the owner performs all operations and maintenance, accepts all liability and owns the downstream property. City approval is required.

3.6.J Private Storm Drain Improvements Within Public Rights-of-Way and/or Easement.

Frequently a grading and drainage plan developed for a particular property involves either discharge directly into a public facility or across a portion of a public right-of-way to a public facility. Examples include connections to the back of an existing storm inlet, construction of sidewalk culverts or a connection to a storm drain manhole or a channel. When such solutions are employed the construction of private storm drain improvements within the City's rights-of-way must comply with the following requirements:

1. Professional Engineer's stamp with signature and date.

2. Vicinity map.

3. North Arrow.

4. Plan drawings size 24"x36".

5. Address of the project.

6. Detail of the proposed improvements:
    a. All work details on these plans to be performed, except as otherwise stated or provided hereon, shall be constructed in agreement with the New Mexico APWA Standard Specifications for Public Works Construction.
7. An excavation permit will be required before beginning any work within City of Rio Rancho City's right-of-way. An approved copy of these plans must accompany the application for permit.
8. Two working days prior to any excavation, contractor must contact Line Locating Services for location of existing utilities.
9. Backfill compaction shall be according to City Standards.
10. Maintenance of these facilities shall be the responsibility of the owner of the property served. Include this maintenance note on the plan.
11. A signature block for approval by either the City Engineer.
12. A signature block for approval by either the City Engineer's inspector.

Note #1: If the proposed improvements are part of a building permit application, this information can be incorporated on the appropriate drainage submittal.

Note #2: Private Storm Drain Improvements within City's ROW is not allowed without City's approval.

3.7 Rights-Of-Way And Easements

3.7.A Rights-of-Way

Projects on/with SSCAFCA owned and/or maintained facilities must have an agreement in place with SSCAFCA.

Land necessary for permanent drainage, flood control or erosion control facilities or major arroyos that the City will ultimately maintain/control, must be dedicated fee simple to operation and maintenance.

3.7.A.I. DEDICATION LANGUAGE

The real estate shown and described in this plat is surveyed with the free consent of and in accordance with the wishes and desires of the undersigned Owner(s) thereof, and the Owner(s) of such real estate do hereby dedicate all drainage rights-of-way which are shown hereon including parcels _________ to [insert name of the entity], a political subdivision of the State of New Mexico, in fee simple with warranty covenants. Subject to the easements shown or noted hereon, and do hereby grant any and all easements shown or noted on the plat including the right of ingress and egress.

3.7.B Easements

Projects on/with SSCAFCA owned and/or maintained facilities must have an agreement in place with SSCAFCA.

Easements for drainage, flood control and erosion control facilities are acceptable in rare, special occasions as long as a clear written and approved agreement exists as to other acceptable uses and no permanent facilities are constructed within them (including masonry fences and retaining walls but excluding pavement) without an agreement between the owner and the City governing the permitted uses. High hazard structures can only be constructed on publicly owned property.

3.7.C Configuration

Rights-of-way and permanent easements required for drainage, flood control and erosion control facilities will conform to the following criteria:

3.7.C.I. SURFACE FACILITIES

The dedicated area shall contain the entire facility including any slopes, maintenance roads, turn arounds or other necessary appurtenances, and may not be less than 10 feet wide.

3.7.C.II. UNDERGROUND FACILITIES

Dedicated areas for underground facilities may be not narrower than 20 feet for any facility defined as a major facility and must conform to the formula:

$$W = 2 \cdot D_i + pipe\ diameter\ +\ 4 feet$$

Where:
W = dedicated width in feet
Di = depth to invert

For box conduits or arch pipes use the inside vertical dimension rather than inside pipe diameter.

Pipe should be installed within the easement to allow for stockpiling of material.

