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Revised 4/2010

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NOTICE

This document was a collective effort by several individuals and, while every effort was made to provide a superior product, some errors or inconsistencies may exist. Please assist us by reporting every error or inconsistency that you find. Corrections will be made periodically and each page will be updated and corrections logged in an internal tracking system. The official office copy and the web site version will have all of the latest changes and it is recommended that you check either of these sources when periodically and starting a new project.

Chapter 22

DRAINAGE, FLOOD CONTROL AND EROSION CONTROL

Section 1. INTENT & SUPPORT DOCUMENTS

The standards, guidelines and criteria presented herein are provided in order 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 thrust of these criteria is toward generalization in order to provide guidance for a large majority of design circumstances, but it must be understood that situations will arise in which these criteria are not appropriate. The SSCAFCA Executive Engineer, may, in specific cases, require more stringent criteria or allow relaxation of these criteria based on his judgment and sound engineering practice. The letter and intent of the Board approved Goals, Mission Statement and Vision Statement are listed below included in this document to ensure compliance with the Board's direction and to add value to this document.

A. Goals, Mission Statement and Vision Statement

1. ***SSCAFCA's Original Goals and Commitments***

- To provide flood protection up to the 100 year storm for the public health, safety and welfare of residents and properties within our boundaries.
- To recognize the value of land purchased or controlled for floodways as areas with multi-use potential.
- To assist in the coordination of flood control with other entities for the common good of the public.

2. ***Mission Statement***

Protect citizens and property by implementing proven flood control solutions that:

- **Manage** our watersheds prudently for future generations
- **Enhance** the quality of life
- **Create** the most appealing multi-use facilities
- **Set an Example** of quality, integrity, leadership and professionalism
- **Educate** the public concerning flood hazards
- **Administer** public funds prudently

3. ***Vision Statement***

Flood control – for a safer tomorrow.

B. Summary of Documents Relating to Drainage, Flood Control and Erosion Control

1. City of Rio Rancho Ordinances and Policies

a. Flood Hazard Prevention Ordinance (Chapter 152)
b. Erosion Control; Storm Drainage (Chapter 153)
c. Planning and Zoning (Chapter 154)
d. Subdivision Ordinance (Chapter 155)

2. SSCAFCA Regulations and Policies

a. Greenbelt Concept Resolution 1992-8
b. Drainage Policy Resolution 1994-08
c. Drainage Policy Resolution 2001-6
   (Drainage Design Criteria for Roadway Projects)
d. Guidelines for Allowable Velocities in Piping Systems approved June 14, 2001
e. Drainage Policy Amendment 2004-1
f. Drainage Policy Amendment 2004-2
g. Drainage Policy Adopted June 20, 2008
h. Sediment and Erosion Design Guide November 2008
i. Sediment and Erosion Design Guide Power Point Presentation

Section 2. HYDROLOGY

A. Preface

Southern Sandoval County Flood Control Authority (SSCAFCA) was created in 1990 (first official day was June 1, 1990) by the New Mexico Legislature with specific responsibilities to address flooding problems in greater Sandoval County. SSCAFCA's goals, Mission Statements and Vision Statement were developed by staff and adopted by the Board. They are listed below to ensure that the letter and intent guide development. With these purposes in mind and the urgency to adopt drainage criteria, SSCAFCA unofficially adopted Chapter 22 of the City of Albuquerque Development Process Manual.

In 2007, in an effort to adopt drainage criteria that is more representative of the desires of the SSCAFCA Board, the Board authorized the Executive Engineer to adapt the City of Albuquerque DPM Chapter 22 to meet its needs and desires. With this authorization, SSCAFCA joined with the City of Rio Rancho in establishing drainage criteria that is mutually agreeable to both jurisdictions. SSCAFCA volunteered to take the lead in the creation of Chapter 22 for Southern Sandoval County by establishing a Subcommittee that met weekly. In conjunction with this update, Bohannan-Huston was charged with the task to prepare for adoption changes to the City of Albuquerque DPM and the AMAFCA Sediment and Erosion Design Guide to supplement the work of the Subcommittee and WHPacific and Stantec investigated public domain hydrology models for inclusion in the DPM. The USACE HEC-HMS model was selected and changes prepared to incorporate this public domain model into the document for use in SSCAFCA's jurisdiction.

On July 31, 2009 SSCAFCA adopted the revised Chapter 22 as an allowable procedure for hydrologic analysis and design of flood control structures.

The City of Rio Rancho is in the process of adopting the revised Chapter 22 as an allowable procedure for hydrologic analysis and design of flood control structures.

SSCAFCA and the City of Rio Rancho wish to acknowledge the assistance of the committee members listed below who helped prepare and/or reviewed the document:

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B. Introduction

There have been many methods used in the City of Rio Rancho's and SSCAFCA's jurisdiction to compute runoff volumes, peak flow rates and runoff hydrographs from drainage basins. Any methodology used should be based on measurable conditions, be as simple as possible and produce accurate, reproducible results. The methods, graphs, and tables which follow will be used by the City of Rio Rancho and SSCAFCA staff in the review and evaluation of development plans and drainage management plans.

Three basic methods of analysis are presented herein:

- **Rational Method -** describes a simplified procedure for smaller watersheds based on the Rational Method. The procedure is applicable to watersheds up to 40 acres in size.

- **Rainfall-runoff modeling with AHYMO -** describes procedures for rainfall-runoff modeling using the AHYMO computer program. AHYMO is a version of the U.S.D.A. Agricultural Research Service HYMO computer program, modified to utilize initial abstraction/uniform infiltration precipitation losses. Rainfall-runoff modeling using AHYMO is applicable for drainage areas between 40 and 320 acres in size.
- **Rainfall-runoff modeling with HEC-HMS-** describes procedures for rainfall-runoff modeling using the U.S. Army Corps of Engineers HEC-HMS software. Rainfall-runoff modeling using HEC-HMS is applicable for drainage areas greater than 40 acres in size.

C. Symbols and Definitions

When evaluating equations use the following order of precedence: 1) parentheses, 2) functions (i.e., SIN or LOG), 3) power or square root, 4) multiplication or division, 5) addition or subtraction.

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

CN .... SCS Curve Number

D .... duration in days

e .... base of natural logarithm system = 2.71828

E .... excess precipitation

E_A .... excess precipitation for treatment A

E_B .... excess precipitation for treatment B

E_C .... excess precipitation for treatment C

E_D .... excess precipitation for treatment D

EA .... elevation adjustment factor for PMP_{60}

Elev .... elevation (feet)

Ft .... feet

hr .... hour

I .... Rational Method intensity (inches/hour)

IA .... initial abstraction (inches)

INF .... infiltration (inches/hour)

K.. conveyance factor for SCS Upland Method

k... recession coefficient for AHYMO program

K_N.. basin factor for lag time equation

K_X.. conveyance factor for watershed subreach

k/t_{pA} .... k divided by t_p for treatment A

k/t_{pB} .... k divided by t_p for treatment B

k/t_{pC} .... k divided by t_p for treatment C

k/t_{pD} .... k divided by t_p for treatment D

k/t_{P40} .... k divided by t_p for 40 acres or smaller area

k/t_{P200} .... k divided by t_p for 200 acres or larger area

L .... length of subreach (feet)

L_{CA} .... distance to centroid of drainage basin (feet)

L_G .... lag time (hours)

L_X .... length of watershed subreach

In .... natural logarithm (base e)

log_{10}... base 10 logarithm

mi^2 .... square mile(s)

n .... Manning's roughness coefficient

P_{12} .... 12-minute precipitation

P_{60} .... 60-minute precipitation at 100-year storm

P_{60-2} .... 60-minute precipitation at 2-year storm

$P_{60-year}$ .... 60-minute precipitation at "year" storm

P_{360} .... 360-minute precipitation at 100-year storm

P_{360-2} .... 360-minute precipitation at 2-year storm

P_{360-10} .... 360-minute precipitation at 10-year storm

P_{1440} .... 1440-minute (24-hr) precipitation, 100-year storm

P_{1440-2} .... 1440-minute (24-hr) precipitation at 2-year storm

P_D .... precipitation for "D"-days duration

P_{N-100} .... "n"-minute precipitation at 100-year storm

P_{N-YEAR} .... "n"-minute precipitation at "year" storm

P_T .... precipitation at any time, t

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

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, view points 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/SSCAFCA 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/SSCAFCA 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.

Dams **–** Storm water retention/detention structures approved and controlled by the Office of the State Engineer (i.e., containing a storage volume equal to or greater than 50 acre feet and/or a berm height of 25' or greater).

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.

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.

DEVEX **–** the runoff with existing platting, full development, unpaved streets, and drainage conveyance. If available, DEVEX flows shall be taken from SSCAFCA approved WMP's.

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.

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.

***Flood Plain* –** 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.

***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.

***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.

***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.

***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 of the State Engineer (i.e., containing a storage volume less than 50 acre feet and/or a berm height of less than 25'.

***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.

***Storm Water Quality Constituents* –** dissolved and suspended nutrients, metals, oils, greases, biological agents, etc.

***Storm Water Quality Treatment Rate (SWQR)* –** the peak rate of flow from the water quality storm event.

***Storm Water 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* –** 0.6 inches of precipitation within a six-hour period. This is approximately equivalent to the average annual precipitation event and represents the 80th percentile rainfall event (i.e., approximately 80% of the total annual rainfall occurs in storm events with 0.6" or smaller precipitation depth).

***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.

D. Rational Method

D.1 INTRODUCTION

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:

$$Q = CiA \tag{D-1}$$

where:

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

D.2 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, and

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).

D.3 LIMITATIONS

The following limitations shall apply to the Rational Method for use in the SSCAFCA jurisdiction. Drainage areas that do not meet the following conditions will require the use of an appropriate rainfall-runoff method as outlined in Sections E or F.

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, and

3. The contributing drainage area cannot have drainage structures or other facilities upstream of the point of interest that require flood routing.

D.4 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. Four land treatment classifications have been created that typify the conditions in the SSCAFCA jurisdiction. Descriptions of the land treatment classifications are provided in Table D-1. Three of the land treatment classifications (A, B and C) are for pervious conditions. The forth classification (D) is for impervious areas. Runoff coefficients for each land treatment type are listed in Table D-2.

TABLE D-1. LAND TREATMENTS

Treatment	Land Condition
A	Soil uncompacted by human activity with 0 to 10 percent slopes. Native grasses, weeds and shrubs in typical densities with minimal disturbance to grading, ground cover and infiltration capacity.
B	Irrigated lawns, parks and golf courses with 0 to 10 percent slopes. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes greater than 10 percent and less than 20 percent.
C	Soil compacted by human activity. Minimal vegetation. Unpaved parking, roads, trails. Most vacant lots. Gravel or rock on plastic (desert landscaping). Irrigated lawns and parks with slopes greater than 10 percent. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes at 20 percent or greater. Native grass, weed and shrub areas with clay or clay loam soils and other soils of very low permeability as classified by SCS Hydrologic Soil Group D.
D	Impervious areas, pavement and roofs.
Most watersheds contain a mixture of land treatments. To determine proportional treatments, measure respective subareas. In lieu of specific measurement for treatment D, the areal percentages in TABLE D-3 may be employed.	

For watersheds with multiple land treatment types present, 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.

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

TABLE D-2. RATIONAL METHOD RUNOFF COEFFICIENT, C				
Recurrence Interval	**Land Treatment**			
Years	**A**	**B**	**C**	**D**
500	0.56	0.62	0.66	0.93
100	0.27	0.43	0.61	0.93
50	0.20	0.35	0.58	0.93
25	0.14	0.31	0.56	0.92
10	0.08	0.24	0.47	0.92
5	0.01	0.10	0.40	0.92
2	0.00	0.02	0.26	0.92
1	0.00	0.00	0.06	0.90

TABLE D-3 SSCAFCA TREATMENT TYPE PERCENTAGE SUMMARY

Parcel Description	Treatments A	B	C	D	Methodology/Notes
1/8 Acre	0%	15%	15%	70%	DPM, Chapter 22.2, Table A-4 for D
1/6 Acre	0%	28%	15%	57%	Northern Meadows Master Plan
1/4 Acre	0%	30%	28%	42%	DPM, and followed SSCAFCA lead on B&C
1/2 Acre	10%	33%	30%	27%	SSCAFCA
1 Acre	43%	20%	20%	17%	SSCAFCA
Single Family Residential N=units/acre, N6					7*√((N*N) + (5*N))
Estate Lots (btwn 1-5ac)	60%	15%	15%	10%	DPM for 2.5 acre lot
M-1 (Light Industrial)	0%	15%	15%	70%	DPM for D, split B & C
Vacant Res./Undevel.	79%	8%	8%	5%	DPM for 5 acre lot
Arroyo	100%	0%	0%	0%	DPM
Major Roads	0%	0%	10%	90%	DPM
School	10%	20%	20%	50%	DPM
Commercial/Industrial	0%	0%	15%	85%	DPM average of Heavy Industrial and Commercial
Open Space	100%	0%	0%	0%	DPM
Parks, Sports and Rec	0%	85%	0%	15%	DPM
Landfill	0%	0%	100%	0%	All disturbed ground
Multi-Family	0%	15%	15%	70%	DPM-Multiple Unit Res. Attached
Northern Meadows	0%	28%	15%	57%	Northern Meadows Master Plan
Drainage Ponds	0%	0%	100%	0%	
County Platted (1)	18.7%	29.5%	27.0%	24.8%	(used Basin P12_104 as typical)
County Unplatted (2)	95%	5%	0%	0%	DPM

NOTES

1. County Platted area is defined as the area between CORR boundary and Rio Rancho Estates boundary.
2. County Unplatted area is defined as the area outside the city limits and the Rio Rancho Estates limits. It is considered to be existing conditions.
3. All roads are assumed to be paved.

D.5 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 basin 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:

$$T_c = \sum_{i=1}^{n} \left(\frac{L_i}{36{,}000 * K_i * \sqrt{S_i}} \right) \qquad \text{(D-2)}$$

Where:
- T_c = Time of concentration, in hours
- L_i = Length of each unique surface flow conveyance condition, in feet
- K_i = Conveyance factor from Table D-4
- S_i = Slope of the flow path, in feet per foot

TABLE D-4. 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 plane surfaces, with flow depths up to 0.1 feet. Sheet flow applies only to the upper 400 feet (maximum) of a subbasin.

D.6 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 for time of a time of concentration of 15-minutes are listed in Table D-5. Rainfall intensities listed in Table D-5 are based on precipitation values for the SSCAFCA jurisdiction derived from NOAA Atlas 14, Precipitation - Frequency Atlas of the United States, Volume 1: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah).

TABLE D-5. RAINFALL INTENSITY

Recurrence Interval Years	Intensity in/hr
500	5.7
100	4.4
50	3.9
25	3.4
10	2.8
5	2.3
2	1.7
1	1.4

D.7 RUNOFF VOLUME

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.

$$V = C\frac{P}{12}A \qquad \text{(D-3)}$$

where:
- V = runoff volume, in acre-feet
- C = weighted runoff coefficient derived from Table D-2
- P = rainfall depth, in inches from Table D-6
- A = drainage area, in acres

Rainfall depths for Equation D-3 are listed in Table D-6. The rainfall depths provided in Table D-6 are for multiple recurrence intervals and storm durations. Those values are adapted from NOAA Atlas 14, 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 web site found at http://hdsc.nws.noaa.gov/hdsc/pfds/sa/nm_pfds.html. At this web site point 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.

TABLE D-6. RECURRENCE INTERVAL POINT PRECIPITATION DEPTHS

Recurrence Interval	**Duration**			
Years	**15-Minute**	**1-Hour**	**6-Hour**	**24-Hour**
500	1.42	2.37	3.01	3.57
100	1.10	1.84	2.37	2.90
50	0.97	1.62	2.11	2.57
25	0.85	1.42	1.86	2.29
10	0.70	1.16	1.54	1.90
5	0.58	0.97	1.31	1.66
2	0.43	0.72	1.02	1.32
1	0.34	0.56	0.81	1.05

D.8 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:

$$t_B = \left(2.017\frac{C * P * A_T}{Q_P}\right) - \left(0.25\frac{A_D}{A_T}\right) \qquad \text{(D-4)}$$

where:
- t_B = time base, in hours
- C = runoff coefficient from Table D-2
- P = rainfall depth, in inches from Table D-6
- Q_P = Rational Method peak discharge, in cfs
- A_D = area in land treatment type D, in acres
- A_T = drainage area, in acres

$$t_p = 0.7 * T_c + \frac{1.6 - A_D / A_T}{12} \qquad \text{(D-5)}$$

where:

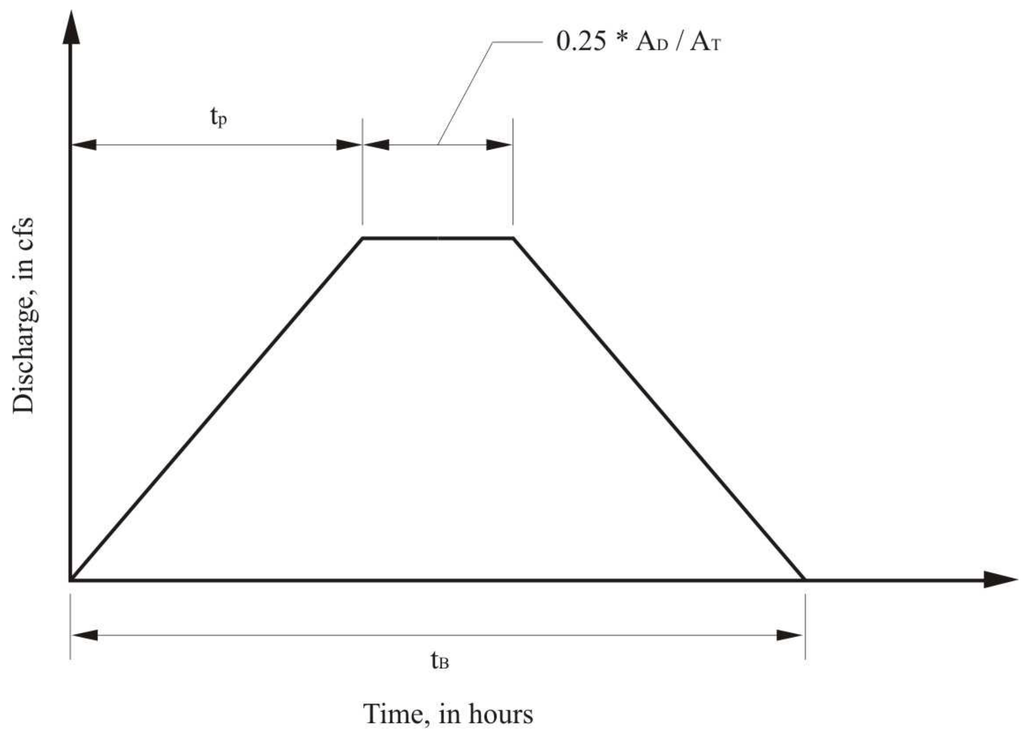
t_p = time to peak in hours

T_c = time of concentration from Eqn. D-2, in hours

A_D = area in land treatment type D, in acres

A_T = drainage area, in acres

FIGURE D-1. RATIONAL METHOD RUNOFF HYDROGRAPH SHAPE



D.9 PROCEDURE

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.

To estimate peak discharge,

1. Determine the drainage area for the point of interest.
2. Calculate the area of each unique land treatment type or zoning classification.

3. Using the percent area of each land treatment type, calculate the area averaged runoff coefficient using the data from Table D-2.
4. For the desired frequency, select the maximum intensity from Table D-5.
5. Calculate the peak discharge using Equation D-1:

To estimate runoff volume,

1. For the desired storm frequency and duration, select the rainfall depth from Table D-6
2. Calculate the runoff coefficient using the procedures for estimating peak discharge
3. Calculate runoff volume using Equation D-3

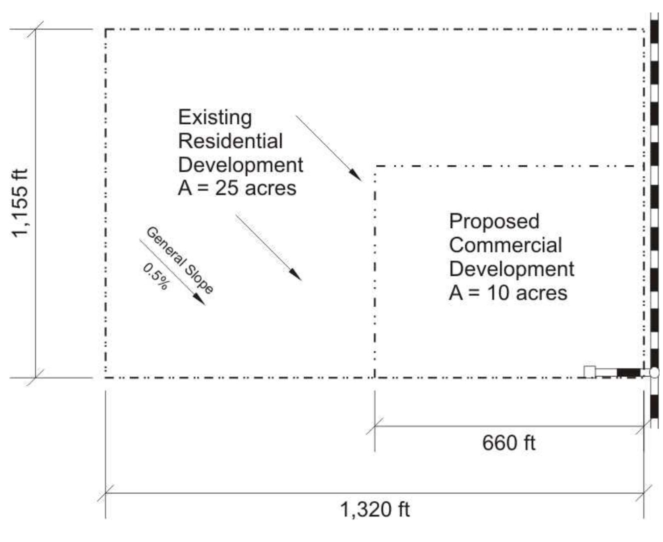
To estimate the Rational Method runoff hydrograph,

1. Calculate the peak discharge using the above procedures
2. From an appropriate map of the drainage area, delineate the time of concentration flow path and measure the length, in feet.
3. Select K from Table D-4
4. Measure the average flow path slope, S
5. Calculate the time of concentration using Equation D-2
6. Calculate the time base of the runoff hydrograph using Equation D-4
7. Calculate the time to peak using Equation D-5
8. Construct the hydrograph starting at time = 0 hours with a discharge of 0 cfs.

D.10 EXAMPLE

Runoff from an existing residential development collects at a roadway intersection. A new storm drain lateral is to be constructed as part of a proposed commercial development (see the following figure). Calculate the following:

1. 10-year peak discharge for the storm drain lateral.
2. Storage volume necessary to temporarily store the entire runoff volume from the 100-year, 6-hour storm.
3. Compute a runoff hydrograph for design of a detention basin to meter the 100-year flow into the storm drain.



Peak Discharge

1. Calculate the weighted runoff coefficient

   From Table D-3, Land Treatment Type percentages for the two parcel descriptions are:

Parcel Description	Area acres	Percent of Land Treatment Type A	B	C	D
1/8 Acre	25	0	15	15	70
Commercial / Industrial	10	0	0	15	85

   From Table D-2, runoff coefficients for a 10-year frequency storm are:

   - $C_B = 0.24$
   - $C_C = 0.47$
   - $C_D = 0.92$

   Area of each Land Treatment Type is calculated as:

   - $Area_B = (0.15)(25) + (0)(10) =$ 3.75 acres
   - $Area_C = (0.15)(25) + (0.15)(10) =$ 5.25 acres
   - $Area_D = (0.70)(25) + (0.80)(10) =$ 26.0 acres

   Total Area = 35.0 acres

   Weighted runoff coefficient (C) is:

$$C = \frac{(3.75)(0.24) + (5.25)(0.47) + (26)(0.92)}{35}$$

$$C = 0.78$$

2. From Table D-5, the rainfall intensity (assuming $T_c \leq 15$ minutes) = 2.8 in/hr

3. Calculate the peak discharge using Equation D-1

$$Q = CiA$$

$$Q = (0.78)(2.8)(35)$$

$$Q = 77\ cfs$$

Note: It is recommended that all flow rates be rounded up to the nearest single unit (e.g. 76.44 cfs is rounded to 77 cfs).

100-Year, 6-hour Runoff Volume

1. From Table D-6, 100-year, 6-hour rainfall depth = 2.37 inches

2. Calculate the weighted runoff coefficient for the 100-year event

   From Table D-3, Land Treatment Type percentages for the two parcel descriptions are:

Parcel Description	Area acres	Percent of Land Treatment Type A	B	C	D
1/8 Acre	25	0	15	15	70
Commercial / Industrial	10	0	0	15	85

   From Table D-2, runoff coefficients for a 100-year frequency storm are:

   - $C_B = 0.43$
   - $C_C = 0.61$
   - $C_D = 0.93$

   Area of each Land Treatment Type is calculated as:

   - $Area_B$ = (0.15)(25) + (0)(10) = 3.75 acres
   - $Area_C$ = (0.15)(25) + (0.15)(10) = 5.25 acres
   - $Area_D$ = (0.70)(25) + (0.85)(10) = 26.0 acres

   Total Area = 35.0 acres

   Weighted runoff coefficient (C) is:

$$C = \frac{(3.75)(0.43) + (5.25)(0.61) + (26)(0.93)}{35}$$

$$C = 0.83$$

3. Calculate the runoff volume using Equation D-3

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

$$V = (0.83)\left(\frac{2.37}{12}\right)(35)$$

$V = 5.7$ *acre-feet*

Runoff Hydrograph

1. Calculate Time of Concentration assuming a total length of 2,475 feet (1,155 + 1,320) and a channel will be constructed to convey runoff along the boundary of the commercial development to the storm drain inlet.

   From Table D-4, select conveyance factors for each conveyance condition

   A. K_1 = 2 (Shallow concentrated flow within residential area)
   B. K_2 = 3 (Street flow, storm sewers and open channels for commercial area)

   From Equation D-2, T_c is:

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

$$T_c = \left[\frac{(1{,}155 + 660)}{(36{,}000)(2)\sqrt{0.005}} + \frac{660}{(36{,}000)(3)\sqrt{0.005}}\right]$$

$$T_c = (0.36 + 0.09)$$

T_c = 0.45 hours (27 minutes)

Note: assumption of a 15 minute T_c for estimating the 10-year peak discharge is reasonable and conservative based on the 100-year T_c of 27 minutes.

2. Calculate the 100-year peak discharge using Equation D-1 and an intensity of 4.4 in/hr taken from Table D-5

$Q = CiA$

Q = (0.83)(4.4)(35)

Q = 128 *cfs*

3. Calculate the shape of the runoff hydrograph time base using Equation D-4 and time to peak using Equation D-5

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

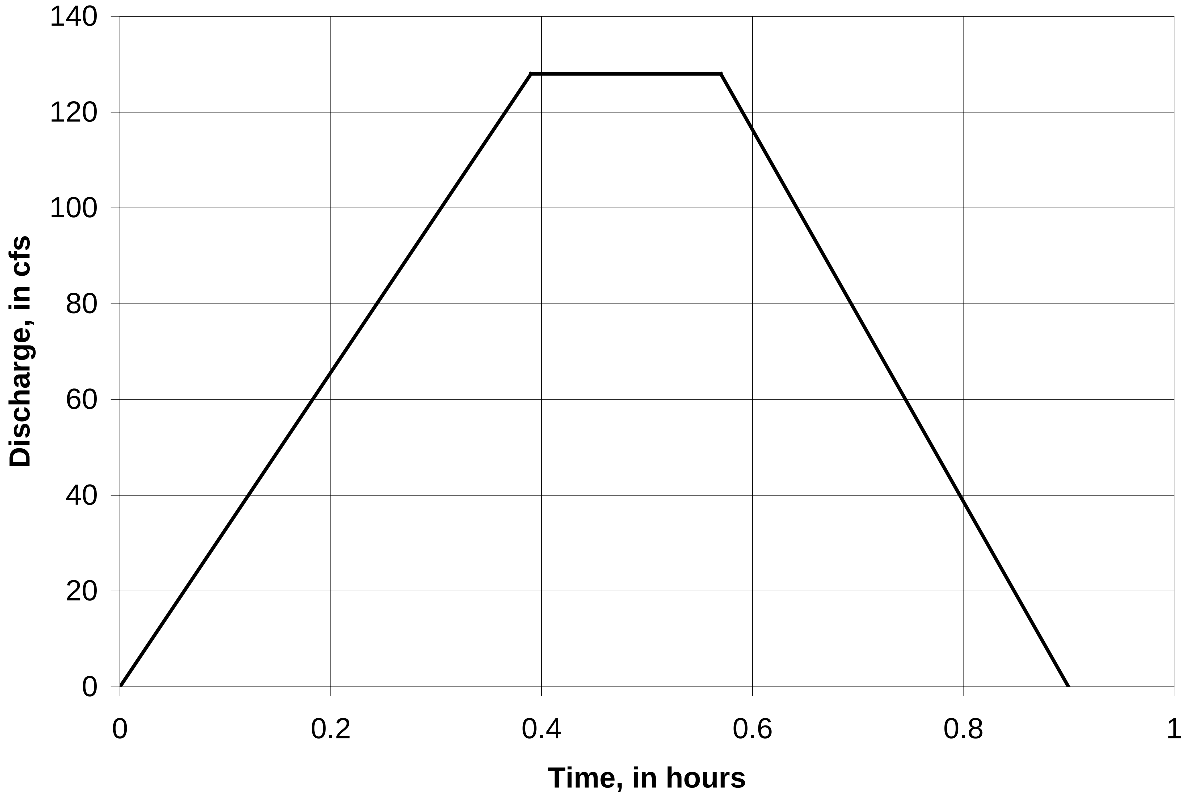
$$t_B = \left(2.017\frac{(0.83)(2.37)(35)}{128}\right) - (0.25)\left(\frac{26}{35}\right)$$

$t_B = 0.90\ hours$

$$t_p = 0.7 * T_c + \frac{1.6 - \frac{A_D}{A_T}}{12}$$

$$t_p = 0.7\left(\frac{27}{60}\right) + \frac{1.6 - \left(\frac{26}{35}\right)}{12}$$

$t_p = 0.39\ hours$



E. Rainfall-Runoff Modeling: AHYMO

E.1 INTRODUCTION

Rainfall-runoff modeling for drainage areas greater than 40 acres and less than 320 acres in size may be conducted using the AHYMO computer program. AHYMO is an arid lands hydrologic model based on the HYMO computer program. The HYMO program was developed by Jimmy R. Williams and Roy W. Hann, Jr. in the early 1970s for the USDA Agricultural Research Service in cooperation with the Texas Agricultural Experiment Station, Texas A&M University. During the 1980s, HYMO was reformulated, enhanced and renamed to AHYMO by Cliff Anderson to simulate rainfall-runoff processes characteristic of the Albuquerque area. The current version of the program was issued in 1997.

Rainfall-runoff methodologies encoded into AHYMO are described in the following sections. In addition, techniques and procedures for developing the necessary input to AHYMO are discussed in the following sections.

E.2 DESIGN RAINFALL CRITERIA

For design hydrology, the characteristics of the major flood producing storm are simulated using a synthetic storm. Components of a synthetic storm are basin average rainfall depth and temporal distribution. Information and procedures for developing the design rainfall criteria for storms other than the Probable Maximum Precipitation are provided in the following sections.

E.2.1 Depth

The principal design storm for peak flow determination is the 100-year, 6-hour event. For analysis and design of retention ponds and detention dams, the 100-year, 24-hour storm is to be used. Additional design analysis may be required if the structure falls under the jurisdiction of the New Mexico Office of State Engineer, Dam Safety Bureau. Point precipitation depths for the 100-year storm to be used within the SSCAFCA jurisdiction are provided in Table E-1. Those values are adapted from NOAA Atlas 14, Precipitation - Frequency Atlas of the United States, Volume 1: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah).

For determining sediment transport and for analysis of watersheds with complex routing conditions, other storm frequencies and durations may be required. Point precipitation depths for use in the SSCAFCA jurisdiction for multiple recurrence intervals and storm durations are listed in Table E-1. For all other recurrence intervals and storm durations, point precipitation depths are to be obtained directly from the National Weather Service through the NOAA 14 Precipitation Frequency Data Server website found at http://hdsc.nws.noaa.gov/hdsc/pfds/sa/nm_pfds.html. At this web site point 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.

TABLE E-1. RECURRENCE INTERVAL POINT PRECIPITATION DEPTHS				
Recurrence Interval	**Duration**			
Years	**15-Minute**	**1-Hour**	**6-Hour**	**24-Hour**
500	1.42	2.37	3.01	3.57
100	1.10	1.84	2.37	2.90
50	0.97	1.62	2.11	2.57
25	0.85	1.42	1.86	2.29
10	0.70	1.16	1.54	1.90
5	0.58	0.97	1.31	1.66
2	0.43	0.72	1.02	1.32
1	0.34	0.56	0.81	1.05

E.2.2 Temporal Distribution

Basin average rainfall for 100-year, 6- and 24-hour storms is distributed temporally using a suite of equations; E-1 through E-6. The equations are a function of the 1-, 6- and 24-hour basin average depths. The design rainfall distribution is front loaded with the peak intensity set at 85.3 minutes (hour 1.42) regardless of storm duration. This distribution results in approximately 80 percent of the total depth occurring in less than one hour. For the 6-hour storm the distribution of rainfall is determined using the first 5 of the 6 equations. For the 24-hour storm, all 6 equations are used. To illustrate the shape of the pattern, the 6-hour storm distribution using the depths from Table E-1 for a 20 square mile watershed is shown in Figure E-2.

$$P_T = 2.334 * \left(P_{360} - P_{60}\right) * \left(1.5^A - \left(1.5 - \frac{t}{60}\right)^A\right) \qquad \text{For } 0 \le t \le 60 \quad \text{(E-1)}$$

$$P_T = P_{T=60} + P_{60} * 0.4754 * \left(0.5^{0.09} - \left(1.5 - \frac{t}{60}\right)^{0.09}\right) \qquad \text{For } 60 < t < 67 \quad \text{(E-2)}$$

$$P_T = P_{T=60} + P_{60} * \left(0.0001818182 * (t - 60) + 0.000018338 * (t - 60)^{3.2}\right) \qquad \text{For } 67 \le t < 85.3 \quad \text{(E-3)}$$

$$P_T = P_{T=60} + P_{60} * \left(0.07 * (t - 60) - 1.1886 - 0.0404768 * (t - 85)^{1.0985865}\right) \qquad \text{For } 85.3 \le t < 120 \quad \text{(E-4)}$$

$$P_T = P_{360} + \left(P_{T=60} + P_{60} - P_{360}\right)\frac{4.4^{3A} - \left(t/60 - 1.6\right)^{3A}}{4.4^{3A} - 0.4^{3A}}$$ For $120 \le t \le 360$ (E-5)

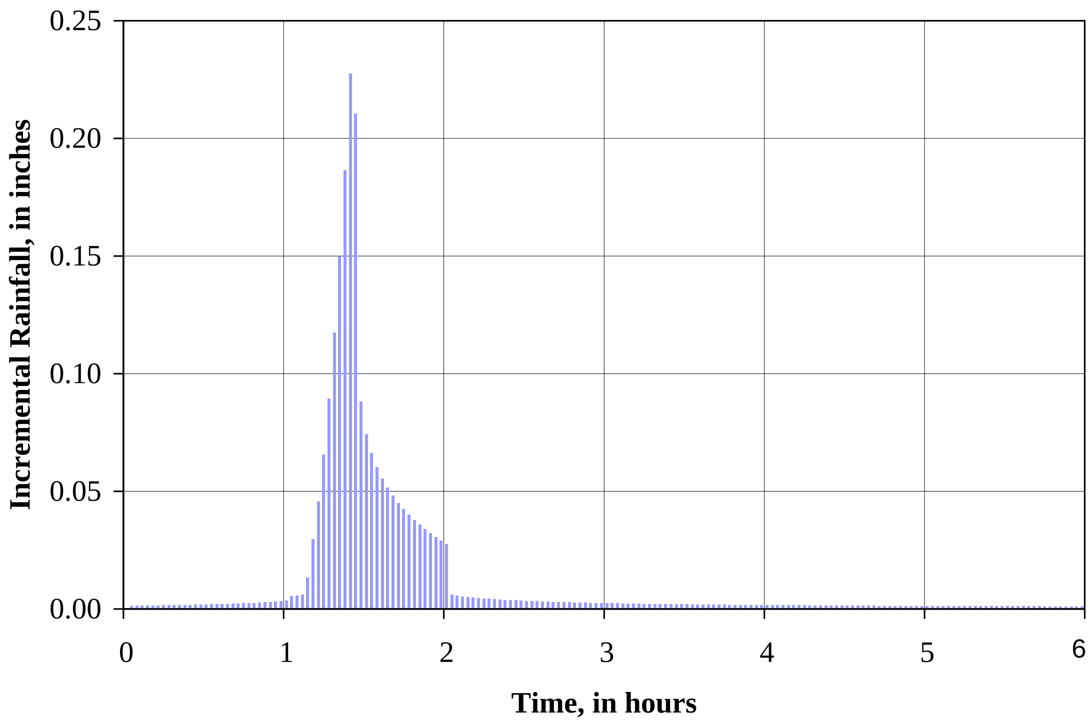
$$P_T = P_{1440} + \left(P_{360} - P_{1440}\right) * \frac{30^B - \left(t/60 + 6\right)^B}{30^B - 12^B}$$ For $360 < t < 1440$ (E-6)

Where: $$A = \frac{Log\left(P_{360}/P_{60}\right)}{Log(6.0)}$$

$$B = \frac{Log\left(P_{1440}/P_{360}\right)}{Log(4.0)}$$

These equations are implemented in the AHYMO program by specifying P_{60}, P_{360}, and P_{1440} with the RAINFALL command. See the AHYMO users manual for additional information at www.ahymo.com.

FIGURE E-1. 100-YR 6-HR RAINFALL HYETOGRAPH



E.2.3 Procedure

A. For design events up to the 500-year and storm durations up to the 24-hour
   1. Select the point rainfall depths from Table E-1
   2. In AHYMO
      a. For a 6-hour storm code the RAINFALL command with the following:
         1. Distribution type = 1
         2. 1-hour rainfall depth from Step 1
         3. 6-hour rainfall depth from Step 1
         4. Incremental time, DT, of 0.033333 hours
      b. For a 24-hour storm code the RAINFALL command with the following:
         1. Distribution type = 2
         2. 1-hour adjusted rainfall depth from Step 1
         3. 6-hour adjusted rainfall depth from Step 1
         4. 24-hour adjusted rainfall depth from Step 1
         5. Incremental time, DT, of 0.05 hours

B. For design storms with durations other than 6- or 24-hours, submit to SSCAFCA/City Engineer in writing a recommendation for depth-area reduction and time distribution of the rainfall for the selected storm event.

E.3 RAINFALL LOSS

Rainfall losses are generally considered to be the result of evaporation of water from the land surface, interception of rainfall by vegetal cover, depression storage on the land surface and the infiltration of water into the soil matrix. The magnitude of rainfall loss is typically expressed as an equivalent uniform depth in inches. By a mass balance, rainfall minus losses equals rainfall excess. Estimation of rainfall loss is an important element in flood analyses that must be clearly understood and estimated with care.

E.3.1 Land Treatment

Estimation of rainfall losses are based on a characterization of the watershed area into land treatment classifications. Four land treatment classifications have been created that typify the conditions in the SSCAFCA jurisdiction. Descriptions of the land treatment classifications are provided in Table E-2. Three of the land treatment classifications (A, B and C) are for pervious conditions. The forth classification (D) is for impervious areas.

TABLE E-2. LAND TREATMENTS	
Treatment	**Land Condition**
A	Soil uncompacted by human activity with 0 to 10 percent slopes. Native grasses, weeds and shrubs in typical densities with minimal disturbance to grading, ground cover and infiltration capacity.
B	Irrigated lawns, parks and golf courses with 0 to 10 percent slopes. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes greater than 10 percent and less than 20 percent.
C	Soil compacted by human activity. Minimal vegetation. Unpaved parking, roads, trails. Most vacant lots. Gravel or rock on plastic (desert landscaping). Irrigated lawns and parks with slopes greater than 10 percent. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes at 20 percent or greater. Native grass, weed and shrub areas with clay or clay loam soils and other soils of very low permeability as classified by SCS Hydrologic Soil Group D.
D	Impervious areas, pavement and roofs.
Most watersheds contain a mix of land treatments. To determine proportional treatments, measure respective subareas. In lieu of specific measurement for treatment D, the areal percentages in Table E-3 may be employed.	

Of the land treatment classifications listed in Table E-2, only treatment type A represents land in its natural, undisturbed state. Land treatment classifications B and C describe conditions that have been impacted by some form of urbanization. Urban areas within a watershed usually contain a mix of the land treatment types. Ideally, the specific area of each land treatment type can be measured from available information. In lieu of specific measurement for each unique land treatment type that occurs within urban areas, generalized percentages based on zoning classifications can be used. Average land treatment type percentages associated with various zoning designations are listed in Table E-3.

TABLE E-3 SSCAFCA TREATMENT TYPE PERCENTAGE SUMMARY

Parcel Description	Treatments A	B	C	D	Methodology/Notes
1/8 Acre	0%	15%	15%	70%	DPM, Chapter 22.2, Table A-4 for D
1/6 Acre	0%	28%	15%	57%	Northern Meadows Master Plan
1/4 Acre	0%	30%	28%	42%	DPM, and followed SSCAFCA lead on B&C
1/2 Acre	10%	33%	30%	27%	SSCAFCA
1 Acre	43%	20%	20%	17%	SSCAFCA
Single Family Residential N=units/acre, N6					7*√((N*N) + (5*N))
Estate Lots (btwn 1-5ac)	60%	15%	15%	10%	DPM for 2.5 acre lot
M-1 (Light Industrial)	0%	15%	15%	70%	DPM for D, split B & C
Vacant Res./Undevel.	79%	8%	8%	5%	DPM for 5 acre lot
Arroyo	100%	0%	0%	0%	DPM
Major Roads	0%	0%	10%	90%	DPM
School	10%	20%	20%	50%	DPM
Commercial/Industrial	0%	0%	15%	85%	DPM average of Heavy Industrial and Commercial
Open Space	100%	0%	0%	0%	DPM
Parks, Sports and Rec	0%	85%	0%	15%	DPM
Landfill	0%	0%	100%	0%	All disturbed ground
Multi-Family	0%	15%	15%	70%	DPM-Multiple Unit Res. Attached
Northern Meadows	0%	28%	15%	57%	Northern Meadows Master Plan
Drainage Ponds	0%	0%	100%	0%	
County Platted (1)	18.7%	29.5%	27.0%	24.8%	(used Basin P12_104 as typical)
County Unplatted (2)	95%	5%	0%	0%	DPM

NOTES

1. County Platted area is defined as the area between CORR boundary and Rio Rancho Estates boundary.
2. County Unplatted area is defined as the area outside the city limits and the Rio Rancho Estates limits. It is considered to be existing conditions.
3. All roads are assumed to be paved.

E.3.2 Initial Abstraction and Infiltration Loss

Simulation of rainfall loss is accomplished using an initial loss coupled with a loss rate. This combined methodology is a two parameter model. The first parameter is the Initial Abstraction (IA). The initial abstraction is the summation of all losses other than infiltration and is applied at the beginning of the storm event. The second parameter is the Infiltration rate (INF) of the soil matrix at saturation. Infiltration losses begin once the initial abstraction is completely satisfied. For pervious conditions, the infiltration rate is constant. For impervious conditions, the infiltration rate is constant up to hour 3 of the design storm. After hour 3 and until hour 6, the infiltration rate is linearly reduced to zero. Beyond hour 6, no infiltration occurs. The constant loss is only applied once the Initial Abstraction is satisfied. An illustration of the application of this method is provided in Figure E-2.

Recommended values for the Initial Abstraction and Infiltration rate are assigned to each land treatment type and are listed in Table E-4. For watersheds and subbasins with multiple, unique land treatment types an arithmetic area averaged value for IA and INF is to be calculated.

FIGURE E-2. REPRESENTATION OF RAINFALL LOSS METHODOLOGY

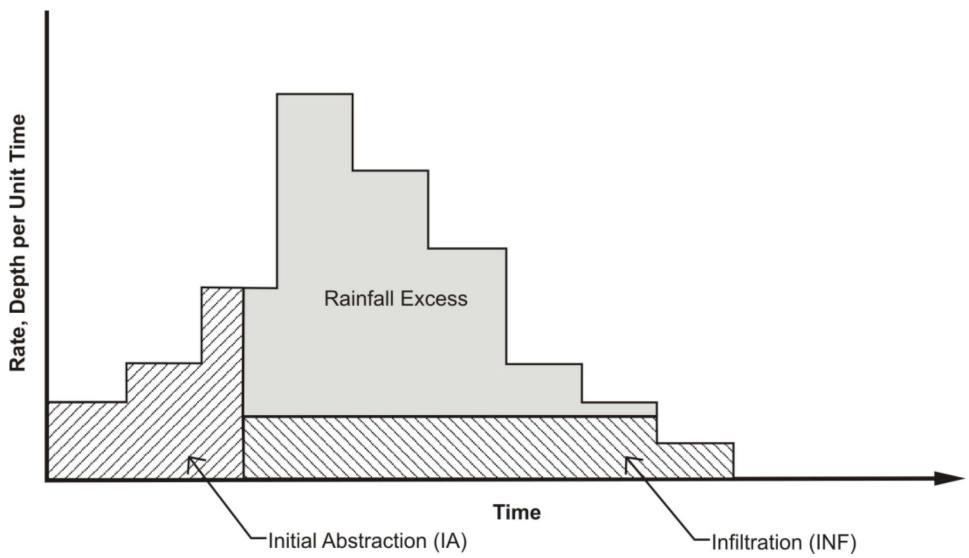


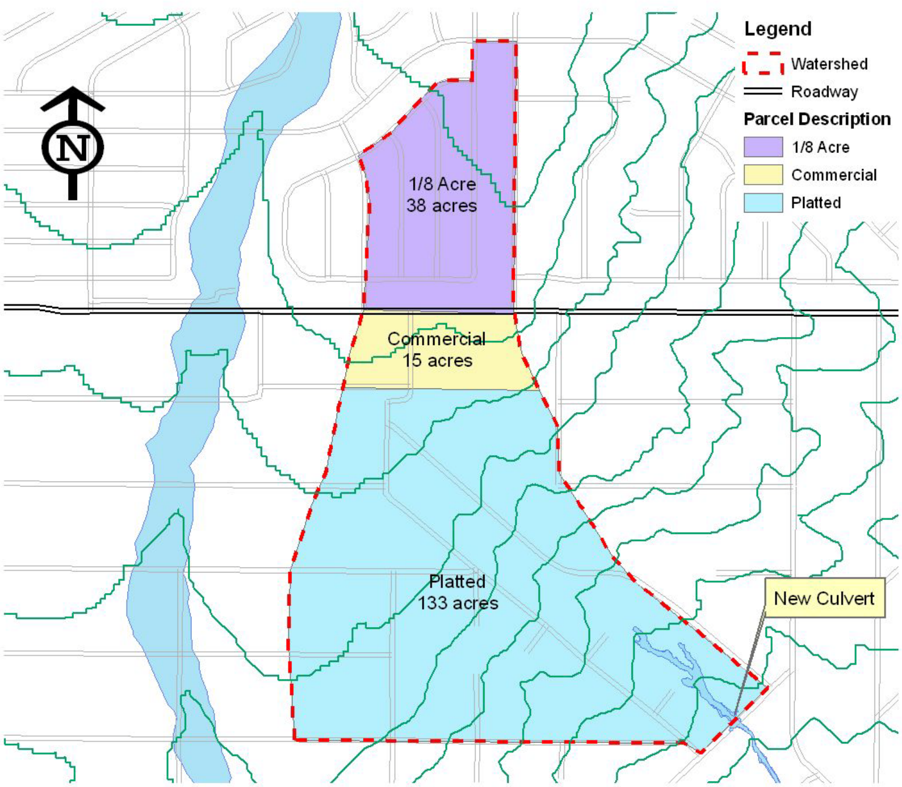
TABLE E-4. INITIAL AND CONSTANT LOSS PARAMETERS		
Land Treatment	**Initial Abstraction (inches)**	**Infiltration (inches/hour)**
A	0.65	1.67
B	0.50	1.25
C	0.35	0.83
D	0.10	0.04

E.3.3 Procedure

1. For each subbasin, calculate the area of each unique land treatment type or zoning classification.
2. Calculate the area weighted percentage of each land treatment type.
3. In AHYMO, for each subbasin code in the percent area of each land treatment type in the COMPUTE NM HYD command.(See AHYMO Users Manual)

E.3.4 Example

A new culvert is to be constructed to convey the 100-year, 6-hour storm at the location shown in the following figure. Compute the rainfall loss parameters for the contributing watershed.



1. From Table E-3, percentage of Land Treatment Types for each parcel within the watershed are:

Parcel Description	Area acres	Percent of Land Treatment Type A	B	C	D
1/8 Acre	38	0	15	15	70
Commercial / Industrial	15	0	0	15	85
Platted	133	18.7	29.5	27.0	24.8

Area of each Land Treatment Type is calculated as:

- $Area_A$ = (0)(38) + (0)(15) + (0.187)(133) = 24.9 acres
- $Area_B$ = (0.15)(38) + (0)(15) + (0.295)(133) = 44.9 acres
- $Area_C$ = (0.15)(38) + (0.15)(15) + (0.27)(133) = 43.9 acres
- $Area_D$ = (0.70)(38) + (0.85)(15) + (0.248)(133) = 72.3 acres

Total Area = 186.0 acres

2. Using values of IA from Table E-4, calculate the weighted value of IA

$$IA = \frac{(24.9)(0.65) + (44.9)(0.50) + (43.9)(0.35) + (72.3)(0.10)}{(24.9 + 44.9 + 43.9 + 72.3)}$$

IA = 0.33 inches

3. Using values of INF from Table E-4, calculate the weighted value of INF

$$INF = \frac{(24.9)(1.67) + (44.9)(1.25) + (43.9)(0.83) + (72.3)(0.04)}{(24.9 + 44.9 + 43.9 + 72.3)}$$

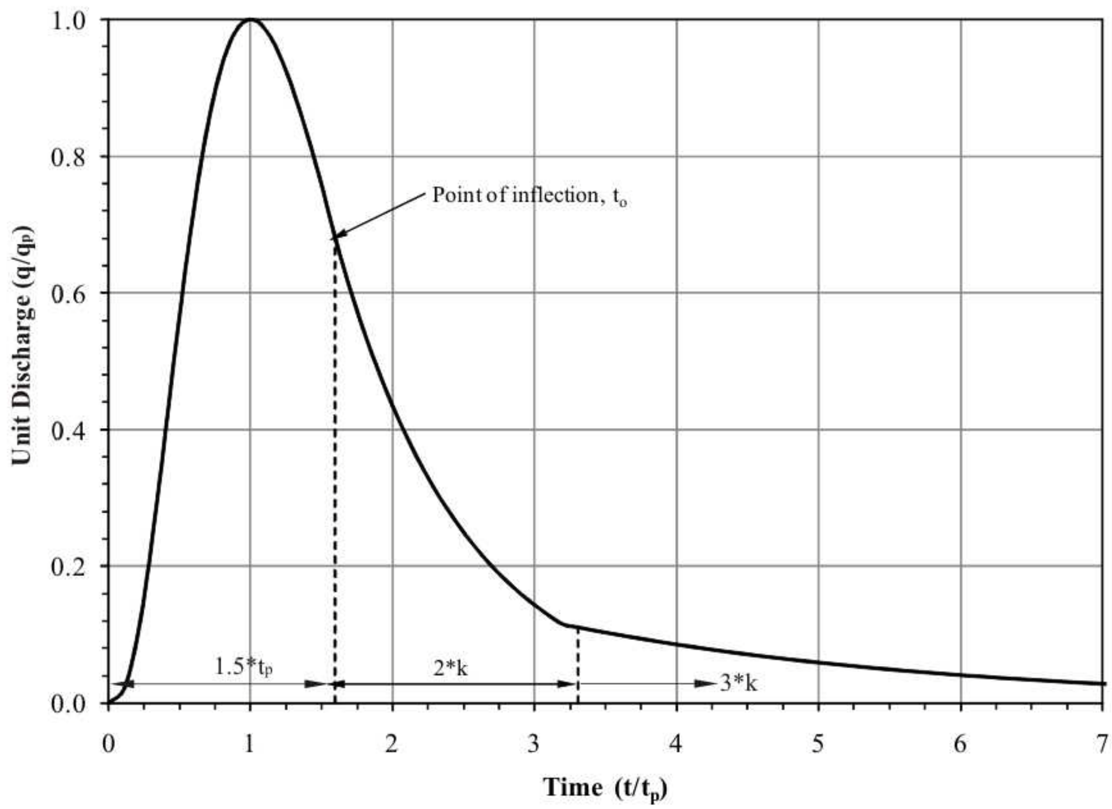
INF = 0.74 in/hr

E.4 UNIT HYDROGRAPH

Rainfall excess generated during a storm event is routed across the basin surface and eventually begins to concentrate at a downstream location (concentration point). The routing process results in the transformation of rainfall excess to a runoff hydrograph. Simulation of rainfall excess transformation is typically accomplished using the concept of a unit hydrograph. A unit hydrograph is defined as the hydrograph of one inch of direct runoff from a storm of a specified duration for a particular basin. Every watershed will have a different unit hydrograph that reflects the topography, land use, and other unique characteristics of the individual watershed. Different unit hydrographs will also be produced for the same watershed for different durations of rainfall excess.

For most watersheds, sufficient data (rainfall and runoff records) does not exist to develop unit hydrographs specific to the watershed. Therefore, indirect methods are used to develop a unit hydrograph. Such unit hydrographs are called synthetic unit hydrographs. The synthetic unit hydrograph encoded in AHYMO is dimensionless and can be defined by two numeric parameters; Time to Peak (t_p) and Recession Constant (k). The shape of the AHYMO dimensionless unit hydrograph is broken into three time segments as illustrated in Figure E-3.

FIGURE E-3. AHYMO DIMENSIONLESS UNIT HYDROGRAPH



E.4.1 Time to Peak

Time to peak is defined as the time from the beginning of unit rainfall excess to the time of the peak flow of the unit runoff hydrograph. It is assumed to be a constant ratio of the time of concentration as given by Equation E-7. Time of concentration (T_c) is defined as the time it takes for runoff to travel from the hydraulically most distant part of the watershed basin 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.

$$t_p = \left(\frac{2}{3}\right) * T_c \qquad \text{(E-7)}$$

Time of concentration is calculated using one of three equations. Selection of the appropriate equation is based on the time of concentration flow path length (in time). Regardless of the selected equation, time of concentration should not be less than 12 minutes.

For basins with flow path lengths less than 4,000 feet the SCS Upland Method is used. 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:

$$T_c = \sum_{i=1}^{n} \left(\frac{L_i}{36{,}000 * K_i * \sqrt{S_i}} \right) \tag{E-8}$$

Where: T_c = Time of concentration, in hours
L_i = Length of each unique surface flow conveyance condition, in feet
K_i = Conveyance factor from Table E-5
S_i = Slope of the flow path, in feet per foot

TABLE E-5. 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 plane surfaces, with flow depths up to 0.1 feet. Sheet flow applies only to the upper 400 feet (maximum) of a subbasin.

For basins with flow path lengths longer than 4,000 feet the following equation should be used for calculating time of concentration:

$$T_c = \left(\frac{12{,}000 - L}{72{,}000 * K * \sqrt{S}} + \frac{(L - 4{,}000) * K_n * \left(L_{ca} / L \right)^{0.33}}{552.2 * S^{0.165}} \right) \tag{E-9}$$

Where: L = Flow path length, in feet
L_{ca} = Distance along L from point of concentration to a point opposite the centroid of the basin, in feet

$K =$ Conveyance factor from Table E-5
$K_n =$ Basin factor, from Table E-6
$S =$ Slope of flow path, in feet per foot

TABLE E-6. LAG EQUATION BASIN FACTORS	
K_n	**Basin Condition**
0.042	Mountain Brush and Juniper
0.033	Desert Terrain (Desert Brush)
0.025	Low Density Urban (Minimum improvements to watershed channels)
0.021	Medium Density Urban (Flow in streets, storm sewers and improved channels)
0.016	High Density Urban (Concrete and rip-rap lined channels)

Calculation of a basin time of concentration is a function of flow path length and, by extension, basin area. Therefore, basin / subbasin delineation is a key consideration that must be addressed early on in the modeling process as it not only influences unit hydrograph parameter estimation but rainfall loss parameters as well. Wherever possible, subbasin delineation should be based on the best available topographic mapping and, if available, detailed aerial photography. For some areas, field investigation may also be necessary to verify subbasin boundaries particularly in urban or distributary areas. The breakdown of a watershed into subbasins should consider the following:

- The subbasin sizes should be as uniform as possible.
- Subbasins should have fairly homogeneous land use and geographic characteristics. For example: mountain, hillslope and valley areas should be delineated separately where possible.
- Soils, vegetation and land treatment characteristics should be fairly homogeneous.
- Subbasins size should be commensurate with the intended use of the model. For example, if the model is to be used for the evaluation and / or design of drainage infrastructure, the subbasin size should be fairly small so that runoff magnitudes are known at multiple locations within the watershed. For drainage management plans, the subbasin size should in general not be greater than 1.5 mi^2 or less than 0.1 mi^2.

E.4.2 Time of Concentration for Steep Slopes and Natural Channels

The equations used to compute time of concentration may result in values that are too small to be sustained for natural channel conditions. In natural channels, flows become unstable when a Froude Number of 1.0 is approached. The equations identified in Section E.4.1 can result in flow velocities for steep slopes that indicate supercritical flow conditions, even though such supercritical flows cannot be sustained for natural channels. For steep slopes, natural channels will likely experience chute and pool conditions with a hydraulic jump occurring at the downstream end of chute areas; or will experience a series of cascading flows with very steep drops interspersed with flatter channel sections.

For the purposes of this section, steep slopes are defined as those greater than 0.04 foot per foot. The procedures outlined in this section should not be used for the following conditions:

- Slopes flatter than 0.04 foot per foot.
- Channels with irrigated grass, riprap, soil cement, gabion, or concrete lining which cannot be clearly identified as natural or naturalistic.
- The hydraulic design of channels or channel elements. The purpose of this section is to define procedures for hydrologic analysis only. The design of facilities adjacent to or within channels with chute and pool conditions cannot be analyzed with the simplified procedures identified herein. It may be necessary to design such facilities for the supercritical flows of chutes (for sediment transport, local scour, stable material size) and for the hydraulic jump of pool conditions (for maximum water surface elevation and flood protection).

The slope of steep natural watercourses should be adjusted to account for the effective slope that can be sustained. The slope adjustment procedures identified in the Denver - Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (Figure 4-1, Runoff chapter, 1990) are applicable for the slope adjustment identified herein. In addition, channel conveyance factors (K) should be checked to make sure that appropriate equivalent Froude Numbers are maintained. The UDFCD Figure 4-1 can be approximated by the following equation:

$$S' = 0.052467 + 0.062627S - 0.18197e^{-62.375S} \qquad \text{(E-10)}$$

Where: S = Measured slope, in feet per foot
S′ = Adjusted slope, in feet per foot

The conveyance factors (K) for the Upland Method should be checked to make sure that appropriate Froude Numbers are maintained. The Basin Factors, K_n, from Table E-6 remain applicable when using equations E-8 and E-9 with the adjusted slope computed by equation E-10. To adjust the conveyance factor (K) it is necessary to estimate the peak flow rate from the watershed. Using estimated conveyance factors (K) from Table E-5 and the Rational Method procedures outlined in Part D, an estimated peak flow rate for the basin (Q_p) can be computed. The following formulas are then used to compute conveyance factor adjustment:

$$K' = 0.302 * S'^{-0.5} * Q_p^{0.18} \qquad \text{(E-11)}$$

$$K'' = 0.207 * S'^{-0.5} * Q_p^{0.18} \qquad \text{(E-12)}$$

An adjusted conveyance factor (K) is then obtained based on the following:

- if K > K' then K= K'
- if K' ≥ K ≥ K" then K = K (no adjustment)

- if K < K" then K= K"

This is an iterative process that is to be repeated until the computed value of Q_p is within 10 percent of original value of Q_p.

E.4.3 Recession Constant

The recession constant is a function of drainage area, rainfall depth and land cover treatment. A value of k is calculated for each land cover treatment present in the watershed. Two sets of equations are provided for the estimation of k. Selection of the appropriate set is based on basin area.

For drainage basins less than or equal to 40 acres in size, k is calculated separately for each land treatment type using Equations E-13 through E-16. For basins with multiple land cover treatments, an arithmetically area-weighted value is calculated for the pervious areas (land treatment types A, B and C) with a separate calculation for land treatment type D. Regardless of the land treatment type or combinations of land treatment type within the basin, the calculated value of k must be no greater than $1.35t_p$ and no less than $0.545t_p$. The following are equations for calculating land treatment types.

Land Treatment Type A

$$k = \begin{cases} t_p(1.58159 - 0.18912P_{60}) & \text{For } P_{60} < 2.10 \text{ inches} \\ t_p(0.98204 + 0.09638P_{60}) & \text{For } P_{60} \geq 2.10 \text{ inches} \end{cases} \quad \text{(E-13)}$$

Land Treatment Type B

$$k = \begin{cases} t_p(1.22953 - 0.132P_{60}) & \text{For } P_{60} < 1.89 \text{ inches} \\ t_p(0.8090 + 0.0905P_{60}) & \text{For } P_{60} \geq 1.89 \text{ inches} \end{cases} \quad \text{(E-14)}$$

Land Treatment Type C

$$k = \begin{cases} t_p(0.90392 - 0.07488P_{60}) & \text{For } P_{60} < 1.68 \text{ inches} \\ t_p(0.63596 + 0.08462P_{60}) & \text{For } P_{60} \geq 1.68 \text{ inches} \end{cases} \quad \text{(E-15)}$$

Land Treatment Type D

$$k = \begin{cases} 0.5450 t_p & \text{For } P_{60} < 1.33 \text{ inches} \\ t_p\left(0.31048 + 0.7356 P_{60}\right) & \text{For } P_{60} \geq 1.33 \text{ inches} \end{cases} \qquad \text{(E-16)}$$

For drainage basins greater than or equal to 200 acres in size, k is calculated separately for each land treatment type using Equations E-17 through E-20. For basins with multiple land cover treatments, an arithmetically area-weighted value is calculated for the pervious areas (land treatment types A, B and C) with a separate calculation for land treatment type D. Regardless of the land treatment type or combinations of land treatment type within the basin, the calculated value of k must not be greater than $1.30t_p$.

Land Treatment Type A

$$k = t_p\left(0.854 + 0.5808 * 4.756828^{1-P_{60}}\right) \qquad \text{(E-17)}$$

Land Treatment Type B

$$k = t_p\left(0.770 + 0.480 * 4.756828^{1-P_{60}}\right) \qquad \text{(E-18)}$$

Land Treatment Type C

$$k = t_p\left(0.686 + 0.3792 * 4.756828^{1-P_{60}}\right) \qquad \text{(E-19)}$$

Land Treatment Type D

$$k = t_p\left(0.528 + 0.1896 * 4.756828^{1-P_{60}}\right) \qquad \text{(E-20)}$$

For drainage basins between 40 and 200 acres in size, calculate k using the appropriate equations for drainage area up to 40 acres and for drainage areas greater than or equal to 200 acres in size. The basin specific values of k for pervious and impervious areas are then calculated using linear interpolation.

E.4.4 Procedure

1. From an appropriate map of the watershed, delineate the time of concentration flow path for each subbasin and measure the length, in feet.
    a. If the flow path length is less than 4,000 feet, calculate T_c using Equation E-8 with the following:
        i. Select K from Table E-5
        ii. Measure the average flow path slope, S. If the flow path slope is greater than 0.04 feet / foot:
            1. Calculate the adjusted slope using Equation E-10.
            2. Estimate the peak discharge using procedures in Part D

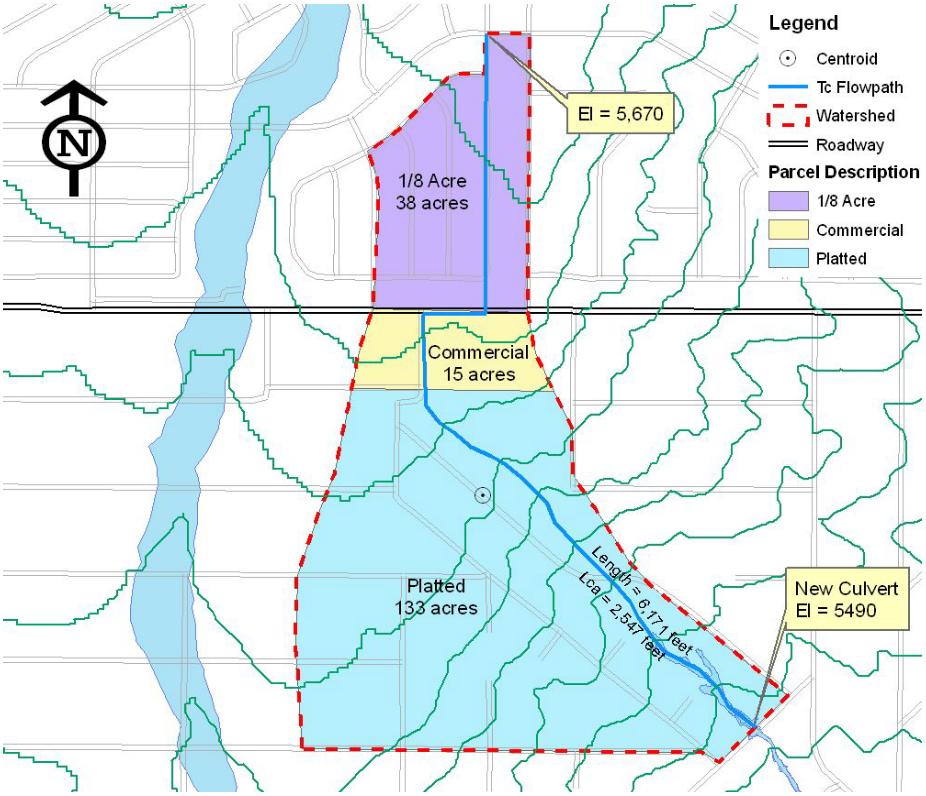
3. Calculate the conveyance factor adjustment range using Equations E-11 and E-12.
4. Recalculate the peak discharge using the procedures in Part D and the adjusted slope and conveyance factor.
5. Repeat steps ii3 and ii4 until the calculated peak discharge is within 10 % of the original value.

b. If the flow path length is longer than 4,000 feet, calculate T_c using Equation E-9 with the following:
   i. Measure L_{ca} and S
   ii. Select appropriate values of K from Table E-5 and K_n from Table E-6

2. Calculate t_p using Equation E-7
3. Calculate k based on the drainage area:
   a. If drainage area is less than or equal to 40 acres in size and contains only one land treatment type, use Equation E-13, E-14 or E-15 as appropriate for the land treatment type present. If multiple land treatment types are present, calculate an arithmetically area-weighted value for pervious areas using Equations E-13 through E-15 and also calculate k for impervious area using Equation E-16.
   b. If drainage area is greater than or equal to 200 acres in size and contains only one land treatment type, use Equation E-17, E-18 or E-19 as appropriate for the land treatment type present. If multiple land treatment types are present, calculate an arithmetically area-weighted value for pervious areas using Equations E-17 through E-19 and also calculate k for impervious area using Equation E-20.
   c. If drainage area is between 40 and 200 acres in size then calculate k according to Step 3a and 3b. Then use linear interpolation to estimate k for the basin drainage area.

E.4.5 Example

A new culvert is to be constructed to convey the 100-year, 6-hour storm at the location shown in the following figure. Compute the unit hydrograph parameters for the contributing watershed.



1. The flow path length is greater than 4,000 feet. Therefore, Equation E-9 is used for the calculating Time of Concentration (T_c). Select K and K_n from Tables E-5 and E-6, respectively.

   C. K = 2 (Shallow concentrated flow within residential area)
   D. K_n = 0.33 (Desert terrain)

2. Using Equation E-9, calculate T_c.

$$T_c = \left(\frac{12{,}000 - 6{,}171}{72{,}000 * 2 * \sqrt{0.029}} + \frac{(6{,}171 - 4{,}000) * 0.033 * \left({2{,}547}/{6{,}171} \right)^{0.33}}{552.2 * 0.029^{0.165}} \right)$$

$$T_c = (0.24 + 0.17)$$

$$T_c = 0.41 \text{ hours}$$

3. Using Equation E-7, calculate t_p.

$$t_p = \left({2}/{3} \right) * T_c$$

$$t_p = \left({2}/{3} \right) * 0.41$$

$$t_p = 0.27 \text{ hours}$$

4. Calculate the recession constant, k, using Equations E-13 through E-20 and the 100-year, 1-hour rainfall depth from Table E-1.

Calculate the k for Land Treatment Type A at 40 and 200 acres

$$k_A^{40} = t_p(1.58159 - 0.18912 P_{60})$$

$$k_A^{40} = 0.27 * (1.58159 - 0.18912 * 1.84)$$

$$k_A^{40} = 0.33 \text{ hours}$$

$$k_A^{200} = t_p\left(0.854 + 0.5808 * 4.756828^{1-P_{60}}\right)$$

$$k_A^{200} = 0.27 * \left(0.854 + 0.5808 * 4.756828^{1-1.84}\right)$$

$$k_A^{200} = 0.27 \text{ hours}$$

Calculate the k for Land Treatment Type B at 40 and 200 acres

$$k_B^{40} = t_p(1.22953 - 0.132 P_{60})$$

$$k_B^{40} = 0.27 * (1.22953 - 0.132 * 1.84)$$

$$k_B^{40} = 0.27 \text{ hours}$$

$$k_B^{200} = t_p\left(0.770 + 0.480 * 4.756828^{1-P_{60}}\right)$$

$$k_B^{200} = 0.27 * \left(0.770 + 0.480 * 4.756828^{1-1.84}\right)$$

$$k_B^{200} = 0.24 \text{ hours}$$

Calculate the k for Land Treatment Type C at 40 and 200 acres

$$k_C^{40} = t_p(0.63596 + 0.08462 P_{60})$$

$$k_C^{40} = 0.27 * (0.63596 + 0.08462 * 1.84)$$

$$k_C^{40} = 0.21 \text{ hours}$$

$$k_C^{200} = t_p\left(0.686 + 0.3792 * 4.756828^{1-P_{60}}\right)$$

$$k_C^{200} = 0.27 * \left(0.686 + 0.3792 * 4.756828^{1-1.84}\right)$$

$$k_C^{200} = 0.21 \text{ hours}$$

Calculate the k for Land Treatment Type D at 40 and 200 acres

$$k_D^{40} = t_p\left(0.31048 + 0.07356 P_{60}\right)$$

$$k_D^{40} = 0.27 * \left(0.31048 + 0.07356 * 1.84\right)$$

$$k_D^{40} = 0.12 \text{ hours}$$

$$k_D^{200} = t_p\left(0.528 + 0.1896 * 4.756828^{1-P_{60}}\right)$$

$$k_D^{200} = 0.27 * \left(0.528 + 0.1896 * 4.756828^{1-1.84}\right)$$

$$k_D^{200} = 0.16 \text{ hours}$$

Calculate the weighted k for the pervious area at 40 and 200 acres

$$k_p^{40} = \frac{(24.9)(0.33) + (44.9)(0.27) + (43.9)(0.21)}{(24.9 + 44.9 + 43.9)}$$

$$k_p^{40} = 0.26 \text{ hours}$$

$$k_p^{200} = \frac{(24.9)(0.27) + (44.9)(0.24) + (43.9)(0.21)}{(24.9 + 44.9 + 43.9)}$$

$$k_p^{200} = 0.23 \text{ hours}$$

Calculate the weighted k for the pervious portion of the watershed using linear interpolation

$$k_p = 0.23 - (0.23 - 0.26) * \left(\frac{200 - 186}{200 - 40}\right)$$

k_p = 0.233 hours

Calculate the weighted k for the impervious portion of the watershed using linear interpolation

$$k_p = 0.16 - (0.16 - 0.12) * \left(\frac{200 - 186}{200 - 40}\right)$$

k_p = 0.157 hours

E.5 CHANNEL ROUTING

Hydrologic channel routing describes the movement of a floodwave (hydrograph) along a watercourse. For most natural rivers, as a floodwave passes through a given reach, the peak of the outflow hydrograph is attenuated and delayed due to flow resistance in the channel and the storage capacity of the river reach. In urban environments, runoff is often conveyed in manmade features such as roadways, storm drains and engineered channels that minimize hydrograph attenuation.

Channel routing is used in flood hydrology models, such as AHYMO, when the watershed is modeled with multiple subbasins and runoff from the upper subbasins must be translated through a channel or system of channels to the watershed outlet. The channel routing method in AHYMO is the Muskingum-Cunge methodology.

The Muskingum-Cunge channel routing is a physically based methodology that solves the continuity and diffusive form of the momentum equation based on the physical channel properties and the inflow hydrograph. The solution procedure involves the discretization of the equations in both time and space (length). The discretized time and distance step size influence the accuracy and stability of the solution.

E.5.1 Physical Parameters

The physical parameters required for the Muskingum-Cunge channel routing are: reach length, flow resistance factor, friction slope and the channel geometry. One limitation of this method is that it cannot account for the effects of backwater. Therefore, the friction slope can be approximated using the average bed slope.

The channel reach length and average bed slope should be estimated from the best available mapping. If there are significant changes in the bed slope over the length of the channel routing reach, a weighted average slope should be estimated or multiple reach lengths used. Also, if the channel bed slope exceeds 0.04 feet per foot then the procedures in Section E.4.2 should be followed.

Hydrologic routing calculations are based on a single cross section that describes the average geometry for the entire reach. The representative geometry can be any prismatic open channel configuration, including a circular section, as well as an irregular channel. Typically, the channel geometry is derived from a single location along the reach that is representative of the overall channel geometry. Channel geometry can be estimated using available topographic mapping or from field survey.

E.5.2 Roughness Coefficients

Flow resistance in the channel and overbank flow area is simulated using Manning's roughness coefficients. Flow resistance is affected by many factors including bed material size, bed form, irregularities in the cross section, depth of flow, vegetation, channel alignment, channel shape, obstructions to flow and the quantity of sediment of being transported in suspension or as bed load. In general, all factors that retard flow and increase turbulent mixing tend to increase Manning's n-values. Manning's roughness coefficients appropriate for hydrologic routing are listed in Table E-7 and are, in general, taken from the SSCAFCA Sediment and Erosion Design Guide (MEI, 2008). Use of roughness coefficients other than those listed in Table E-7 must be estimated using the information and procedures in the Sediment and Erosion Design Guide and approved by SSCAFCA.

TABLE E-7. MANNING'S ROUGHNESS COEFFICIENTS

Channel or Floodplain Type	n-value
Sand bed arroyos	0.055
Tined concrete	0.018
Shotcrete	0.025
Reinforced concrete pipe	0.013
Trowled concrete	0.013
No-joint cast-in-place concrete pipe	0.014
Reinforced concrete box	0.015
Reinforced concrete arch	0.015
Streets	0.017
Flush grouted riprap	0.020
Corrugated metal pipe	0.025
Grass-lined channels (sodded & irrigated)	0.025
Earth-lined channels (smooth)	0.030
Wire-tied riprap	0.040
Medium weight dumped riprap	0.045
Grouted riprap (exposed rock)	0.045
Jetty type riprap (D50 > 24")	0.050

E.5.3 Procedure

1. From an appropriate map of the watershed, measure the routing reach length in feet and estimate the friction slope as the channel bed slope in feet per foot.
2. Select and identify cross sectional geometry that represents that average hydraulic conditions of the reach. If a single cross section cannot be identified that represents

the average hydraulic conditions, break the reach into multiple sections and treat each as a unique element in AHYMO.

3. Conduct a field reconnaissance of the watershed and routing reaches to observe the flow resistance characteristics.
4. Select an appropriate Manning's roughness coefficient for the channel and overbank flow areas using Table E-7.

E.6 SEDIMENT BULKING

Flow bulking occurs when sediment is eroded from the land surface and entrained into the flowing water. Entrained sediment has the effect of increasing the runoff volume and flow rate. Within this jurisdiction there is potential for high sediment yields. For undeveloped watersheds the bulking factor is 18%. Similarly, sediment yield from developed areas shall be 6%. Developed conditions are those areas that have paved roads with curb and gutter. Given the high potential for surface erosion, all watershed models will include flow bulking.

E.6.1 Procedure

In AHYMO, flow bulking for sediment is simulated using a ratio. The ratio is applied to direct runoff estimated for each subbasin. The bulking factor is applied globally using the SEDIMENT BULK Command. The bulking factor specified on this command is used for all subsequent runoff calculation until changed by another SEDIMENT BULK Command.

F. Rainfall-Runoff Modeling: HEC-HMS

F.1 INTRODUCTION

Rainfall-runoff modeling for drainage areas greater than 320 acres in size is to be conducted using the U.S. Army Corps of Engineers HEC-HMS software. HEC-HMS can also be applied to drainage areas between 40 and 320 acres in size. HEC-HMS is the successor to HEC-1 and has been in use since 1998. HEC-HMS is a public domain software that is part of the Hydrologic Engineering Center's Next Generation Software Development Project. Input to HEC-HMS is to be developed using the recommended methodologies, techniques and procedures presented in the following sections.

F.2 DESIGN RAINFALL CRITERIA

For design hydrology, the characteristics of the major flood producing storm are simulated using a synthetic storm. Components of a synthetic storm are basin average rainfall depth and temporal distribution. Information and procedures for developing the design rainfall criteria for storms other than the Probable Maximum Precipitation are provided in the following sections.

F.2.1 Depth

The principal design storm for peak flow determination is the 100-year, 6-hour event. For analysis and design of retention ponds and detention dams, the 100-year, 24-hour storm is to be used unless the structure falls under the jurisdiction of the New Mexico Office of State Engineer, Dam Safety Bureau. Point precipitation depths for the 100-year storm to be used within the SSCAFCA jurisdiction are provided in Table F-1. Those values are adapted from NOAA Atlas 14, Precipitation - Frequency Atlas of the United States, Volume 1: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah).

For determining sediment transport and for analysis of watersheds with complex routing conditions, other storm frequencies and durations may be required. Point precipitation depths for use in the SSCAFCA jurisdiction for multiple recurrence intervals and storm durations are listed in Table F-1. For all other recurrence intervals and storm durations, point precipitation depths are to be obtained directly from the National Weather Service through the NOAA 14 Precipitation Frequency Data Server web site found at http://hdsc.nws.noaa.gov/hdsc/pfds/sa/nm_pfds.html. At this web site point 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.

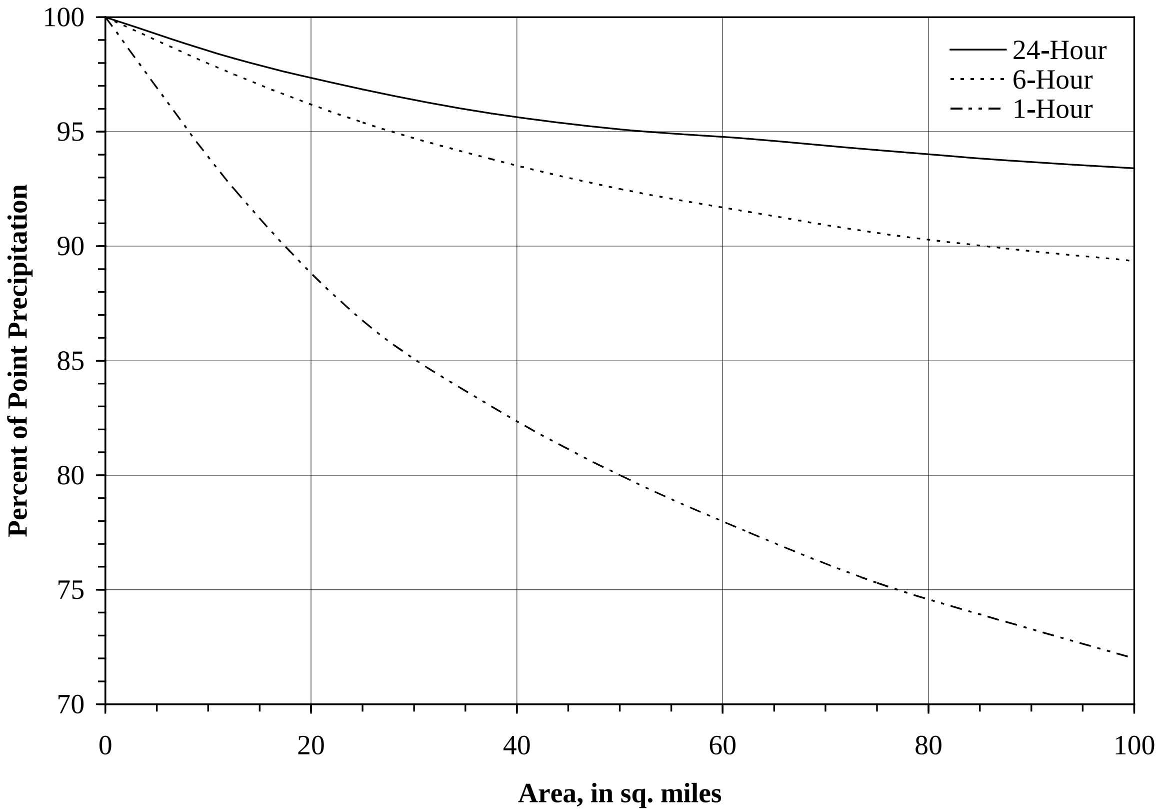
TABLE F-1. RECURRENCE INTERVAL POINT PRECIPITATION DEPTHS				
Recurrence Interval	**Duration**			
Years	**15-Minute**	**1-Hour**	**6-Hour**	**24-Hour**
500	1.42	2.37	3.01	3.57
100	1.10	1.84	2.37	2.90
50	0.97	1.62	2.11	2.57
25	0.85	1.42	1.86	2.29
10	0.70	1.16	1.54	1.90
5	0.58	0.97	1.31	1.66
2	0.43	0.72	1.02	1.32
1	0.34	0.56	0.81	1.05

F.2.2 Depth-Area-Reduction

The rainfall depths listed in Table F-1 or obtained from the NOAA 14 Precipitation Frequency Data Server web site are point rainfall depths for specified durations. This depth is not the areal-averaged rainfall over the basin that would occur during a storm. For uncontrolled watersheds (those areas not controlled by dams, ponds and / or partial diversions), a reduction factor is used to convert the point rainfall to an equivalent uniform depth over the entire watershed. Reduction factors for converting point rainfall depths to basin averaged rainfall are depicted graphically in Figure F-1. That figure is adapted from NOAA Atlas 2 Precipitation-Frequency Atlas of the Western United States, Vol. IV - New Mexico.

The use of Figure F-1 is appropriate for sizing major dams, channels and arroyos but is usually not appropriate for sizing channel inlets, side drainage and storm sewers associated with these major facilities. Use of a single depth-area reduction factor for large drainage studies may cause flows in the upper reaches of the study area to be under estimated. It may be necessary to evaluate major projects with and without area reduction factors and to establish the capacity of intermediate facilities based on a ratio of the values obtained.

FIGURE F-1. 100-YR DEPTH-AREA REDUCTION FACTORS



F.2.3 Temporal Distribution

Basin average rainfall for 100-year, 6- and 24-hour storms is distributed temporally using a suite of equations; F-1 through F-6. The equations are a function of the 1-, 6- and 24-hour basin average depths. The design rainfall distribution is front loaded with the peak intensity set at 85.3 minutes (hour 1.42) regardless of storm duration. This distribution results in approximately 80 percent of the total depth occurring in less than one hour. For the 6-hour storm the distribution of rainfall is determined using the first 5 of the 6 equations. For the 24-hour storm, all 6 equations are used. To illustrate the shape of the pattern, the 6-hour storm distribution using the depths from Table F-1 for a 20 square mile watershed is shown in Figure F-2.

$$P_T = 2.334 * (P_{360} - P_{60}) * \left(1.5^A - \left(1.5 - \frac{t}{60}\right)^A\right)$$ For $0 \leq t \leq 60$ (F-1)

$$P_T = P_{T=60} + P_{60} * 0.4754 * \left(0.5^{0.09} - \left(1.5 - \frac{t}{60}\right)^{0.09}\right)$$ For $60 < t < 67$ (F-2)

$$P_T = P_{T=60} + P_{60} * \left(0.0001818182 * (t - 60) + 0.000018338 * (t - 60)^{3.2}\right)$$ For $67 \leq t < 85.3$ (F-3)

$$P_T = P_{T=60} + P_{60} * \left(0.07 * (t - 60) - 1.1886 - 0.0404768 * (t - 85)^{1.0985865}\right)$$ For $85.3 \leq t < 120$ (F-4)

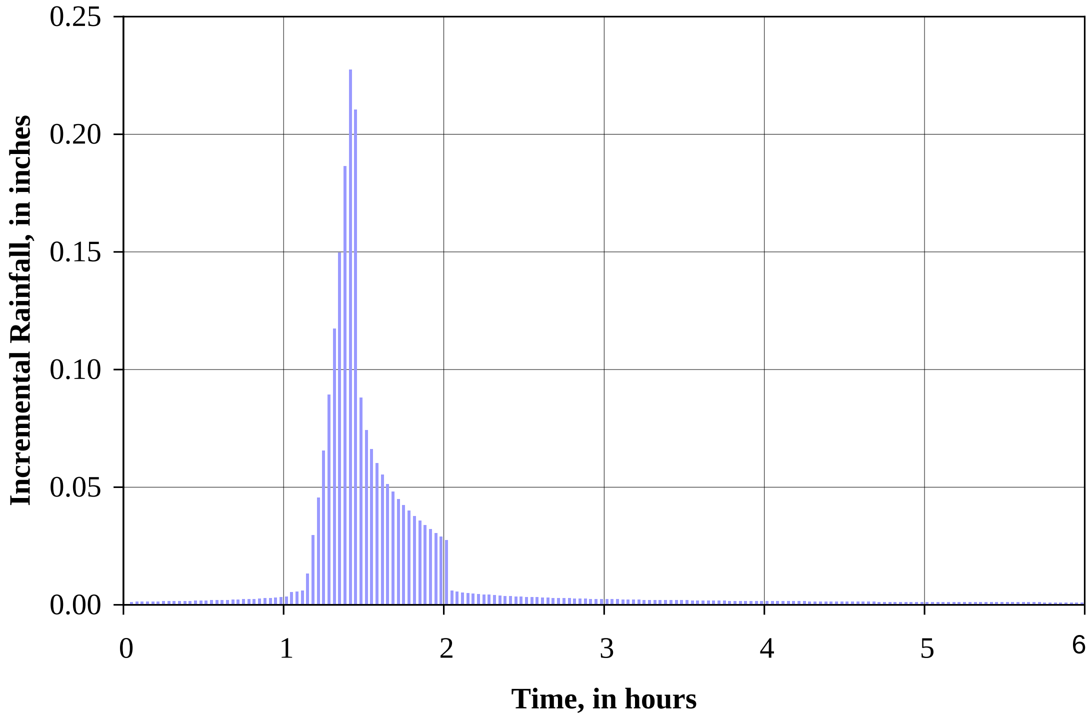
$$P_T = P_{360} + (P_{T=60} + P_{60} - P_{360}) \frac{4.4^{3A} - \left(t/60 - 1.6\right)^{3A}}{4.4^{3A} - 0.4^{3A}}$$ For $120 \leq t \leq 360$ (F-5)

$$P_T = P_{1440} + (P_{360} - P_{1440}) * \frac{30^B - \left(t/60 + 6\right)^B}{30^B - 12^B}$$ For $360 < t < 1440$ (F-6)

Where: $$A = \frac{Log\left(P_{360}/P_{60}\right)}{Log(6.0)}$$

$$B = \frac{Log\left(P_{1440}/P_{360}\right)}{Log(4.0)}$$

FIGURE F-2. 100-YR 6-HOUR RAINFALL HYETOGRAPH



F.2.4 Procedure

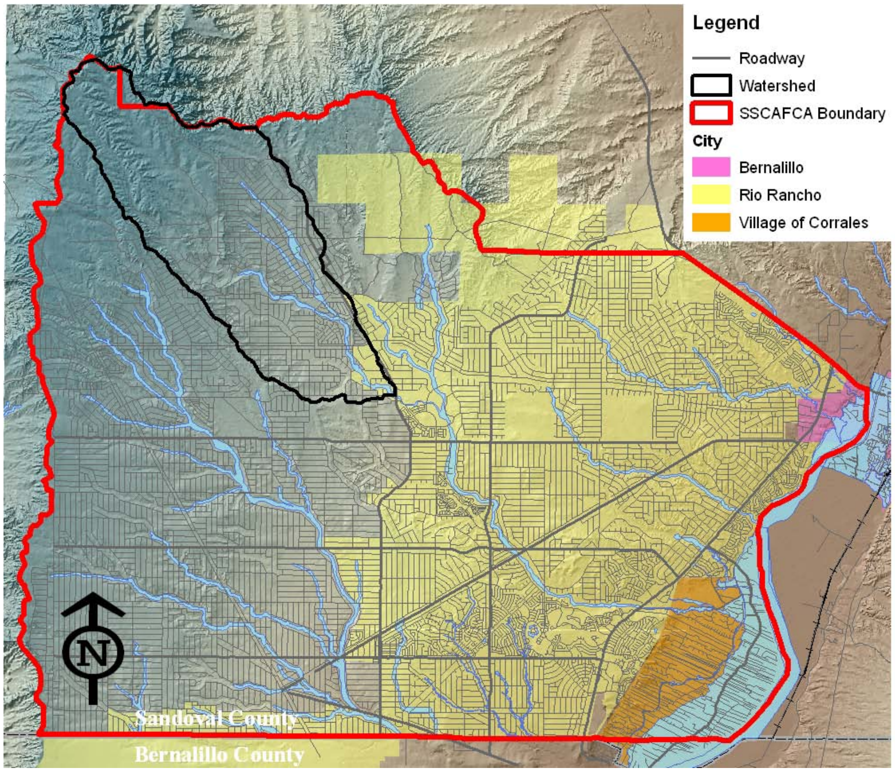
A. For design events up to the 500-year and storm durations up to the 24-hour
   1. Select the point rainfall depths from Table F-1
   2. Using Figure F-1, determine the depth-area adjustment factor for each duration using the total watershed area.
   3. Areally reduce the point precipitation depths from Table F-1 using the depth-area adjustment factors from Figure F-1.
   4. Obtain the rainfall distribution from SSCAFCA.
   5. In HEC-HMS
      a. Code the distribution in as time distribution data.
      b. Select the "Specified Hyetograph" as the Meterological Model
      c. Select "Yes" to include subbasins

B. For design storms with durations other than 6- or 24-hours, submit in writing a recommendation to SSCAFCA for depth-area reduction and time distribution of the rainfall for the selected storm event.

F.2.5 Example

Compute the 100-year, 6-hour storm design rainfall data for the watershed shown in the following figure. The watershed area is approximately 20.5 square miles.

FIGURE F-3. EXAMPLE WATERSHED MAP

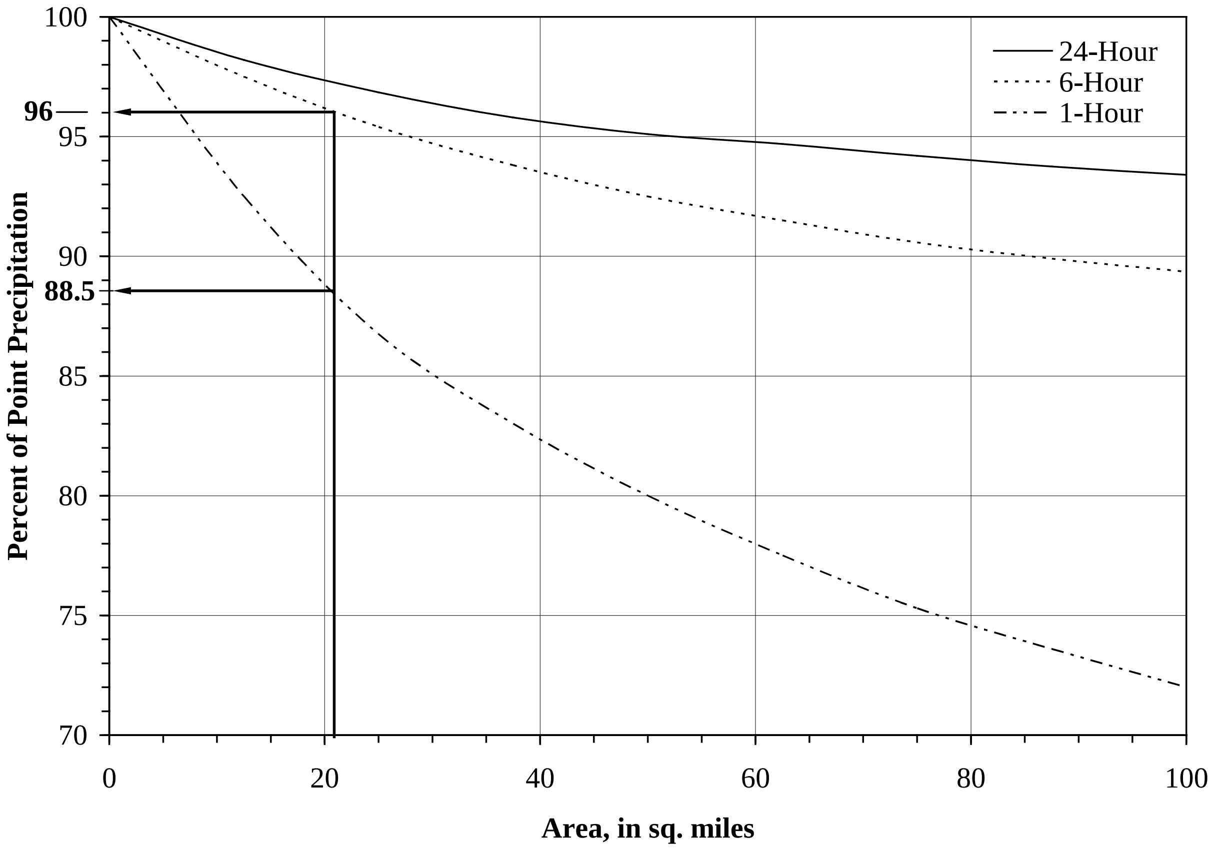


1. 100-year point rainfall depths from Table F-1 are:

   F. 100-year, 1-hour = 1.84 inches
   G. 100-year, 6-hour = 2.37 inches

2. Estimate depth-area reduction factors for the watershed area of 20.5 square miles using Figure F-1

FIGURE F-4. EXAMPLE WATERSHED DEPTH-AREA REDUCTION



3. Calculate the equivalent uniform rainfall depth

$$P_{60}^{100} = (1.84)(0.885) = 1.63 \text{ inches}$$

$$P_{360}^{100} = (2.37)(0.960) = 2.28 \text{ inches}$$

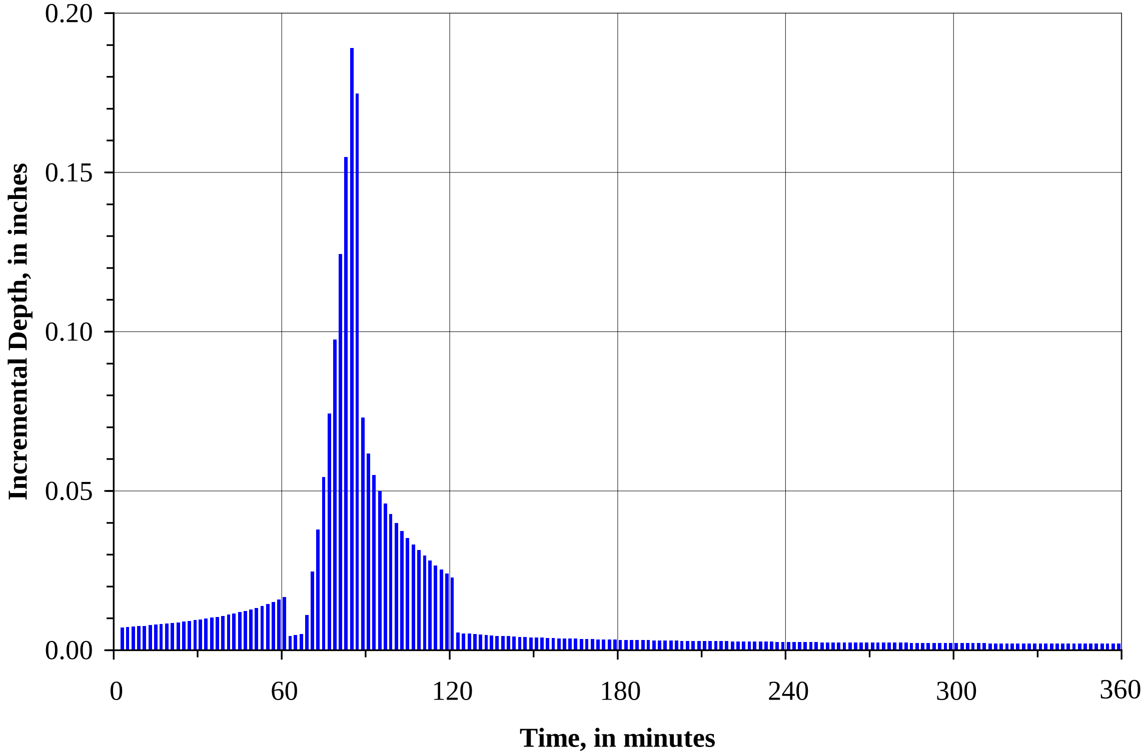
4. Calculate the cumulative rainfall mass curve using Equations F-1 through F-5 for the 6-hour storm. The computation time interval is 2 minutes.