3.7.D Designation Language

3.7.D.I. DRAINAGE FACILITIES AND/OR DETENTION AREAS MAINTAINED BY LOT OWNER

Areas designated on the accompanying plat as “drainage easement” [“detention areas”] are hereby dedicated by the owner as a perpetual easement for the common use and benefit of the various lots within the subdivisions for the purpose of permitting the conveyance of storm water runoff and the constructing* and maintaining of drainage facilities [storm water detention facilities] in accordance with standards prescribed by the City of Rio Rancho. ** No fence, wall, planting, building or other obstruction may be placed or maintained in said easement area without approval of the City Engineer, and there shall be no alteration of the grades or contours in said easements area without the approval of said City Engineer. It shall be the duty of the lot owners of this subdivision to maintain said drainage easement [detention area] and facilities at their cost in accordance with standards prescribed by the City. The City shall have the right to enter periodically to inspect the facilities. In the event said lot owners should fail to adequately and properly maintain said drainage easement [detention area] and facilities, at any time following fifteen (15) days written notice to said lot owners, the City may enter upon said area, perform said maintenance, and the cost of performing said maintenance shall be paid by said lot owners proportionately on the basis of lot ownership. In the event said lot owners fail to pay the cost of said maintenance or any part thereof within thirty (30) days after demand for payment made by the City, the City may file a lien therefor against all lots in the subdivision for which proportionate payment has not been made. The obligations imposed herein shall be binding upon the owner, his heirs, and assigns and shall run with all lots within this subdivision.

The Grantor agrees to defend, indemnify, and hold harmless, the City, its officials, agents and employees from and against any and all claims, actions, suits, or proceedings of any kind brought against said parties for or on account of any matter arising from the drainage facility provided for herein or the Grantor's failure to construct, maintain, or modify said drainage facility.

*This assumes owner's promise to construct will be imposed by a separate agreement.
** [Possible alternative:] Grantor shall construct drainage [detention] facilities in the easement in accordance with standards prescribed by the City and plans and specifications approved by the City Engineer in accordance with the drainage report entitled ________________________, submitted by ____________________ on, _______________________ and approved by the City on _________________, together with the amendments approved on ________________, which report and amendments are on file in the office the City Engineer.

3.7.D.II. DEDICATION OF DRAINAGE EASEMENTS: OWNER CONSTRUCTS AND MAINTAINS

A perpetual easement on the areas designated on this plat as "drainage easement" ["detention area"] is here by dedicated to the City of Rio Rancho for the purpose of permitting the conveyance of storm water runoff and for the purpose of constructing, maintaining, operating, removing, and replacing storm water drainage facilities [detention facilities]. No fence, wall, planting, building, or other obstruction may be placed or maintained in said easement area and there shall be no alteration of the grades or contours in said dedicated area without the approval of said City Engineer. No obstructions may be placed in said easement area which would prevent ingress and egress to same by maintenance vehicles or which would prevent said vehicles traveling on said drainage way for maintenance purposes.

*The City could require dedication of this property in fee simple since the City here will be responsible for maintenance. The beginning of the first sentence could read: "the areas designated on this plat as 'drainage facilities' are hereby dedicated to the City of Rio Rancho in fee simple for the purpose of ____." We might then add: "the City may use the property hereby dedicated for other public purposes."

3.7.D.III. GRANT OF DRAINAGE EASEMENT

This easement grant is made and executed this _________ day of _________________________

20___, by and between ____, hereinafter

called the "Grantor" and the City of Rio Rancho, New Mexico, a municipal corporation, hereinafter call the "City"

1. The Grantor is the owner of the following described real property within the City of Rio Rancho:

2. * For Good and valuable consideration, the receipt of which is hereby acknowledged, Grantor does hereby grant and deliver to the City of Rio Rancho a perpetual easement over and across a portion of Grantor's property for the purpose of permitting the flow, conveyance, and discharge of storm water runoff. [For the purpose of constructing and maintaining a storm water detention facility].

3. The land affected by the grant of this easement and right-of-way is more particularly described as follows:

4. ** Grantor shall construct drainage [detention] facilities in the easement in accordance with standards prescribed by the City and plans and specifications approved by the City Engineer.

5. The easement and any drainage facilities constructed thereon shall be maintained by the Grantor, at his cost, in accordance with standards prescribed by the City. The City shall have the right to enter periodically upon the premises to inspect the drainage facilities.

===================================

* [Alternative purpose:] Storm water detention

** [Possible alternative:] Grantor shall construct drainage detention] facilities in the easement in accordance with standards prescribed by the City and plans and specifications approved by the City Engineer in accordance with the drainage report entitled __________________, submitted by _____________________ on __________, and approved by the City Engineer on _______________ together with the amendments approved on ______________, which report and amendments are on file in the office of the City Engineer.