Sample – To be obtained directly form SSCAFCA for use in hydrologic modeling.

CUMULATIVE RAINFALL DISTRIBUTION

Time hours	Rainfall inches	Time hours	Rainfall inches	Time hours	Rainfall inches	Time hours	Rainfall inches
0	0.000	92	1.459	184	2.065	276	2.190
2	0.007	94	1.509	186	2.068	278	2.192
4	0.014	96	1.555	188	2.071	280	2.194
6	0.021	98	1.598	190	2.074	282	2.197
8	0.028	100	1.638	192	2.078	284	2.199
10	0.036	102	1.676	194	2.081	286	2.201
12	0.043	104	1.712	196	2.084	288	2.203
14	0.051	106	1.745	198	2.087	290	2.206
16	0.059	108	1.777	200	2.090	292	2.208
18	0.067	110	1.807	202	2.093	294	2.210
20	0.075	112	1.835	204	2.096	296	2.213
22	0.084	114	1.862	206	2.099	298	2.215
24	0.092	116	1.887	208	2.101	300	2.217
26	0.101	118	1.911	210	2.104	302	2.219
28	0.110	120	1.934	212	2.107	304	2.221
30	0.120	122	1.940	214	2.110	306	2.224
32	0.129	124	1.945	216	2.113	308	2.226
34	0.139	126	1.951	218	2.116	310	2.228
36	0.149	128	1.956	220	2.118	312	2.230
38	0.160	130	1.961	222	2.121	314	2.232
40	0.171	132	1.965	224	2.124	316	2.235
42	0.182	134	1.970	226	2.127	318	2.237
44	0.193	136	1.975	228	2.129	320	2.239
46	0.205	138	1.979	230	2.132	322	2.241
48	0.218	140	1.984	232	2.135	324	2.243
50	0.231	142	1.988	234	2.137	326	2.245
52	0.244	144	1.992	236	2.140	328	2.247
54	0.258	146	1.996	238	2.143	330	2.249
56	0.273	148	2.000	240	2.145	332	2.251
58	0.288	150	2.004	242	2.148	334	2.254
60	0.304	152	2.008	244	2.150	336	2.256
62	0.309	154	2.012	246	2.153	338	2.258
64	0.314	156	2.016	248	2.155	340	2.260
66	0.319	158	2.020	250	2.158	342	2.262
68	0.330	160	2.024	252	2.160	344	2.264
70	0.355	162	2.027	254	2.163	346	2.266
72	0.393	164	2.031	256	2.165	348	2.268
74	0.448	166	2.035	258	2.168	350	2.270
76	0.522	168	2.038	260	2.170	352	2.272
78	0.620	170	2.042	262	2.173	354	2.274
80	0.746	172	2.045	264	2.175	356	2.276
82	0.902	174	2.048	266	2.178	358	2.278
84	1.092	176	2.052	268	2.180	360	2.280
86	1.268	178	2.055	270	2.182		
88	1.341	180	2.058	272	2.185		
90	1.403	182	2.062	274	2.187		

FIGURE F-5. 100-YR 6-HOUR RAINFALL HYETOGRAPH



F.3 RAINFALL LOSS

Rainfall losses are generally considered to be the result of evaporation of water from the land surface, interception of rainfall by vegetal cover, depression storage on the land surface and the infiltration of water into the soil matrix. The magnitude of rainfall loss is typically expressed as an equivalent uniform depth in inches. By a mass balance, rainfall minus losses equals rainfall excess. Estimation of rainfall loss is an important element in flood analyses that must be clearly understood and estimated with care.

F.3.1 Land Treatment

Estimation of rainfall losses are based on a characterization of the watershed area into land treatment classifications. Four land treatment classifications have been created that typify the conditions in the SSCAFCA jurisdiction. Descriptions of the land treatment classifications are provided in Table F-2. Three of the land treatment classifications (A, B and C) are for pervious conditions. The fourth classification (D) is for impervious areas.

TABLE F-2. LAND TREATMENTS	
Treatment	**Land Condition**
A	Soil uncompacted by human activity with 0 to 10 percent slopes. Native grasses, weeds and shrubs in typical densities with minimal disturbance to grading, ground cover and infiltration capacity.
B	Irrigated lawns, parks and golf courses with 0 to 10 percent slopes. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes greater than 10 percent and less than 20 percent.
C	Soil compacted by human activity. Minimal vegetation. Unpaved parking, roads, trails. Most vacant lots. Gravel or rock on plastic (desert landscaping). Irrigated lawns and parks with slopes greater than 10 percent. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes at 20 percent or greater. Native grass, weed and shrub areas with clay or clay loam soils and other soils of very low permeability as classified by SCS Hydrologic Soil Group D.
D	Impervious areas, pavement and roofs.
Most watersheds contain a mix of land treatments. To determine proportional treatments, measure respective subareas. In lieu of specific measurement for treatment D, the areal percentages in Table F-3 may be employed.	

Of the land treatment classifications listed in Table F-2, only treatment type A represents land in its natural, undisturbed state. Land treatment classifications B and C describe conditions that have been impacted by some form of urbanization. Urban areas within a watershed usually contain a mix of the land treatment types. Ideally, the specific area of each land treatment type can be measured from available information. In lieu of specific measurement for each unique land treatment type that occurs within urban areas, generalized percentages based on zoning classifications can be used. Average land treatment type percentages associated with various zoning designations are listed in Table F-3.

TABLE F-3 SSCAFCA TREATMENT TYPE PERCENTAGE SUMMARY

Parcel Description	Treatments A	Treatments B	Treatments C	Treatments D	Methodology/Notes
1/8 Acre	0%	15%	15%	70%	DPM, Chapter 22.2, Table A-4 for D
1/6 Acre	0%	28%	15%	57%	Northern Meadows Master Plan
1/4 Acre	0%	30%	28%	42%	DPM, and followed SSCAFCA lead on B&C
1/2 Acre	10%	33%	30%	27%	SSCAFCA
1 Acre	43%	20%	20%	17%	SSCAFCA
Single Family Residential N=units/acre, N6					7*√((N*N) + (5*N))
Estate Lots (btwn 1-5ac)	60%	15%	15%	10%	DPM for 2.5 acre lot
M-1 (Light Industrial)	0%	15%	15%	70%	DPM for D, split B & C
Vacant Res./Undevel.	79%	8%	8%	5%	DPM for 5 acre lot
Arroyo	100%	0%	0%	0%	DPM
Major Roads	0%	0%	10%	90%	DPM
School	10%	20%	20%	50%	DPM
Commercial/Industrial	0%	0%	15%	85%	DPM average of Heavy Industrial and Commercial
Open Space	100%	0%	0%	0%	DPM
Parks, Sports and Rec	0%	85%	0%	15%	DPM
Landfill	0%	0%	100%	0%	All disturbed ground
Multi-Family	0%	15%	15%	70%	DPM-Multiple Unit Res. Attached
Northern Meadows	0%	28%	15%	57%	Northern Meadows Master Plan
Drainage Ponds	0%	0%	100%	0%	
County Platted (1)	18.7%	29.5%	27.0%	24.8%	(used Basin P12_104 as typical)
County Unplatted (2)	95%	5%	0%	0%	DPM

NOTES

1. County Platted area is defined as the area between CORR boundary and Rio Rancho Estates boundary.
2. County Unplatted area is defined as the area outside the city limits and the Rio Rancho Estates limits. It is considered to be existing conditions.
3. All roads are assumed to be paved.

F.3.2 Initial and Constant Loss

Simulation of rainfall loss in HEC-HMS is accomplished using the Initial and Constant Loss Method. The Initial and Constant Loss Methodology is a two parameter model. The first parameter is the Initial Abstraction (IA). The initial abstraction is the summation of all losses other than infiltration and is applied at the beginning of the storm event. The second parameter is the constant loss. The constant loss is the Infiltration rate (INF) of the soil matrix at saturation. The constant loss is only applied once the Initial Abstraction is satisfied. An illustration of the application of this method is provided in Figure F-6.

Recommended values for the Initial Abstraction and Infiltration rate are assigned to each pervious land treatment type and are listed in Table F-4. For watersheds and subbasins with multiple unique land treatment types an arithmetic area averaged value for IA and INF is to be calculated.

FIGURE F-6. REPRESENTATION OF THE INITIAL AND CONSTANT LOSS METHODOLOGY

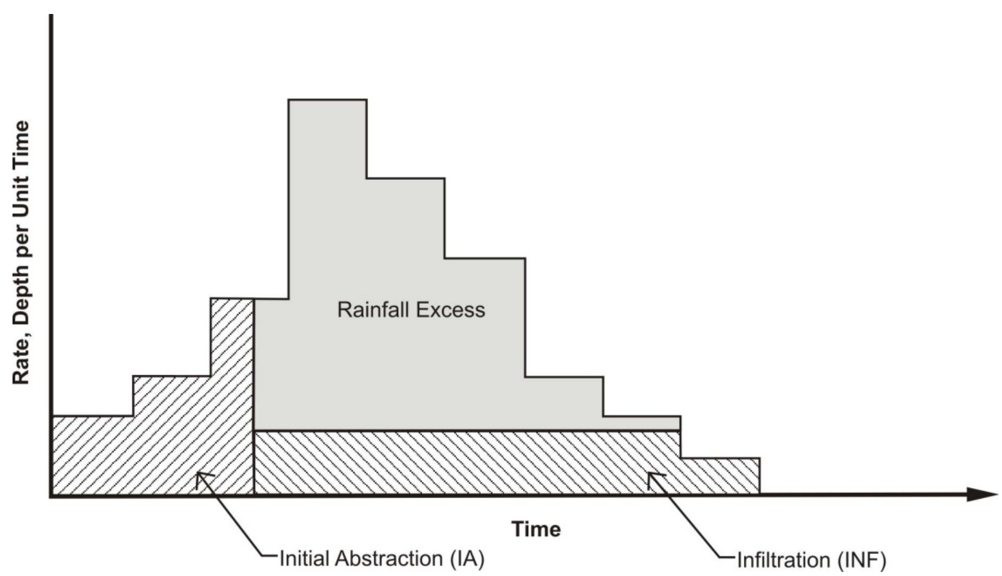


TABLE F-4. INITIAL AND CONSTANT LOSS PARAMETERS		
Land Treatment	**Initial Abstraction (inches)**	**Infiltration (inches/hour)**
A	0.65	1.67
B	0.50	1.25
C	0.35	0.83

F.3.3 Impervious Area

For the Initial and Constant Loss Method as employed in HEC-HMS, it is assumed that there are no losses associated with impervious area (land treatment type D) and rainfall over the impervious area is converted directly to rainfall excess. The percentage of rainfall converted directly to excess is the same as the percent area of land treatment type D. Computationally, rainfall to be converted directly to excess occurs prior to any loss calculations for each model time step. The rainfall not converted directly to excess is then available to the loss calculations.

F.3.4 Procedure

1. For each subbasin, calculate the area of each unique land treatment type or zoning classification.
2. Using the percent area of each pervious area land treatment type, calculate the area averaged value of IA and INF using the data from Table F-4 for each subbasin.
3. For each subbasin sum the percent impervious area as the percent area of Land Treatment Type D.
4. In HEC-HMS, for each subbasin within the Basin Model:
    a. code the subbasin area average value of IA as the Initial Loss.
    b. code the subbasin area average value of INF as the Constant Rate.
    c. code the total percent area of Land Treatment Type D as the impervious percentage.

F.3.5 Example

Calculate the rainfall loss parameters for a 20.5 square mile watershed using the following data:

Parcel Description	**Area sq. miles**
1/8 acre	**1.0**
Platted	**11.5**
Unplatted	**8.0**

1. From Table F-3, percentage of Land Treatment Types for each parcel within the watershed are:

Parcel	**Area**	**Percent of Land Treatment Type**			
Description	**acres**	**A**	**B**	**C**	**D**
1/8 Acre	1.0	0	15	15	70
Commercial / Industrial	11.5	18.7	29.5	27.0	24.8
Platted	8.0	95	5	0	0

Area of each Land Treatment Type is calculated as:

- $Area_A$ = (0)(1.0) + (0.187)(11.5) + (0.95)(8.0) = 9.8 sq. miles
- $Area_B$ = (0.15)(1.0) + (0.295)(11.5) + (0.05)(8.0) = 3.9 sq. miles
- $Area_C$ = (0.15)(1.0) + (0.270)(11.5) + (0.0)(8.0) = 3.3 sq. miles
- $Area_D$ = (0.70)(1.0) + (0.248)(11.5) + (0.0)(8.0) = 3.5 sq. miles

Total Area = 20.5 sq. miles

2. Using values of IA from Table F-4, calculate the weighted value of IA

$$IA = \frac{(9.8)(0.65)+(3.9)(0.50)+(3.3)(0.35)}{(9.8+3.9+3.3)}$$

IA = 0.56 inches

3. Using values of INF from Table E-4, calculate the weighted value of

$$INF = \frac{(9.8)(1.67)+(3.9)(1.25)+(3.3)(0.83)}{(9.8+3.9+3.3)}$$

INF = 1.41 in/hr

4. Assign the impervious area as the percent area of Land Treatment Type D

$$\textit{Percent Impervious} = \left(3.5 / 20.5\right) = 17.1\%$$

F.4 UNIT HYDROGRAPH

Rainfall excess generated during a storm event is routed across the basin surface and eventually begins to concentrate at a downstream location (concentration point). The routing process results in the transformation of rainfall excess to a runoff hydrograph. Simulation of rainfall excess transformation is typically accomplished using the concept of a unit hydrograph. A unit hydrograph is defined as the hydrograph of one inch of direct runoff from a storm of a specified duration for a particular basin. Every watershed will have a different unit hydrograph that reflects the topography, land use, and other unique characteristics of the individual watershed. Different unit hydrographs will also be produced for the same watershed for different durations of rainfall excess.

For most watersheds, sufficient data (rainfall and runoff records) does not exist to develop unit hydrographs specific to the watershed. Therefore, indirect methods are used to develop a unit hydrograph. Such unit hydrographs are called synthetic unit hydrographs. The synthetic unit hydrograph method in HEC-HMS that is to be used to transform rainfall excess to a runoff hydrograph is the Clark unit hydrograph.

The Clark unit hydrograph is analogous to the routing of an inflow hydrograph through a reservoir. The inflow hydrograph, called the translation hydrograph in the Clark method, is determined from the temporal and spatial distribution of rainfall excess over a basin. The translation hydrograph is then routed by a form of the continuity equation. The Clark method uses two numeric parameters; Time of Concentration (T_c) and Storage Coefficient (R) and a graphical parameter, the time-area relation. The time-area relation defines the relation between the accumulated area of a basin and the time it takes for runoff from that area to reach the basin outlet. In the current version of HEC-HMS, the time-area relation is hard coded and cannot be changed by the user.

F.4.1 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 basin 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 one of three equations. Selection of the appropriate equation is based on the time of concentration flow path length (in time). Regardless of the selected equation, time of concentration should not be less than 8 minutes.

For basins with flow path lengths less than 4,000 feet the SCS Upland Method is used. 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:

$$T_c = \frac{2}{3} * \sum_{i=1}^{n} \left(\frac{L_i}{36{,}000 * K_i * \sqrt{S_i}} \right) \tag{F-7}$$

Where:
- T_c = Time of concentration, in hours
- L_i = Length of each unique surface flow conveyance condition, in feet
- K_i = Conveyance factor from Table F-5
- S_i = Slope of the flow path, in feet per foot

TABLE F-5. 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, natural channels, and arroyos 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 plane surfaces, with flow depths up to 0.1 feet. Sheet flow applies only to the upper 400 feet (maximum) of a subbasin.

For basins with flow path lengths greater than 12,000 feet the time of concentration is calculated using a form of the basin lag equation. Coefficients and exponents follow USDI Bureau of Reclamation recommendations.

$$T_c = \frac{8}{9} * 26K_n \left(\frac{L * L_{ca}}{5280^2 * \sqrt{5280 * S}} \right)^{0.33} \qquad \text{(F-8)}$$

Where:
- T_c = Time of concentration, in hours
- L = Flow path length, in feet
- L_{ca} = Distance along L from point of concentration to a point opposite the centroid of the basin, in feet
- K_n = Basin factor, from Table F-6
- S = Slope of flow path, in feet per foot

K_n in Equation F-8 is a measure of the hydraulic efficiency of the watershed to convey runoff to the basin outlet. This is analogous to a Manning's roughness coefficient. Selection of K_n should reflect the conditions of all the watercourse in the basin that convey runoff to the outlet.

TABLE F-6. LAG EQUATION BASIN FACTORS	
K_n	**Basin Condition**
0.042	Mountain Brush and Juniper
0.033	Desert Terrain (Desert Brush)
0.025	Low Density Urban (Minimum improvements to watershed channels)
0.021	Medium Density Urban (Flow in streets, storm sewers and improved channels)
0.016	High Density Urban (Concrete and rip-rap lined channels)

For basins with flow path lengths between 4,000 and 12,000 feet a transition equation is used that is a composite of equations F-7 and F-8. This transition equation is expressed as:

$$T_c = \left(\frac{2}{3}\right) * \left(\frac{12{,}000 - L}{72{,}000 * K * \sqrt{S}} + \frac{(L - 4{,}000) * K_n * \left(L_{ca} / L \right)^{0.33}}{552.2 * S^{0.165}} \right) \quad \text{(F-9)}$$

Where:

- T_c = Time of concentration, in hours
- L = Flow path length, in feet
- L_{ca} = Distance along L from point of concentration to a point opposite the centroid of the basin, in feet
- K = Conveyance factor from Table F-5. For composite reaches, K is computed using equation F-9a or F-9b as discussed below.
- K_n = A basin factor based on an estimate of the weighted, by stream length, average Manning's n value for the principal watercourses in the drainage basin. For the Albuquerque/Rio Rancho area, values of K_n may be estimated from Table F-6.
- S = Slope of flow path, in feet per foot. For composite reaches, s is computed using equation F-9c (weighted average) as discussed below.

For composite reaches where the basin slope is uniform, the composite basin conveyance condition, K, can be computed using the following equation:

$$K = \frac{L}{(L_1/K_1 + L_2/K_2 + \cdots + L_x/K_x)} \quad \text{(F-9a)}$$

Where L = $L_1 + L_2 + \cdots + L_x$

For composite reaches where the basin slope is <u>not</u> uniform, the composite basin conveyance condition, K, can be computed using the following equation:

$$K = \frac{(L/\sqrt{s})}{(L_1/(K_1 * \sqrt{s_1}) + L_2/(K_2 * \sqrt{s_2}) + \cdots + L_x/(K_x * \sqrt{s_x}))} \quad \text{(F-9b)}$$

Where L = $L_1 + L_2 + \ldots + L_x$

And, $s = \frac{(L1 * s1 + L2 * s2 + \cdots + Lx * sx)}{L}$ (F-9c)

Calculation of a basin time of concentration is a function of flow path length and by extension basin area. Therefore, basin / subbasin delineation is a key consideration that must be addressed early on in the modeling process as it not only influences unit hydrograph parameter estimation but rainfall loss parameters as well. Wherever possible, subbasin delineation should be based on the best available topographic mapping and if available detailed aerial photography. For some areas, field investigation may also be necessary to verify subbasin boundaries particularly in urban or distributary areas. The breakdown of a watershed into subbasins should consider the following:

- The subbasin sizes should be as uniform as possible.
- Subbasins should have fairly homogeneous land use and geographic characteristics. For example: mountain, hillslope and valley areas should be separated by subbasin where possible.
- Soils, vegetation and land treatment characteristics should be fairly homogeneous.
- Subbasins size should be commensurate with the intended use of the model. For example, if the model is to be used for the evaluation and / or design of drainage infrastructure, the subbasin size should be fairly small so that runoff magnitudes are known at multiple locations within the watershed. For drainage management plans, the subbasin size shall in general not be greater than 1.5 mi^2 or less than 0.1 mi^2.

F.4.2 Time of Concentration for Steep Slopes and Natural Channels

The equations used to compute time of concentration may result in values that are too small to be sustained for natural channel conditions. In natural channels, flows become unstable when a Froude Number of 1.0 is approached. The equations identified in Section A.3.1 can result in flow velocities for steep slopes that indicate supercritical flow conditions, even though such supercritical flows cannot be sustained for natural channels. For steep slopes, natural channels will likely experience chute and pool conditions with a hydraulic jump occurring at the downstream end of chute areas; or will experience a series of cascading flows with very steep drops interspersed with flatter channel sections.

For the purposes of this section, steep slopes are defined as those greater than 0.04 foot per foot. The procedures outlined in this section should not be used for the following conditions:

- Slopes flatter than 0.04 foot per foot.
- Channels with irrigated grass, riprap, soil cement, gabion, or concrete lining which cannot be clearly identified as natural or naturalistic.
- The hydraulic design of channels or channel elements. The purpose of this section is to define procedures for hydrologic analysis only. The design of facilities adjacent to or within channels with chute and pool conditions cannot be analyzed with the simplified procedures identified herein. It may be necessary to design such facilities for the supercritical flows of chutes (for sediment transport, local scour, stable material size) and for the hydraulic jump of pool conditions (for maximum water surface elevation and flood protection).

The slope of steep natural watercourses should be adjusted to account for the effective slope that can be sustained. The slope adjustment procedures identified in the Denver - Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (Figure 4-1, Runoff chapter, 1990) are applicable for the slope adjustment identified herein. In addition, channel conveyance factors (K) should be checked to make sure that appropriate equivalent Froude Numbers are maintained. The UDFCD Figure 4-1 can be approximated by the following equation:

$$S' = 0.052467 + 0.062627S - 0.18197e^{-62.375S} \quad \text{(F-10)}$$

Where: S = Measured slope, in feet per foot
S′ = Adjusted slope, in feet per foot

The conveyance factors (K) for the Upland Method should be checked to make sure that appropriate Froude Numbers are maintained. The Lag Equation Basin Factors, K_n, from Table F-6 remain applicable when using equations F-8 and F-9 with the adjusted slope computed by equation F-10. To adjust the conveyance factor (K) it is necessary to estimate the peak flow rate from the watershed. Using estimated conveyance factors (K) from Table F-5 and the procedures outlined in Part D, an estimated peak flow rate for the basin (Q_p) can be computed. The following formulas are then used to compute conveyance factor adjustment:

$$K' = 0.302 * S'^{-0.5} * Q_p^{0.18} \quad \text{(F-11)}$$

$$K'' = 0.207 * S'^{-0.5} * Q_p^{0.18} \quad \text{(F-12)}$$

An adjusted conveyance factor (K) is then obtained based on the following:

- if K > K' then K= K'
- if K' ≥ K ≥ K" then K = K (no adjustment)
- if K < K" then K= K"

This is an iterative process that is to be repeated until the computed value of Q_p is within 10 percent of original value of Q_p.

F.4.3 Storage Coefficient

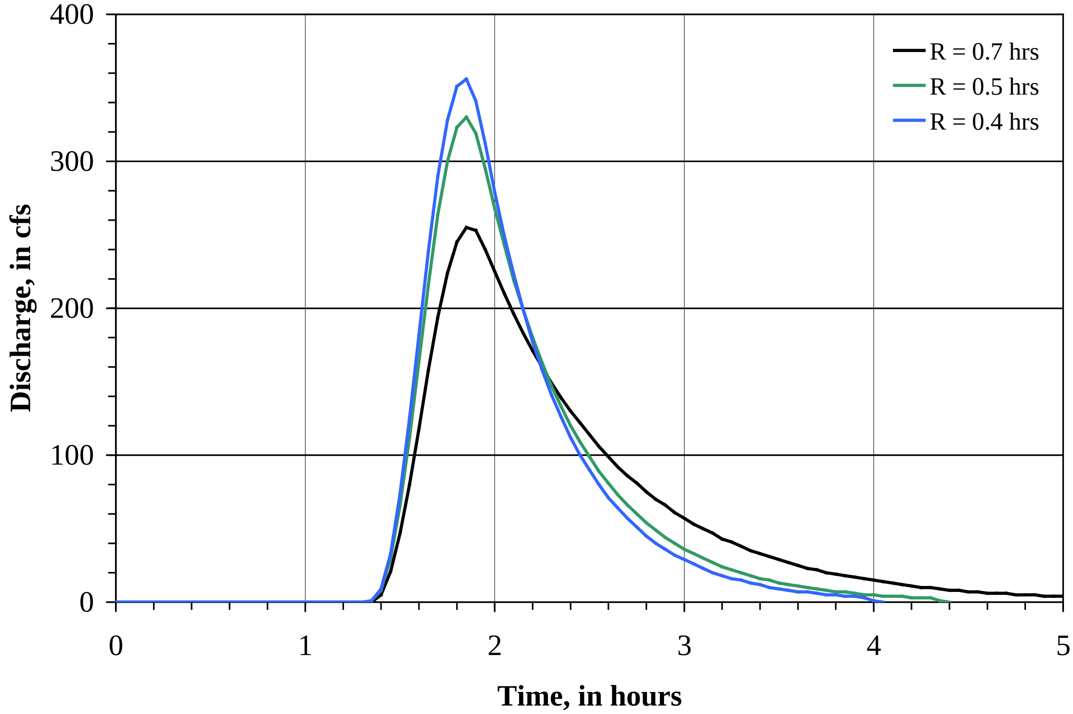
The storage coefficient describes the effect that temporary storage in the basin has on the hydrograph. The storage coefficient has the units of time and is interrelated with time of concentration. The temporary storage potential of runoff for a basin is also influenced by the land treatment conditions present. The equation for estimating the storage coefficient is:

$$R = 1.165 * T_c \left(INF^{0.45} - IA^{1.4} \left(\frac{D}{100} \right)^{0.40} \right) \quad \text{(F-13)}$$

Where: R = Storage coefficient, in hours
T_c = Time of concentration, in hours (from Eqn. F-7, F-8 or F-9)
INF = Infiltration loss rate for the subbasin, in in/hr
IA = Initial abstraction for the basin, in inches
D = Land treatment type D, expressed in percent

Land treatment conditions (impervious area in particular), influence the storage coefficient in that as the degree of development increases, the storage coefficient decreases. This results in a decrease in the time that runoff is stored in the basin. Thus a greater proportion of runoff volume is conveyed to the basin outlet over a shorter time period, resulting in a higher peak discharge. This is illustrated in Figure F-7. In that figure runoff hydrographs are plotted for a hypothetical basin 1 square mile in size. Reducing the storage coefficient while holding all other parameters constant results in the compression of the time distribution of runoff and thus an increase in peak discharge.

FIGURE F-7. INFLUENCE OF WATERSHED STORAGE ON THE RUNOFF HYDROGRAPH



F.4.4 Procedure

1. Delineate the time of concentration flow path for each subbasin and measure the length, in feet.
    a. If the flow path length is less than 4,000 feet, calculate T_c using Equation F-7 with the following:
        i. Select K from Table F-5
        ii. Measure the average flow path slope, S. If the flow path slope is greater than 0.04 feet / foot:
            1. Calculate the adjusted slope using Equation F-10.
            2. Estimate the peak discharge using procedures in Part D
            3. Calculate the conveyance factor adjustment range using Equations F-11 and F-12.
            4. Recalculate the peak discharge using the procedures in Part D and the adjusted slope and conveyance factor.
            5. Repeat steps ii3 and ii4 until the calculated peak discharge is within 10 % of the original value.
    b. If the flow path length is between 4,000 and 12,000 feet, calculate T_c using Equation F-9 with the following:

i. Measure L_{ca} and S
ii. Select appropriate values of K from Table F-5 and K_n from Table F-6

c. If the flow path length is greater than 12,000 feet, calculate T_c using Equation F-8 with the following:
   i. Measure L_{ca} and S
   ii. Select appropriate values of K_n from Table F-6

2. Calculate the storage coefficient for each subbasin using Equation F-13
3. In HEC-HMS code in the calculated values for time of concentration and storage coefficient for each subbasin.

F.4.5 Example

Calculate the unit hydrograph parameters for a 20.5 square mile watershed based on the following data. Rainfall loss parameters for the watershed are from the example in Section F.3.5.

- Flow path length, L = 8.5 miles
- Length to centroid, L_{ca} = 4.0 miles
- Flow path slope, S = 1.8%

1. Calculate T_c

   The flow path length is greater than 12,000 feet. Therefore, use Equation F-8 and assume a value for K_n of 0.033.

$$T_c = \frac{8}{9} * 26K_n \left(\frac{L * L_{ca}}{5280^2 * \sqrt{5280 * S}} \right)^{0.33}$$

$$T_c = \frac{8}{9} * 26 * (0.033) \left(\frac{8.5 * 4.0}{\sqrt{5280 * 0.018}} \right)^{0.33}$$

T_c 1.15 hours

2. Using Equation F-13, calculate the Clark unit hydrograph storage coefficient, R.

$$R = 1.165 * T_c \left(INF^{0.45} - IA^{1.4} \left(\frac{D}{100} \right)^{0.40} \right)$$

$$R = 1.165 * 1.15 * \left(1.41^{0.45} - 0.56^{1.4} \left(\frac{17.1}{100} \right)^{0.40} \right)$$

R = 1.27 hours

F.5 CHANNEL ROUTING

Hydrologic channel routing describes the movement of a floodwave (hydrograph) along a watercourse. For most natural rivers, as a floodwave passes through a given reach, the peak of the outflow hydrograph is attenuated and delayed due to flow resistance in the channel and the storage capacity of the river reach. In urban environments, runoff is often conveyed in man made features such as roadways, storm drains and engineered channels that minimize hydrograph attenuation.

Channel routing is used in flood hydrology models, such as HEC-HMS, when the watershed is modeled with multiple subbasins and runoff from the upper subbasins must be translated through a channel or system of channels to the watershed outlet. The channel routing method to be used in HEC-HMS is the Muskingum-Cunge methodology.

The Muskingum-Cunge channel routing is a physically based methodology that solves the continuity and diffusive form of the momentum equation based on the physical channel properties and the inflow hydrograph. The solution procedure involves the discretization of the equations in both time and space (length). The discretized time and distance step size influence the accuracy and stability of the solution. In HEC-HMS the time and distance step size are calculated internally.

F.5.1 Physical Parameters

The physical parameters required for the Muskingum-Cunge channel routing are: reach length, flow resistance factor, friction slope and the channel geometry. One limitation of this method is that it cannot account for the effects of backwater. Therefore, the friction slope should be approximated using the average bed slope. Channel geometry can be one of the following:

- Circular
- Trapezoidal
- Rectangular
- Triangular
- 8 point irregular cross section

Although a circular section can be simulated, the Muskingum-Cunge solution assumes open channel flow conditions regardless of the geometric constraint. If the inflow to the routing reach results in the flow depth exceeding approximately 77% of the diameter, HEC-HMS will report a warning message and the routing results should be checked for reasonableness. In particular, the results should be checked for volume conservation.

When using the 8-point irregular cross section, the cross section must be exactly 8 points. Additionally, the 3rd and 6th point of the cross section defines the break in Manning's n-values for the overbank and channel areas.

F.5.2 Roughness Coefficients

Flow resistance in the channel and overbank flow area is simulated using Manning's roughness coefficients. Flow resistance is affected by many factors including bed material size, bed form, irregularities in the cross section, depth of flow, vegetation, channel alignment, channel shape, obstructions to flow and the quantity of sediment of being transported in suspension or as bed load. In general, all factors that retard flow and increase turbulent mixing tend to increase Manning's n-values. Manning's roughness coefficients appropriate for hydrologic routing are listed in Table F-7 and are, in general, taken from the SSCAFCA Sediment and Erosion Design Guide (MEI, 2008). Use of roughness coefficients other than those listed in Table E-7 must be estimated using the information and procedures in the Sediment and Erosion Design Guide and approved by SSCAFCA.

TABLE F-7. MANNING'S ROUGHNESS COEFFICIENTS	
Channel or Floodplain Type	**n-value**
Sand bed arroyos	0.055
Tined concrete	0.018
Shotcrete	0.025
Reinforced concrete pipe	0.013
Trowled concrete	0.013
No-joint cast-in-place concrete pipe	0.014
Reinforced concrete box	0.015
Reinforced concrete arch	0.015
Streets	0.017
Flush grouted riprap	0.020
Corrugated metal pipe	0.025
Grass-lined channels (sodded & irrigated)	0.025
Earth-lined channels (smooth)	0.030
Wire-tied riprap	0.040
Medium weight dumped riprap	0.045
Grouted riprap (exposed rock)	0.045
Jetty type riprap (D50 > 24")	0.050

F.5.3 Procedure

1. From an appropriate map of the watershed, measure the routing reach length in feet and estimate the friction slope as the channel bed slope in feet per foot.
2. Select a cross sectional geometry that represents that average hydraulic conditions of the reach. If a single cross section cannot be identified that represents the average hydraulic conditions, break the reach into multiple sections and treat each as a unique element in HEC-HMS.
3. Conduct a field reconnaissance of the watershed and routing reaches to observe the flow resistance characteristics.
4. Select an appropriate Manning's roughness coefficient for the channel and overbank flow areas using Table F-7.

F.6 SEDIMENT BULKING

Flow bulking occurs when sediment is eroded from the land surface and entrained into the flowing water. Entrained sediment has the effect of increasing the runoff volume and flow rate. Within this jurisdiction there is potential for high sediment yields. Studies indicate that the sediment yield from undeveloped watersheds can result in bulking factors up to 18%. Similarly, sediment yield from developed areas can result in bulking factors up to 6% for developed conditions. Developed conditions are those areas that have paved roads with curb and gutter. Given the high potential for surface erosion, all watershed models will include flow bulking.

F.6.1 Procedure

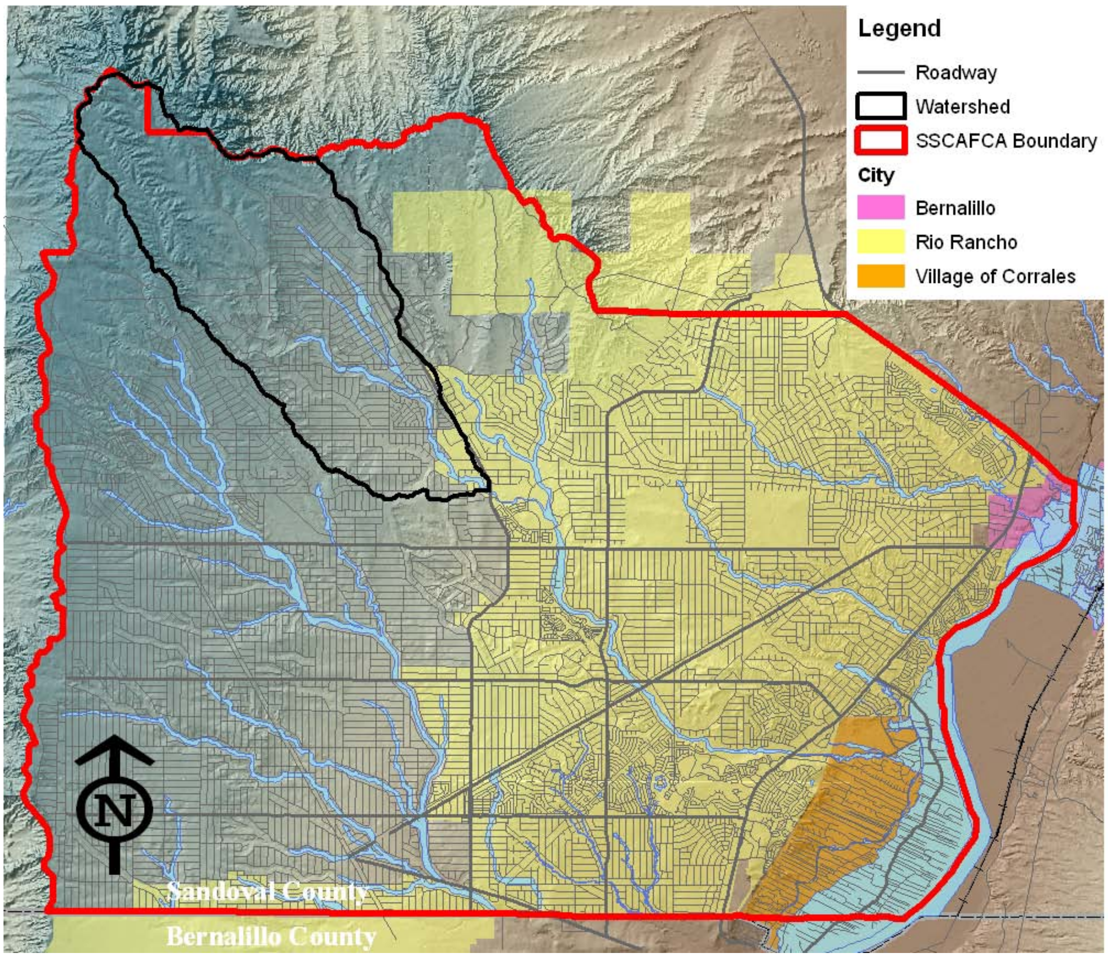
In HEC-HMS, flow bulking for sediment is simulated using a ratio. The ratio is applied to direct runoff estimated for each subbasin. There are two approaches for coding ratios in HEC-HMS. The first is a global assignment. For this option, only one ratio can be applied. Therefore, this option can only be applied to watersheds that are entirely undeveloped or developed. A globally assigned ratio is applied through the computation options for each run.

The second approach for simulating flow bulking due to sediment in HEC-HMS is to apply the appropriate ratio for each subbasin within the watershed. This option is to be used for watersheds with both undeveloped and developed areas.

F.7 HEC-HMS EXAMPLE

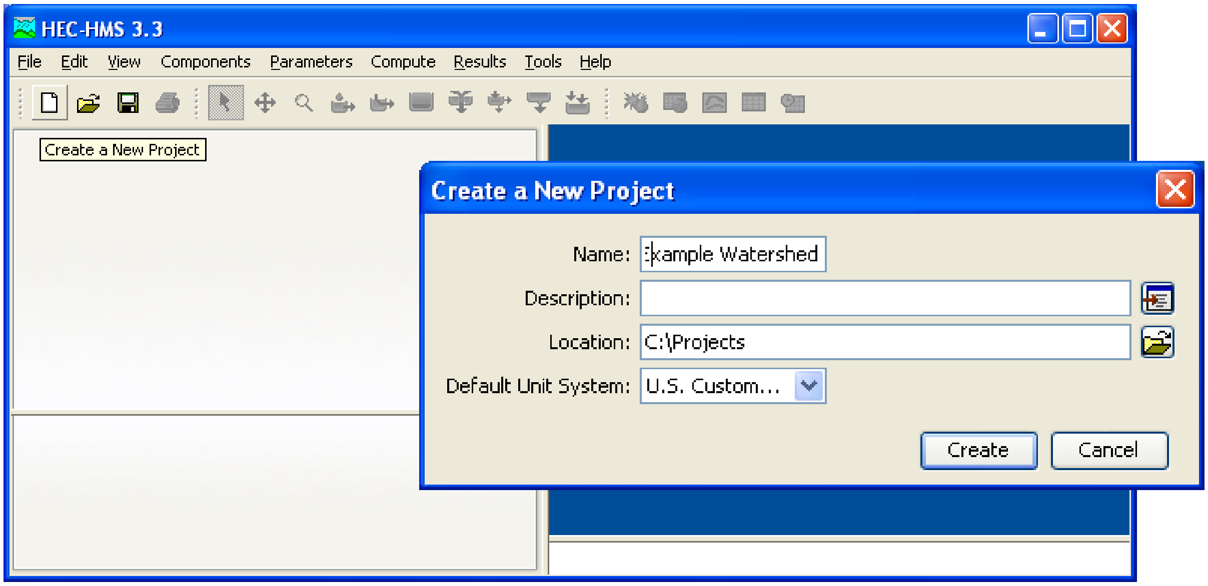
A new roadway crossing is needed for Rainbow Blvd. at Montoyas Arroyo. The new crossing must be designed to covey the 100-year, 6-hour peak flow without overtopping. The contributing drainage area at the roadway crossing is approximately 20.5 square miles. Compute the peak discharge for watershed at Rainbow Blvd.

FIGURE F-8. EXAMPLE WATERSHED MAP

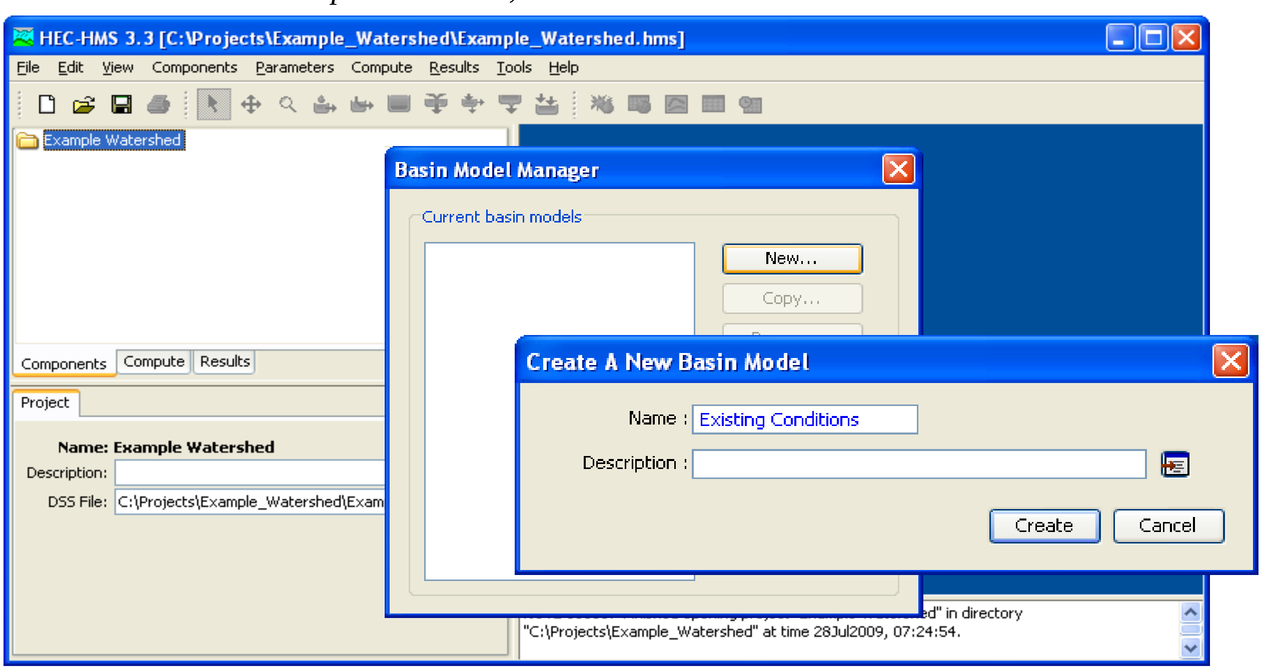


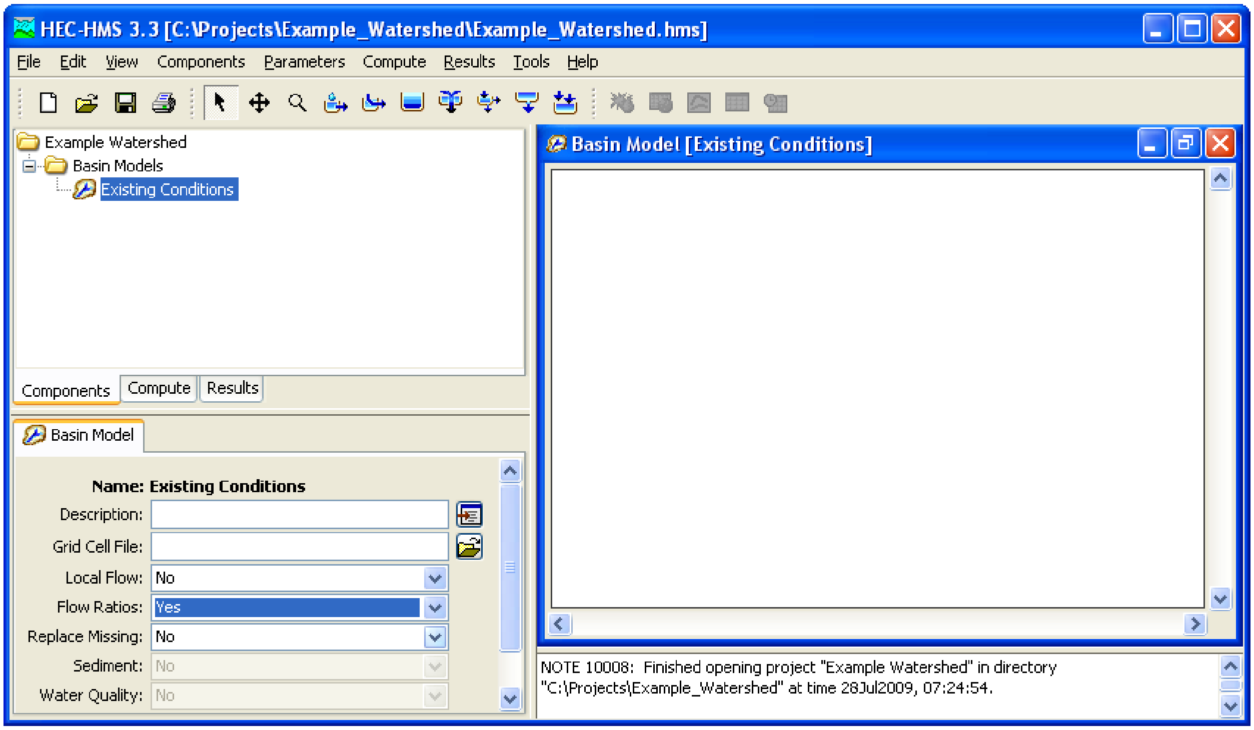
F.8.1 Project Setup

1. Create a new project and provide the following:
   a. Project name (e.g. Example Watershed)
   b. Path to model data
   c. Default system of units

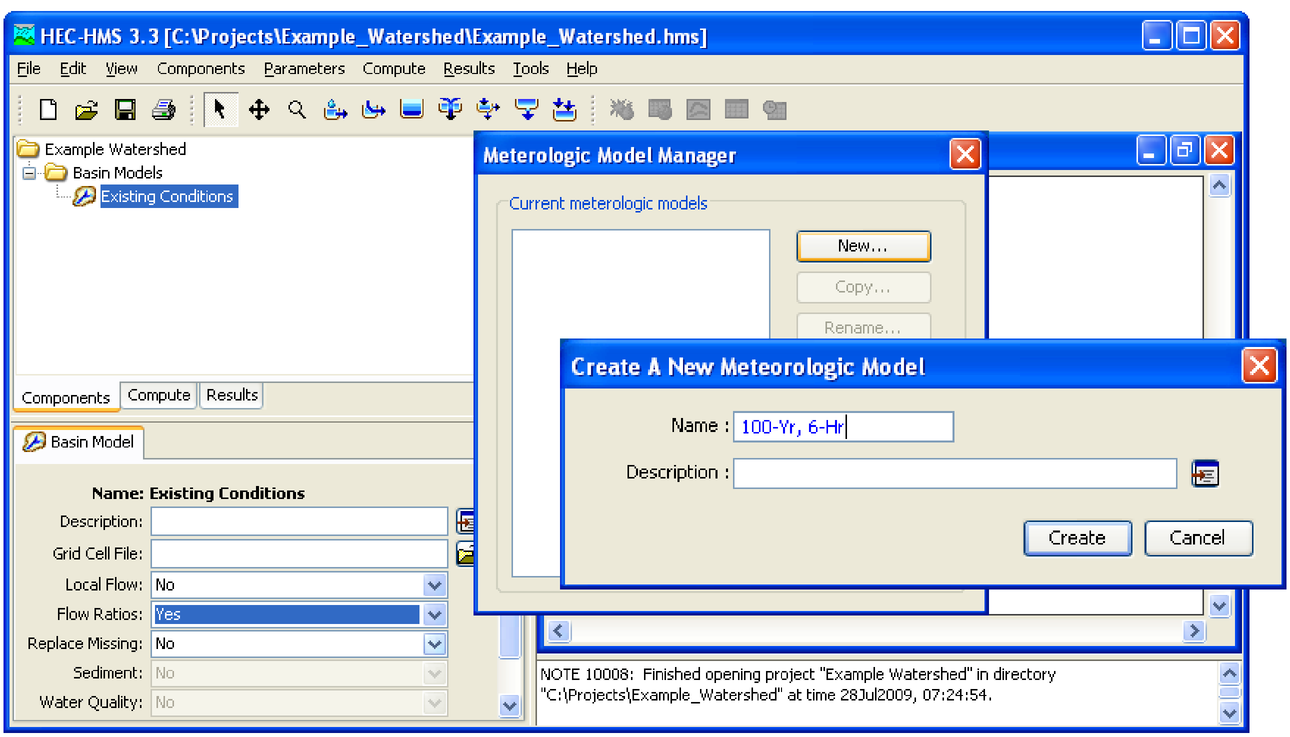


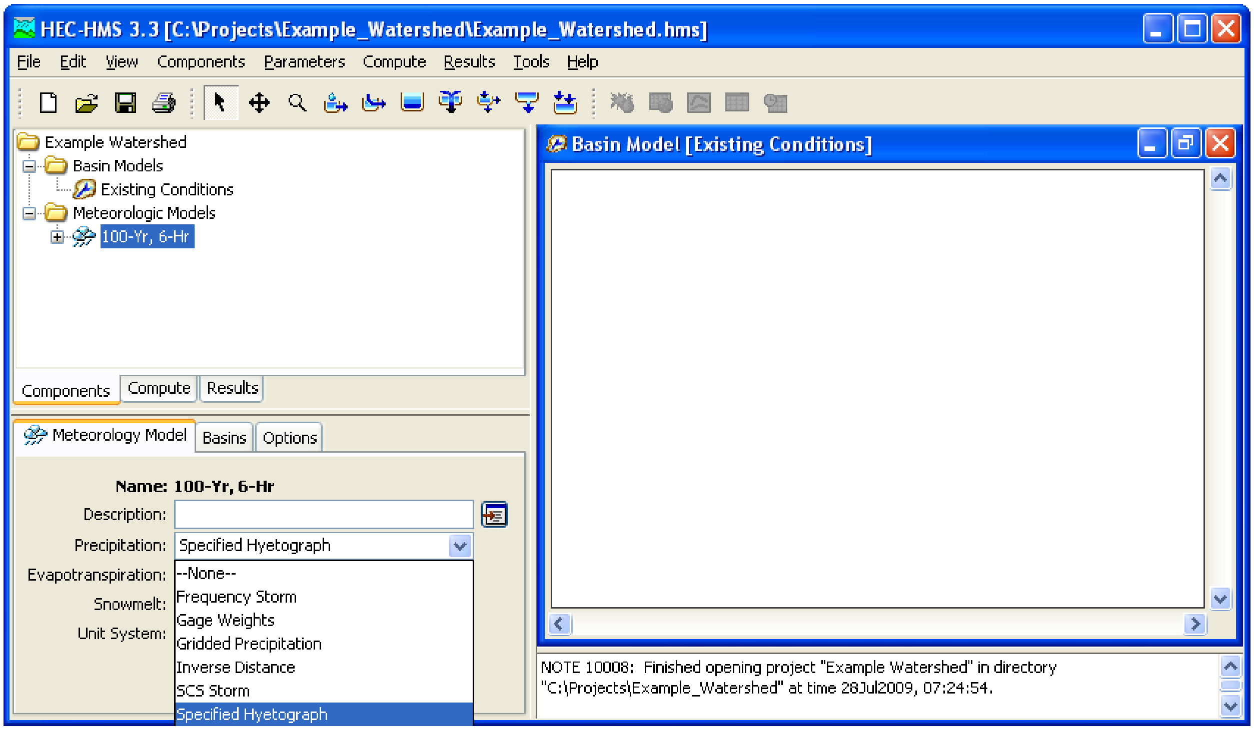
2. Create a Basin Model: From the *Components* pull down menu, select *Basin Model Manager*
   a. Select *New*
   b. Enter a name for the basin model (e.g. Existing Conditions)
   c. In the *Component Editor*, select "Yes" in the *Flow Ratio* list box



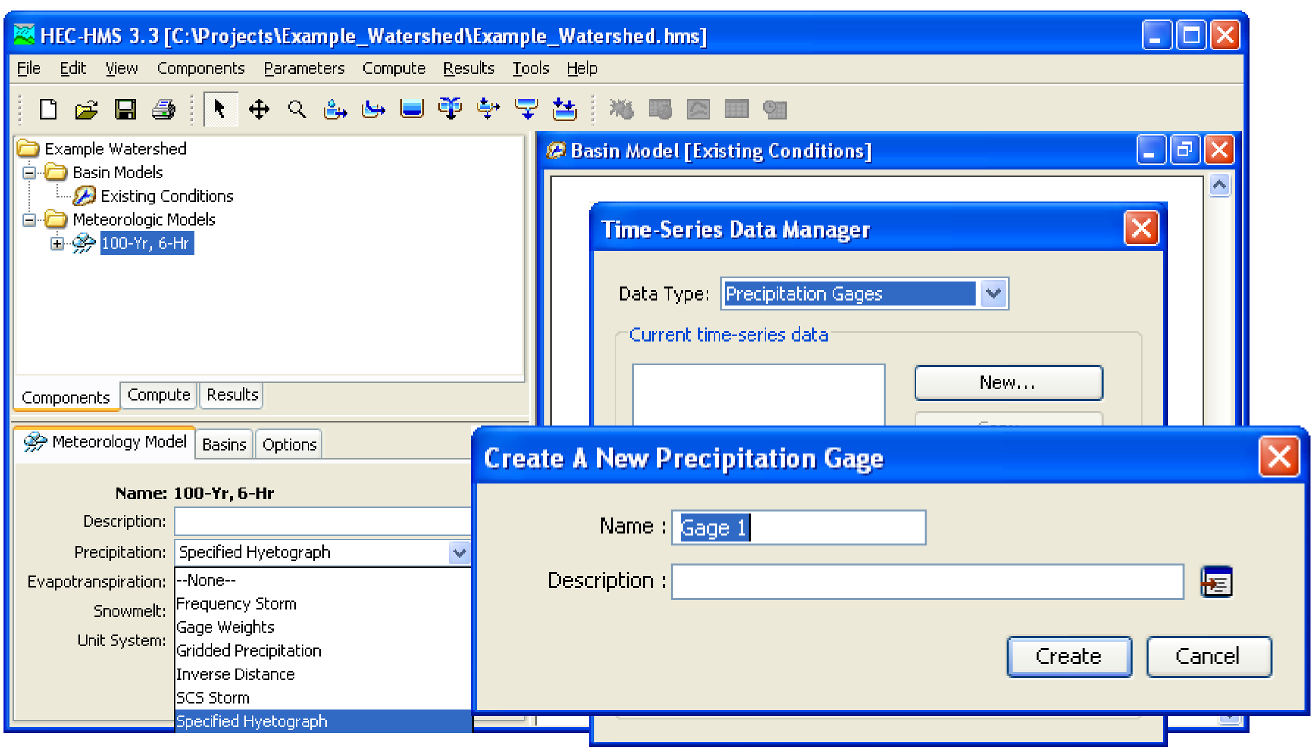


3. Create a Meteorologic Model: From the *Components* pull down menu, select *Meteorologic Model Manager*
   a. Select *New*
   b. Enter a name for the meteorologic model (e.g. 100-Yr, 6-Hr)
   c. In the *Component Editor*, select "Specified Hyetograph" in the *Precipitation* list box





4. Create a precipitation gage: from the *Components* pull down menu, select *Time-Series Data Manager*
   a. With the *Data Type* set to "Precipitation Gages", select *New*
   b. Assign a name for the gage (e.g. Gage-1)



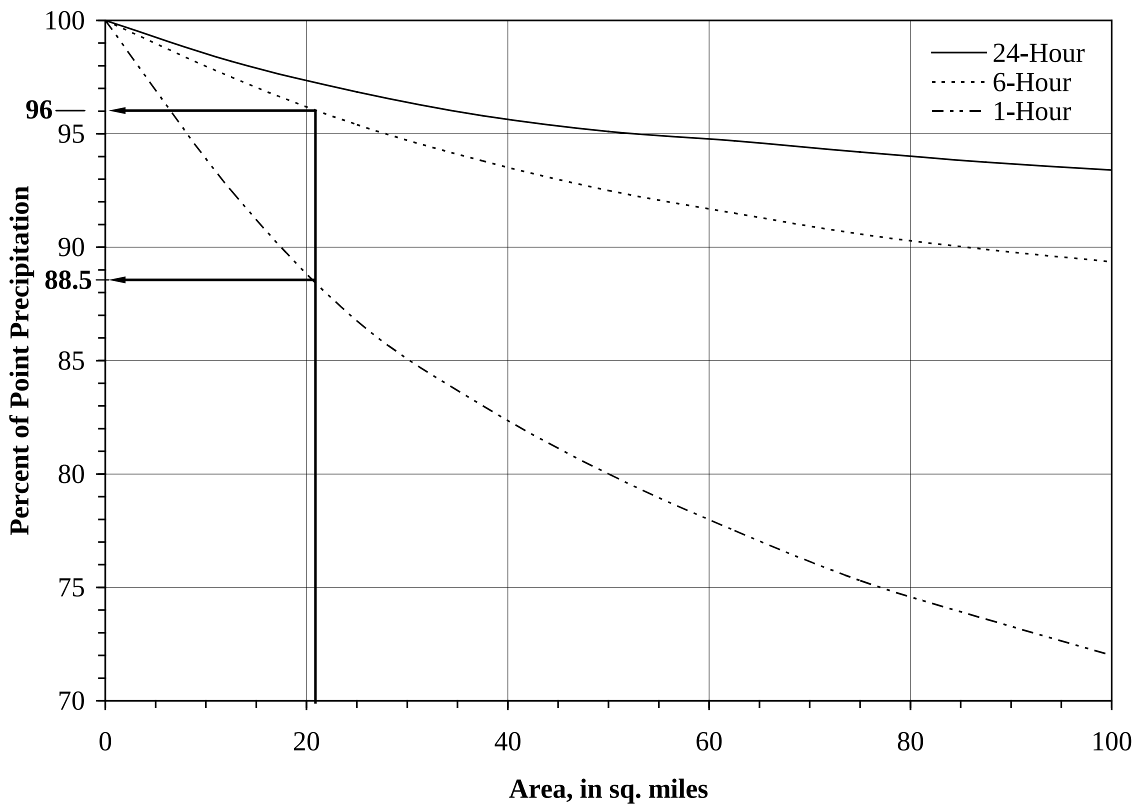
F.8.2 Design Rainfall

Determine the 100-year, 6-hour rainfall data for the watershed, plot the rainfall hyetograph and code the data into the HEC-HMS project.

1. 100-year point rainfall depths taken from Table F-1 are:
   - 100-year, 1-hour = 1.84 inches
   - 100-year, 6-hour = 2.37 inches

2. Estimate depth-area reduction factors for the watershed area of 20.5 square miles using Figure F-1.

FIGURE F-9. EXAMPLE WATERSHED DEPTH-AREA REDUCTION



3. Calculate the equivalent uniform rainfall depth

$$P_1^{100} = (1.84)(0.885) = 1.63 \text{ inches}$$

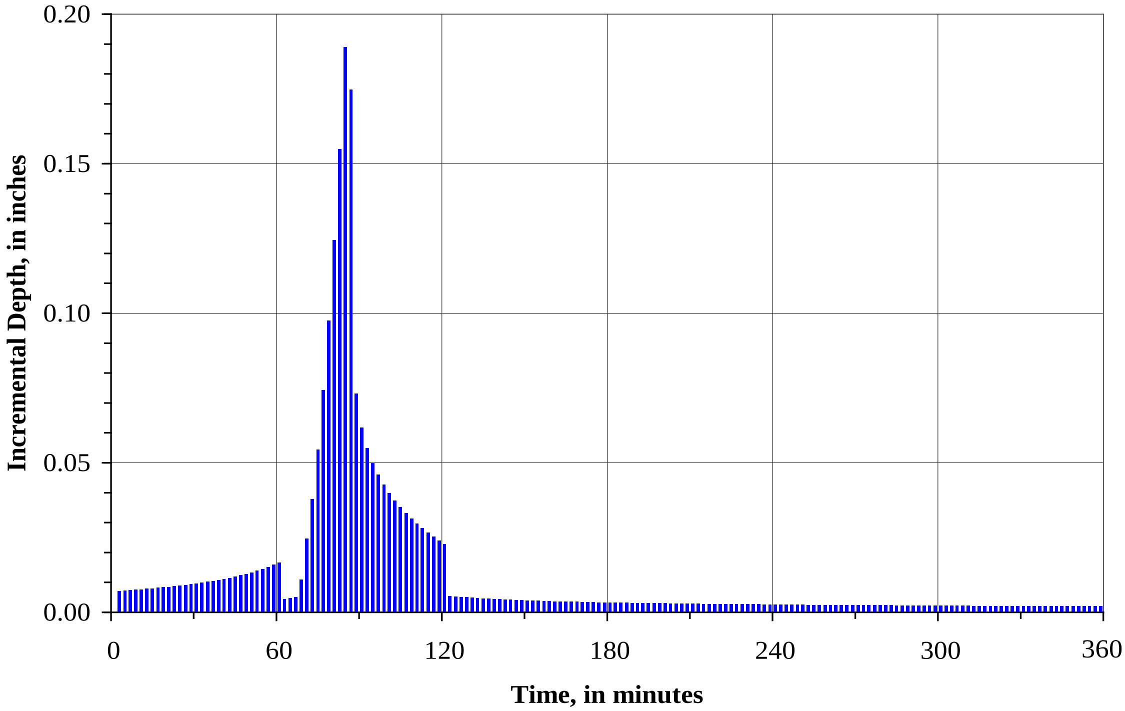
$$P_6^{100} = (2.37)(0.960) = 2.28 \text{ inches}$$

4. Calculate the cumulative rainfall mass curve using Equations F-1 through F-5 for the 6-hour storm. The computation time interval is 2 minutes.

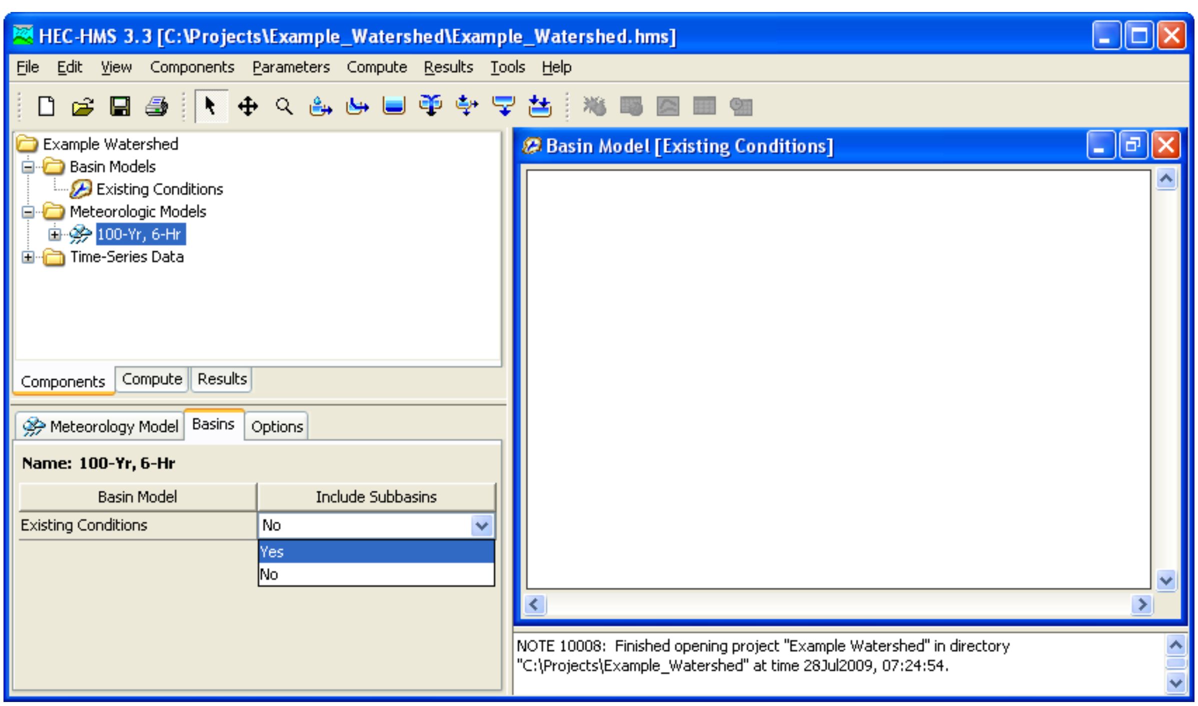
TABLE F-8. CUMULATIVE RAINFALL DISTRIBUTION

Time min	Rainfall inches	Time min	Rainfall inches	Time min	Rainfall inches	Time min	Rainfall inches
0	0.000	92	1.459	184	2.065	276	2.190
2	0.007	94	1.509	186	2.068	278	2.192
4	0.014	96	1.555	188	2.071	280	2.194
6	0.021	98	1.598	190	2.074	282	2.197
8	0.028	100	1.638	192	2.078	284	2.199
10	0.036	102	1.676	194	2.081	286	2.201
12	0.043	104	1.712	196	2.084	288	2.203
14	0.051	106	1.745	198	2.087	290	2.206
16	0.059	108	1.777	200	2.090	292	2.208
18	0.067	110	1.807	202	2.093	294	2.210
20	0.075	112	1.835	204	2.096	296	2.213
22	0.084	114	1.862	206	2.099	298	2.215
24	0.092	116	1.887	208	2.101	300	2.217
26	0.101	118	1.911	210	2.104	302	2.219
28	0.110	120	1.934	212	2.107	304	2.221
30	0.120	122	1.940	214	2.110	306	2.224
32	0.129	124	1.945	216	2.113	308	2.226
34	0.139	126	1.951	218	2.116	310	2.228
36	0.149	128	1.956	220	2.118	312	2.230
38	0.160	130	1.961	222	2.121	314	2.232
40	0.171	132	1.965	224	2.124	316	2.235
42	0.182	134	1.970	226	2.127	318	2.237
44	0.193	136	1.975	228	2.129	320	2.239
46	0.205	138	1.979	230	2.132	322	2.241
48	0.218	140	1.984	232	2.135	324	2.243
50	0.231	142	1.988	234	2.137	326	2.245
52	0.244	144	1.992	236	2.140	328	2.247
54	0.258	146	1.996	238	2.143	330	2.249
56	0.273	148	2.000	240	2.145	332	2.251
58	0.288	150	2.004	242	2.148	334	2.254
60	0.304	152	2.008	244	2.150	336	2.256
62	0.309	154	2.012	246	2.153	338	2.258
64	0.314	156	2.016	248	2.155	340	2.260
66	0.319	158	2.020	250	2.158	342	2.262
68	0.330	160	2.024	252	2.160	344	2.264
70	0.355	162	2.027	254	2.163	346	2.266
72	0.393	164	2.031	256	2.165	348	2.268
74	0.448	166	2.035	258	2.168	350	2.270
76	0.522	168	2.038	260	2.170	352	2.272
78	0.620	170	2.042	262	2.173	354	2.274
80	0.746	172	2.045	264	2.175	356	2.276
82	0.902	174	2.048	266	2.178	358	2.278
84	1.092	176	2.052	268	2.180	360	2.280
86	1.268	178	2.055	270	2.182		
88	1.341	180	2.058	272	2.185		
90	1.403	182	2.062	274	2.187		

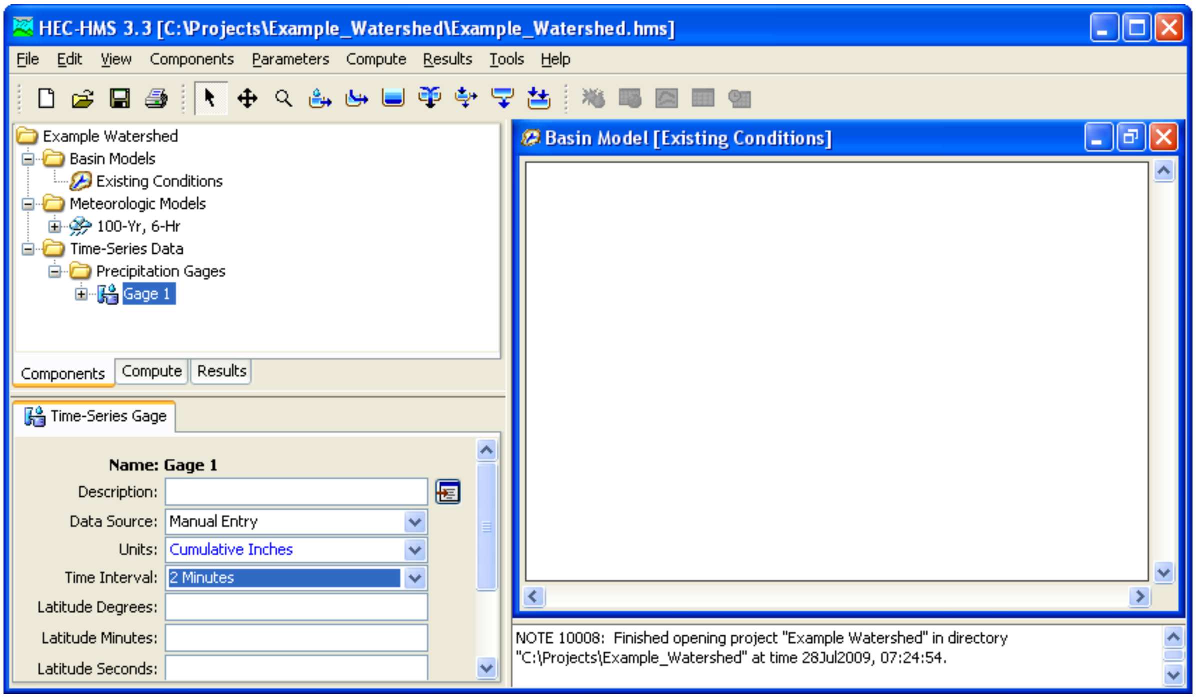
FIGURE F-10. 100-YEAR, 6-HOUR RAINFALL HYETOGRAPH



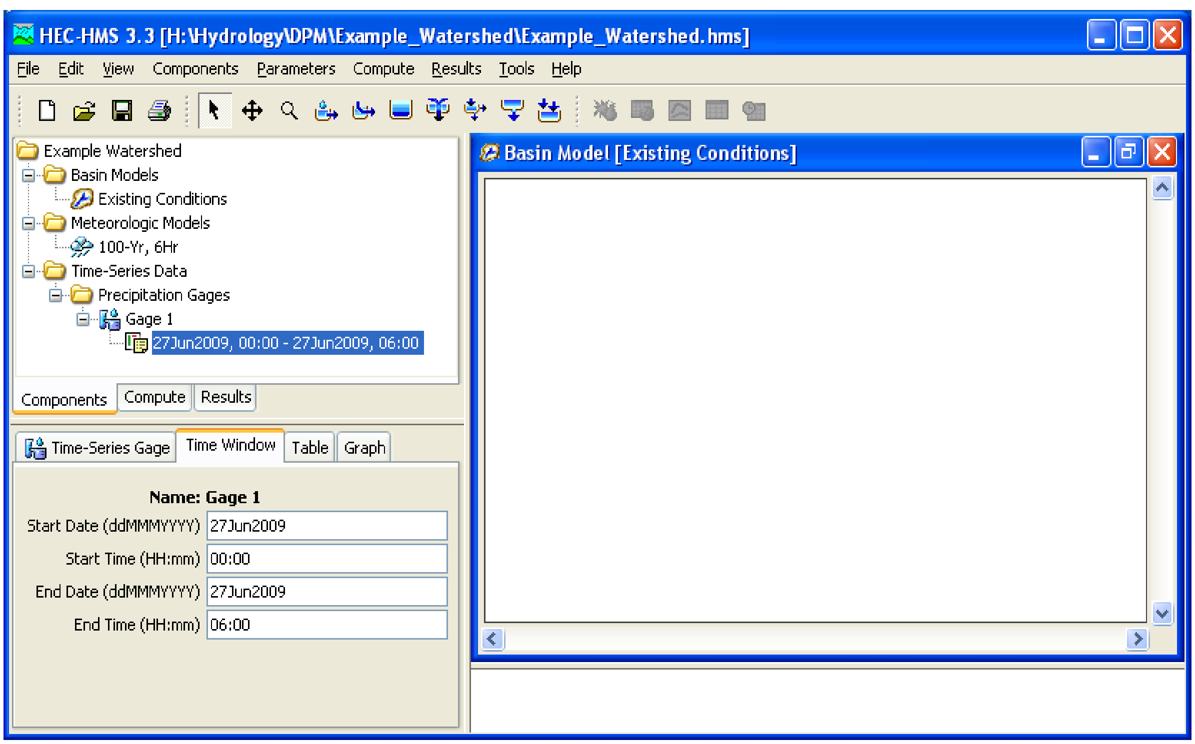
5. Code the cumulative rainfall data into HEC-HMS
   a. In the *Basin* tab of the *Component Editor* for the "100-Yr, 6-Hr" precipitation model, toggle on the "Include Subbasins" option



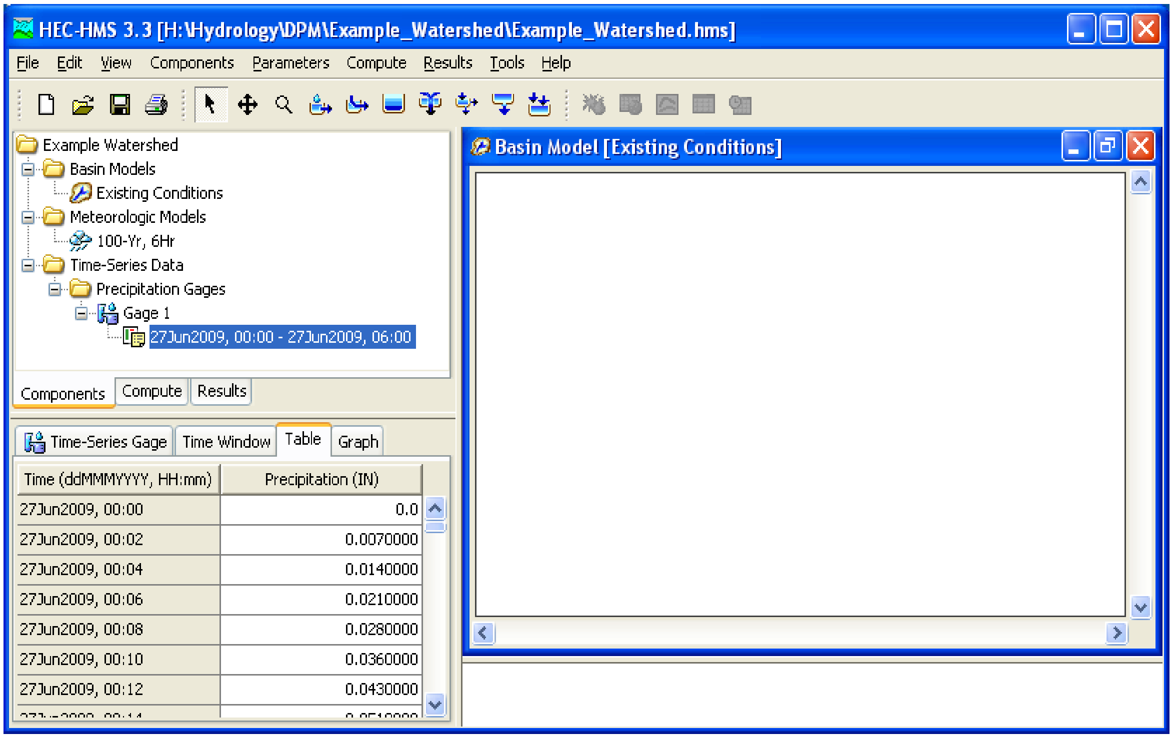
b. In the *Component Editor* for “Gage-1”, set the following:
   i. Units = Cumulative Inches
   ii. Time Interval = 2 Minutes



c. Set the time duration of rainfall

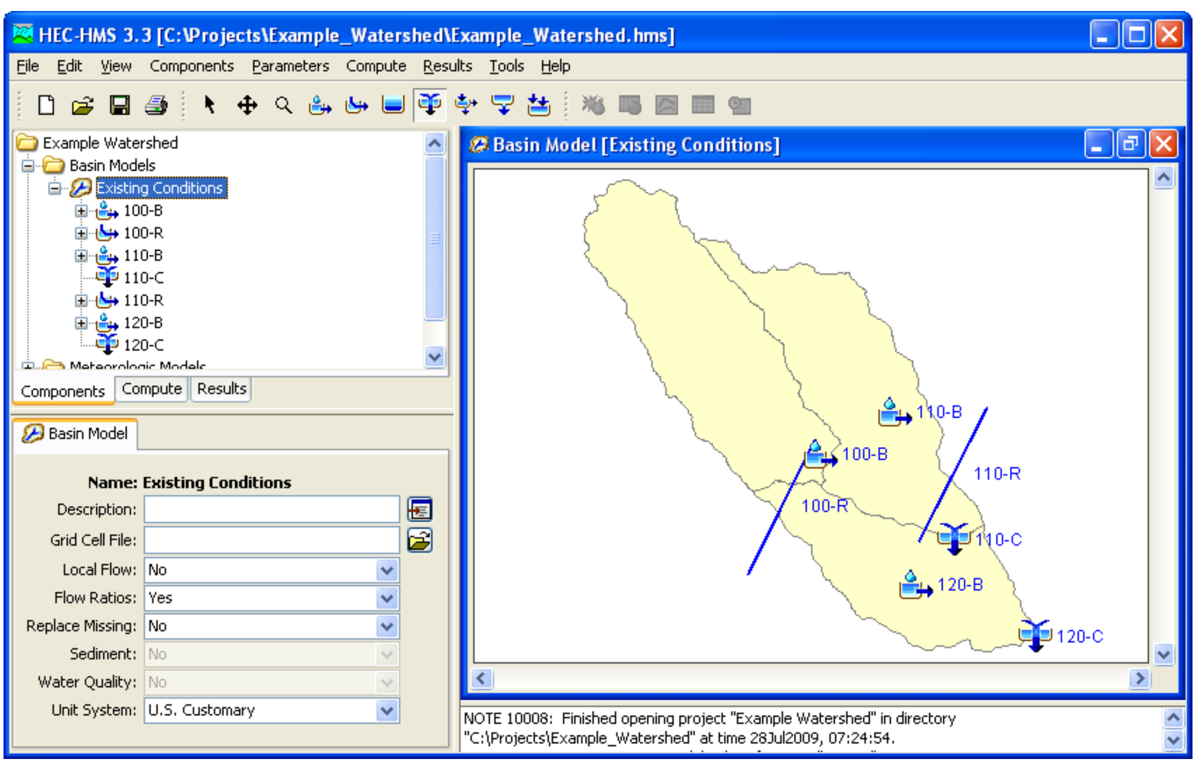


d. Cut and paste the cumulative rainfall data from Table F-8

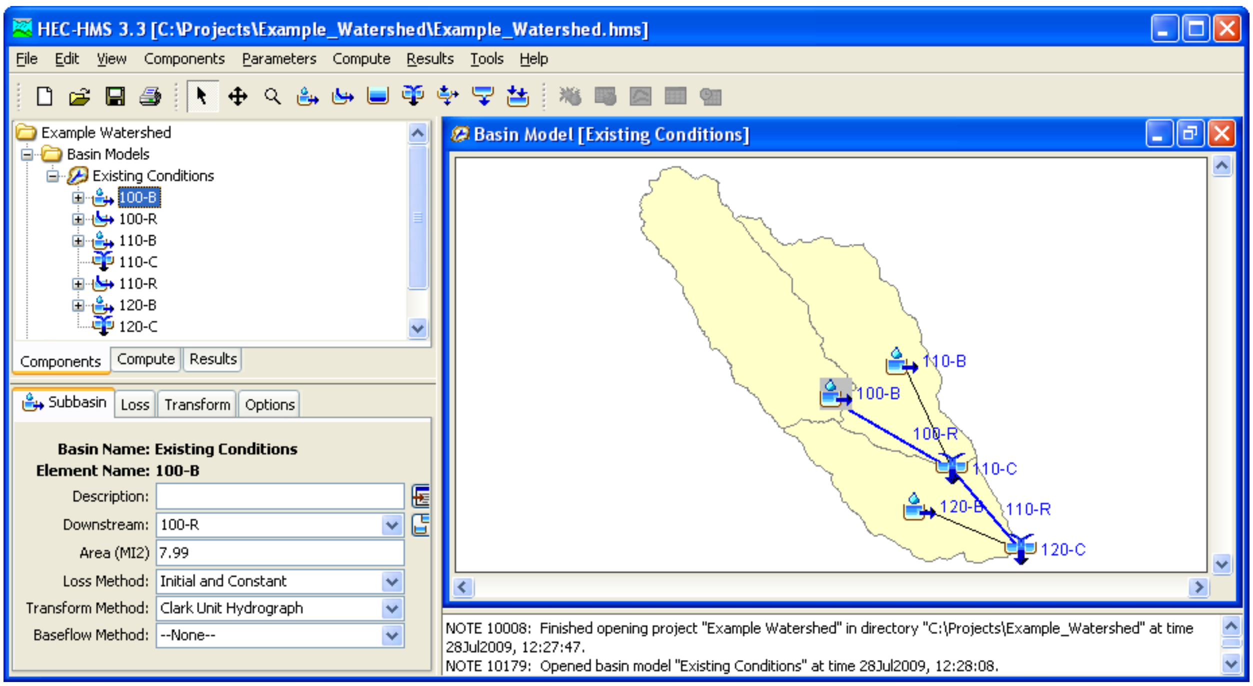


F.8.3 Basin Data

1. Build watershed schematic in the HEC-HMS Desktop using the watershed icons for each element.



2. Set the default methodologies for subbasin and channel routing elements
    a. From the *Parameters* pull down menu
        i. Select *Subbasin Methods*
            - Select *Loss* and set the Method to "Initial and Constant"
            - Select *Transform* and set the Method to "Clark Unit Hydrograph"
            - Select *Baseflow* and set the Method to "None"
        ii. Select *Reach Methods*
            - Select *Routing* and set the Method to "Muskingum-Cunge"
            - Select *Loss/Gain* and set the Method to "None"
3. Code in subbasin areas and set downstream connectivity



F.8.4 Rainfall Loss Parameters

Compute the subbasin average rainfall loss parameters and code the values into the HEC-HMS project for the watershed. Existing condition land use within the watershed is illustrated in Figure F-11. The areas for each unique land use type with each subbasin are listed in the following Table F-9.

FIGURE F-11. EXAMPLE WATERSHED LAND USE CONDITIONS

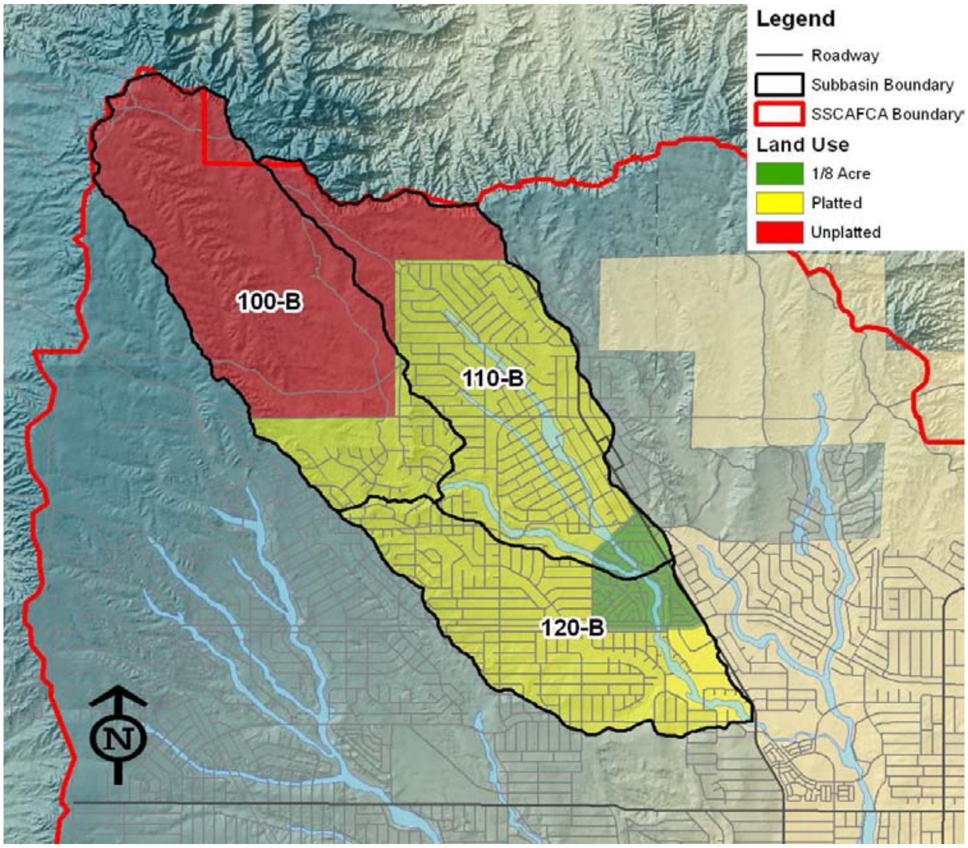


TABLE F-9 EXAMPLE WATERSHED LAND USE DATA

Parcel Description	Area, in sq. miles 100-B	110-B	120-B	Total Area sq. miles
1/8 Acre	---	0.38	0.62	1.00
Platted	1.60	4.58	5.69	11.87
Unplatted	6.39	1.24	---	7.63
Total	7.99	6.20	6.31	20.50

1. From Table F-3, percentage of Land Treatment Types for each parcel within the watershed are:

Parcel Description	Percent of Land Treatment Type A	B	C	D
1/8 Acre	0	15	15	70
Platted	18.7	29.5	27.0	24.8
Unplatted	95	5	0	0

2. Calculate the area of each Land Treatment type within each subbasin by multiplying the area of each parcel type by the percent of Land Treatment type, for example:

For subbasin 100-B, the area of each Land Treatment type is as follows:

$Area_A$ = (0)(0%) + (1.6)(18.7%) + (6.39)(95%) = 6.37 sq. miles

$Area_B$ = (0)(15%) + (1.6)(29.5%) + (6.39)(5%) = 0.79 sq. miles

$Area_C$ = (0)(15%) + (1.6)(27.0%) + (6.39)(0%) = 0.43 sq. miles

$Area_D$ = (0)(70%) + (1.6)(24.8%) + (6.39)(0%) = 0.40 sq. miles

Total Area = 7.99 sq. miles

Therefore, the area of each Land Treatment type for each subbasin is as follows:

Subbasin ID	Land Treatment Type Area, in sq. miles A	B	C	D	Total Area sq. miles
100-B	6.37	0.79	0.43	0.40	7.99
110-B	2.03	1.47	1.30	1.40	6.20
120-B	1.06	1.77	1.63	1.85	6.31
Total	9.46	4.03	3.36	3.65	20.50

3. Using values of IA from Table F-4, calculate the weighted value of IA for each subbasin, for example:

For subbasin 100-B, the area weighted IA is calculated as follows:

$$IA = \frac{(6.37)(0.65) + (0.79)(0.50) + (0.43)(0.35)}{6.37 + 0.79 + 0.43} = 0.62$$

Therefore, the area weigthed IA for each subbasin is as follows:

Subbasin ID	IA inches
100-B	0.62
110-B	0.52
120-B	0.48

4. Using values of INF from Table F-5, calculate the weighted value of INF for each subbasin, for example:

   For subbasin 100-B, the area weighted INF is calculated as follows:

$$IA = \frac{(6.37)(1.67) + (0.79)(1.25) + (0.43)(0.83)}{6.37 + 0.79 + 0.43} = 1.58$$

   Therefore, the area weigthed INF for each subbasin is as follows:

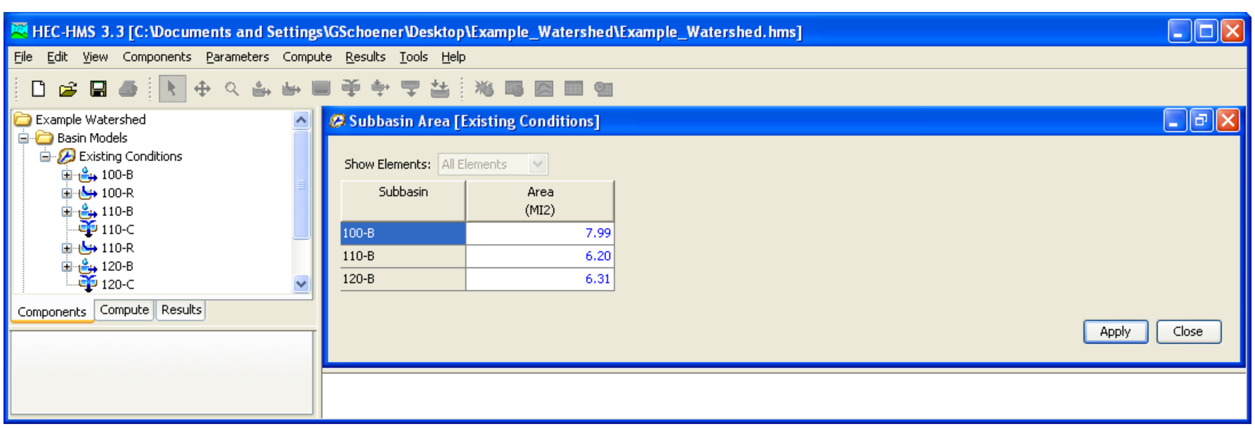
Subbasin ID	**INF in/hr**
100-B	1.58
110-B	1.32
120-B	1.20

5. Using the area of Land Treatment Type D, compute the impervious area percentage for each subbasin

Subbasin ID	**Impervious Area %**
100-B	5.0
110-B	22.6
120-B	29.3

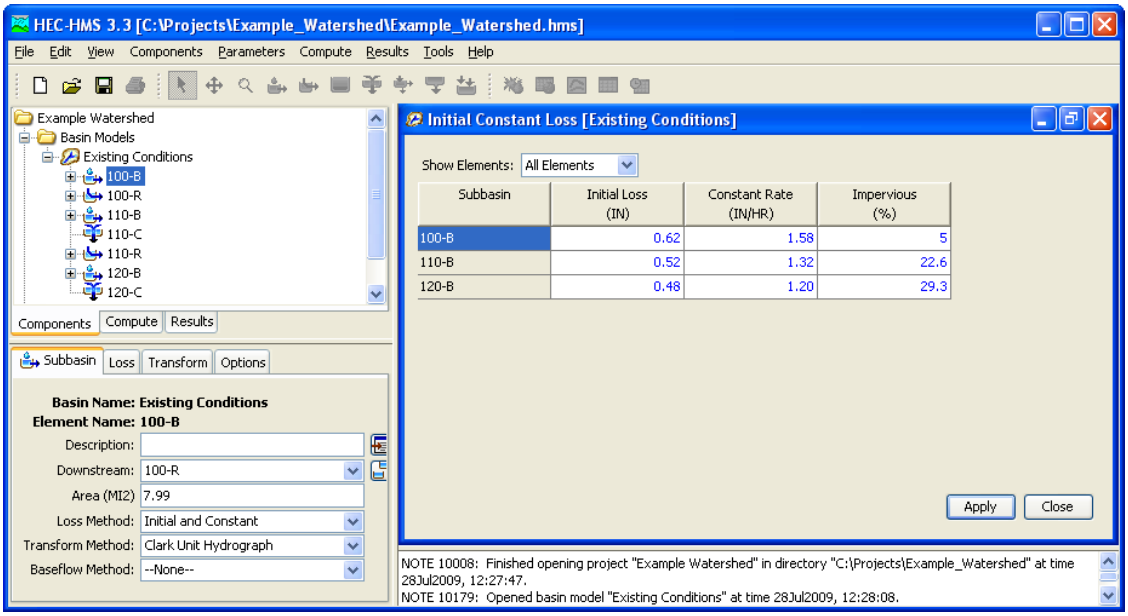
6. Code subbasin areas in HEC-HMS: from the Parameters pull down menu

   a. Select Subbasin Area
   b. Code area for each subbasin



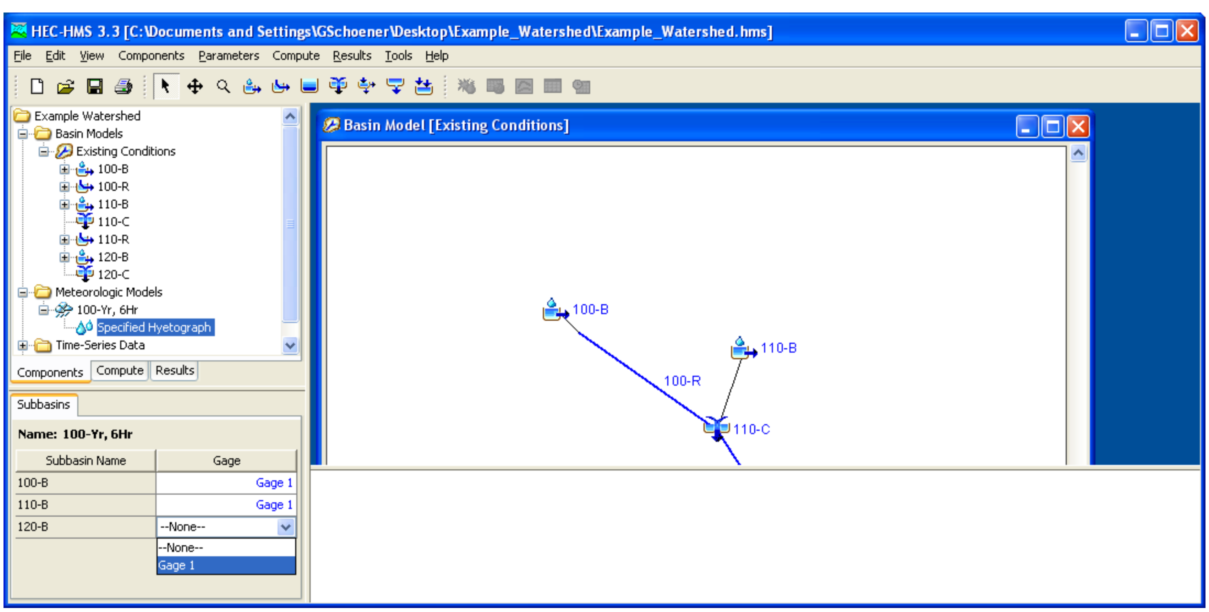
7. Code the rainfall loss parameters in HEC-HMS: from the Parameters pull down menu

   a. Select *Loss* and then *Initial and Constant*
   b. Select "All Elements"
   c. Code in the rainfall loss parameters for each subbasin



8. Assign rainfall data to each subbasin.

   a. Select *Specified Hyetograph* under *Meteorologic Models*.
   b. In the *Component Editor* for the *Specified Hyetograph*, select *Gage 1* for each of the three subbasins.