6. In the event that the Grantor should fail to construct the drainage facilities contemplated here in or fail to adequately and property maintain the easement and any facilities constructed thereon, the City of Rio Rancho or its agents, at any time following fifteen (15) days written notice to the owner of record of said property, may enter upon said property to perform necessary construction or maintenance. The cost of performing such construction or maintenance shall be paid by the property owner. In the event the property owner fails to pay the costs of such construction or maintenance within thirty (30) days after being notified in writing of the cost of same, the City may file a lien therefore against the real property described in paragraph 1.

7. No fence, wall, planting, building or other obstruction may be placed or maintained in the easement without the written approval of the City Engineer of the City of Rio Rancho and there shall be no alteration of the grades or contours in said easement after drainage facilities are constructed without the written approval of the Rio Rancho City Engineer. Any violation of this provision will be promptly corrected upon receipt of notice from the City, or the City shall have the right to remove or otherwise eliminate such violation and assess the cost to the property owner as provided in paragraph 6 above.

8. Said easement is intended to be permanent in nature for the uses and purposes recited above to the City, it's successors and assigns, until such time as the City releases said easement in writing.

9. The obligation of the Grantor set forth herein shall be binding upon the Grantor, his heirs, and assigns and the property of the Grantor as described herein and will run with said property until released by the City.

10. The City shall not be liable for any damages to the Grantor resulting from its construction, modification, or maintenance of said facilities.

    The Grantor agrees to defend, indemnify, and hold harmless, the City, its officials, agents and employees from and against any and all claims, actions, suits, or proceedings of any kind brought against said parties for or on account of any matter arising from the drainage facility provided for herein or the Grantor's failure to construct, maintain, or modify the drainage facility under this covenant.

11. The written notice provided for herein shall be accomplished by mailing same to:______

12. The Grantor may change said address by written notice, certified mail, return receipt requested to the City Engineer, 3200 Civic Center Circle, Rio Rancho, New Mexico 87144.

    IN WITNESS WHEREOF, the parties have set their hands and seals this ____________ day of _______________________ 20______.

GRANTOR
By: _________________________
Title: ________________________

REVIEWED BY THE CITY OF RIO RANCHO LEGAL DEPARTMENT

________________________________ ______________________________
City Manager

ACKNOWLEDGMENTS
STATE OF NEW MEXICO)
) SS.
COUNTY OF SANDOVAL)

The foregoing instrument was acknowledged before me this ____ day of ____________, 20____, by ____.
(Name of Grantor)

____
Notary Public

My Commission Expires:

IN WITNESS WHEREOF, the parties have set their hands and seals this
_____________ day of _________________________ 20______.

GRANTOR

By: ___________________________

Title: __________________________

3.7.E Drainage Right-of-Way Access

All newly constructed drainage facilities within a public right-of-way must have restricted access control to prevent unauthorized vehicular access with Pipe or Tube Gate.

3.8 Miscellaneous

3.8.A Maintenance Standards

3.8.A.I. GENERAL

All private drainage control, flood control and erosion control facilities shall be regularly inspected and maintained. Accumulations of silt, trash, litter or stagnant water which create a health or safety hazard or which endanger the design function of the facility are not permitted. Excessive growth or accumulation of woody vegetation in channels and on dams and levees shall not be permitted. Active erosion due to wind or water associated with drainage control, flood control and erosion control facilities shall not be permitted.

All newly constructed drainage facilities within a public right-of-way must provide restricted access to prevent unauthorized vehicular access. Restricted and authorized access shall be provided with City Standard Tube Gate.

3.8.A.II. PRIVATELY MAINTAINED FACILITIES

Privately maintained facilities must be maintained to ensure functional operation. The City reserves the right to inspect privately maintained facilities, as necessary, to ensure facilities will operate as expected and necessary during storm events.