F.8.5 Unit Hydrograph Parameters

Compute the Clark unit hydrograph parameters and code the values into the HEC-HMS project for the watershed. Runoff from each subbasin should account for sediment bulking. Time of Concentration (Tc) flow paths, subbasin centroid locations and Lca flow paths for each subbasin are illustrated in Figure F-12. The physical data for calculation of the Clark unit hydrograph parameters for each subbasin are listed in Table F-9.

FIGURE F-12. EXAMPLE WATERSHED FLOW PATHS

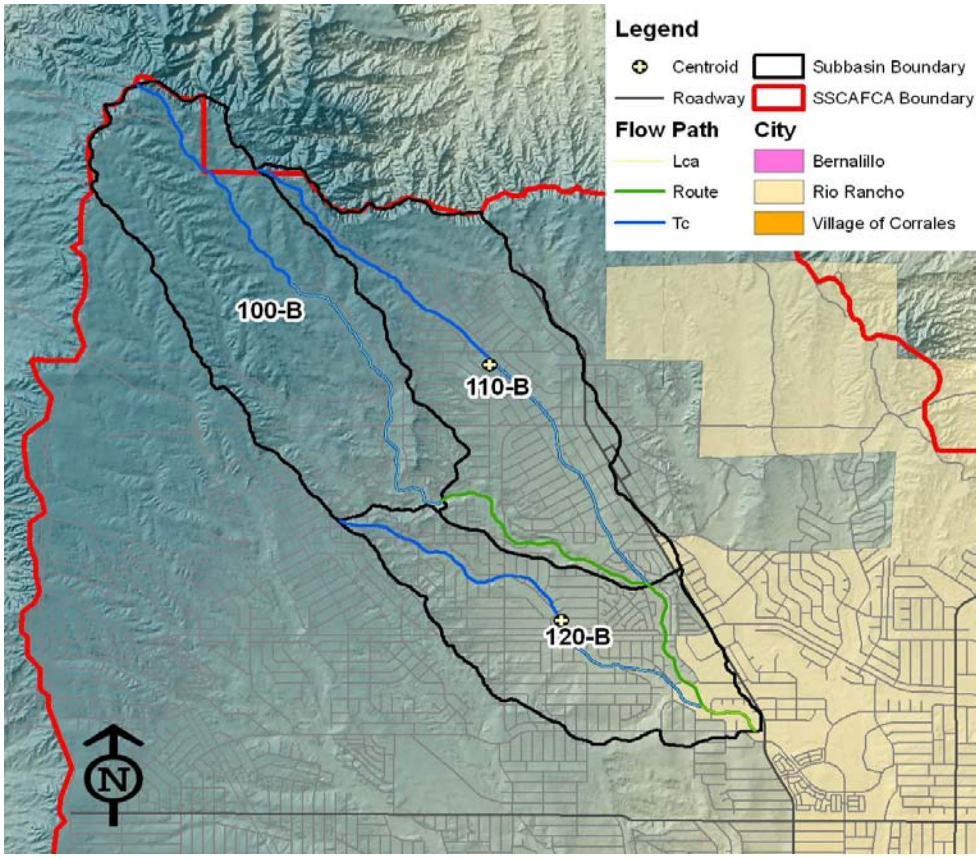


TABLE F-10 EXAMPLE WATERSHED FLOW PATH DATA

Subbasin ID	Flow Path Length L miles	Flow Path Length L_{ca} miles	Slope ft/ft
100-B	5.15	2.71	0.0185
110-B	5.81	2.68	0.0171
120-B	4.92	2.35	0.0165

1. Calculate the T_c for each subbasin

   The Tc flow path length is greater than 12,000 feet for all subbasins, therefore use Equation F-8 and select a value of K_n from Table F-6.

   The majority of each subbaisn is undeveloped land, either platted or unplatted, therefore assume a value of K_n of 0.033 for all subbasins.

   Using Equation F-8, T_c for subbasin 100-B is:

$$T_c = \frac{8}{9} * 26(0.033) * \left(\frac{27{,}192 * 14{,}309}{5280^2 * \sqrt{5280 * 0.0185}} \right)^{0.33} = \textit{0.855 hrs}$$

   Using Equation F-8, T_c for subbasin 110-B is:

$$T_c = \frac{8}{9} * 26(0.033) * \left(\frac{30{,}677 * 14{,}150}{5280^2 * \sqrt{5280 * 0.0171}} \right)^{0.33} = \textit{0.899 hrs}$$

   Using Equation F-8, T_c for subbasin 120-B is:

$$T_c = \frac{8}{9} * 26(0.033) * \left(\frac{25{,}998 * 12{,}408}{5280^2 * \sqrt{5280 * 0.0165}} \right)^{0.33} = \textit{0.819 hrs}$$

2. Calculate the Storage Coefficient (R) for each subbasin using Equation F-13 and the results from Example Problem No. 2

   Using Equation F-13, R for subbasin 100-B is:

$$R = 1.165 * 0.855 * \left(1.58^{0.45} - 0.62^{1.4} \left(\frac{5}{100} \right)^{0.40} \right) = \textit{1.070 hrs}$$

   Using Equation F-13, R for subbasin 110-B is:

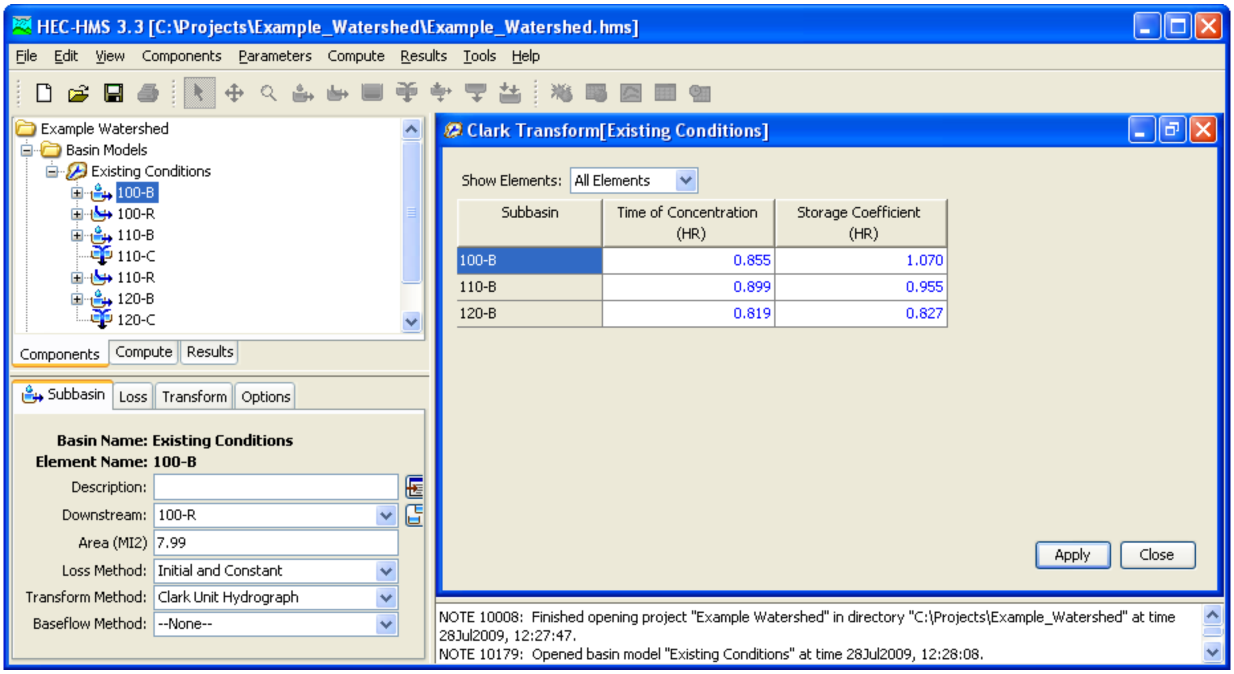
$$R = 1.165 * 0.899 * \left(1.32^{0.45} - 0.52^{1.4} \left(\frac{22.6}{100} \right)^{0.40} \right) = \textit{0.955 hrs}$$

   Using Equation F-13, R for subbasin 120-B is:

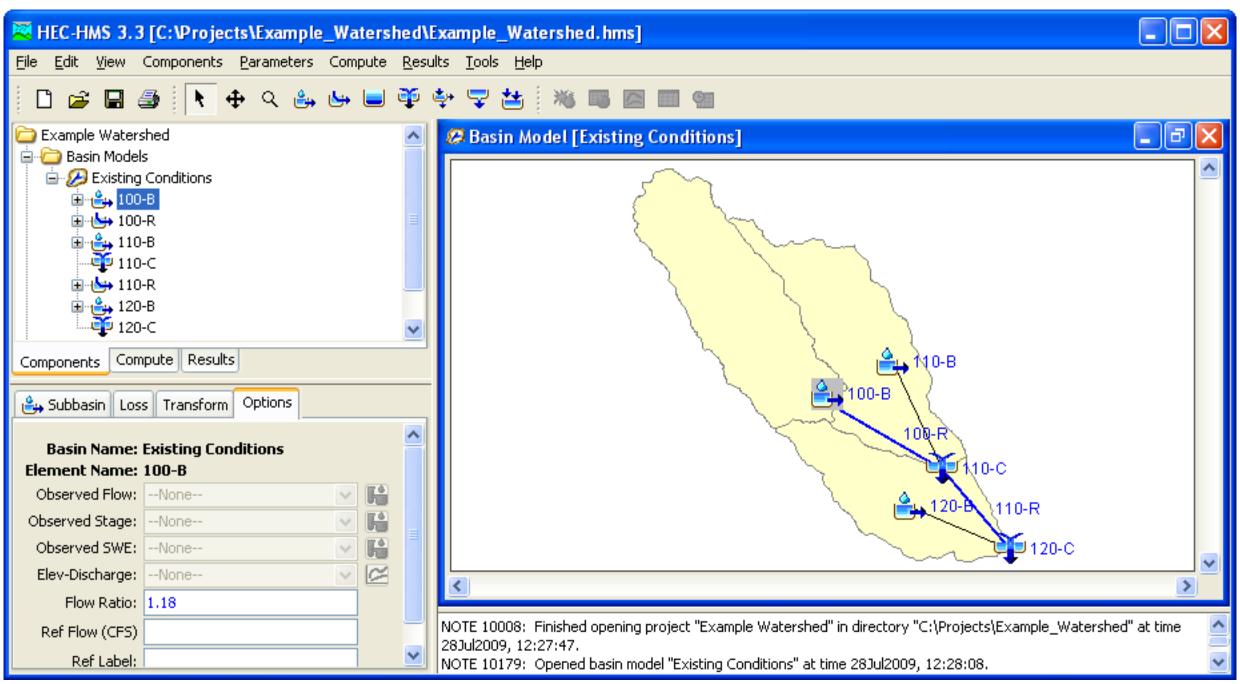
$$R = 1.165 * 0.819 * \left(1.20^{0.45} - 0.48^{1.4} \left(\frac{29.3}{100} \right)^{0.40} \right) = \textit{0.827 hrs}$$

3. Assign sediment bulking factors for each subbasin based on the guidance in Section F.6. Since the majority of all three subbasins are undeveloped, but platted lands, use a sediment bulking factor of 18% for all subbasins.

4. Code the Clark unit hydrograph parameters in HEC-HMS: from the *Parameters* pull down menu
    a. Select *Transform* and then Clark Unit Hydrograph
    b. Select "All Elements"
    c. Code in the rainfall loss parameters for each subbasin



5. Code in the sediment bulking ratio: on the *Options* tab in the *Component Editor* for each subbasin, code in 1.18 as the flow ratio



F.8.6 Channel Routing Parameters

Develop the Muskingum-Cunge channel routing data and code that data into the HEC-HMS project for the watershed, execute the model and summarize the results. Routing reaches for the watershed are illustrated in Figure F-13. The physical data for routing reach is listed in Table F-11. Cross sections typical of the geometry for each reach are shown in Figures F-14 and F-15 for Routing Reach 100-R and 110-R, respectively.

FIGURE F-13. EXAMPLE WATERSHED ROUTING REACHES

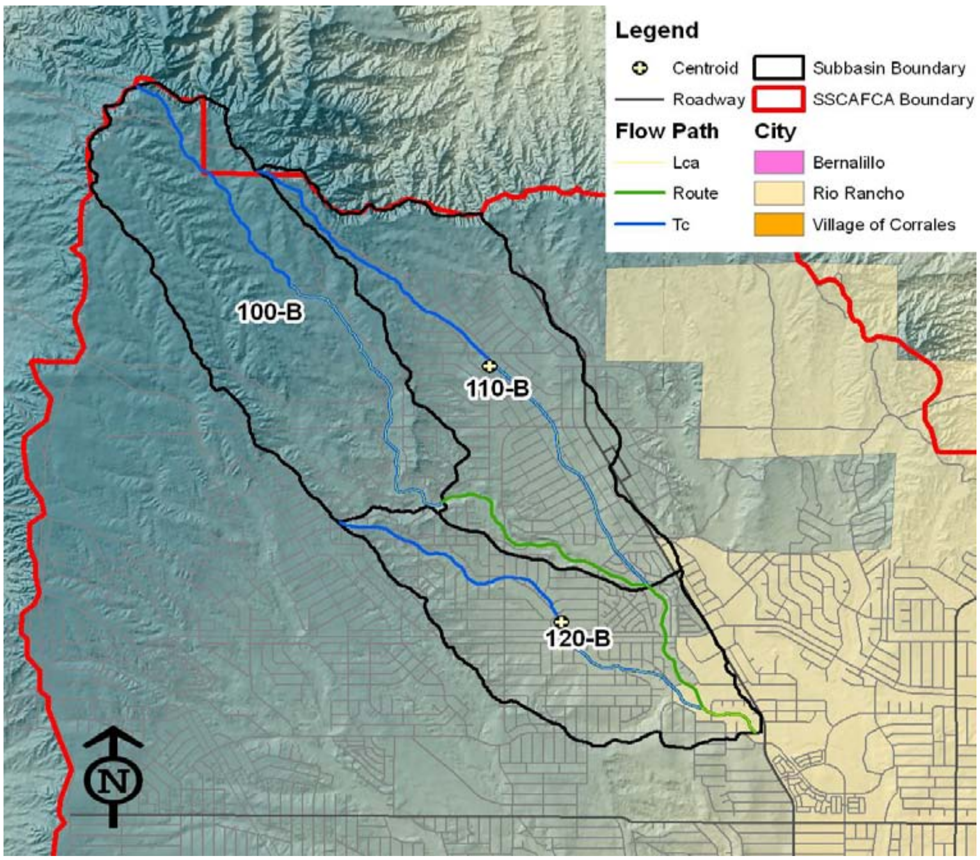


TABLE F-11 EXAMPLE WATERSHED CHANNEL ROUTING DATA

Reach ID	Reach from Subbasin	Length feet	Slope ft/ft
100-R	100-B	11,263	0.0165
110-R	120-B	9,685	0.0158

FIGURE F-14. REACH 100-R CROSS SECTIONAL GEOMETRY

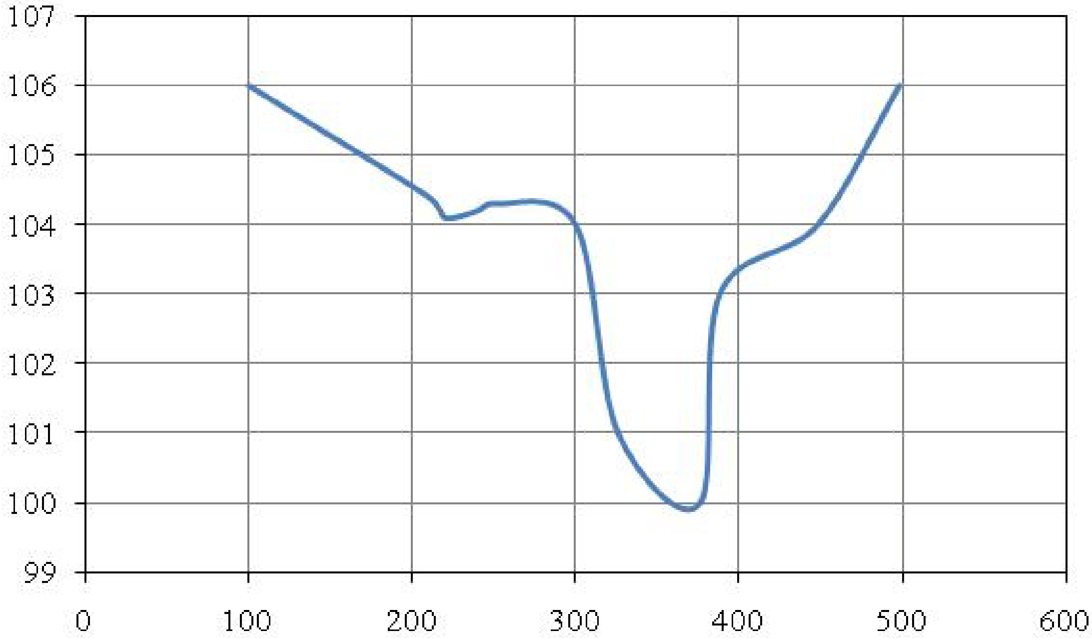
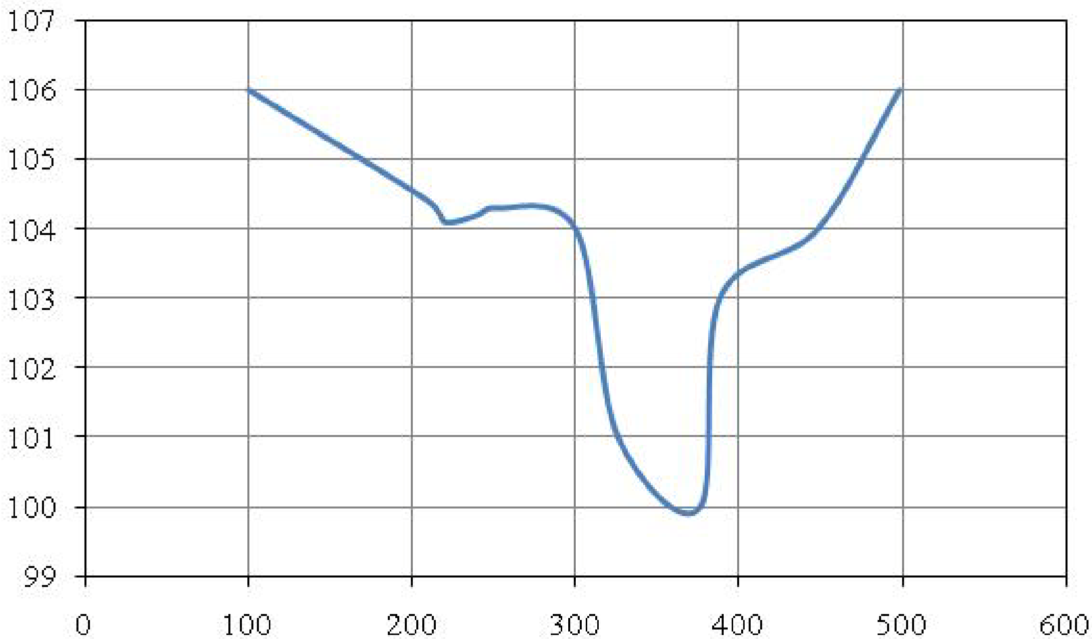


FIGURE F-15. REACH 110-R CROSS SECTIONAL GEOMETRY



1. Simplify the channel geometry for each reach into an 8-point irregular section.

FIGURE F-16. 8-POINT GEOMETRY FOR REACH 100-R

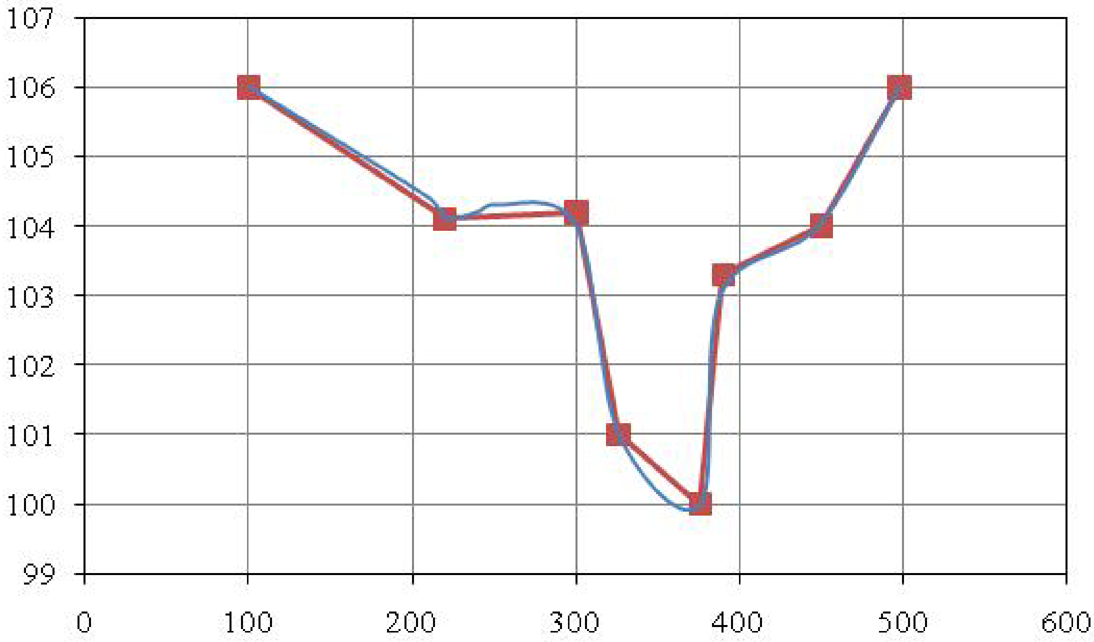
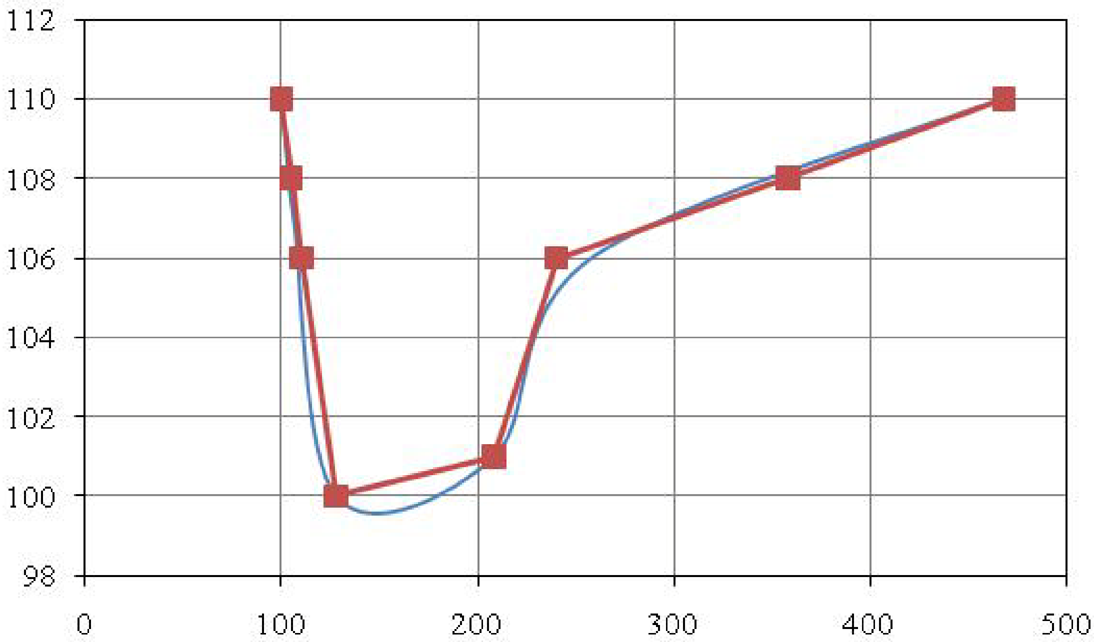


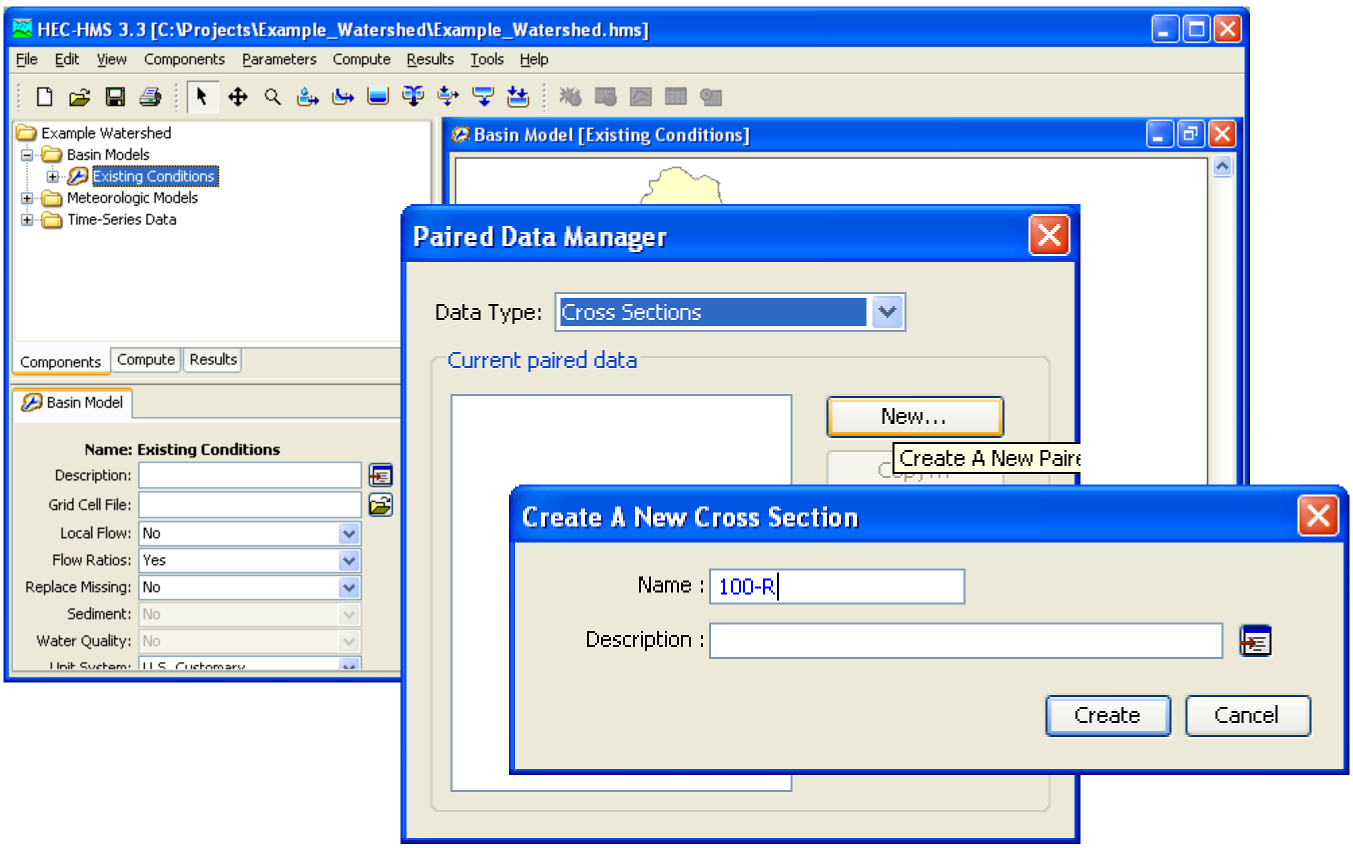
FIGURE F-17. 8-POINT GEOMETRY FOR REACH 110-R



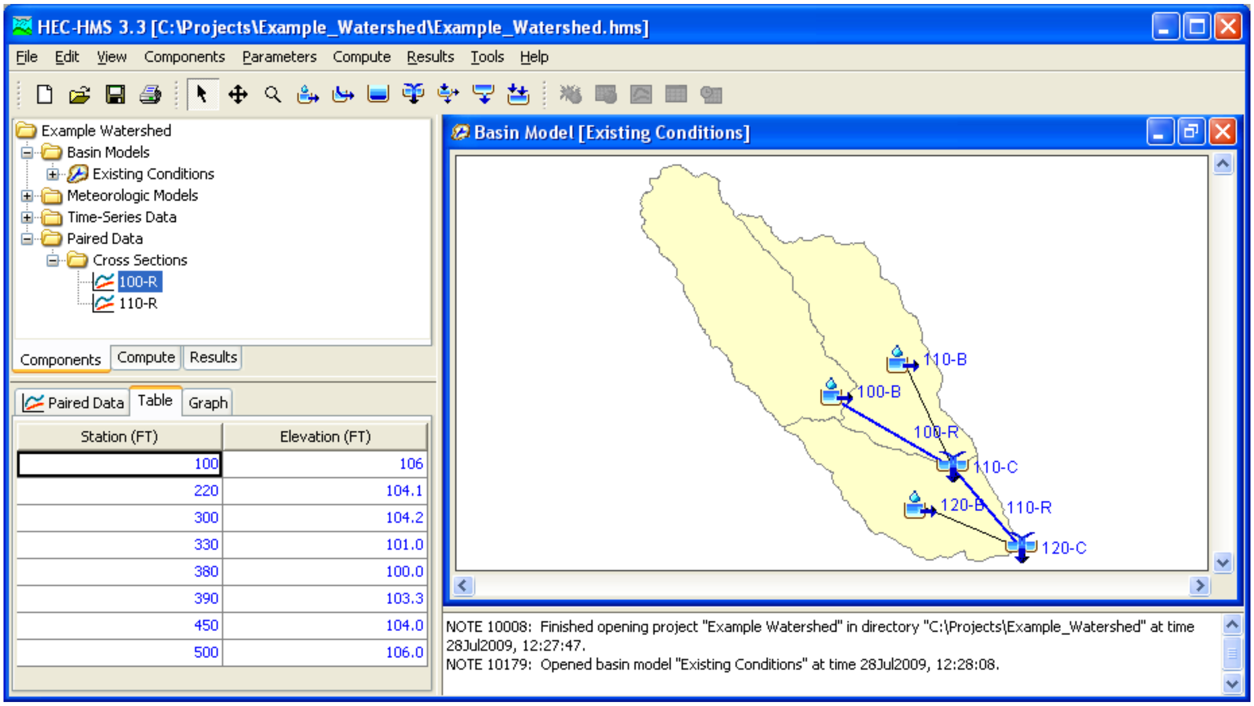
2. From Table F-7, select the appropriate Manning's n-value(s) for each reach.

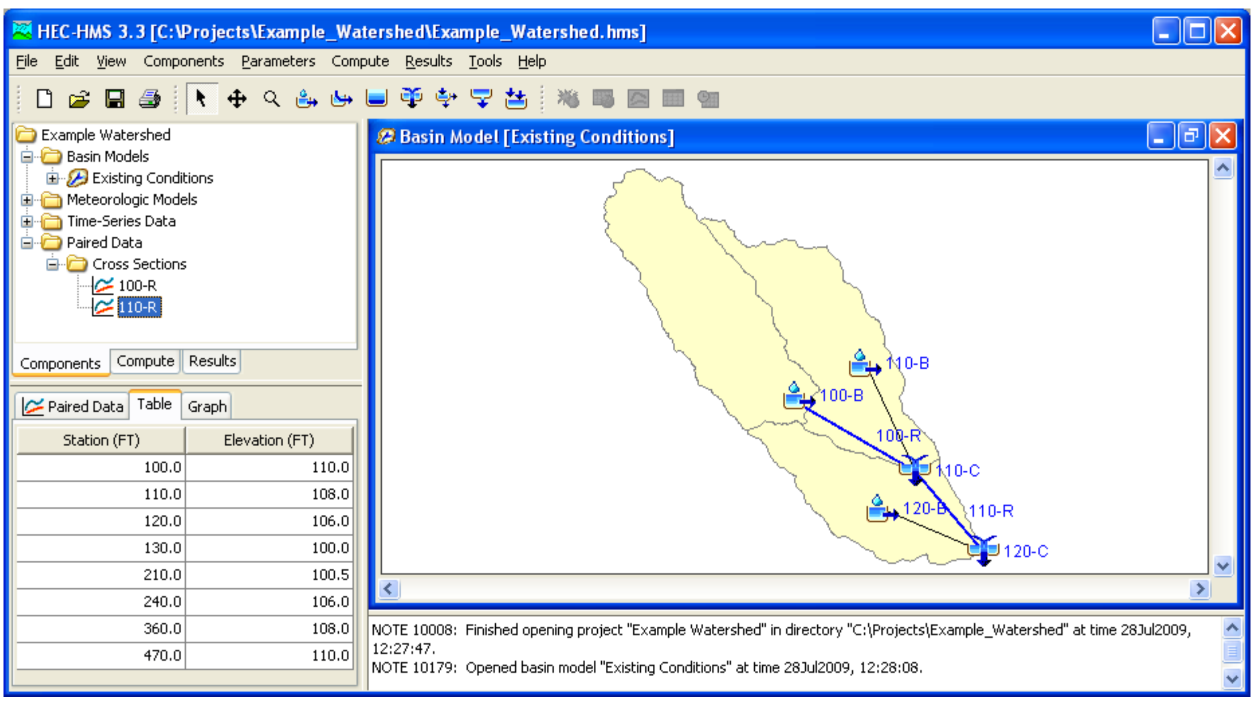
   Both routing reaches are natural, sand bed arroyos. From Table F-7 use a Manning's n-value of 0.05 for the entire section.

3. Code the routing data into HEC-HMS
   a. From the *Components* pull down menu, select *Paired Data Manager*
   b. Select "Cross Sections" as the *Data Type*
   c. Select *New* and enter a name for the first cross section (e.g. 100-R)
   d. Repeat Step 3.c for the second cross section

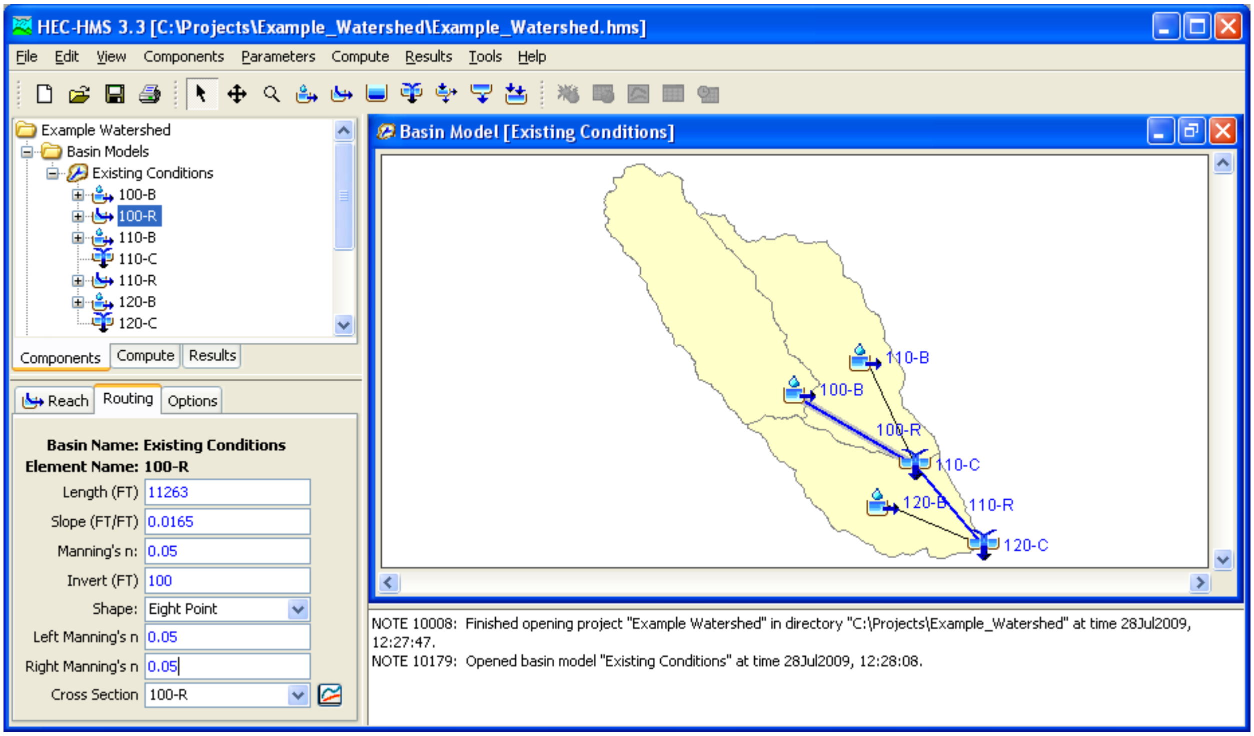


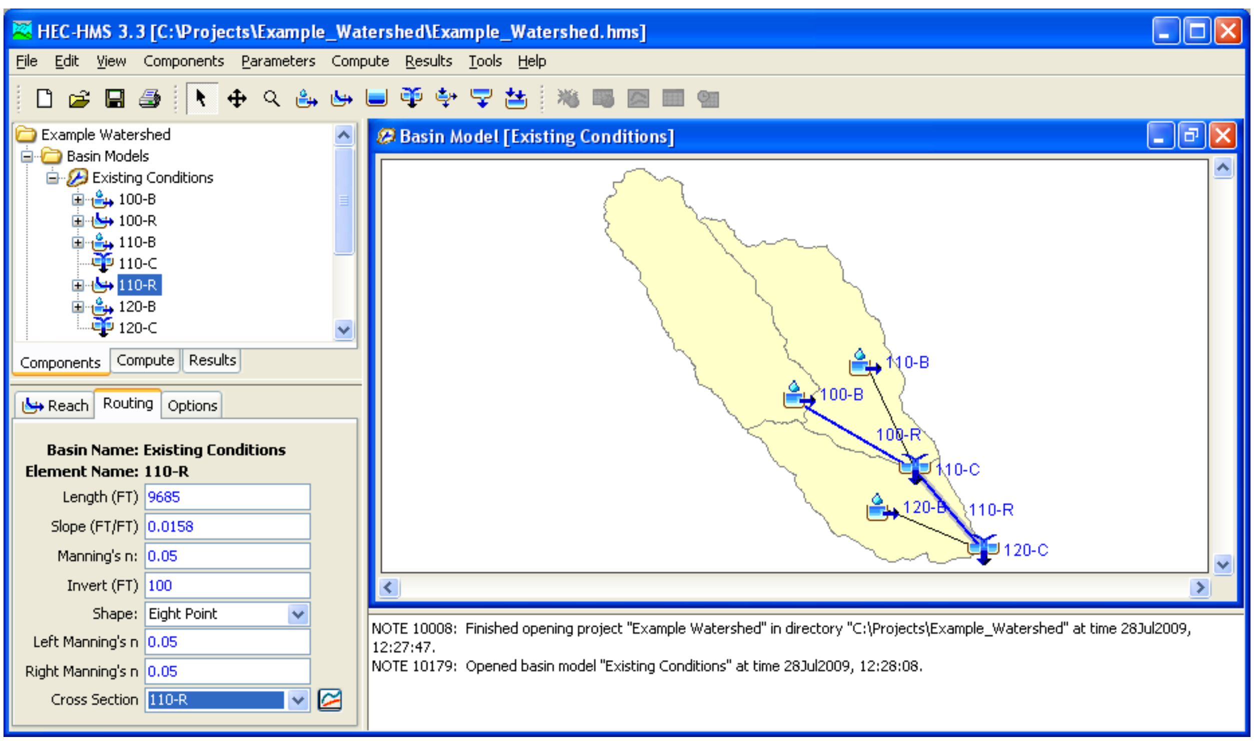
4. On the Table tab in the Component Editor of the Cross Section data, code in the 8-point geometry for each cross section using Figures F-11 and F-12





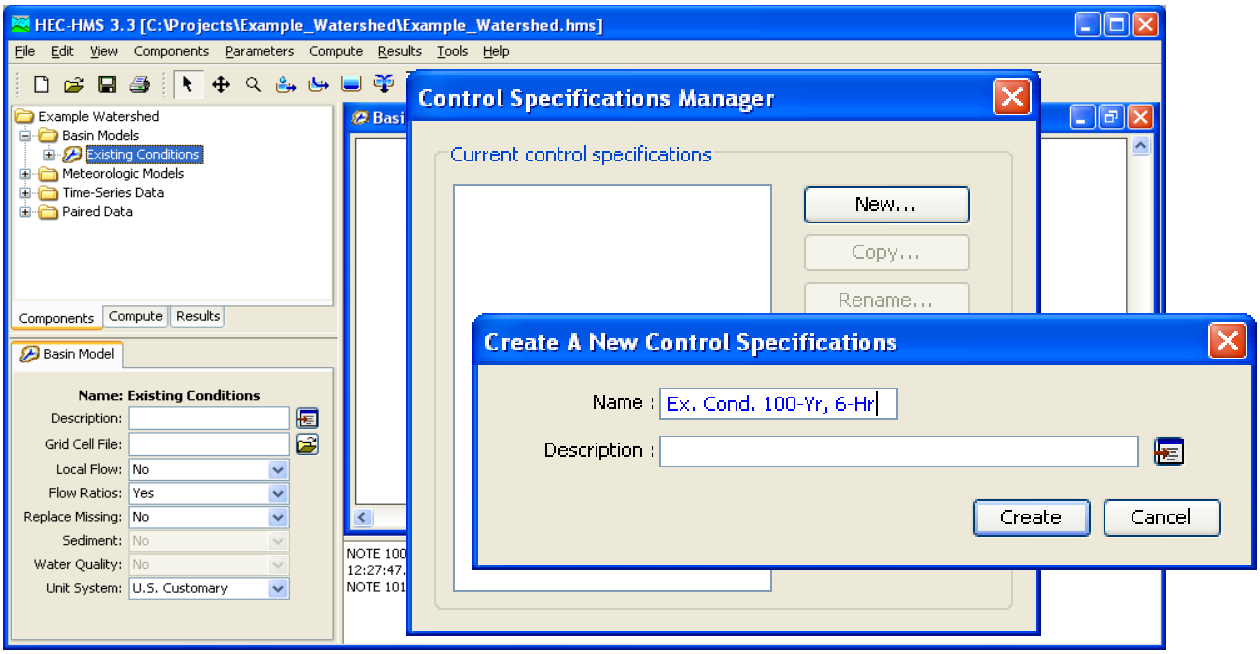
5. On the Routing tab of the Component Editor for each routing reach, code in the physical routing parameters