The private owner shall regularly maintain, make available upon request, and keep written records of all maintenance activities for drainage control, flood control and erosion control facilities for which it has responsibility based on the above general requirements and the following schedule:

Facility	Maintenance	Inspection
Channels	Monthly June-October	Semi-Annual
Channel Joints	Monthly June-October	Semi-Annual
Crossing Structures	Monthly June-October	Semi-Annual
Pump Stations	Monthly June-October	Semi-Annual
Detention Facilities	Silt removal and weed control	After any major operation or monthly during flood season
Storm Pump	Periodic cycling	Semi-Annually in April and October
	Vibration analysis	3-5 Years

Storm Drain Systems	Annual	Bi-Annual
Storm Drain Inlets	On-going process	Semi-Annual during flood season

Every facility shall be inspected by the owner and qualified engineer after ½" of rain to ensure the facility features are functioning as designed.

Privately owned drainage control, flood control, water quality, and erosion control facilities shall be maintained according to the general standards above and such that adjacent upstream or downstream public or private facilities are not damaged or endangered. A sign must be erected adjacent to the facility indicating the private maintenance responsibility. The sign must be prominently located and must include the name and telephone number of the party responsible for the maintenance.

3.8.B Multiple Use of Rights-of way and Easements Criteria

Multiple uses are encouraged for drainage rights-of-way and drainage easements including, but not limited to, utility corridors, wildlife habitat, open space and recreation trails. Where multiple uses are planned by the city, another public agency, or a public utility, the city may require that dedication statements include language which permits said specified multiple uses and Watershed Management Parks amenities in addition to the primary drainage function. Land required to be dedicated for drainage rights-of-way shall include those land areas necessary for drainage control, flood control, erosion control, Watershed Management Park amenities, recreation trails, sanitary sewer corridors and necessary appurtenances. The following is the criteria for the subject encroachment:

To determine the feasibility of installing underground utilities in an existing drainage way or arroyo, consultation with the underlying land owner is required.

Visit the SSCAFCA's Resources Website. The utility line shall be designed and constructed to reduce the failure potential to the maximum extent practicable. Design, permitting, construction, operation and maintenance of utility lines are the responsibility of the Utility Owner and Operator; including, but not limited to, the construction of drainage improvements necessary to protect the utility and amenities associated with the utility.

All utilities planned to be installed within SSCAFCA's right-of-way require an agreement with SSCAFCA.

3.8.B.I. UTILITIES

All utilities planned to be installed within SSCAFCA's right-of-way require an agreement with SSCAFCA. All utilities in a City facility require an easement granted by City for construction, operation and maintenance. The easement shall include the following language:

The Utility Owner (Utility) is responsible for operations and maintenance of all Utility owned facilities. Any damage to any drainage facilities or downstream arroyos as a result of the installation, operation or maintenance of Utility owned facilities is the responsibility of the Utility Owner, including environmental mitigation of any spills, leaks or blockages of Utility owned facilities.

All designs shall be submitted to and require approval by the City Engineer.

3.8.B.I.a. Engineering Design Criteria for Underground Utilities in and Adjacent to Arroyos

Underground Utilities in Arroyos and Utilities Adjacent to Arroyos include both “wet” utilities such as sanitary sewer lines, water lines, etc.; and “dry” utilities such as electric lines, communication lines, etc. Design considerations shall include 100-year flood plains, floodways, and the areas included within the LEE.

The design criterion applies to all arroyos.

3.8.B.I.b. Engineering Design Criteria for Gravity Sewer Lines in Arroyos

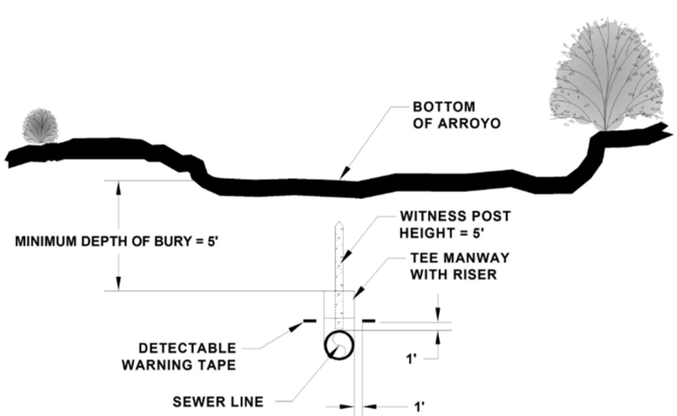
3.8.B.I.b.i. Design Capacity Criteria

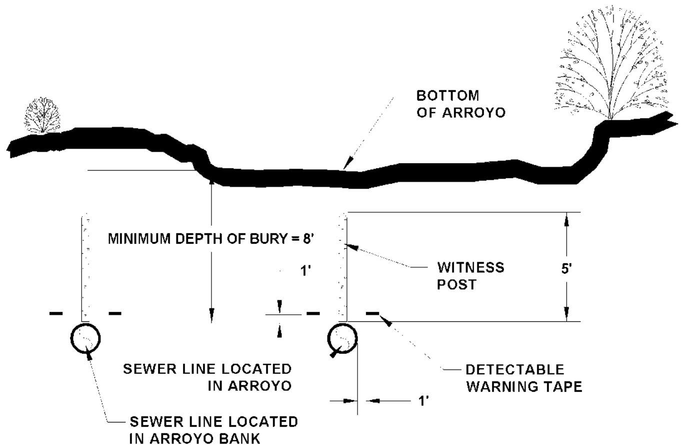
Develop design flow as defined in the Water Utility Design of the City of Rio Rancho’s DPM.

3.8.B.I.b.ii. Longitudinal Placement

Longitudinal placement includes locations more or less aligned with the average down-valley direction as defined in SSCAFCA’s Sediment and Erosion Design Guide, November 2008.

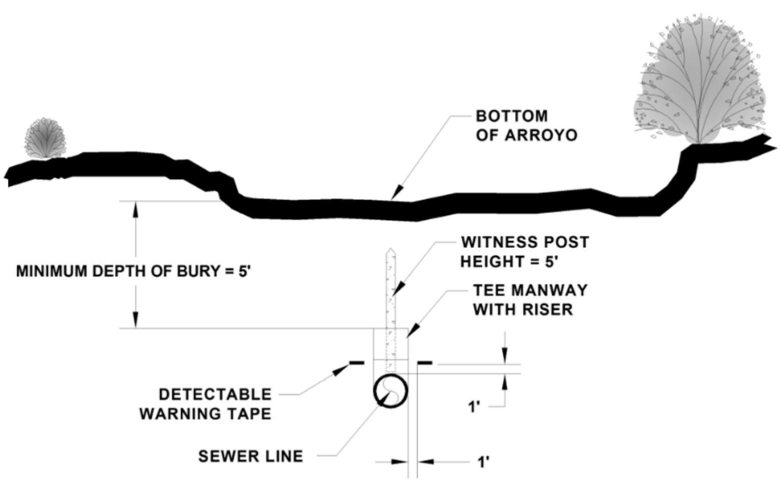
1. Horizontal Location
    a. Place the utility in the bottom of the existing arroyo where practical. This will minimize disturbance to existing habitat and vegetation.
2. Vertical Location
    a. Place the utility at a depth of 8 feet or the depth of scour for the 100-year discharge (the “SAS Erosion Control Zone”), whichever is greater. The depth shall be measured from the minimum elevation of the channel bed.
        i. Sewer line shall be marked with a witness post, 5-feet in height, placed above the pipe. Maximum distance between witness posts: 300-feet.
        ii. Sewer line shall be marked with detectable warning tape on either side of the pipe, at 1-foot above the top of pipe, for the entire length of the pipe.