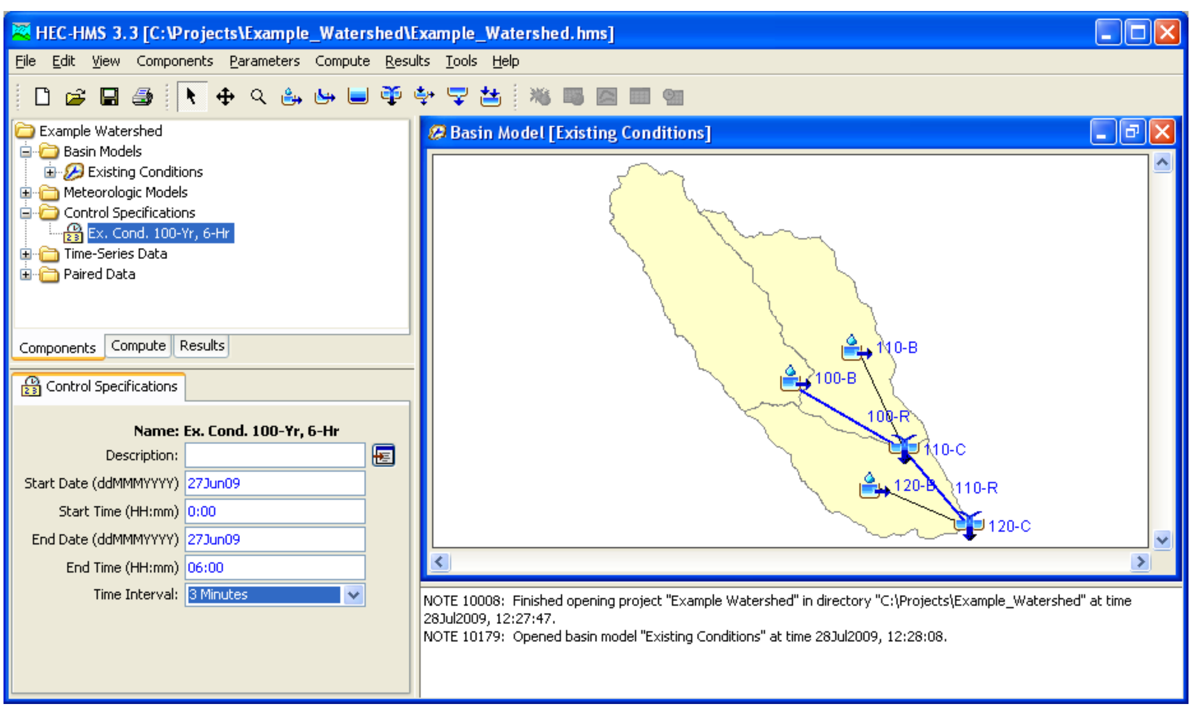


F.8.7 Model Execution

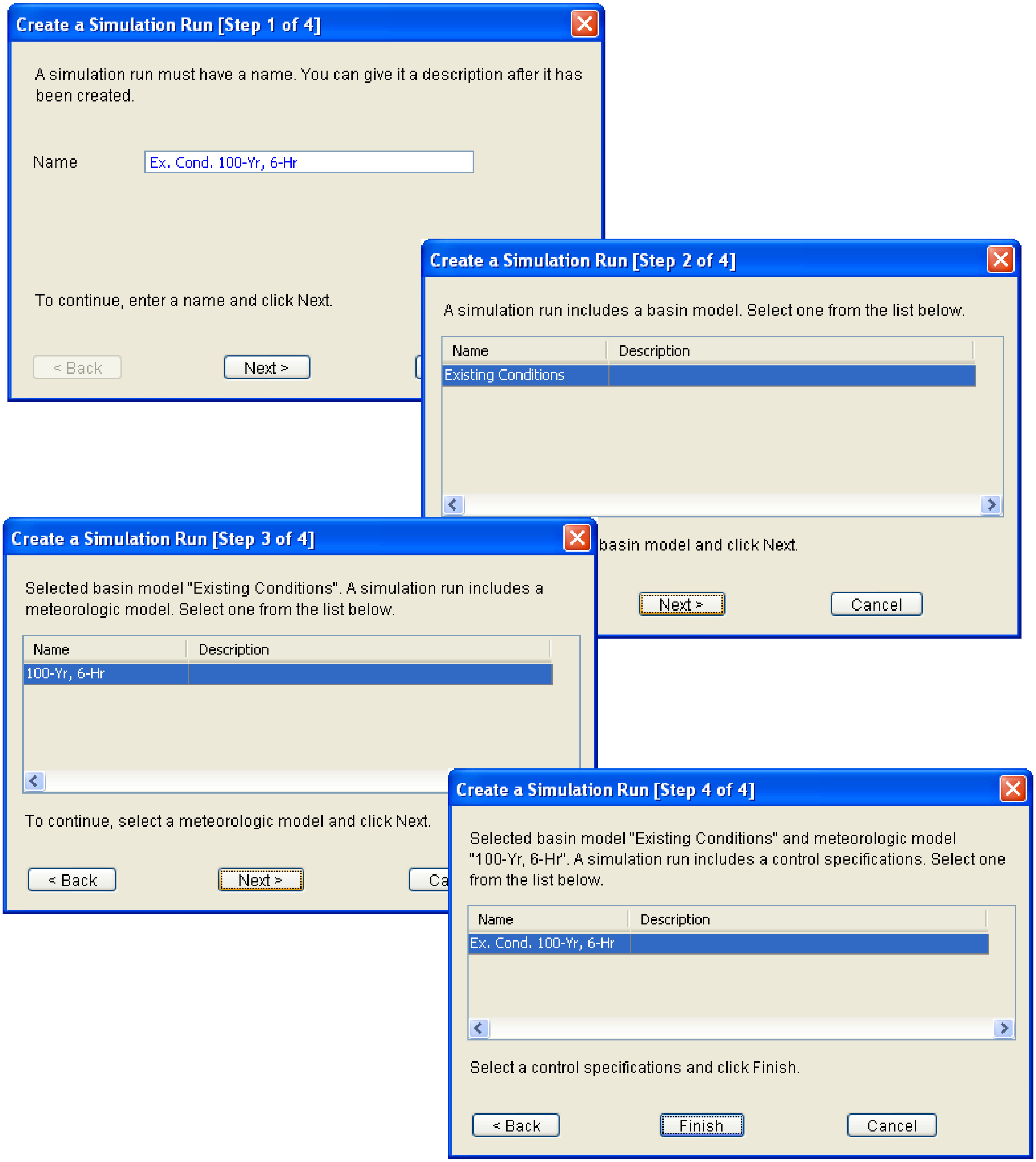
1. Create the Control Mata for model execution: From the *Components* pull down menu, select *Control Specifications Manager*
   a. Select *New*
   b. Enter a name for the control model (e.g. Ex. Cond. 100-Yr, 6-Hr)



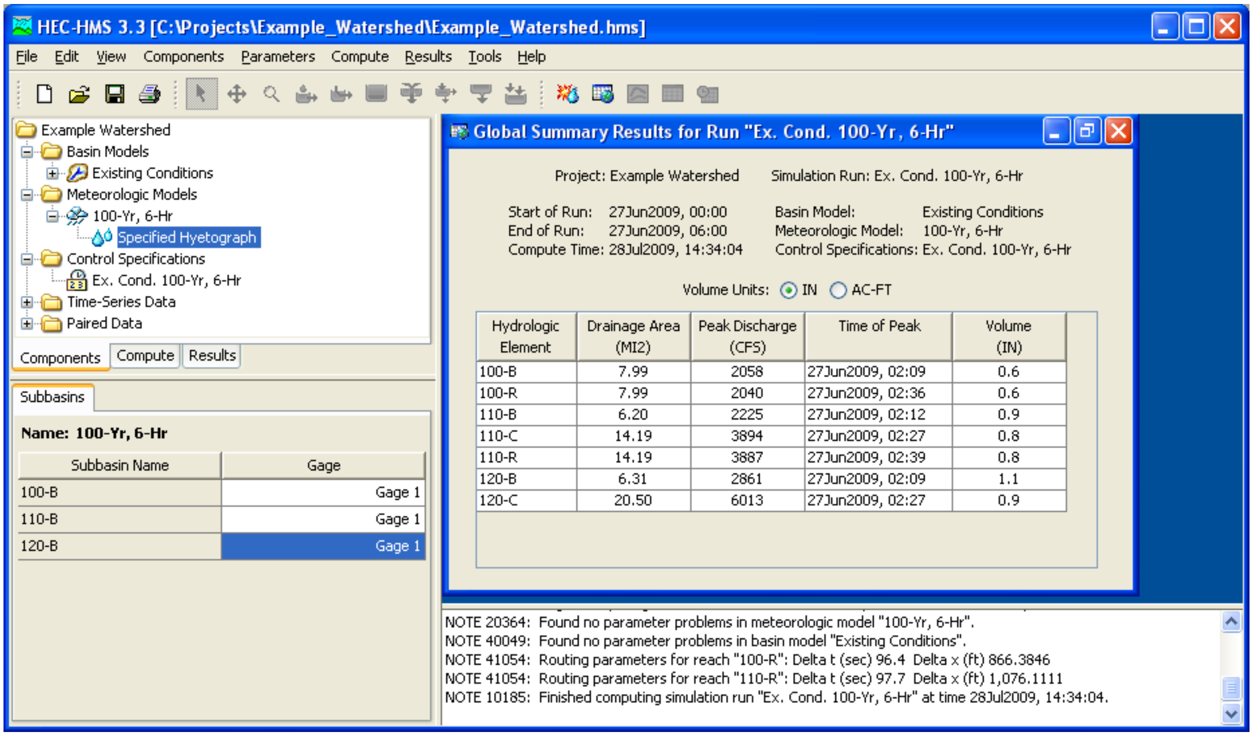
2. In the Component Editor for the Control Specifications input the model simulation time and the computational interval



3. From the *Compute* pull down menu, select *Create Simulation Run*
   a. Input a run name (e.g. Ex. Cond. 100-Yr, 6-Hr)
   b. Select the Basin Model, Meteorologic Model and Component Model



4. From the Compute pull down menu, select Compute Run and view the global summary results.



G. 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.

G.1 JURISDICTION OF THE OFFICE OF THE STATE ENGINEER (OSE)

NOTE: FACILITIES THAT COME UNDER THE OSE MUST BE COORDINATED WITH THAT JURISDICTION.

The OSE has jurisdiction over the design and construction of non-federal dams. OSE 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/SSCAFCA. Before proceeding to design any project requiring a permit for a dam, the Office of the State Engineer should be contacted to obtain guidance on applicable regulations and design criteria. City/SSCAFCA review must occur before submittal to OSE to obtain concurrence on determination of PMP. This includes dams intended for sediment, erosion and flood control.

Copies of the Manual of Rules and Regulations Governing the Appropriation and Use of the Surface Waters of the State of New Mexico and the Summary of New Mexico State Engineer Office Procedure on Design Criteria and Safety of Dams are available from the OSE, Santa Fe, New Mexico. 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.

H. Use of Alternate Procedures

Hydrology methods other than those specified in Parts A through D may be appropriate for local conditions and may be acceptable to SSCAFCA and other reviewing agencies. The use of alternate procedures should be reviewed with the SSCAFCA agency early in the project to establish that such alternate procedures are acceptable and to establish specific parameters.

In general, computer programs which are in the public domain, have available users manuals and established use in the engineering community will most likely be accepted as an alternative. Areas which require special analysis because of unusual terrain conditions, special sediment considerations, unique hydraulic conditions, or extraordinary soil conditions are candidates for alternate procedures. Use of special procedures will be considered when experimental testing and analysis of measured precipitation and runoff conditions indicates that the special procedures will provide more accurate results. The use of proprietary computer programs and programs available only to a small segment of the engineering community will require additional documentation to establish that they are an acceptable alternative. Documentation should include users manuals, discussion of the engineering principals and formulas utilized, and calibration to establish that the methodology is applicable to the local area. The use of an alternate computer program solely on the basis that it gives lower or higher numbers will not be acceptable.

H.1 PROGRAMS FOR ALTERNATE PROCEDURE ACCEPTANCE

Some computer programs which have had previous use in the community and will be considered for alternate procedure acceptance include:

1) **SWMM -** Stormwater Management Model. Version 5 by the U.S. Environmental Protection Agency. This is an extremely complex model with an extensive range of capabilities. The program was developed for urban areas with storm sewer systems. Of special interest is the capability to model stormwater quality in addition to water quantity. The EXTRAN module of the SWMM model has been used locally to model flow in irrigation canals and drains because its dynamic flow routing capability can compute backwater profiles in open channels and closed conduits under unsteady flow conditions. Hydrograph input for the EXTRAN application can use hydrographs generated by the HYMO computer program. Specific parameters to calibrate SWMM parameters for local conditions have not been established.

2) **TR-20 -** Computer Program Project Formulation, Hydrology by the U.S.D.A. Soil Conservation Service. This SCS computer program is widely used throughout the U.S. It is available through independent licensed software vendors and from the National Technical Information Service. The program was initially developed for rural areas with relatively large sub-basins. The "TYPE-II" (24-hour) rainfall distribution commonly used with TR-20 is not applicable for the Albuquerque area. In New Mexico, a TYPE II-a (24-hour) distribution should be used with TR-20. The "a" used in the TYPE II-a distribution refers to the percentage of the one-hour precipitation (P_{60}) to the 24-hour precipitation (P1440) or, a = 100 * P60 / P1440. The value of "a" is rounded to the nearest five percent (i.e.: 60, 65, 70 and 75). Tables of TYPE II-60, 11-65, II-70, and II-75 distributions, with a 0.25 hour incremental time, are available from the SCS. SCS CNs should be consistent with TR-55, Chapter 2 procedures; but should not be less than the values in TABLE E-1, or as computed by equation E-7.

3) **TR-48 -** Computer Program for Project Formulation - Structure Site Analysis by the U.S.D.A. Soil Conservation Service. This program has particular application to the analysis and design of dams and therefore may have special application to this area. The program normally uses the sites' storage-discharge capacities to floodroute inflow hydrographs through a potential reservoir. Inflow hydrographs may be input from other models or developed from a storm rainfall distribution. The program will compute runoff by the standard SCS CN procedure or by the initial abstraction-average infiltration

method. The program also has limited routing capability for analysis of multiple structures and channels.

H.2 BIBLIOGRAPHY

Alley, W.M. and Smith, P.E., 1982, *Distributed Routing Rainfall-Runoff Model, Version II, Computer Program Documentation,* Users Manual, Open-File Report 82-344, U.S.D.I. Geological Survey, Denver, Colorado, 56 p.

Anderson, C.E., 1992, *AHYMO, Computer Program Users Manual, (AMAFCA Hydrologic Model)*, Albuquerque Metropolitan Arroyo Flood Control Authority, Albuquerque, New Mexico, 44 p.

Anderson, C.E., and Heggen, R.J., 1990, "Evolution of Drainage Criteria, Albuquerque, New Mexico", *Hydraulics/Hydrology of Arid Lands, Proceedings of the International Symposium*, Hydraulics Division, American Society of Civil Engineers, New York, New York, pp. 84-89.

Cudworth, A.G., 1989, *Flood Hydrology Manual,* U.S.D.I. Bureau of Reclamation, Denver, Colorado, 243 p.

Hansen, E.M., Fenn, D.P., Schreiner, L.C., Stodt, R.W., and Miller, J.F., 1988, *Hydrometeorological Report No. 55A, Probable Maximum Precipitation Estimates - United States Between the Continental Divide and the 103rd Meridian*, U.S.D.C. National Oceanic and Atmospheric Administration, Silver Springs, Maryland.

Heggen, R.J., 1987, *Split Ring Infiltration Basic Data Collection and Interpretation,* Report No. PDS 110/210, Bureau of Engineering Research, University of New Mexico, Albuquerque, New Mexico, 28 p.

Huber, W.C., and Dickinson, R.E., 1988, *Storm Water Management Model, Version 4, Users Manual*, Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, Georgia, 569 p.

James, W.P., 1986, *A & M Watershed Model, Users Manual*, Texas A & M University, College Station, Texas, 281 p.

Miller, J.F., Frederick, R.H., and Tracey, R.J., 1973, *Precipitation-Frequency Atlas of the Western United States, Volume IV, New Mexico,* NOAA Atlas 2, National Oceanic and Atmospheric Administration, Silver Springs, Maryland.

Roesner, L.A., Aldrich, J.A., and Dickinson, R.E., 1988, *Storm Water Management Model, Version 4, Addendum I EXTRAN*, Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, Georgia, 157 p.

Sabol, G.V., Ward, T.J., and Seiger, A.D., 1982, *Rainfall Infiltration of Selected Soils in the Albuquerque Drainage Area for the Albuquerque Metropolitan Arroyo Flood Control*

Authority, Civil Engineering Department, New Mexico State University, Las Cruces, New Mexico, 110 p.

Urban Drainage and Flood Control District, 1969, Update 1990, *Urban Storm Drainage Criteria Manual*, Volume I and II, Denver, Colorado.

U.S. Army Corps of Engineers, 1987, *HEC*-1, *Flood Hydrograph Package, Users Manual,* Hydrologic Engineering Center, Davis, California, 32 p. plus appendices.

U.S.D.A. Soil Conservation Service, 1969, *National Engineering Handbook, Section 4, Hydrology,* Washington, D.C.

U.S.D.A. Soil Conservation Service, 1983, *TR-20 Computer Program for Project Formulation, Hydrology,* draft Second Edition, Lanham, Maryland, 302 p.

U.S.D.A. Soil Conservation Service, 1984, *TR*-48 *DAMS2*, *Structure Site Analysis Computer Program,* draft, Washington, D.C.

U.S.D.A. Soil Conservation Service, 1986, *TR-55 Urban Hydrology for Small Watersheds,* Second Edition, Washington, D.C.

U.S.D.I. Bureau of Reclamation, 1973, *Design of Small Dams,* Second Edition, Denver, Colorado, 816 p.

U.S.D.I. Bureau of Reclamation, 1987, *Design of Small Dams,* Third Edition, Denver, Colorado, 860 p.

U.S.D.I. Bureau of Reclamation, Flood Section, 1989, *Personal Computer Programs, Estimating Probable Maximum Precipitation and Precipitation Frequency-Duration in the Western United States,* Denver, Colorado, 72 p.

Williams, J.R., 1968, *Runoff Hydrographs from Small Texas Blacklands Watersheds,* ARS-41-143, U.S.D.A. Agricultural Research Service, Riesel, Texas, 24 p.

Williams, J.R., and Hann, R.W., 1973 HYMO: *Problem-Oriented Computer Language for Hydrologic Modeling, Users Manual*, ARS-S-9, U.S.D.A. Agricultural Research Service, Riesel, Texas.

Woolhiser, D.A., Smith, R.E., and Goodrich, D.C., 1990, *KINEROS, A Kinematic Runoff and Erosion Model, Documentation and User Manual,* ARS-77, U.S.D.A. Agricultural Research Service, Tucson, Arizona, 130 p.

PART G - HYMO INPUT AND OUTPUT

G.1 HYMO INPUT FILE

```
*S FILE:TESTDPM.DAT
START       TIME=0.0    NPU=O       PRINT LINE=O
*S****COMPUTE HYDROGAPHS FOR SECTION 22.2, HYDROLOGY, DPM

******************
*S EXAMPLE C-2  **
******************

****PERVIOUS PORTION *****

* TREATMENT A, B,  C  - 100 YEAR STORM
COMPUTE HYD    ID=1  HYD N0=101.1 DT=.033333 HRS   DA=1.2500   SQ MI
               IA=-0.515  INF=1.292     K= -0.263600     TP=-0.292000 RAIN=
      .0000     .0017     .0035     .0053     .0071     .0090    .0109
      .0128     .0148     .0169     .0190     .0212     .0234    .0257
      .0280     .0304     .0329     .0355     .0381     .0409    .0437
      .0467     .0497     .0529     .0563     .0597     .0633    .0672
      .0712     .0754     .0798     .0850     .0906     .0965    .1093
      .1379     .1819     .2450     .3311     .4444     .5887    .7685
      .9878     1.1907    1.2756    1.3473    1.4111    1.4691   1.5226
      1.5722    1.6185    1.6620    1.7029    1.7414    1.7779   1.8124
      1.8450    1.8760    1.9054    1.9333    1.9598    1.9660   1.9719
      1.9774    1.9827    1.9877    1.9926    1.9972    2.0017   2.0060
      2.0102    2.0143    2.0182    2.0220    2.0257    2.0292   2.0327
      2.0361    2.0395    2.0427    2.0459    2.0490    2.0520   2.0550
      2.0579    2.0607    2.0635    2.0663    2.0690    2.0716   2.0742
      2.0767    2.0793    2.0817    2.0842    2.0865    2.0889   2.0912
      2.0935    2.0958    2.0980    2.1002    2.1023    2.1045   2.1066
      2.1087    2.1107    2.1127    2.1147    2.1167    2.1187   2.1206
      2.1225    2.1244    2.1263    2.1281    2.1299    2.1317   2.1335
      2.1353    2.1371    2.1388    2.1405    2.1422    2.1439   2.1456
      2.1472    2.1489    2.1505    2.1521    2.1537    2.1553   2.1568
      2.1584    2.1599    2.1615    2.1630    2.1645    2.1660   2.1675
      2.1689    2.1704    2.1718    2.1733    2.1747    2.1761   2.1775
      2.1789    2.1803    2.1816    2.1830    2.1844    2.1857   2.1870
      2.1884    2.1897    2.1910    2.1923    2.1936    2 1948   2.1961
      2.1974    2.1986    2.1999    2.2011    2.2024    2.2036   2.2048
      2.2060    2.2072    2.2084    2.2096    2.2108    2.2120   2.2131
      2.2143    2.2154    2.2166    2.2177    2.2189    2.2200
PRINT HYD       ID=1      CODE=1
**** IMPERVIOUS PORTION **** TREATMENT D
COMPUTE HYD     ID=2      HYD NO=101.2       DT=.033333 HRS DA=0.5000 SQ MI
                IA=-0.10  INF=0.04  K=-0.168200 TP= -0.292000      RAIN=-1
PRINT HYD       ID=2      CODE=1
**** COMBINED HYDROGRAPH ****
ADD HYD         ID=2      HYD NO=101.3 ID=1 ID=2
PRINT HYD       ID=2      CODE=1

********************
*S  EXAMPLE C-3   **
********************

*** PERVIOUS PORTION ***** TREATMENT A, B & C

COMPUTE HYD     ID=1 HYD NO=101.1    DT=.033333 HRS       DA=0.1250 SQ MI
                IA=0.515  INF= -1.292 K= -0.156500 TP= -0.16200O    RAIN=-1
PRINT HYD       ID=1      CODE=1
*** IMPERVIOUS PORTION ***** TREATMENT D
COMPUTE HYD     ID=2 HYD N0=101.2    DT=.033333 HRS       DA=0.0500 SQ MI
```

```
                 IA=-0.10   INF=0.04   K= -0.090600 TP= -0.162000      RAIN=-1
PRINT HYD        ID=2       CODE=1
***** COMBINED HYDROGRAPH *****
ADD HYD          ID=2 HYD N0=101.3 ID=1 ID=2
PRINT HYD        ID=2 CODE=l

*******************
*S EXAMPLE C 4   **
*******************

RAINFALL         TYPE=1     RAIN QUARTER=0.0       RAIN ONE=1. 88
                 RAIN SIX=2 22 RAIN DAY=2.68 DT=.033333
COMPUTE NM HYD   ID= 2      HYD NO= 101.3          DA=0.175 SQ MI
                 PER A=21.43 PER B=35.71 PER C=14.29 PER D=28.57
                 TP= -0.162 MASSRAIN=-1
PRINT HYD        ID=2 CODE=1

*******************
*S EXAMPLE D-3   **
*******************

***** PERVIOUS PORTION ****** TREATMENT A, B & C

COMPUTE HYD      ID=1 HYD NO=101.1 DT=.033333 HRS DA=1.2500 SQ MI
                 IA=-0.515   INF=-1.292    K=-0.173400    TP=-0.292000 RAIN=
      .0000      .0070      .0142      .0217       .0294     .0375      .0459
      .0547      .0638      .0733      .0832       .0936     .1044      .1156
      .1272      .1394      .1520      .1650       .1786     .1927      .2072
      .2223      .2379      .2540      .2707       .2879     .3056      .3239
      .3428      .3622      .3822      .4028       .4240     .4457      .4681
      .4911      .5146      .5388      .5636       .5890     .6150      .6417
      .6690      .6969      .7255      .7548       .7847     .8152      .8464
      .8783      .9109      .9441      .9780       1.0126    1.0479     1.0838
      1.1205     1.1578     1.1959     1.2347      1.2741    1.7377     2.6322
      3.9411     5.4901     7.0155     8.1916      8.6459    9.0766     9.4890
      9.8382     10.1365    10.3938    10.6181     10.8157   10.9918    11.1507
      11 2957    11.4294    11.5541    11.6715     11.7830   11.8898    11.9928
      12.0928    12.1902    12.2857    12.3795     12.4721   12.5636    12.6542
      12.8014    12.9384    13.0662    13.1855     13.2969   13.4009    13.4983
      13.5894    13.6748    13.7549    13.8301     13.9008   13.9673    14.0300
      14.0892    14.1451    14.1979    14.2480     14.2954   14.3405    14.3834
      14.4243    14.4633    14.5006    14.5363     14.5705   14.6033    14.6349
      14.6654    14.6948    14.7231    14.7506     14.7773   14.8031    14.8283
      14.8527    14.8766    14.8999    14.9227     14.9450   14.9669    14.9883
      15.0094    15.0301    15.0505    15.0706     15.0905   15.1101    15.1294
      15.1485    15.1675    15.1862    15.2048     15.2232   15.2415    15.2596
      15.2777    15.2956    15.3134    15.3311     15.3487   15.3662    15.3837
      15.4011    15.4184    15.4356    15.4528     15.4700   15.4871    15.5042
      15.5212    15.5382    15.5551    15.5720     15.5889   15.6058    15.6226
      15.6395    15.6562    15.6730    15.6898     15.7065   15.7232    15.7400
      15.7567    15.7733    15.7900    15.8067     15.8233   15.8400
PRINT HYD        ID=1       CODE=1
***** IMPERVIOUS PORTION***** TREATMENT D
COMPUTE HYD      ID=2       HYD NO.=101.2     DT=.033333 HRS   DA=0.5000 SQ MI
                 IA=-0.10  INF=0.04   K=-0.159700 TP=-0.292000 RAIN=-1
PRINT HYD        ID=2       CODE=1
***** COMBINED HYDROGRAPH*****
ADD HYD          ID=2       HYD NO.=101.3          ID=1      ID=2
PRINT HYD        ID=2       CODE=1

*******************
* S EXAMPLE D-4  **
*******************
```

```
RAINFALL          TYPE=3    RAIN QUARTER=7. 58     RAIN ONE=11.38
                  RAIN SIX=15.84  RAIN DAY=0.0  DT=.033333
COMPUTE NM HYD    ID=2   HYD NO= 101.3  DA=1.750 SQ MI
                  PER A=240   PER B=400   PER C=160     PER D=320  TP=-0.292
                  MASSRAIN=1
PRINT HYD         ID=2      CODE=1
FINISH
G.2 HYMO OUTPUT FILE
      AHYMO PROGRAM (AHYM0392) AMAFCA VERSION OF HYMO - MARCH, 1992
      RUN DATE (MON/DAY/YR) = 01/18/1993
      START TIME (HR:MIN:SEC) = 18:32:27         USER NO. - AMAFCA01.491
      INPUT FILE = TESTDPM.DAT
*TEST OF THE DPM EXAMPLES - JANUARY 1993
*S FILE:TESTDPM.DAT
START             TIME=0.0  NPU=0      PRINT LINE=0
*S*******COMPUTE HYDROGRAPHS FOR SECTION 22.2, HYDROLOGY, DPM

******************
*S EXAMPLE C-2  **
******************

***** PERVIOUS PORTION *****

* TREATMENT A, B & C - 100 YEAR STORM
COMPUTE HYD       ID=1      HYD NO=101.1   DT=.033333 HR    DA=1.2500 SQ MI
                  IA=-0.515   INF=-1.292   K=-0.263600   TOP=-0.292000RAIN=
      .0000     .0017     .0035     .0053       .0071    .0090     .0109
      .0128     .0148     .0169     .0190       .0212    .0234     .0257
      .0280     .0304     .0329     .0355       .0381    .0409     .0437
      .0467     .0497     .0529     .0563       .0597    .0633     .0672
      .0712     .0754     .0798     .0850       .0906    .0965     .1093
      .1379     .1819     .2450     .3311       .4444    .5887     .7685
      .9878     l.1907    l.2756    1.3473      l.4111   l.4691    l.5226
      1.5722    1.6185    1.6620    1.7029      1.7414   1.7779    1.8124
      1.8450    1.8760    1.9054    1.9333      1.9598   1.9660    1.9719
      l.9774    l.9827    1.9877    l.9926      l.9972   2.0017    2.0060
      2.0102    2.0143    2.0182    2.0220      2.0257   2.0292    2.0327
      2.0361    2.0395    2.0427    2.0459      2.0490   2.0520    2.0550
      2.0579    2.0607    2.0635    2.0663      2.0690   2.0716    2.0742
      2.0767    2.0793    2.0817    2.0842      2.0865   2.0889    2.0912
      2.0935    2.0958    2.0980    2.1002      2.1023   2.1045    2.1066
      2.1087    2.1107    2.1127    2.1147      2.1167   2.1187    2.1206
      2.1225    2.1244    2.1263    2.1281      2.1299   2.1317    2.1335
      2.1353    2.1371    2.1388    2.1405      2.1422   2.1439    2.1456
      2.1472    2.1489    2.1505    2.1521      2.1537   2.1553    2.1568
      2.1584    2.1599    2.1615    2.1630      2.1645   2.1660    2.1675
      2.1689    2.1704    2.1718    2.1733      2.1747   2.1761    2.1775
      2.1789    2.1803    2.1816    2.1830      2.1844   2.1857    2.1870
      2.1884    2.1897    2.1910    2.1923      2.1936   2.1948    2.1961
      2.1974    2.1986    2.1999    2.2011      2.2024   2.2036    2.2048
      2.2060    2.2072    2.2084    2.2096      2.2108   2.2120    2.2131
      2.2143    2.2154    2.2166    2.2177      2.2189   2.2200
      K = .263600HR         TP =  29200H      SHAPE CONSTANT, N = 3.92515
      UNIT PEAK = 1498.9  CFS        UNIT VOLUME = 1.000  B = 350.15
RUNOFF COMPUTED BY INITIAL ABSTRACTION - INFILTRATION METHOD - DT =.033333
PRINT HYD         ID=1      CODE=1

                                     PARTIAL HYDROGRAPH   101.10

RUNOFF VOLUME = .65128 INCHES        = 43.4181 ACRE-FEET
PEAK DISCHARGE RATE = 905.66 CFS  AT 1.700 HOURS BASIN AREA = 1.2500 SQ. MI

****IMPERVIOUS PORTION **** TREATMENT D
```

```
COMPUTE HYD      ID=2      HYD NO=101.2    DT=.033333 HRS   DA=0.5000 SQ MI
                 IA=-0.10  INF=0.04  K=-0.168200 TP=-0.292000       RAIN=-1
      K= .168200HR         TP = .292000HR        SHAPE CONSTANT, N = 6.62354
      UNIT PEAK = 861.53   CFS UNIT VOLUME = 1.000        B = 503.13
      RUNOFF COMPUTED BY INITIAL ABSTRACTION - INFILTRATION METHOD - DT =
.033333
PRINT HYD        ID=2      CODE=1
                                     PARTIAL HYDROGRHAPH  101.20
RUNOFF VOLUME = 1.98503 INCHES       =           52.9338 ACRE-FEET
PEAK DISCHARGE RATE = 923.75 CFS AT 1.667 HOURS  BASIN AREA = .5000 SQ. MI.

*****COMBINED HYDROGRAPH*****

ADD HYD          ID=2      HYD NO=101.3          IN=1     ID=2
PRINT HYD        ID=2      CODE=1
PARTIAL HYDROGRAPH 101.30
      RUNOFF VOLUME = 1.03235 INCHES = 96.3518 ACRE-FEET
      PEAK DISCHARGE RATE = 1827.79 CFS AT 1.667 HOURS BASIN AREA = 1.7500 SQ.

******************
*S EXAMPLE C-3  **
******************

**** PERVIOUS PORTION **** TREATMENT A, B & C
COMPUTE HYD      ID=1   HYD NO=101.1 DT=.033333  HRS DA=0.1250 SQ.MI
                 IA =-0.515 INF=-1.292 K=-0.156500  TP=-0.162000 RAIN=-1
      K = .156500 HR       TP = .162000HR        SHAPE CONSTANT, N = 3.65682
      UNIT PEAK = 255.86 CFS         UNIT VOLUME = 1.000  B = 331.60
      RUNOFF COMPUTED BY INITIAL ABSTRACTION - INFILTRATION METHOD - DT = .033333

      PRINT HYD            ID=1      CODE=1

                                     PARTIAL HYDROGRAPH  101.10

      RUNOFF VOLUME = .65128 INCHES  = 4.3418 ACRE-FEET
      PEAK DISCHARGE RATE = 139.88 CFS AT 1.533 HOURS    BASIN AREA = .1250 SQ. MI.

****IMPERVIOUS PORTION****TREATMENT D
COMPUTE HYD      ID=2      HYD NO=101.2     DT=.033333 HRS DA=0.0500 SQ. MI.
                 IA=-0.10  INF=0.04  K=-0.090600 TP=-0.162000       RAIN=-1
      K = .090600 HR       TP = .162000HR        SHAPE CONSTANT, N = 6.87595
      UNIT PEAK = 159.06 CFS         UNIT VOLUME = .9999  B = 515.35
      RUNOFF COMPUTED BY INITIAL ABSTRACTION - INFILTRATION METHOD - DT = .033333

PRINT HYD        ID=2      CODE=1
      PARTIAL HYDROGRAPH 101.20

      RUNOFF VOLUME = 1.98503 INCHES = 5.2934 ACRE-FEET
      PEAK DISCHARGE RATE = 127.85 CFS AT 1.533 HOURS BASIN AREA = .0500 SQ. MI.

*****COMBINED HYDROGRAPH*****

ADD HYD          ID=2 HYD NO=1-1.3    ID=1        ID=2
PRINT HYD        ID=2      CODE=1

                                     PARTIAL HYDROGRAPH    101.30

      RUNOFF VOLUME =      1.03235 INCHES         =        9.6352 ACRE-FEET
      PEAK DISCHARGE RATE =     267.72 CFS AT   1.533 HOURS    BASIN AREA = .1750 SQ. MI.

******************
*S EXAMPLE C-4  **
******************
```

```
RAINFALL         TYPE=1    RAIN QUARTER=0.0       RAIN ONE-1.88
                 RAIN SIX=2.22         RAIN DAY=2.68         DT=.033333
      COMPUTED 6-HOUR RAINFALL DISTRIBUTION BASED ON NOAA ATLAS 2 - PEAK AT 1.40 HR.
      DT=        .033333 HOURS         END TIME =  5.999940 HOURS
      .0000      .0017      .0035      .0053       .0071     .0090      .0109
      .0128      .0148      .0169      .0190       .0212     .0234      .0257
      .0280      .0304      .0329      .0355       .0381     .0409      .0437
      .0467      .0497      .0529      .0563       .0597     .0633      .0672
      .0712      .0754      .0798      .0850       .0906     .0965      .1093
      .1379      .1819      .2450      .3311       .4444     .5887      .7685
      .9878      1.1907     1.2756     1.3473      1.4111    1.4691     1.5226
      1.5722     1.6185     1.6620     1.7029      1.7414    1.7779     1.8124
      1.8450     1.8760     1.9054     1.9333      l.9598    1.9660     1.9719
      1.9774     1.9822     1.9877     1.9926      l.9972    2.0017     2.0060
      2.0102     2.0143     2.0182     2.0220      2.0257    2.0292     2.0327
      2.0361     2.0395     2.0427     2.0459      2.0490    2.0520     2.0550
      2.0579     2.0607     2.0635     2.0663      2.0690    2.0716     2.0742
      2.0767     2.0793     2.0817     2.0842      2.0865    2.0889     2.0912
      2.0935     2.0958     2.0980     2.1002      2.1023    2.1045     2.1066
      2.1087     2.1107     2.1127     2.1147      2.1167    2.1187     2.1206
      2.1225     2.1244     2.1263     2.1281      2.1299    2.1317     2.1335
      2.1353     2.1371     2.1388     2.1405      2.1422    2.1439     2.1456
      2.1472     2.1489     2.1505     2.1521      2.1537    2.1553     2.1568
      2.1584     2.1599     2.1615     2.1630      2.1645    2.1660     2.1675
      2.1689     2.1704     2.1718     2.1733      2.1747    2.1761     2.1775
      2.1789     2.1803     2.1816     2.1830      2.1844    2.1857     2.1870
      2.1884     2.1897     2.1910     2.1923      2.1936    2.1948     2.1961
      2.1974     2.1986     2.1999     2.2011      2.2024    2.2036     2.2048
      2.2060     2.2072     2.2084     2.2096      2.2108    2.2120     2.2131
      2.2143     2.2154     2.2166     2.2177      2.2189    2.2200

COMPUTE NM HYD   ID=2      HYD NO.= 101.3         DA=0.175 SQ. MI
                 PER A=21.43           PER B=35.71 PERC=14.29     PER D=28.57
                 TP= -0.1162           MASSRAIN =-1

      K = .090554HR     TP = .162000HR    K/TP RATIO = .558978 SHAPE CONSTANT, N = 6.880332
      UNIT PEAK = 159.11 CFS   UNIT VOLUME = .9999        B = 515.56       P60 = 1.8800
      AREA = .049998 SQ. MI.  IA - .1000 INCHES   INF = .04000 INCHES PER HOUR
      RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD  - DT = .033333

      K = .156460HR    TP = .162000HR    K/TP RATIO = .965805 SHAPE CONSTANT, N = 3.657761
      UNIT PEAK = 255.92 CFS          UNIT VOLUME = 1.000       B = 331.67       P60 = 1.8800
      AREA = .125003  SQ. MI.       IA - .51499 INCHES      INF = 1.29198 INCHES PER HOUR
      RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD  - DT = .033333

PRINT HYD        ID=2      CODE=1

                                       PARTIAL HYDROGRAPH 101.30

      RUNOFF VOLUME = 1.03234 INCHES = 9.6351 ACRE-FEET
      PEAK DISCHARGE RATE = 267.77 CFS AT 1.533 HOURS     BASIN AREA = 1750 SQ. MI

******************
*S EXAMPLE D-3  **
******************

***** PERVIOUS PORTION ***** TREATMENT A, B & C

COMPUTE HYD      ID=1     HYD NO=101.1      DT=.033333 HRS   DA=1.2500 SQ. MI
                 IA=-0.515 INF=-1.292 K=-0.173400 TP=-0.292000 RAIN =
      .0000      .0070      .0142      .0217       .0294     .0375      .0459
      .0547      .0638      .0733      .0832       .0936     .1044      .1156
      .1272      .1394      .1520      .1650       .1786     .1927      .2072
```

.2223	.2379	.2540	.2707	.2879	.3056	.3239
.3428	.3622	.3822	.4028	.4240	.4457	.4681
.4911	.5146	.5388	.5636	.5890	.6150	.6417
.6690	.6969	.7255	.7548	.7847	.8152	.8464
.8783	.9109	.9441	.9780	1.0126	1.0479	1.0838
1.1205	1.1578	1.1959	1.2347	1.2741	1.7377	2.6322
3.9411	5.4901	7.0155	8.1916	8.6459	9.0766	9.4890
9 8382	10.1365	10.3938	10.6181	10.8157	10.9918	11.1507
11.2957	11.4294	11.5541	11.6715	11.7830	11.8898	11.9928
12.0928	12.1902	12.2857	12.3795	12.4721	12.5636	12.6542
12.8014	12.9384	13.0662	13.1855	13.2969	13.4009	13.4983
13.5894	13.6748	13.7549	13.8301	13.9008	13.9673	14.0300
14.0892	14.1451	14.1979	14.2480	14.2954	14.3405	14.3834
14.4243	14.4633	14.5006	14.5363	14.5705	14.6033	14.6349
14.6654	14.6948	14.7231	14.7506	14.7773	14.8031	14.8283
14.8527	14.8766	14.8999	14.9227	14.9450	14.9669	14.9883
15.0094	15.0301	15.0505	15.0706	15.0905	15.1101	15.1294
15.1485	15.1675	15 1862	15.2048	15.2232	15.2415	15.2596
15.2777	15.2956	15.3134	15.3311	15.3487	15.3662	15.3837
15.4011	15.4184	15.4356	15.4528	15.4700	15.4871	15.5042
15.5212	15.5382	15.5551	15.5720	15.5889	15.6058	15.6226
15 6395	15.6562	15.6730	15 6898	15.7065	15.7232	15.7400
15.7567	15.1733	15.7900	15.8067	15.8233	15.8400	

```
K = .173400HR    TP = .292000HR       SHAPE CONSTANT, N =   6.37493
UNIT PEAK = 2101.2 CFS     UNIT VOLUME = .9999    B = 490.85
RUNOFF COMPUTED BY INITIAL ABSTRACTION - INFILTRATION METHOD - DT = .033333

PRINT HYD        ID=1       CODE=1
                                     PARTIAL HYDROGRAPH 101.10

RUNOFF VOLUME = 10.91309 INCHES      =            727.5348 ACRE-FEET
PEAK DISCHARGE RATE = 14586.49 CFS AT 2.433 HOURS          BASIN AREA = 1.2500 SQ. MI.

***** IMPERVIOUS PORTION ***** TREATMENT D

COMPUTE HYD      ID=2      HYD NO-101.2   DT=.033333 HRS     DA=0.50000   SQ MI
                 IA=-0.10  INF=0.04  K=-0.159700 TP=-0.292000       RAIN=-1

      K = 1.59700HR        TP = .292000HR         SHAPE CONSTANT, N =7.07453
      UNIT PEAK = 898.59 CFS         UNIT VOLUME = 1.000  B = 524.78
      RUNOFF COMPUTED BY INITIAL ABSTRACTION - INFILTRATION METHOD - DT = .033333
PRINT HYD        ID=1       CODE=1
                                     PARTIAL HYDROGRAPH 101.20

RUNOFF VOLUME = 15.57613 INCHES      =            415.3609  ACRE-FEET
PEAK DISCHARGE RATE = 6494.75 CFS AT 2.433 HOURS  BASIN AREA = .5000 SQ. MI.

***** COMBINED HYDROGRAPH *****

ADD HYD               ID=2     HYD NO-101.3     ID=1     ID=2
PRINT HYD               ID=2     CODE =1
PARTIAL HYDROGRAPH 101.3
RUNOFF VOLUME =            12.24539 INCHES        =        1142.8960 ACRE-FEET
PEAK DISCHARGE RATE = 21081.24 CFS AT 2.433 HOURS BASIN AREA = 1.7500 SQ. MI.

******************
*S EXAMPLE D-4  **
******************

RAINFALL         TYPE=3    RAIN QUARTER = 7.58    RAIN ONE=11.38
                 RAIN SIX=15.84       RAIN DAY=0.0          DT =.033333
      COMPUTED P.M.P.  6-HOUR RAINFALL DISTRIBUTION BASED ON H.M.R.-55a
      DT = .033333 HOURS             END TIME = 5.999940 HOURS
```

.0000	.0070	.0142	.0217	.0294	.0375	.0459
.0547	.0638	.0733	.0832	.0936	.1044	.1156
.1272	.1394	.1520	.1650	.1786	.1927	.2072
.2223	.2379	.2540	.2707	.2879	.3056	.3239
.3428	.3622	.3822	.4028	.4240	.4457	.4681
.4911	.5146	.5388	.5636	.5890	.6150	.6417
.6690	.6969	.7255	.7548	.7847	.8152	. 8464
.8783	.9109	.9441	1.9780	1.0126	1.0479	1.0838
1.1205	1.1578	1.1959	l.2347	1.2741	1.7377	2.6322
3.9411	5.4901	7.0155	8.1916	8.6459	9.0766	9.4890
9.8382	10.1365	10.3938	10.6181	10.8157	10.9918	11.1507
11.2957	11.4294	11.5541	11.6715	11.7830	11.8898	11.9928
12.0928	12.1902	12.2857	12.3795	12.4721	12.5636	12.6542
12.8014	12.9384	13.0662	13.1855	13.2969	13.4009	13.4983
13.5894	13.6748	13.7549	13.8301	13.9008	13.9673	14.0300
14.0892	14.1451	14.1979	14.2480	14.2954	14.3405	14.3834
14.4243	14.4633	14.5006	14.5363	14.5705	14.6033	14.6349
14.6654	14.6948	14.7231	14.7506	14.7773	14.8031	14.8283
14.8527	14.8766	14.8999	14.9227	14.9450	14.9669	14.9883
15.0094	15.0301	15.0505	15.0706	15.0905	15.1101	15.1294
15.1485	15.1675	15.1862	15.2048	15.2232	15.2415	15.2596
15.2777	15.2956	15.3134	15.3311	15.3487	15.3662	15.3837
15.4011	15.4184	15.4356	15.4528	15.4700	15.4871	15.5042
15.5212	15.5382	15.5551	15.5720	15.5889	15.6058	15.6226
15.6395	15.6562	15.6730	15.6898	15.7065	15.7232	15.7400
15.7567	15.7733	15.7900	15.8067	15.8233	15.8400	

```
COMPUTE NM HYD   ID=2       HYD NO= 101.3          DA=1.750 SQ. MI
      PER A=240    PER B=400   PER C=160      PER D=320      TP=-0.292

K = .159697HR   TP = .292000HR   K/TP RATIO = .546909 SHAPE CONSTANT, N = 7.074674
UNIT PEAK - 898.60 CFS     UNIT VOLUME = 1.000    B = 524.78    P60 = 11.380
AREA = .500000 SQ MI       IA = .10000 INCHES     INF = .04000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .033333

K = .173405HR   TP = .292000HR   K/TP RATIO = .593853   SHAPE CONSTANT, N = 6.374689
UNIT PEAK - 2101.2 CFS     UNIT VOLUME = .9999    B = 490.84    P60 = 11.380
AREA = 1.250000 SQ MI     IA = .51500 INCHES     INF = 1.29200 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .033333

PRINT HYD        ID=2       CODE=1
                                     PARTIAL HYDROGRAPH 101.30

      RUNOFF VOLUME = 12.24539 INCHES     =   1142.8960 ACRE-FEET
      PEAK DISCHARGE RATE = 21081.04 CFS AT    2.433 HOURS       BASIN AREA = 1.7500 SQ. MI

FINISH

      NORMAL PROGRAM FINISH          END TIME (HR:MIN:SEC) = 18:32:38
```

Section 3. HYDRAULIC DESIGN

A. Weirs and Orifices

NOTE: Some of the graphs contained in this section are copied from the Los Angeles Hydraulics Manual and we wish to give them credit for their efforts. Also, applicable graphs are for 8” curb heights which may not meet Rio Rancho standards.

A.1. 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. Special care must be exercised when selecting weir coefficients in the following cases:

a. Submerged weirs

b. Broad crested weirs

c. Weirs with obstructions (i.e., guardrails, piers, etc.)

A.2. 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 = Coefficient of discharge from Handbook of Hydraulics, King and Brater, 5th 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.

B. Criteria for Hydraulic Design: Closed Conduits

B.1. 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:

a. 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/SSCAFCA will use 18% for undeveloped conditions and 6% for developed conditions.

b. 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.

B.2. WATER SURFACE PROFILE CALCULATIONS

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.

b. 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.

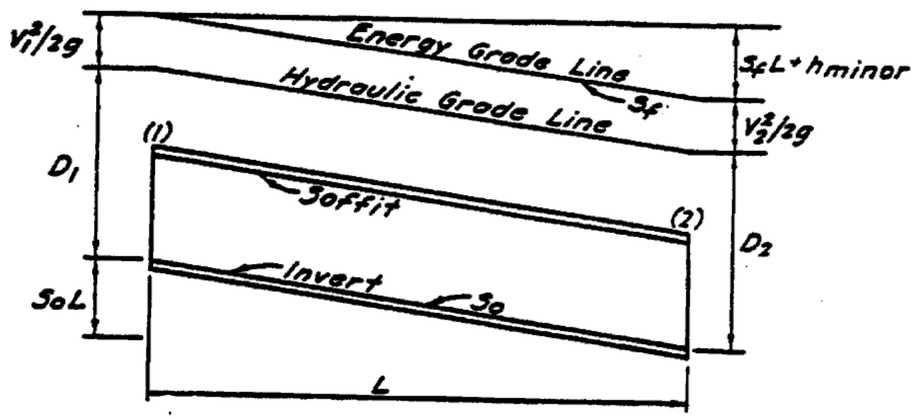
Whenever case (1) or (2) above is used, the possibility of having flow out of manholes or inlets due to discharge elevations at the 100-year level must be investigated and appropriate steps taken to prevent its occurrence.

c. 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 2b.

d. 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:

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



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

Minor head 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 head losses are ignored and the result rearranged,

$$L = \frac{E2 - E1}{S_o - S_f}$$

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

e. Head Losses

(1) 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:

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

in which Q = Discharge, in c.f.s.

n = Roughness coefficient

A = Area of water normal to flow in ft.

R = Hydraulic radius

S_f = Friction slope

When rearranged into a more useful form,

in which

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

in which:

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

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

$$h_f = S_f L = \left[\frac{Q}{K} \right]^2 L$$

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 are shown in Plate 22.3 B-1.