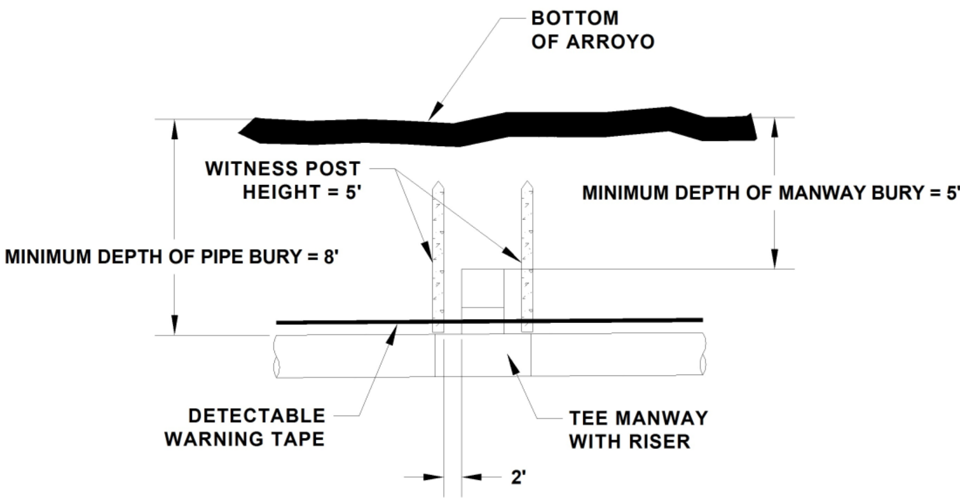




3.8.B.I.b.iii. Manway Criteria

1. Manways must be located in the arroyo bottom and buried. Manholes in arroyos are not acceptable. All manways must be accessible by sewer maintenance truck.
2. Manways shall be marked with two witness posts, one on each side of manway. Witness post shall be 5-feet in height.
3. Minimum depth of bury to top of manway: 5-feet below bottom of arroyo.





4. Manways shall be fabricated of a fused HDPE tee with a HDPE riser, and a bolted blind flange. The required inside diameter for a manway shall be the same inside diameter as the inlet/outlet pipe.
5. Inlet/outlet connections shall be continuously fused to manway and shall be restrained with an electrofusion flex restraint. Gasketed joints are not acceptable.
6. The maximum distance allowed between manways is 600-feet.

3.8.B.I.b.iv. Manhole Criteria

1. Manholes shall be located at all roadway crossings. Manways in roadway crossings are not acceptable.
2. Manholes shall be fabricated from fusible HDPE.
3. Inlet/outlet connections shall be continuously fused to manholes and shall be restrained with an electrofusion flex restraint. Gasketed joints are not acceptable.
4. The minimum required inside diameter for a manhole is 6-feet.
5. Invert elevations shall be called out for each inlet and outlet at a manhole.

3.8.B.I.b.v. Line Criteria

1. Sewer line shall be continuously fused HDPE pipe only. All other materials are not acceptable. Gasketed joints are not acceptable.
2. Minimum line size allowed: 15-inch inside diameter.
3. Curvilinear sewers are permitted, in accordance with manufacturer’s recommendations.
4. Service connections are not acceptable.
5. Sewer line shall be marked with a witness post, 5-feet in height, placed at the top of the pipe. Maximum distance between witness posts: 300-feet.

6. Sewer line shall be marked with detectable warning tape on either side of the pipe, at 1-foot above the top of pipe, for the entire length of the pipe.

7. Connecting sewer lines are only allowable at a manway or manhole. Connections on the pipe, between manways or manholes, are not acceptable. Minimum connecting line size allowed: 8-inch inside diameter. Connecting sewer lines shall conform to the same criteria listed above from LEE line to LEE line or manhole to manhole, whichever is the greater distance.

3.8.B.I.c. Engineering Design Criteria for Gravity Sanitary Sewer Lines Crossing Arroyos

Sewer lines crossing the arroyo shall conform to the same criteria listed above from LEE line to LEE line or manhole to manhole, whichever is the greater distance.

3.8.B.I.d. Watershed Park Amenities

Each design shall incorporate Watershed Park amenities. The types of amenities required shall be determined on a case-by-case basis. Appropriate Watershed Park amenities associated with a utility line include linkage elements such as trails and wildlife corridors; and, supporting elements such as trailheads, view sites, benches, and educational/informational signage.

3.8.B.II. AMENITIES

If an amenity is identified as required with the installation of a utility, it shall be designed in accordance with the City of Rio Rancho Development Standards for Parkland and the following criteria:

3.8.B.II.a. Design Criteria for Trail Systems

1. For public health, safety, and welfare, trails shall have signage notifying users they are in an arroyo. The sign shall use City standard language for warning signs.

2. Trails shall have signage notifying users of the agency operating and maintaining the trail (i.e. Utility Owner, City of Rio Rancho, etc.)

3. Due to location, trails may not be ADA compliant. Trails shall have signage that indicates ADA accessibility constraints.

3.8.B.II.b. Design Criteria for Trail Heads

Construct Trail Heads in conjunction with trail systems at roadway crossings.

1. Trail heads shall control access to the arroyos with the following elements:

2. Fencing

    a. Trail head step-through gates

    b. Access gates for operations and maintenance.

    c. Trail heads shall have areas designated for vehicular and bicycle parking.