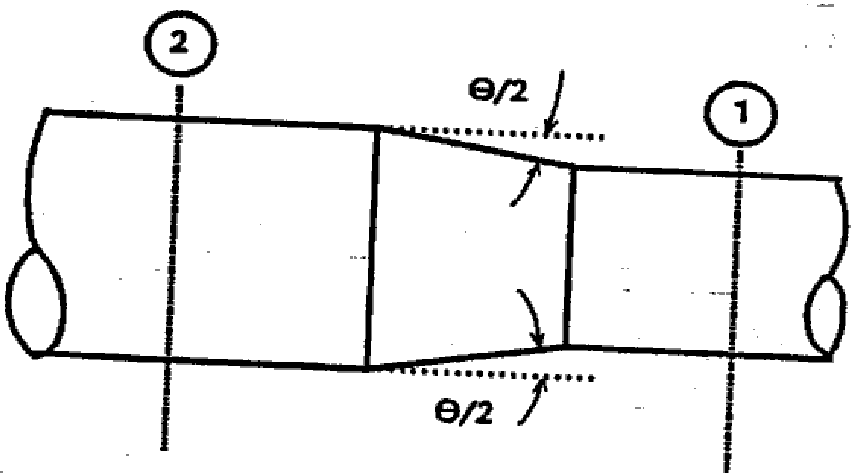
PLATE 22.3 B-1 VALUES OF MANNING'S n

	n
Tined Concrete	0.018
Shotcrete	0.025
Reinforced Concrete Pipe	0.013
Troweled Concrete	0.013
No-joint cast in place concrete pipe	0.014
Reinforced Concrete Box	0.015
Reinforced Concrete Arch	0.015
Streets	0.017
Flush Grouted Riprap	0.020
Corrugated Metal Pipe	0.025
Grass Lined Channels (sodded & irrigated)	0.025
Earth Lined Channels (smooth)	0.030
Wire Tied Riprap	0.040
Medium Weight Dumped Riprap	0.045
Grouted Riprap (exposed rock)	0.045
Jetty Type Riprap (D_{50} > 24")	0.050

See SSCAFCA's Sediment and Erosion Design guide for recommended Manning's n values for naturalistic channels. For materials not listed contact City Engineer/SSCAFCA prior to use.

(2) Transition Loss

Transition losses will be calculated from the equations shown below. 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.



For increasing velocities in the direction of flow from (2) to (1)

$$h_t = 0.1 \left[\frac{v_1^2}{2g} - \frac{v_2^2}{2g} \right]$$

For decreasing velocities in the direction of flow from (1) to (2)

$$h_t = 0.2 \left[\frac{v_1^2}{2g} - \frac{v_2^2}{2g} \right]$$

Deviations from the above criteria must be approved by the City Engineer/SSCAFCA. 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.

TRANSITION HEAD LOSS

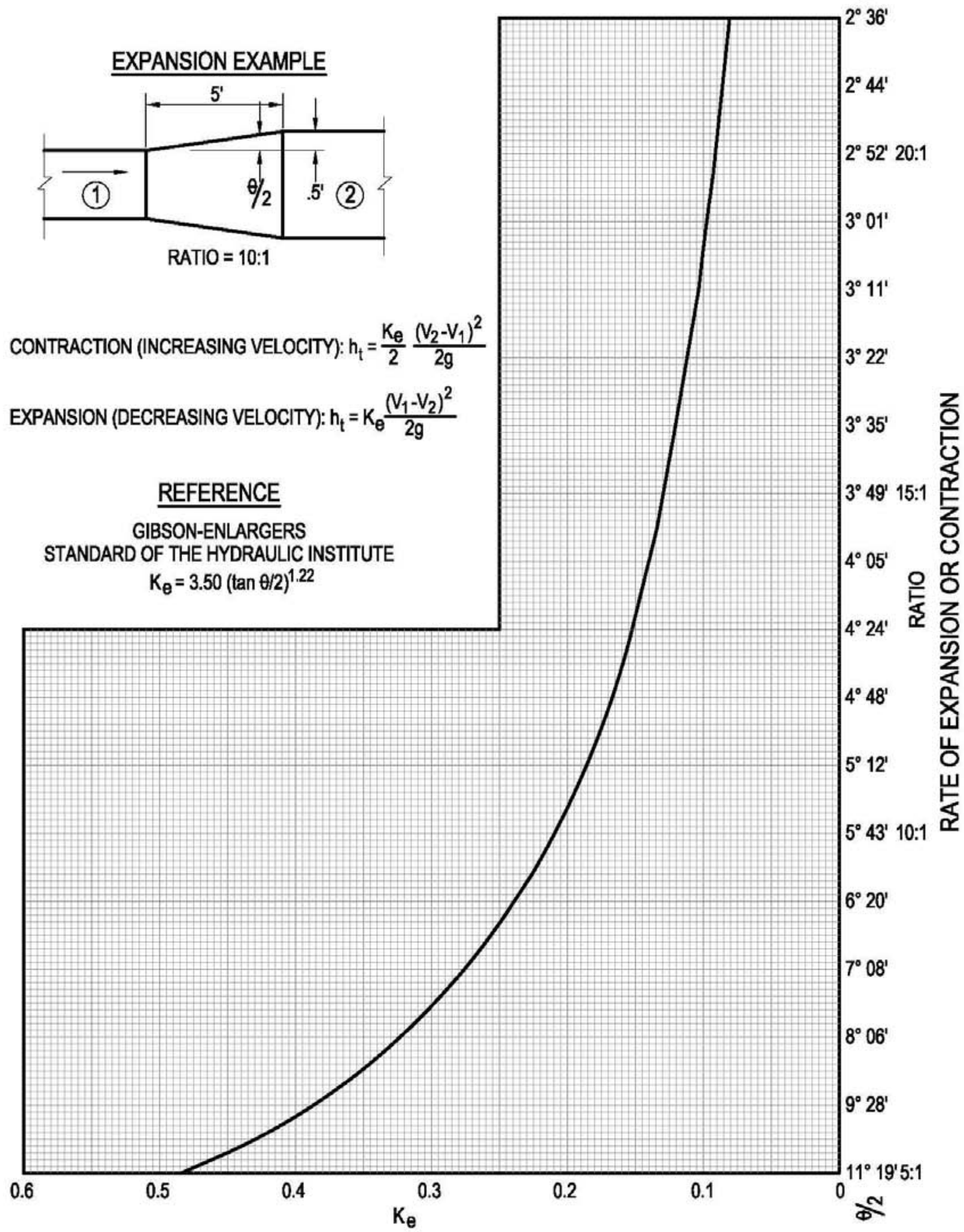
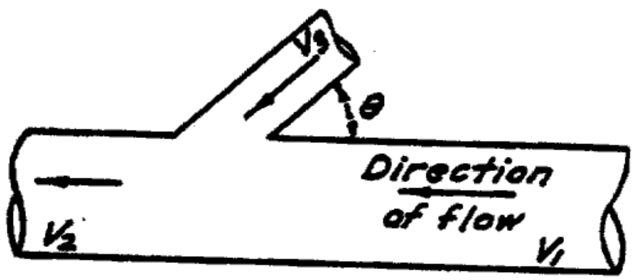


PLATE 22.3 B-2

(3) 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 22, Section 8. 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,



$$h_j = \frac{V_2^2}{2g} - \frac{V_1^2}{2g} - \frac{2A_3}{A_2} \cdot \frac{V_3^2}{2g} \cdot \cos \theta$$

(4) Manhole Loss

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 Sections (2) and (3), preceding.

$$h_{m.h.} = .05 \left[\frac{V^2}{2_g} \right]$$

(5) Bend Loss

Bend losses will be calculated from the following equations:

$$h_b = K_b \left[\frac{V^2}{2_g} \right]$$

BEND LOSSES

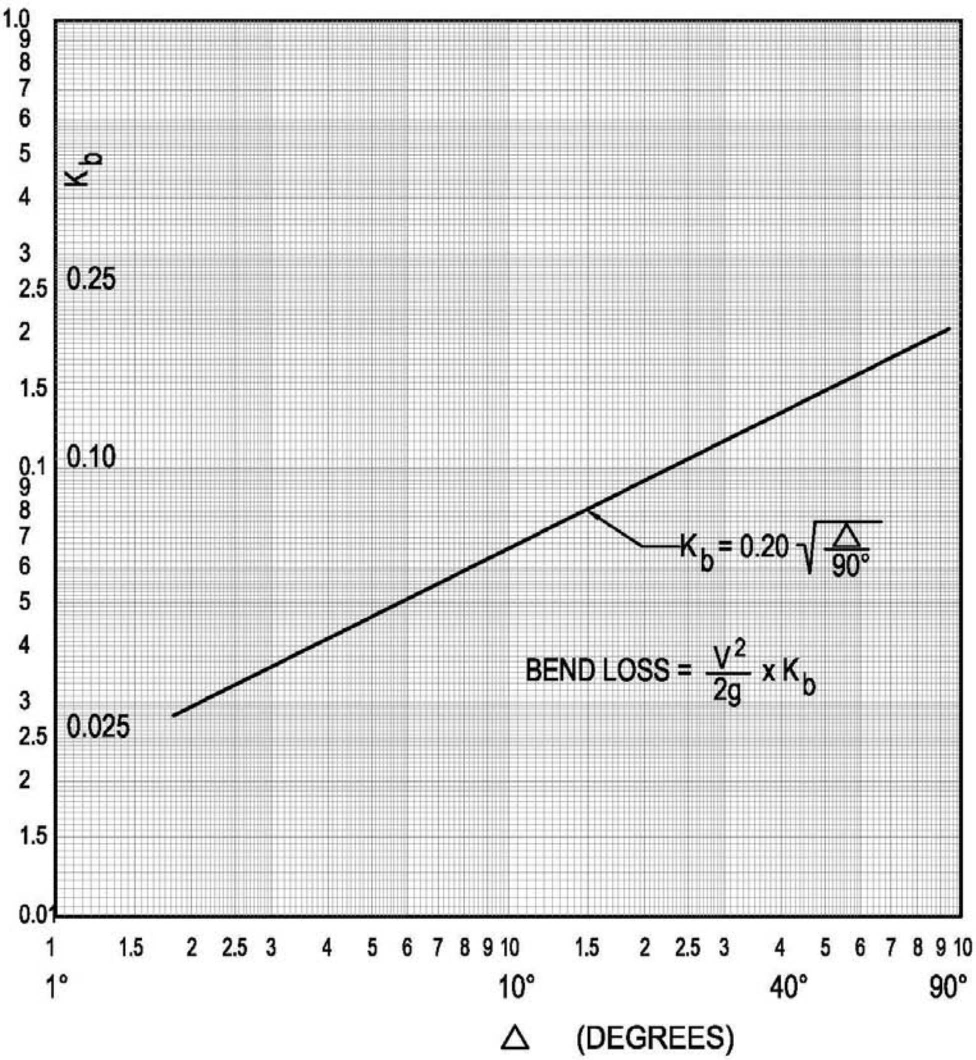


PLATE 22.3 B-3

in which:

$$K_b = 0.20 \sqrt{\frac{\Delta}{90^\circ}}$$

where Δ = Central angle of bend in degrees

K_b may be evaluated graphically from 22.3 B-3 for values of not exceeding 90 degrees.

Bend losses should be included for all closed conduits, those flowing partially full as well as those flowing full.

(6) Angle Point Loss

Angle point losses shall be calculated from the following equation:

$$h_{a.pt.} = .0033\,\Theta \left[\frac{V^2}{2_g}\right]$$

in which Θ = Deflection angle in degrees, not to exceed 6^0 without prior approval.

B.3. SPECIAL CASES

a. 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/SSCAFCA approval.

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

Where conduits are to be decreased in size due to a change in grade, the criteria for locating the transition will be as shown on Plate 22.3 B-4.

B.4. DESIGN REQUIREMENTS FOR MAINTENANCE AND ACCESS

a. Manholes

(1) Spacing

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.

The spacing requirements shown above apply regardless of design velocities. Deviations from the above criteria are subject to City Engineer/SSCAFCA approval.

(2) Location

Manholes should be located outside of street intersections wherever possible, especially when one or more streets are heavily traveled.

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.

Manholes should be located as close to changes in grade as feasible when the following conditions exist:

(a) 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.

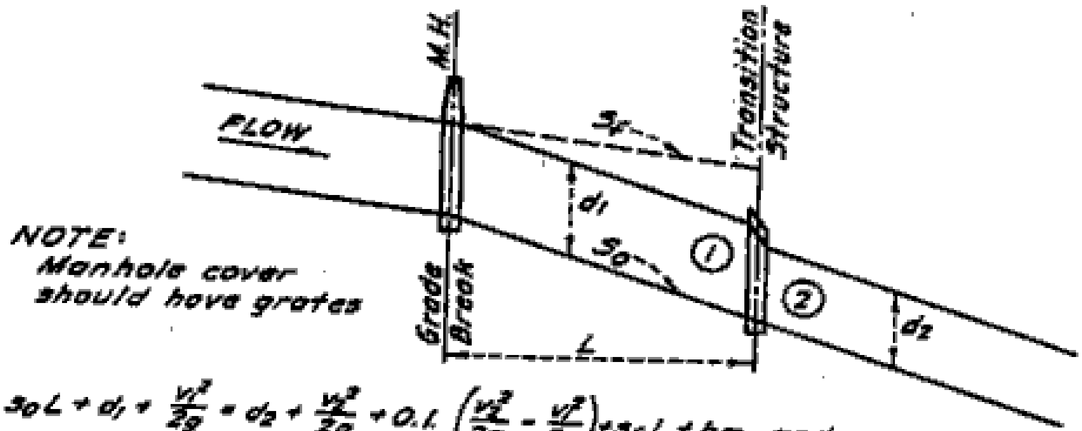
(b) When transitioning to a smaller downstream conduit due to an abruptly steeper slope downstream, sediment tends to accumulate at the point of transition.

(3) Design

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'.

LOCATION OF TRANSITION

Large to Small Conduit



$$S_o L + d_1 + \frac{v_1^2}{2g} = d_2 + \frac{v_2^2}{2g} + 0.1\left(\frac{v_2^2}{2g} - \frac{v_1^2}{2g}\right) + s_f L + hm,\ \text{and}$$

$$S_o L - s_f L = d_2 - d_1 + 1.1\left(\frac{v_2^2}{2g} - \frac{v_1^2}{2g}\right) + hm \ldots\ldots\ \text{therefore:}$$

$$L = \frac{d_2 - d_1 + 1.1\left(\frac{v_2^2}{2g} - \frac{v_1^2}{2g}\right) + hm}{s_o - s_f}$$

where
- s_o = slope of conduit
- s_f = friction slope of larger conduit
- d_1 = diameter or depth of larger conduit
- v_1 = velocity in larger conduit flowing full
- d_2 = diameter or depth of smaller conduit
- v_2 = velocity in smaller conduit flowing full
- h_m = other losses occuring between the transition and the grade break such as bend and confluence losses

EXAMPLE PROBLEM

$Q = 400$ cfs

$d_1 = 84'' = 7'$	$d_2 = 78'' = 6.5'$
$A_1 = 38.49$ sq. ft.	$A_2 = 33.18$ sq. ft.
$v_1 = 10.4$ fps	$v_2 = 12.0$ fps
$\frac{v_1^2}{2g} = 1.68'$	$\frac{v_2^2}{2g} = 2.24'$

$S_o = .00474$

$S_f = .00395$

$$L = \frac{6.5 - 7.0 + 1.1(2.24 - 1.68)}{.00474 - .00395} = 147$$

PLATE 22.3 B-4

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.

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/SSCAFCA during the review of preliminary plans.

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/SSCAFCA requirements.

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.

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.

g. Minimum Slope

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

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/SSCAFCA approval.

i. Outlet Structures

(1) Where a storm drain discharges into a detention reservoir, the designer should check with the City Engineer/SSCAFCA 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. 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/SSCAFCA.

(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/SSCAFCA will furnish, upon request, guidance on types of energy dissipators appropriate for each application.

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 type. 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.

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.

l. 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. Debris basins must be cleaned out on a regular basis, however, if they are to continue to function effectively. Refer to the City Engineer/SSCAFCA and State Engineer regarding the criteria to be used in designing these structures.

m. Safety

Entry into any of these structures should be in accordance with OSHA requirements.

B.5. OTHER CLOSED CONDUIT CRITERIA

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/SSCAFCA.

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

b. Flapgates (FLAPGATES ARE DISCOURAGED AND WILL ONLY BE USED ON A CASE BY CASE BASIS AND WITH APPROVAL FROM THE CITY ENGINEER/SSCAFCA)

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/SSCAFCA standards.

c. Rubber-Gasketed Pipe

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

d. Non-Reinforced Concrete Pipe

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

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/SSCAFCA 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: $Q = \frac{1.486}{n} AR^{2/3} s^{1/2}$

$K = \frac{Q}{S^{1/2}} = \frac{1.486\ AR^{2/3}}{0.013}$, for pipe $K = 35.6259\ d^{8/3}$
for box $K = 114.3077\ \frac{A^{5/3}}{p2/3}$

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

$s = \left[\frac{Q}{K}\right]^2$

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				
.50	18	1.767	105.0				
.75	21	2.405	158.4				
2.00	24	3.142	226.2				
.25	27	3.976	309.7				
.50	30	4.909	410.1				
.75	33	5.939	528.7				
3.00	36	7.068	666.9				
.25	39	8.295	825.8				
.50	42	9.621	1,006				
.75	45	11.044	1,209				
4.00	48	12.566	1,436				
.25	51	14.186	1,688				
.50	54	15.904	1,967				
.75	57	17.721	2,272				
5.00	60	19.635	2,604				
.25	63	21.648	2,966				
.50	66	23.758	3,358				
.75	69	25.967	3,780				
6.00	72	28.274	4,236				
.25	75	30.680	4,720				
.50	78	33.183	5,244				
.75	81	35.785	5,796				
7.00	84	38.485	6,388	5'-10"	5.83	40.3	6,357
.25	87	41.283	7,015				
.50	90	44.179	7,677	6'-4"	6.33	47.0	7,780
.75	93	47.173	8,379				
8.00	96	50.266	9,120	6'-9"	6.75	53.5	9,256
.50	102	56.745	10,720	7'-1"	7.08	59.7	10,685
9.00	108	63.617	12,487	7'-6"	7.50	67.0	12,452
.50	114	70.882	14,421	8'-0"	8.00	75.4	14,598
10.00	120	78.540	16,538	8'-5"	8.42	83.6	16,726
.50	126	86.590	18,835	8'-10"	8.83	92.1	19,026
11.00	132	95.033	21,322	9'-2"	9.17	100.3	21,303
.50	138	103.879	24,005	9'-7"	9.58	109.5	23,954
12.00	144	113.098	26,890	10'-0"	10.00	119.4	26,849

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
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

FACTORS FOR CIRCULAR CONDUITS FLOWING PARTLY FULL

D = depth of water
d = diameter of conduit

Tabulated Values

$K = \frac{\text{momentum}}{(Q/d)^2}$ $C = \frac{\text{pressure}}{d^3}$ $F = \frac{\text{Velocity Head}}{(Q/d^2)^2}$

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

C. Criteria for Hydraulic Design: Open Channels

C.1. 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/SSCAFCA.

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 C-3 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 and SSCAFCA 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 C-3 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.

C.2. WATER SURFACE PROFILE CALCULATIONS

a. General

Water surface profile calculations must be calculated using the Bernoulli energy equation (see Section B-2) 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.

b. Determination of Controlling Water Surface Elevation

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

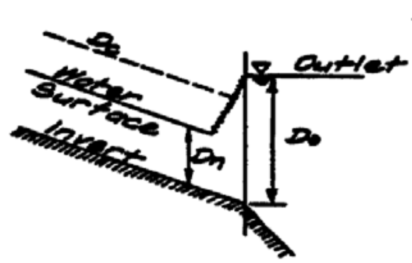
(1) Where the channel slope changes from mild to steep or critical, the depth at the grade break is critical depth.

(2) Where the channel slope changes from critical to steep, the depth at the grade break is critical depth.

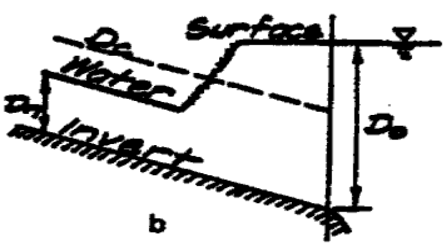
(3) Where a discharging or outletting channel or conduit is on a mild slope, the water surface is generally controlled by the outlet (see Section B-2.1).

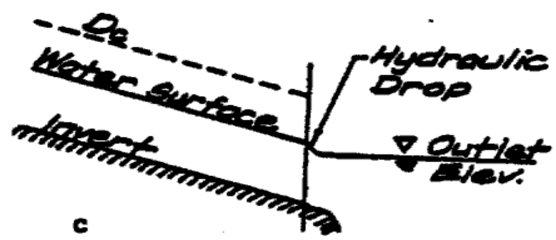
(4) When a channel on a steep slope discharges into a facility that has a water surface depth greater than the normal depth of the channel, calculate pressure plus momentum for normal depth and compare it to the pressure plus momentum for the water surface depth at the outlet according to the equation,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

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



(b) If $P_n + M_n < P_o + M_o$, 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.

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.

d. Head Losses

(1) 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:

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

in which

Q	=	Flow rate, 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 arranged into a more useful form,

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

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

$$h_f = S_f \cdot L$$

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

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

(2) Junction Loss

Junction losses will be evaluated by the pressure plus momentum equation and must conform to closed conduit angle of confluence criteria, Section B-5. Refer to Section G for cases and alternate solutions.

e. Channel Inlets

(1) 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 SSCAFCA. 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.

(2) 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 or SSCAFCA 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 "f" 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 8" 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.

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

(3) Direct Pipe to Channel

Junctions involving direct pipe connection to a channel must conform to the criteria listed in Section 5 of the closed conduit criteria. 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. Paragraph 18(h), Corps of Engineers EM 1110-2-1061 has additional design criteria.

f. Transitions

(l) 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:

$$L \geq 2.5 \; \Delta \; B$$

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:

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

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 G-5. For transitions, both methods are applicable in all cases and will give the same results.

(2) Supercritical Flow

(a) Divergent Walls

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

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

$$L \geq 1.5 \, \Delta B \cdot F$$

where F = Upstream Fourde number based on depth of flow

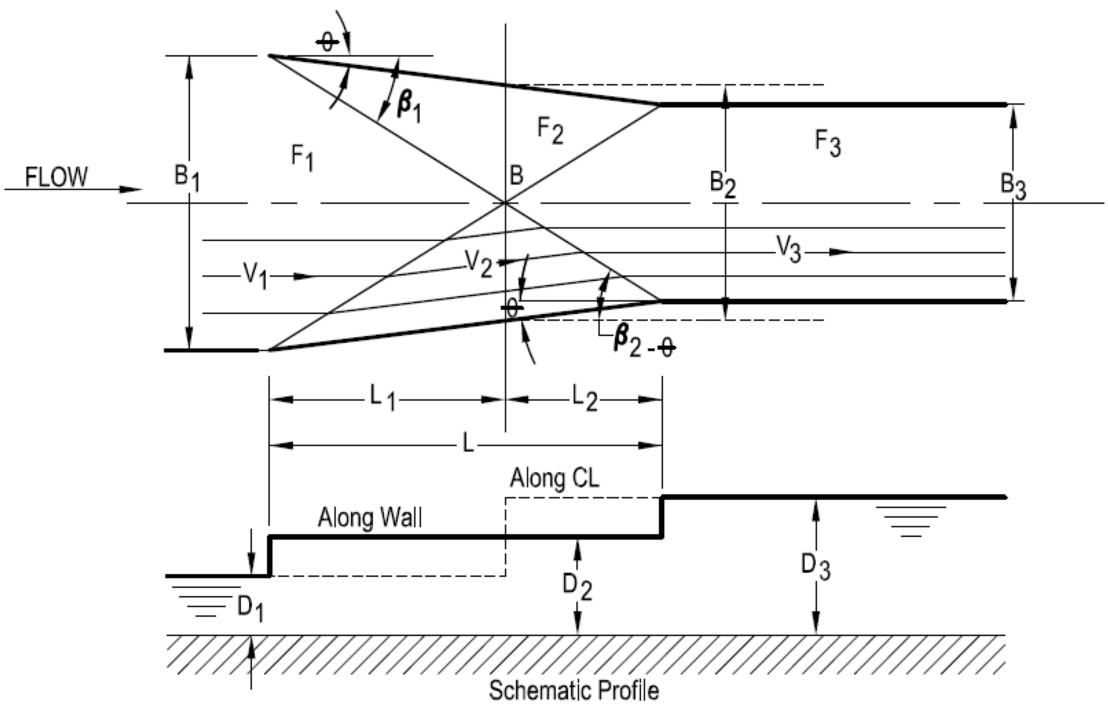
Δ B = The difference in channel width at the water surface

(b) Convergent Walls

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 and to avoid unstable flow regimes. The walls of the transition should be straight lines.

i. For convergent walls less than or equal to 5 degrees, design to avoid unstable flow regime in accordance with Section 3.C.1 and/or account for increased freeboard in accordance with Section 3.C.4. See Example problem No. 7 at the end of this section.

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



CONVERGENT WALL SCHEMATIC

$$L = \frac{B_1 - B_3}{2 \tan \theta}$$

With the initial Froude number and the contraction ratio fixed, and with the continuity equation:

$$\frac{B_1}{B_3} = \left(\frac{D_3}{D_1}\right)^{3/2} * \left(\frac{F_3}{F_1}\right)$$

trial curves can produce the geometry of the construction suggested above. The curves represent the equation

$$\tan\theta = \frac{\tan\beta_1 \,(\sqrt{1 + 8F_1^2 \sin^2\beta_1} - 3)}{2\tan^2\beta_1 + \sqrt{1 + 8F_1^2 \sin^2\beta_1} - 1}$$

Refer to Plate 22.3 C-1 and to examples in the COA DPM and LA Hydraulic Design Manual.

(3) Transitions Between Channel Treatment Types

(a) 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.

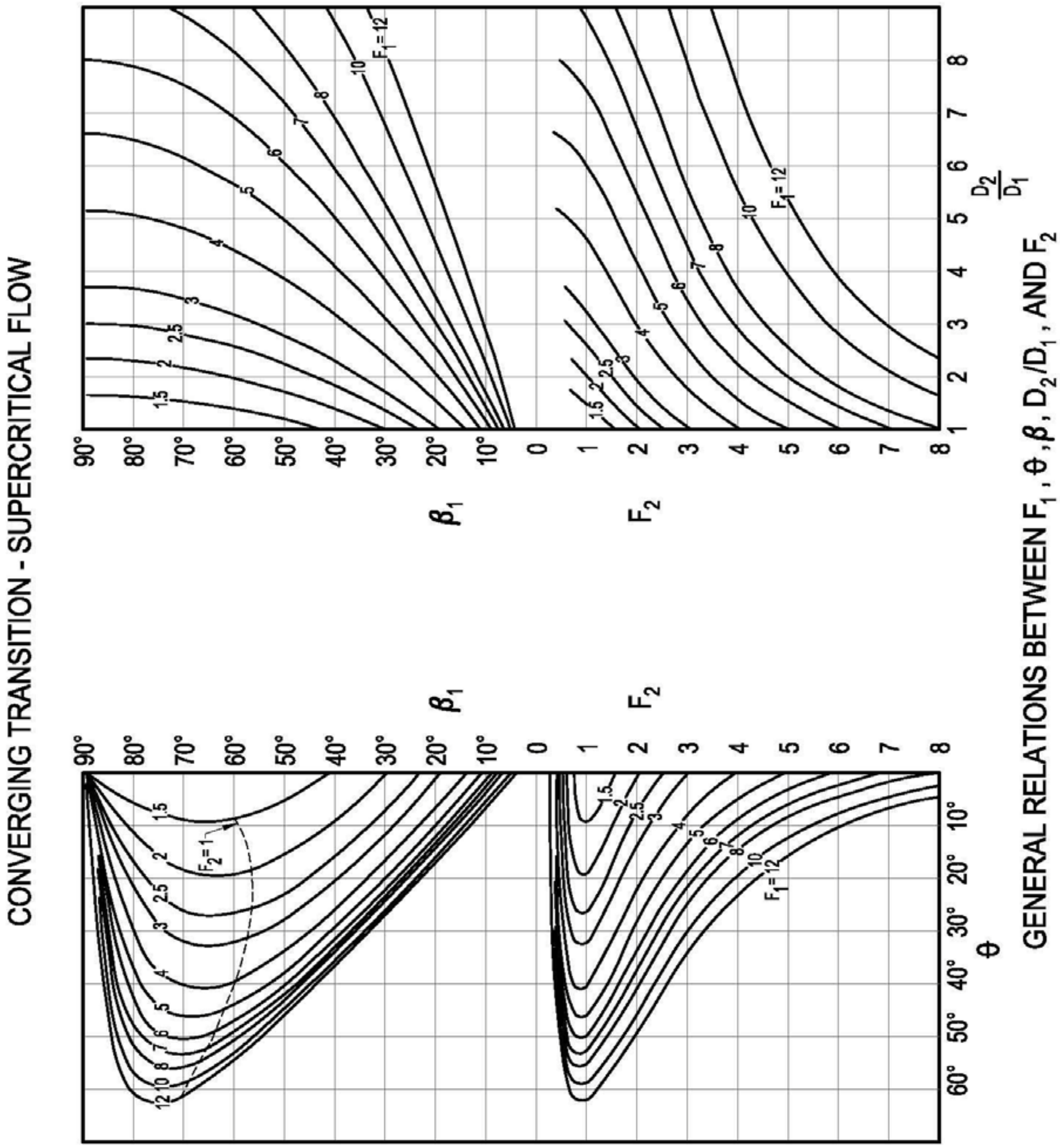

CONVERGING TRANSITION - SUPERCRITICAL FLOW
GENERAL RELATIONS BETWEEN F1 , θ , β , D2/D1 , AND F2
β1
F2
θ
D2/D1
F2=1
F1=12

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 projected with gravel filter blankets.

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

(b) 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.

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/SSCAFCA.

- ► 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/SSCAFCA. Grouted and wire-tied material require gravel filters as well. The length of riprap shall be determined by engineering analysis.

g. Piers

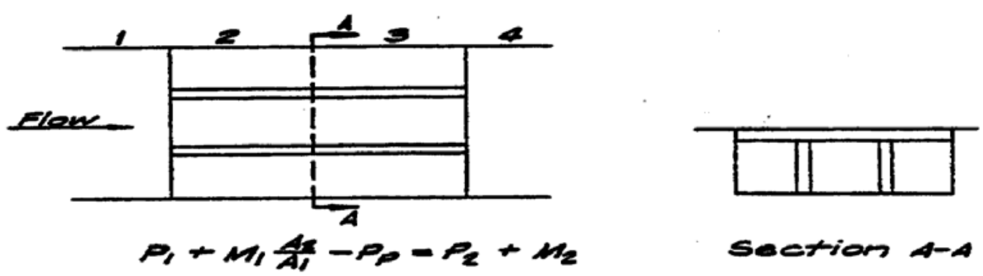
(1) General

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/SSCAFCA 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. Refer to Section 22.8 for design data regarding streamline piers.

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.

(2) Pressure plus Momentum (P + M) Equation as Applied to Bridge Piers



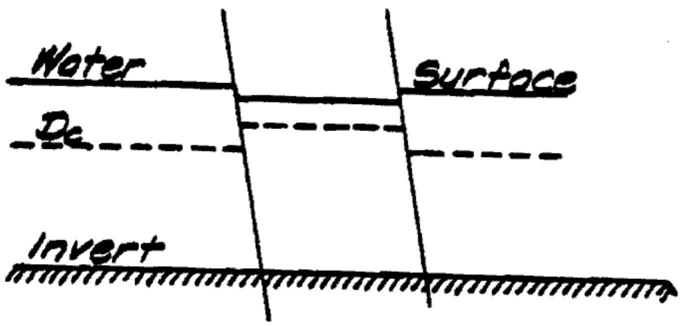
where P_1 = Hydrostatic pressure in unobstructed channel
M_1 = Kinetic momentum in unobstructed channel
where A_1 = Area of unobstructed channel
A_2 = A1 - Kp Ap = Area of water within bridge
P_2 = Hydrostatic pressure within bridge based on net flow area
M_2 = Kinetic momentum within bridge based on 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) Hydraulic Analysis

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

(a) 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

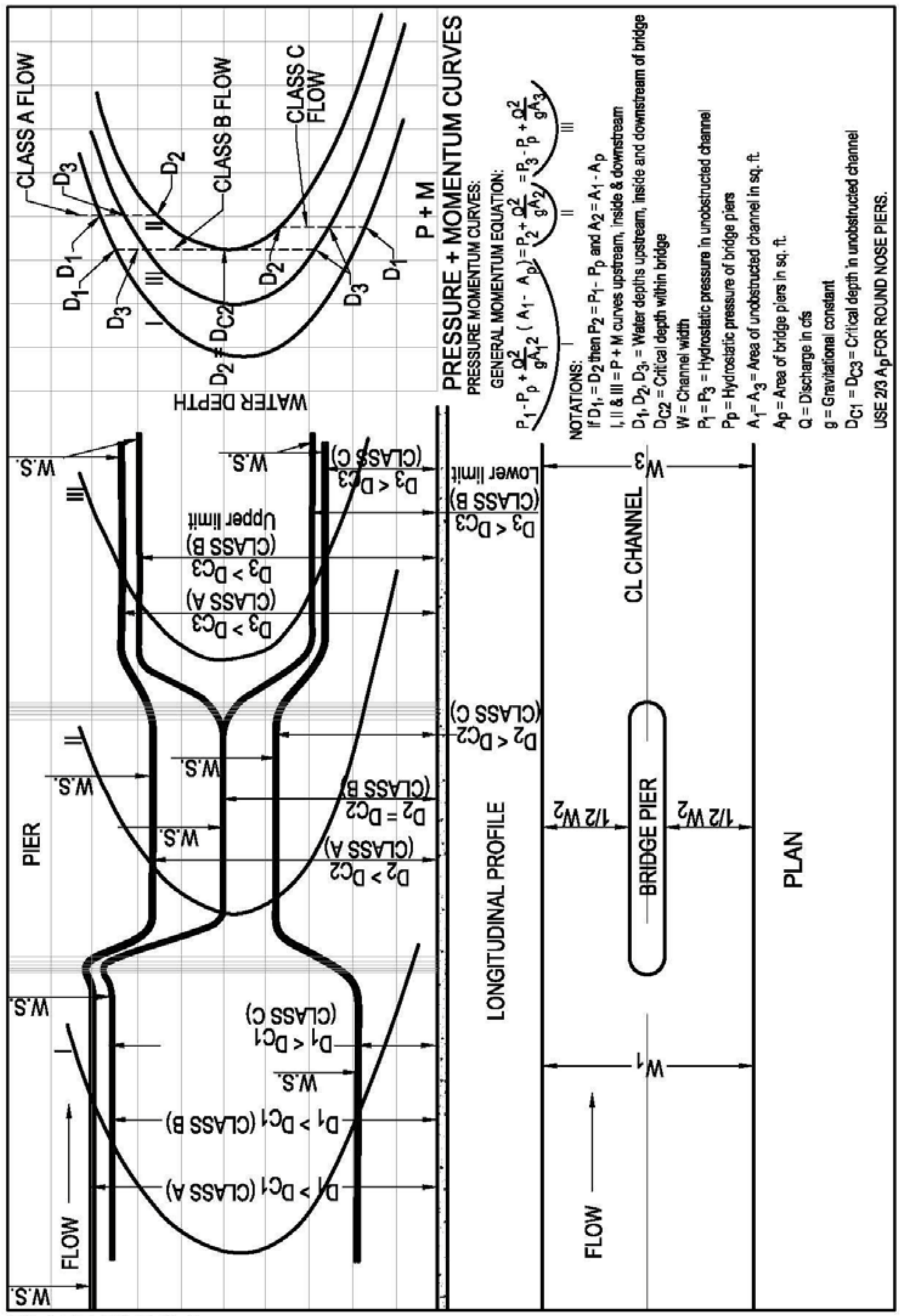


PLATE 22.3 C-2

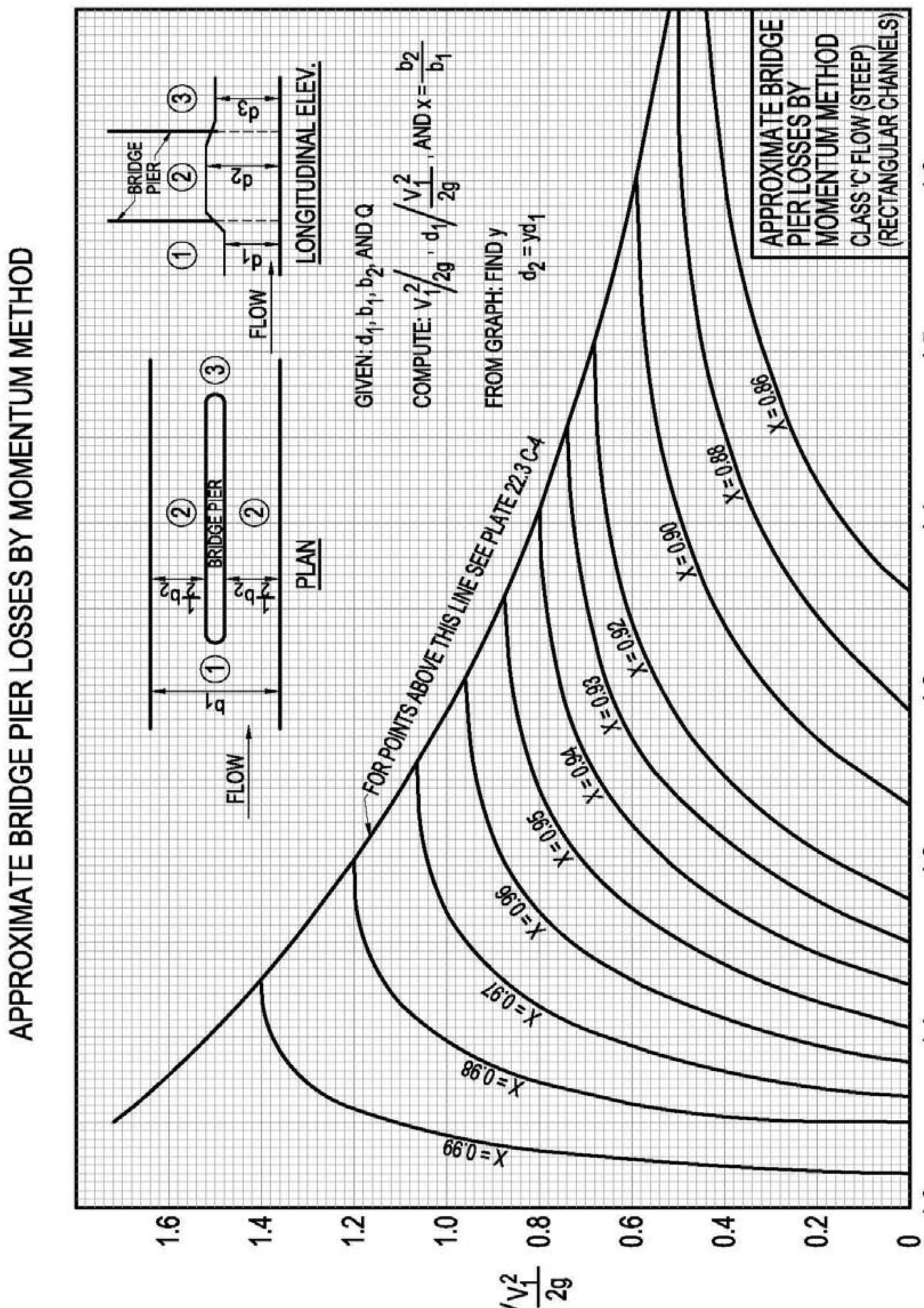

APPROXIMATE BRIDGE PIER LOSSES BY MOMENTUM METHOD
FLOW
BRIDGE PIER
PLAN
FLOW
BRIDGE PIER
LONGITUDINAL ELEV.
GIVEN: d1, b1, b2, AND Q
COMPUTE: V1²/2g , d1/(V1²/2g) , AND x = b2/b1
FROM GRAPH: FIND y
d2 = yd1
FOR POINTS ABOVE THIS LINE SEE PLATE 22.3 C-4
X = 0.99
X = 0.98
X = 0.97
X = 0.96
X = 0.95
X = 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

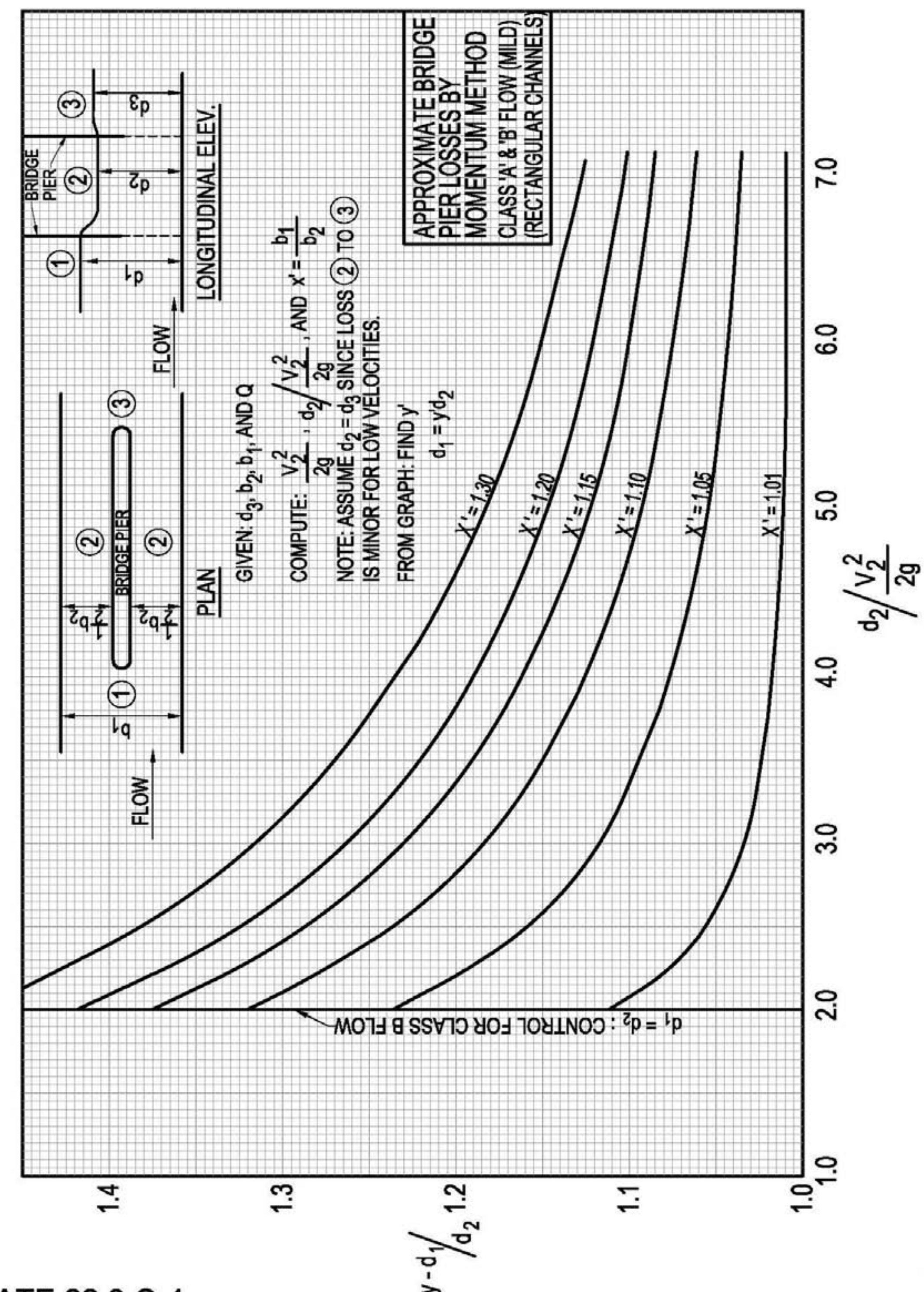
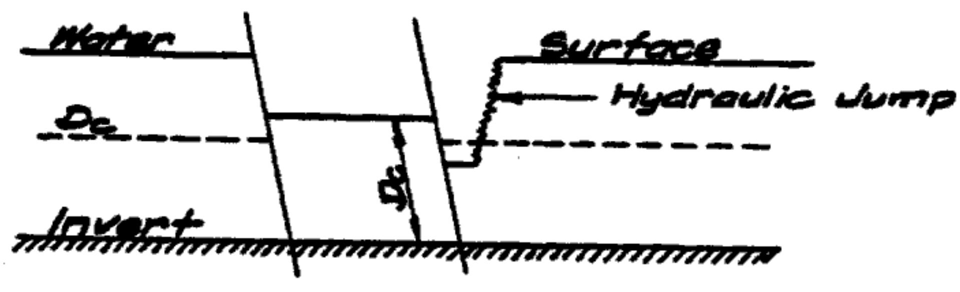


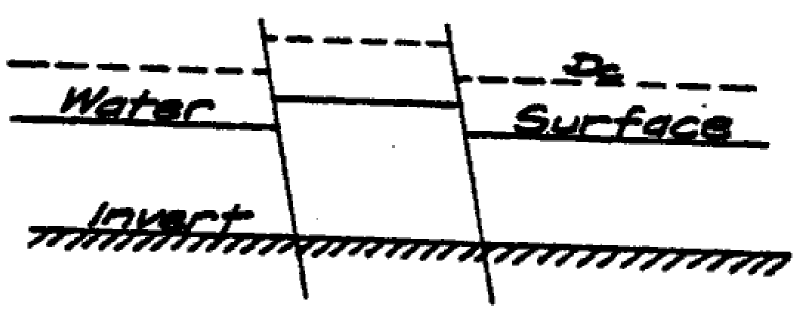
PLATE 22.3 C-4

(b) 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.

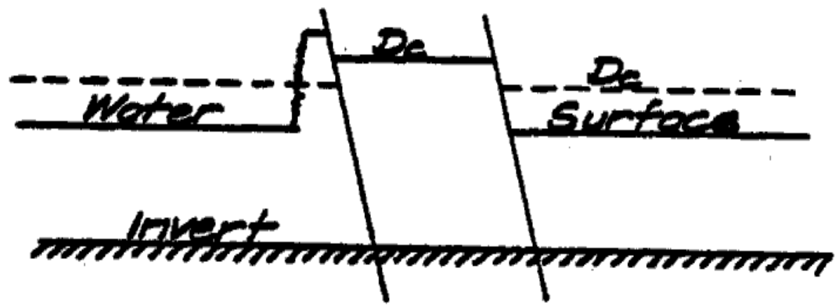


For supercritical flow the following cases, numbers 3 or 4, generally apply.

(c) 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.



(d) 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.



C.3. CURVING ALIGNMENTS

a. 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:

$$S = \frac{V^2 b}{2g r}$$

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

$$S = \frac{V^2 b}{g r}$$

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

$$X = \frac{\pi b V}{\sqrt{12 g D}} = \frac{.16 b V}{\sqrt{D}} = \frac{0.908 b}{\sin \beta}$$

$$\sin \beta = \frac{\sqrt{gD}}{V} = \frac{1}{F}$$

"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:

$$S = 1.15 \quad V^2 (b + 2 z D) / 2 g r$$

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:

$$S = 1.3 \quad V^2 (b + 2 z D) / 2 g r$$

(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.

4. Freeboard:

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

a. Rectangular Channels will not be used except with City Engineer/SSCAFCA's approval)

b. 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:

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

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

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

Freeboard (Feet) = $0.7\ (2.0 + 0.025\ Vd^{1/3})$

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/SSCAFCA.

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.

c. 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 and 22.3 C-7.

5. Other Criteria

a. 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 nonerodible velocity than shallower ones.