3. Trail heads shall be designed in accordance with ADA.

4. Trail heads shall have signage notifying users of trail name.
5. It is recommended to incorporate the following design elements at trail heads:
    a. Shade structures.
    b. Benches.
    c. Educational/informational signage and maps.
    d. Bear-proof trash receptacles.
    e. Dog-waste bag dispensers.

3.8.B.II.c. Protection and Restoration of Existing Wildlife Habitat and Existing Vegetation

1. Maintain wildlife habitat and existing vegetation to the maximum extent practicable.
2. Provide for the protection of existing wildlife habitat and existing vegetation in the design and construction of the utility.
3. Limit construction work zone areas to minimize disturbance to existing wildlife habitat and existing vegetation.
4. Re-vegetate all disturbed areas not in arroyo bottom.
5. Restore disturbed habitat as appropriate.

3.8.B.III. OPERATIONS AND MAINTENANCE

The City of Rio Rancho is responsible for the operation and maintenance of the Watershed Park amenities. Operation in arroyos during monsoon season is potentially dangerous and is discouraged.

3.8.C Lateral Erosion Envelope

Encroachment into the LEE Line will require the following:

1. Update the existing LEE Line Study.
2. Identify the drainage improvements required to reduce the LEE Line.
3. Construct and/or financially guarantee the required drainage improvements prior to building permit/subdivision plat approval. If these drainage improvements benefit other properties within the drainage basin.
4. Provide construction plans for the required drainage improvements and related SSCAFCA Quality of Life Master Plan improvements, if applicable.

For information regarding LEE, visit SSCAFCA’s website.

3.9 Stormwater Quality and Low Impact Development

3.9.A General

Stormwater runoff is generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. The runoff picks up pollutants like trash, chemicals, oils, and dirt/sediment that can harm our rivers, streams, lakes, and wetlands.

Population growth and development of urban/urbanized areas are major contributors to the amount of pollutants in stormwater runoff as well as the volume and rate of runoff from impervious surfaces. Traditional stormwater management approaches that rely on peak flow storage have generally not targeted pollutant reduction and can exacerbate problems associated the changes in hydrology and hydraulics.

Therefore, sustainable stormwater management strategies must be utilized to control runoff by minimizing impervious cover and by using natural or man-made systems to filter and recharge stormwater into the ground. The goal is to reduce runoff and to mimic a site's predevelopment hydrology by minimizing disturbed areas and impervious cover and then infiltrating, filtering, storing, evaporating, and detaining stormwater runoff close to its source.

3.9.B Applicability

Stormwater quality is regulated by the EPA National Pollutant Discharge Elimination System (NPDES) permit program, including Construction General Permit (CGP), Multi-Sector General Permit (MSGP), and Municipal Separate Storm Sewer (MS4) Permit. This section addresses post-construction stormwater management in new development and redevelopment. Specifically, stormwater quality design standards that manage on-site the 90th percentile storm event discharge volume associated with new development sites and 80th percentile storm event discharge volume associated with redevelopment sites.

All land development projects must comply with the MS4 Permit and City of Rio Rancho, Municipal Code, Chapter 153, which requires stormwater Best Management Practices (BMP) to manage the stormwater quality design volume onsite for all new development and redevelopment projects with land disturbance equal to or greater than one acre. This includes sites which disturb less than one acre but are part of a larger common plan of development. Projects must also evaluate opportunities to implement low impact development and green infrastructure best management practices.

Structural and non-structural runoff controls / BMPs remove pollutants from Stormwater Quality Volume (SWQV) by decreasing or delaying the volume of stormwater that enters the storm drain system, reducing the maximum flow rate by decreasing the stormwater volume and lengthening the duration of discharge, and improving water quality through infiltration, filtering, and biological and chemical processes.

3.9.C Stormwater Quality Volume

Direct runoff values may be calculated though site specific pre-development hydrology and associated storm event discharge volume using the methodology specified in U.S. Environmental Protection Agency (USEPA) Technical Report entitled *"Estimating Predevelopment Hydrology in the Middle Rio Grande Watershed, New Mexico, EPA Publication Number 832-R-14-007"*. Estimated rainfall depths for the 90th percentile storm event (new development) and 80th percentile storm event (redevelopment) are 0.615 and 0.48 inches, respectively.

The NRCS Runoff Curve Number method used in the USEPA Technical Report, yields runoff values of 0.424 inches for the 90th percentile storm event and 0.30 inches for the 80th percentile storm event.

For new development, to calculate required post-construction SWQV, multiply post-construction impervious area draining to the BMP by the 90th percentile storm rainfall depth. Required water quality volume, provided water quality volume and surface water quality elevation, as well as 100-year water surface elevation shall be shown on the Grading and Drainage Plan. Permeable areas (e.g., landscaped depression, lawn, parking lot island, depressed median, planter box, etc.) used to disconnect impervious surface shall be identified on construction plans.

Redevelopment applies to project that alter the footprint of an existing site or building resulting in disturbance equal or greater than one acre of land or smaller sites that are part of a larger common plan of development or sale. To calculate required post-construction SWQV, multiply net increase impervious area (post- minus pre-construction impervious area) draining to the BMP by the 80th percentile storm rainfall depth.

Post-Construction 80th and 90th Percentile Rainfall Depths and Runoff Depths

New Development Sites		**Redevelopment Sites**	
90th Percentile Storm Rainfall Depth (inches)	90th Percentile Storm Runoff Depth (inches)	80th Percentile Storm Rainfall Depth (inches)	80th Percentile Storm Runoff Depth (inches)
0.615	0.424	0.48	0.30

Equation: **Stormwater Quality Volume** = (R/12) x A

Where:
SWQV = Stormwater Quality volume to be treated, ac-ft
R = 90th or 80th percentile event direct runoff depth, inches
A = Impervious area of new development or redevelopment, acres

For single-family subdivisions, stormwater quality ponds will not be allowed on individual lots. Instead, a centralized stormwater quality pond for the entire subdivision must be constructed for all impervious areas or combination of on-site ponding and payment-in-lieu can be paid to the entity who will apply funds to a public stormwater quality project.

Impervious area calculations shall include all roads, driveways, parking areas buildings, concrete, and other impermeable construction covering the natural land surface. Unpaved roads, driveways, and parking areas compacted by vehicle use shall be considered impervious surface area.

3.9.D Low Impact Development

Low Impact Development (LID) refers to engineered systems, either structural or natural, that use or mimic natural processes to promote infiltration, evapotranspiration, and/or reuse of storm water as close to its source as possible to protect water quality. LID practices at the regional and sites specific level preserve, restore, and create green space using soils, vegetation, and rainwater harvesting techniques. These systems and practices are referred to as Best Management Practices. Green Infrastructure (GI) includes LID practices but is a broader practice that also includes ecological services and approaches such as "filtering air pollutants, reducing energy demands, mitigating urban heat islands, sequestering and storing carbon, enhancing aesthetics and property values, and preserving and creating natural habitat functions." (United States Environmental Protection Agency, 2012).

BMPs that employ LID and GI can be found in the "National Pollutant Discharge Elimination System Manual – Stormwater Management Guidelines for Construction, MS4, and Industrial Activities". Appendix A3 provides technical guidance and illustrations, as well as maintenance requirements to consider when selecting LID/GI intervention strategies.

EPA GI/LID Resources:

EPA Green Infrastructure website

Green Infrastructure in the Semi-Arid West website

Green Infrastructure Opportunities that Arise During Municipal Operations website

New Mexico GI/LID Resources:

Los Alamos Low Impact Development Standards website

Bernalillo County Green Stormwater Infrastructure – Low Impact Design Strategies for Desert Communities website

References:

National Pollutant Discharge Elimination System Manual, Stormwater Management Guidelines for Construction, MS4, and Industrial Activities website

3.10 Bibliography

3.10.A Hydraulics

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    c. Merritt: Standard Handbook for Civil Engineers, McGraw Hill Book Company, Inc., New York, 1968.

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    a. Los Angeles County Flood Control Authority, Design Manual - Hydraulic P.O. Box 2418 Los Angeles, California 90054 Rev. 1972.

5. Sediment & Erosion Control

    a. SSCAFCA’s Sediment and Erosion Design Guide prepared by Mussetter Engineering, Inc. dated November 2008. Available on SSCAFCA’s webiste.