Maximum side slopes are determined pursuant to an analysis of soil reports. However, in general, slopes should be 6:l or flatter with erosion protection measures.

b. 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 Table 22.3 B-l. 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:

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

ROLL WAVES

Maximum Wave Height

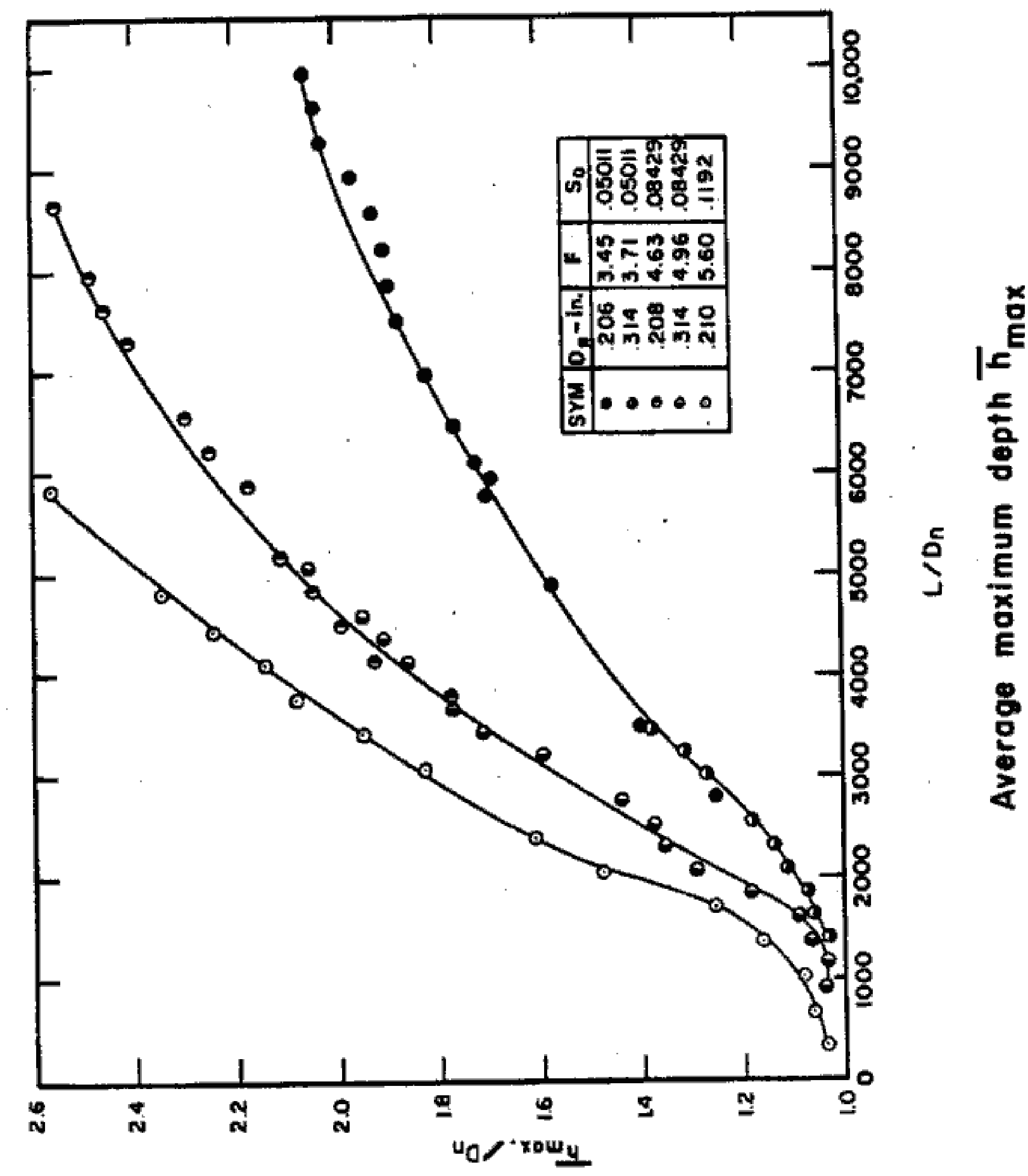
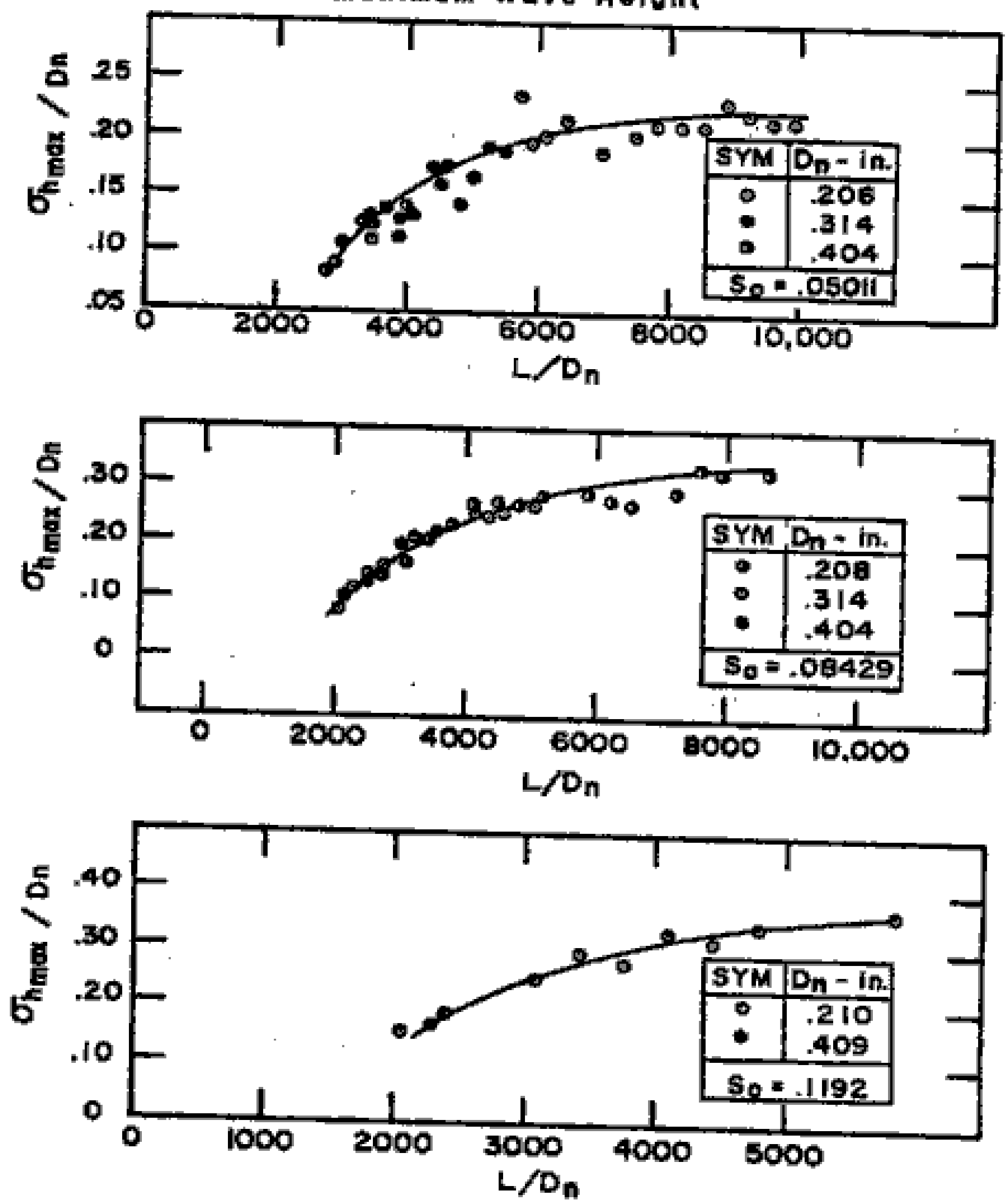


PLATE 22.3 C-5

ROLL WAVES

Maximum Wave Height



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

PLATE 22.3 C-6

ROLL WAVES

Maximum Wave Height

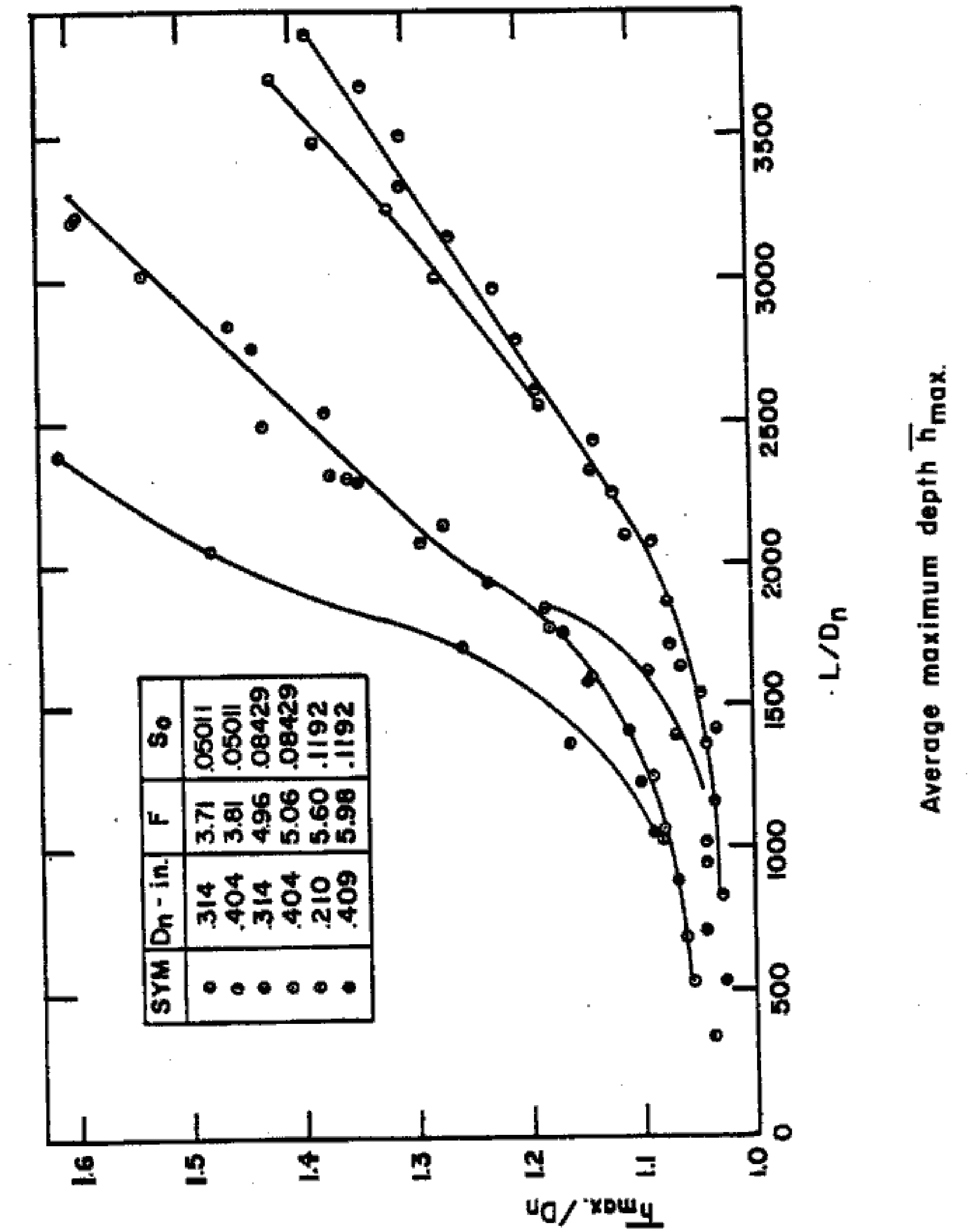


PLATE 22.3 C-7

c. 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

d. 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/SSCAFCA 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.

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.

e. 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 SSCAFCA. 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.

f. 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/SSCAFCA, all crossing structures must have at least 8.0 feet of clear height.

g. 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.

D. Storm Inlets

D.1. DESIGN Q

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

a. Outline the drainage area on a map with an appropriate scale.

b. Outline the drainage area tributary 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.

c. Calculate the tributary area in acres for each storm inlet or battery of storm inlets.

d. Assuming satisfactory drainage area relationships, the storm inlet design Q will be calculated as follows:

$$Q_{DES} = \frac{Q_P}{A_T} A$$

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 Qs are reduced because of a restricted outlet, the storm inlet design Qs 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 Qs should be adjusted accordingly.

2. Required Data and Calculations

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.

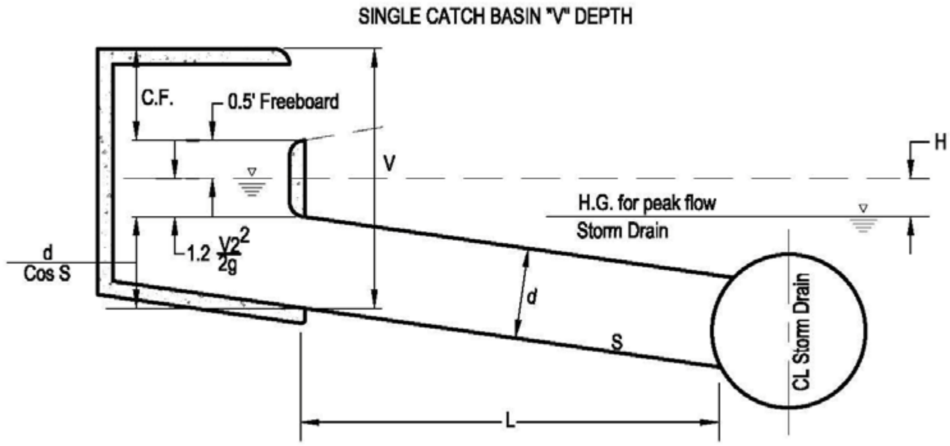
Please refer to Plates 22.3 D-1 to 22.3 D-4 inclusive, for nomographs giving street capacities for some typical street sections. These nomographs have been developed for 8” curb heights. Be aware that the City of Rio Rancho standard height is 6”.

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.

c. Connector Pipe and "V" Depth Calculation

(1) Single Storm Inlet



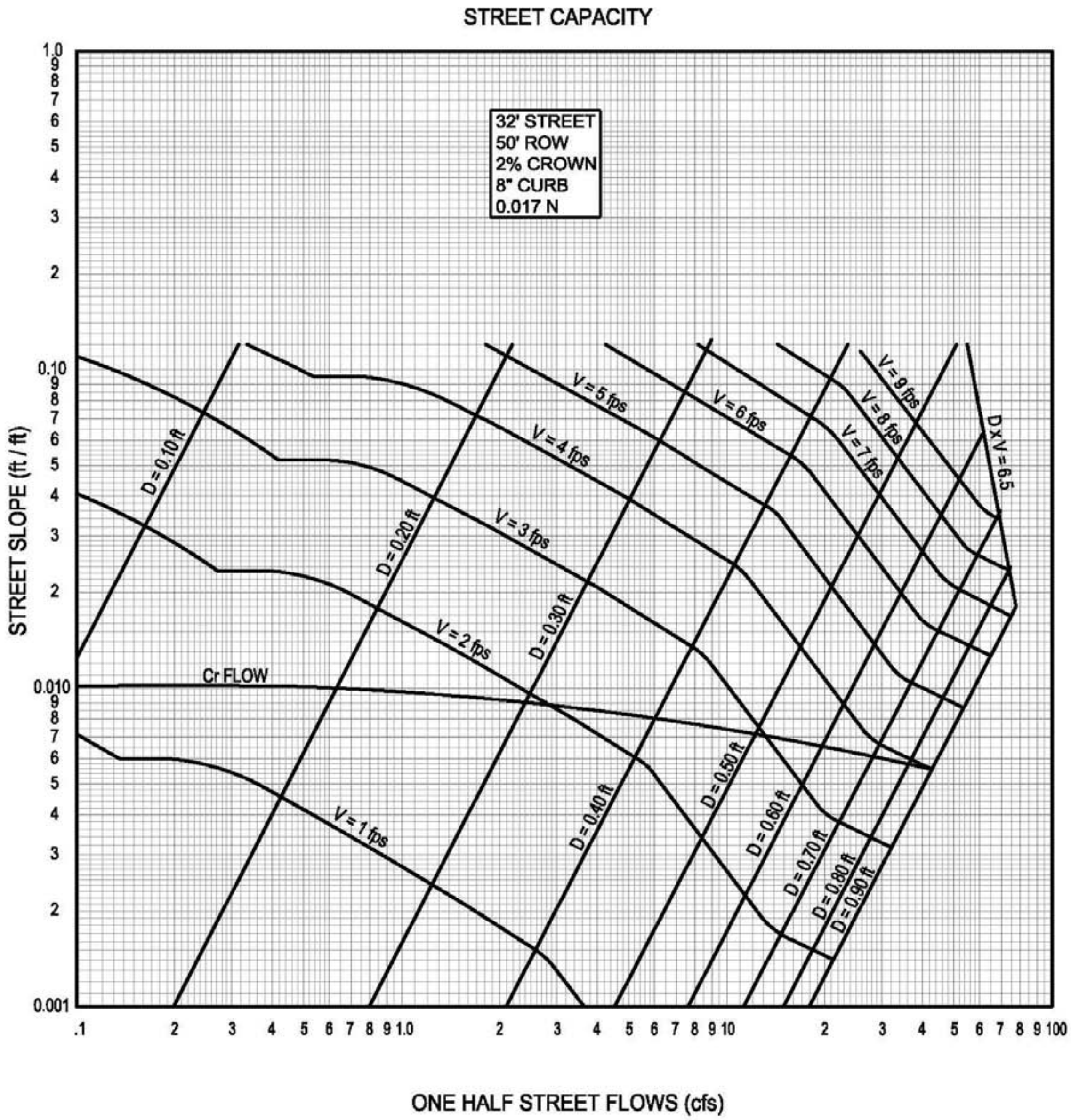

STREET CAPACITY
32' STREET
50' ROW
2% CROWN
8" CURB
0.017 N
STREET SLOPE (ft / ft)
ONE HALF STREET FLOWS (cfs)
V = 1 fps
V = 2 fps
V = 3 fps
V = 4 fps
V = 5 fps
V = 6 fps
V = 7 fps
V = 8 fps
V = 9 fps
D x V = 6.5
D = 0.10 ft
D = 0.20 ft
D = 0.30 ft
D = 0.40 ft
D = 0.50 ft
D = 0.60 ft
D = 0.70 ft
D = 0.80 ft
D = 0.90 ft
Cr FLOW

PLATE 22.3 D-1

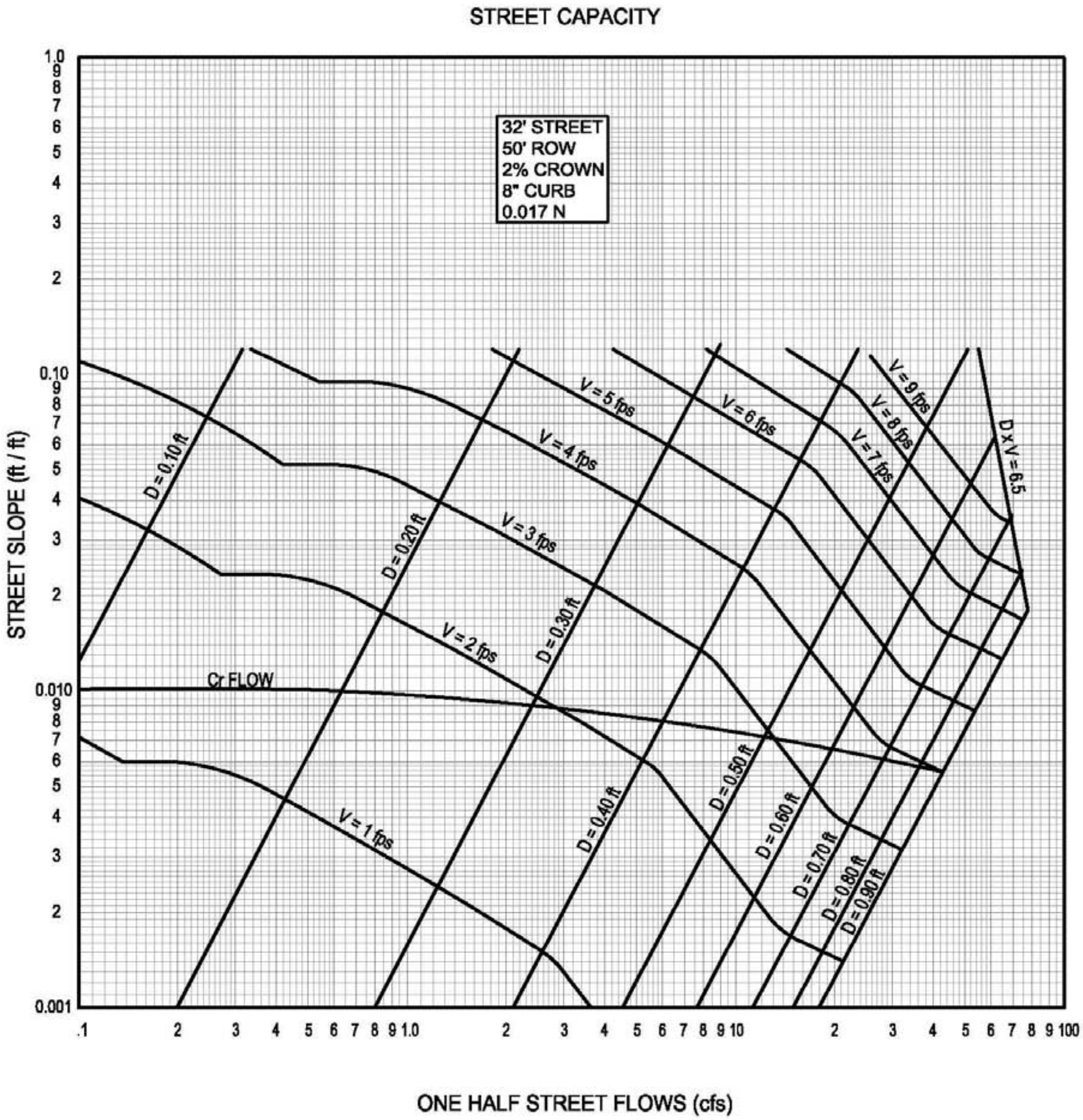

STREET CAPACITY
32' STREET
50' ROW
2% CROWN
8" CURB
0.017 N
STREET SLOPE (ft / ft)
ONE HALF STREET FLOWS (cfs)
V = 1 fps
V = 2 fps
V = 3 fps
V = 4 fps
V = 5 fps
V = 6 fps
V = 7 fps
V = 8 fps
V = 9 fps
D x V = 6.5
D = 0.10 ft
D = 0.20 ft
D = 0.30 ft
D = 0.40 ft
D = 0.50 ft
D = 0.60 ft
D = 0.70 ft
D = 0.80 ft
D = 0.90 ft
Cr FLOW

PLATE 22.3 D-2

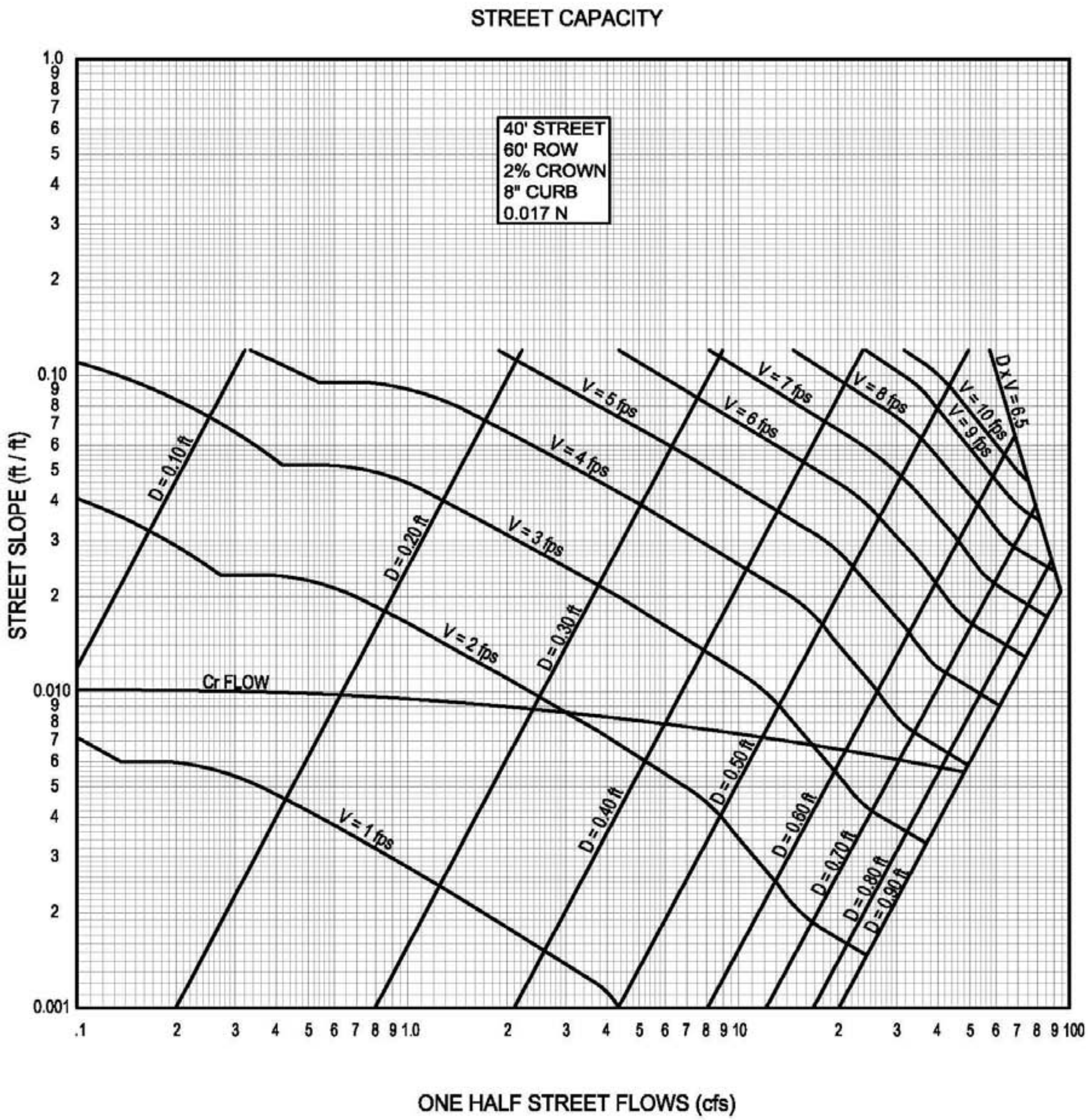

STREET CAPACITY
40' STREET
60' ROW
2% CROWN
8" CURB
0.017 N
STREET SLOPE (ft / ft)
ONE HALF STREET FLOWS (cfs)
V = 1 fps
V = 2 fps
V = 3 fps
V = 4 fps
V = 5 fps
V = 6 fps
V = 7 fps
V = 8 fps
V = 9 fps
V = 10 fps
D x V = 6.5
D = 0.10 ft
D = 0.20 ft
D = 0.30 ft
D = 0.40 ft
D = 0.50 ft
D = 0.60 ft
D = 0.70 ft
D = 0.80 ft
D = 0.90 ft
Cr FLOW

PLATE 22.3 D-3

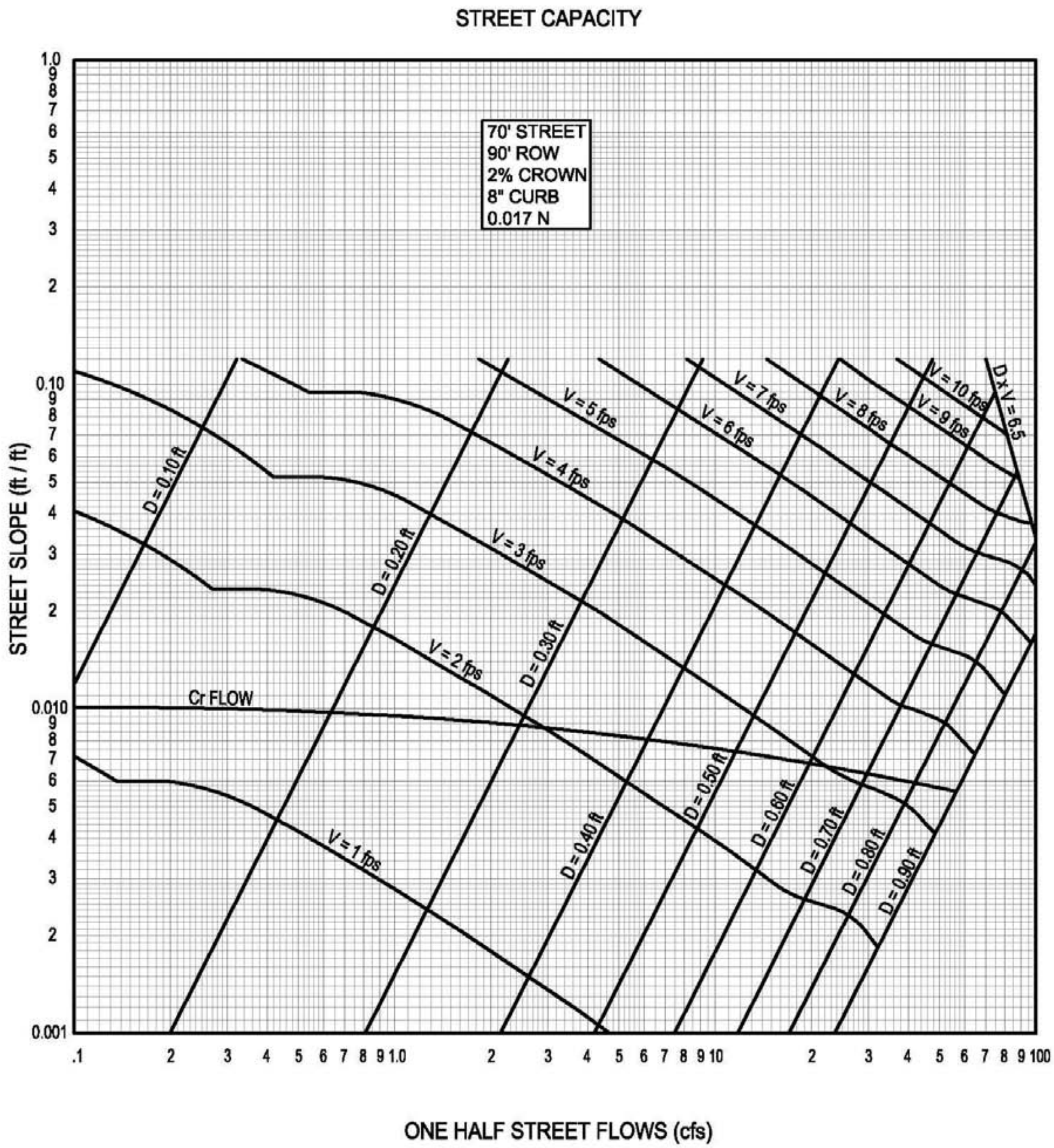

STREET CAPACITY
70' STREET
90' ROW
2% CROWN
8" CURB
0.017 N
STREET SLOPE (ft / ft)
ONE HALF STREET FLOWS (cfs)
D = 0.10 ft
D = 0.20 ft
D = 0.30 ft
D = 0.40 ft
D = 0.50 ft
D = 0.60 ft
D = 0.70 ft
D = 0.80 ft
D = 0.90 ft
V = 1 fps
V = 2 fps
V = 3 fps
V = 4 fps
V = 5 fps
V = 6 fps
V = 7 fps
V = 8 fps
V = 9 fps
V = 10 fps
D x V = 6.5
Cr FLOW

PLATE 22.3 D-4

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

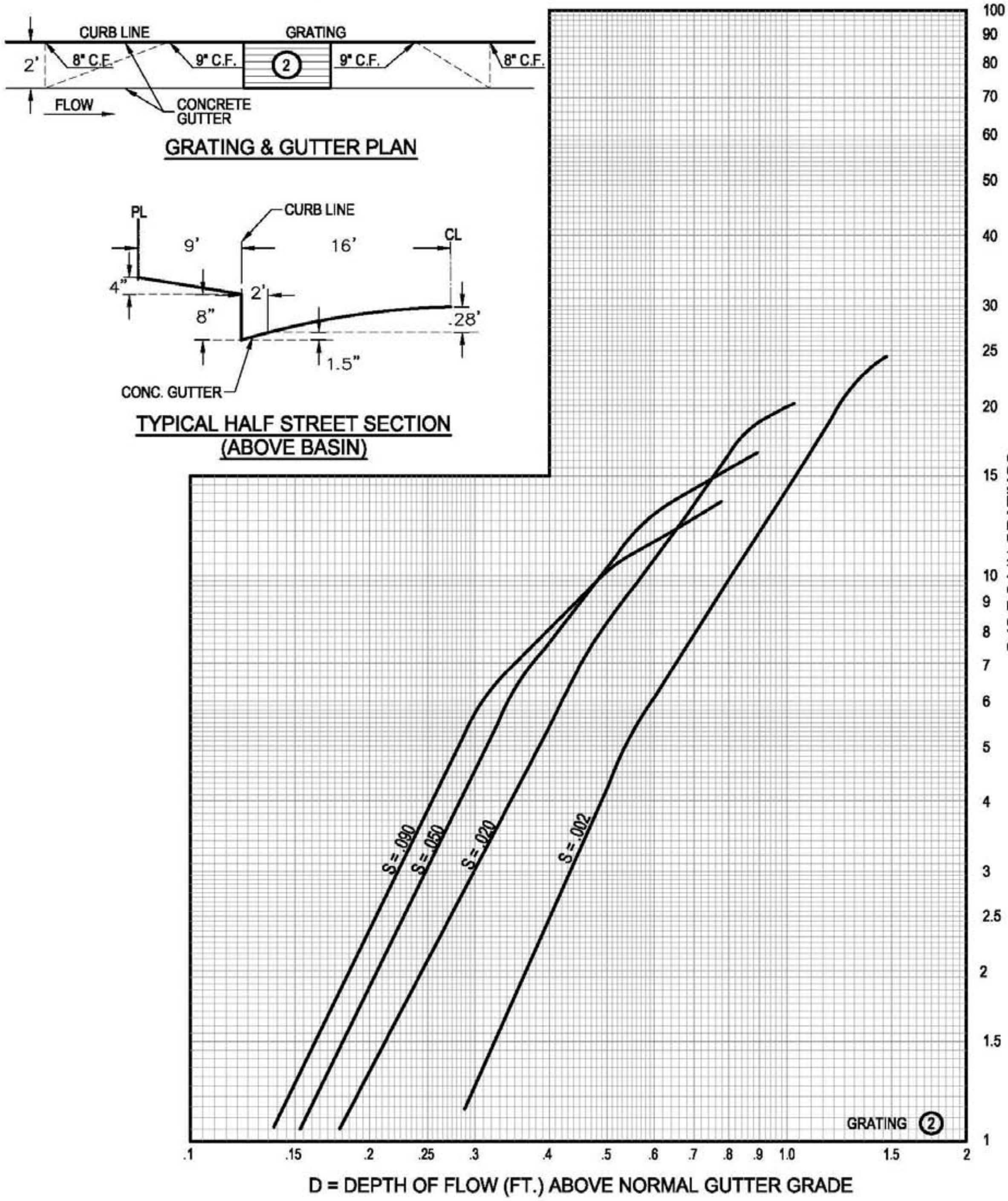


PLATE 22.3 D-5

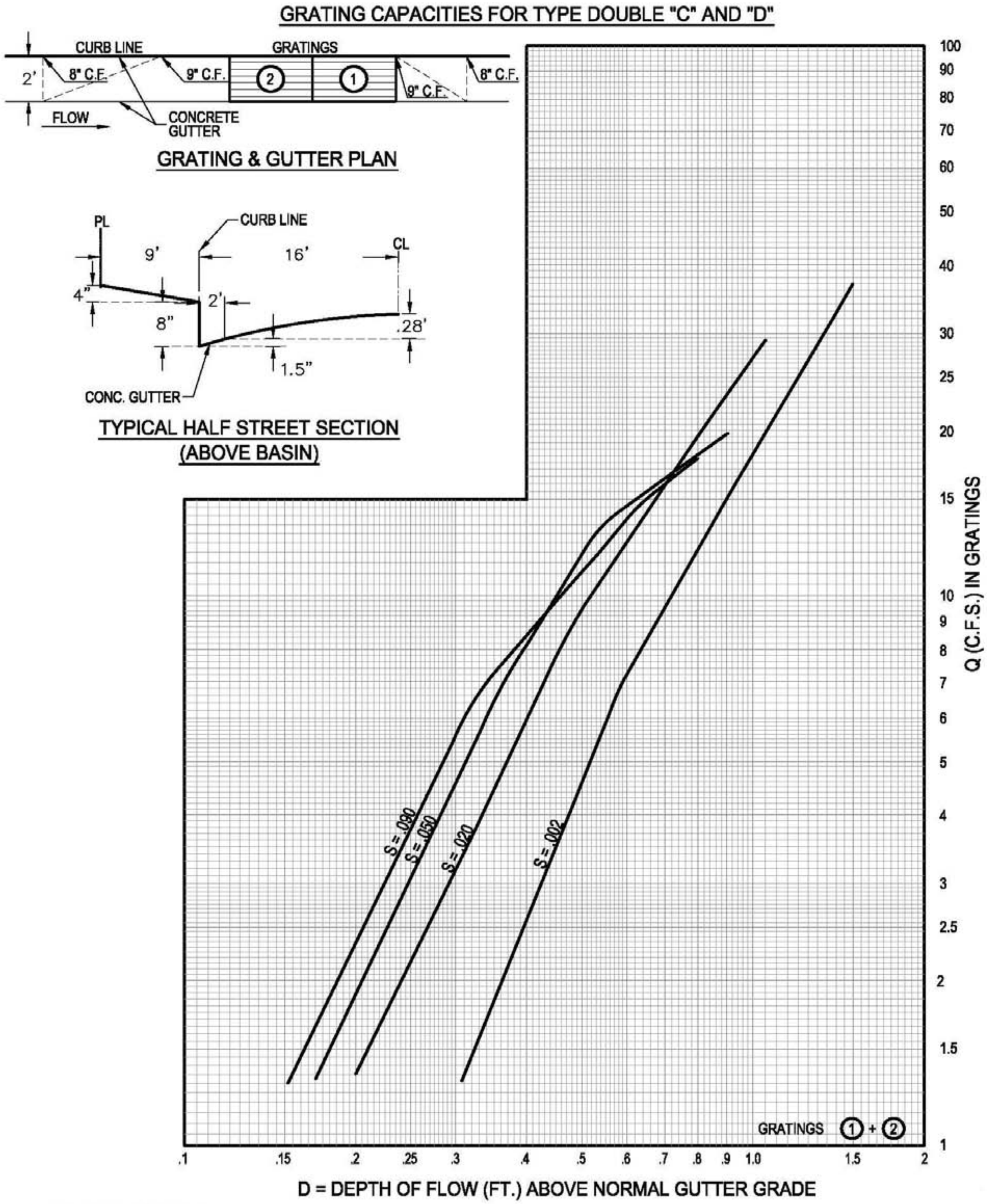

GRATING CAPACITIES FOR TYPE DOUBLE "C" AND "D"
CURB LINE
GRATINGS
2'
8" C.F.
9" C.F.
9" C.F.
8" C.F.
FLOW
CONCRETE GUTTER
GRATING & GUTTER PLAN
PL
CURB LINE
9'
16'
CL
4"
2'
8"
.28'
1.5"
CONC. GUTTER
TYPICAL HALF STREET SECTION (ABOVE BASIN)
S = .090
S = .050
S = .020
S = .002
GRATINGS ① + ②
Q (C.F.S.) IN GRATINGS
D = DEPTH OF FLOW (FT.) ABOVE NORMAL GUTTER GRADE

PLATE 22.3 D-6

GRATING CAPACITIES FOR TYPE "B"

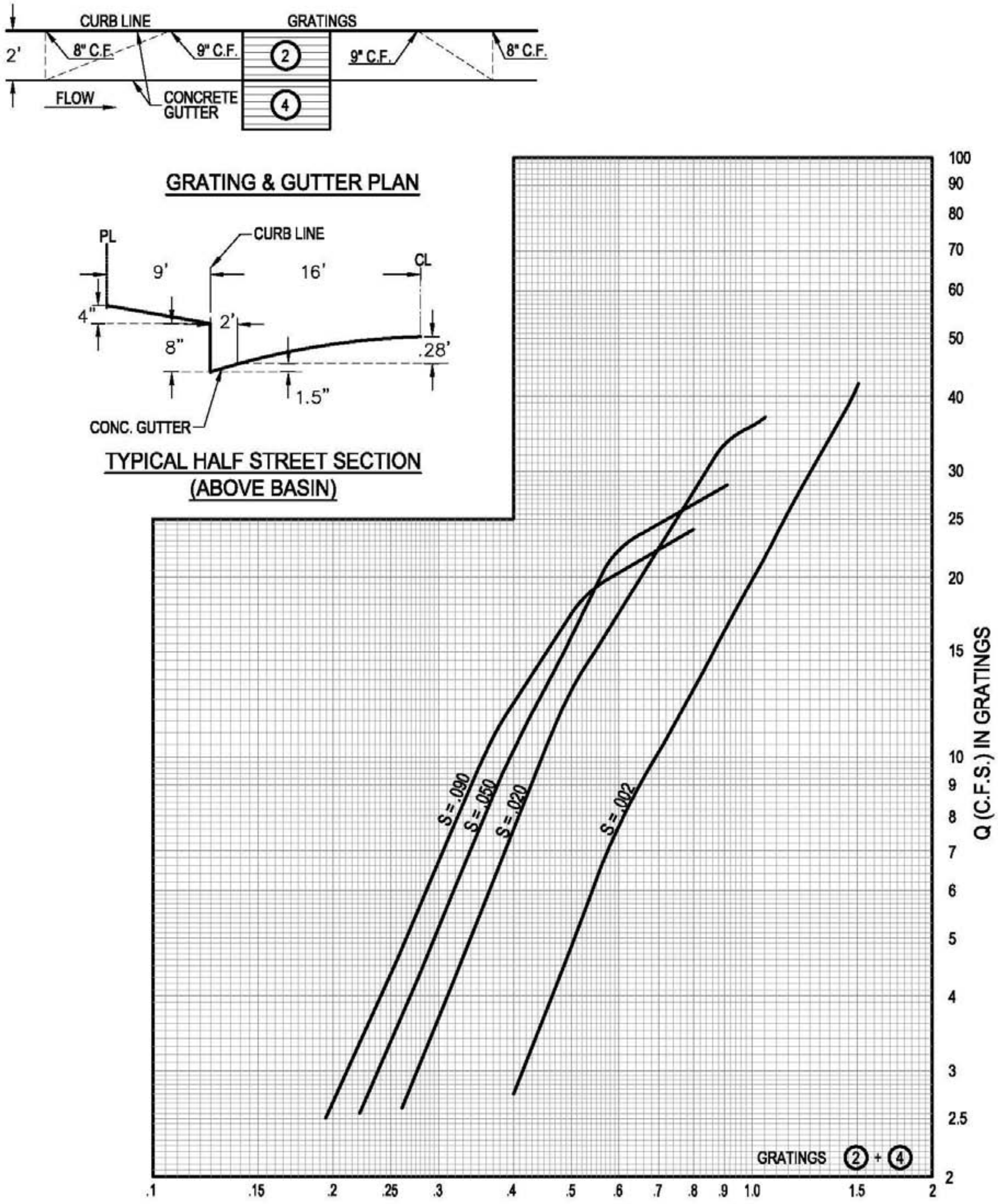


PLATE 22.3 D-7

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:

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

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.

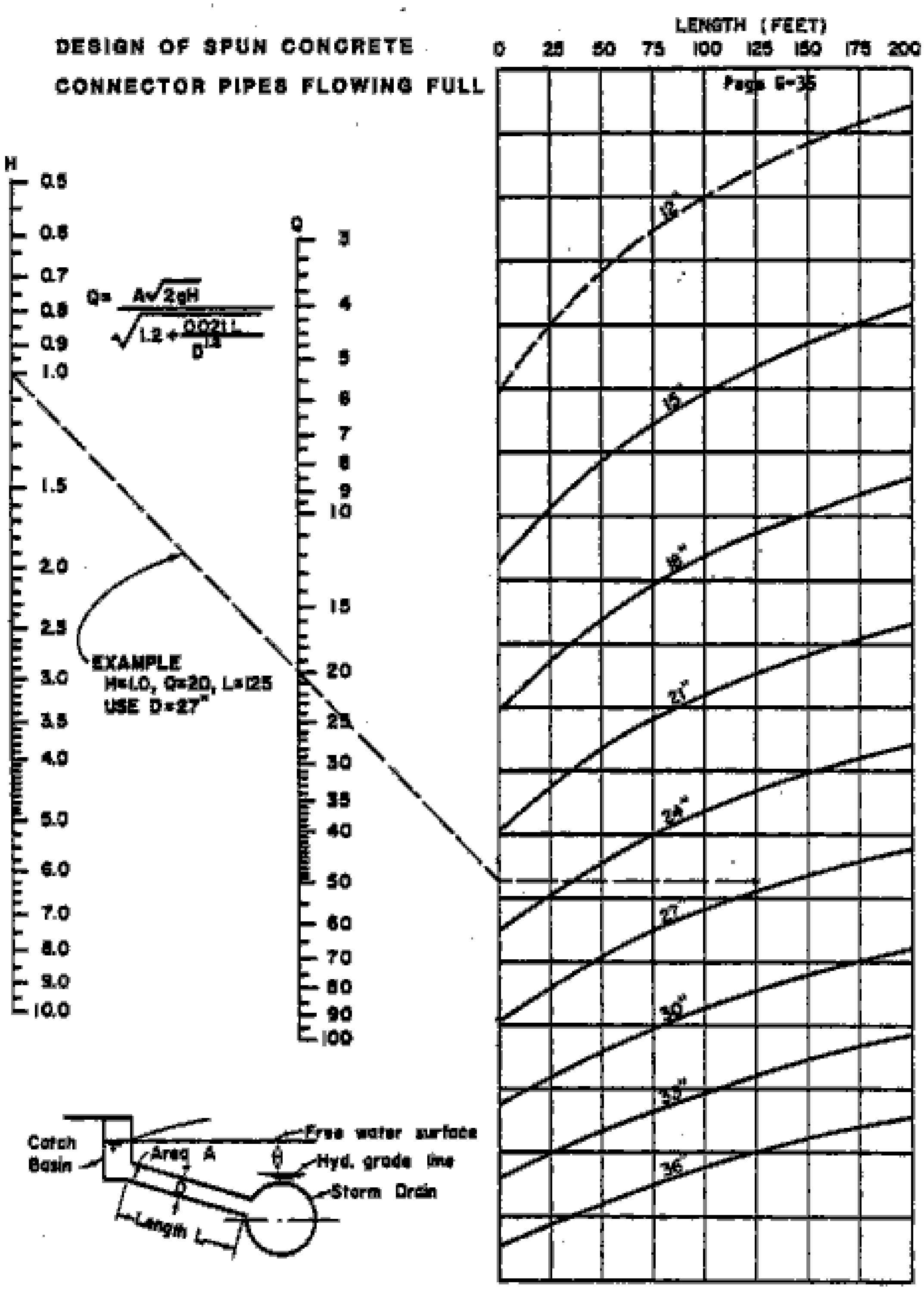
S = Slope of connector pipe.

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.



$$Q = \frac{A\sqrt{2gH}}{\sqrt{1.2 + \frac{0.021L}{D^{1.3}}}}$$

PLATE 22.3 D-8

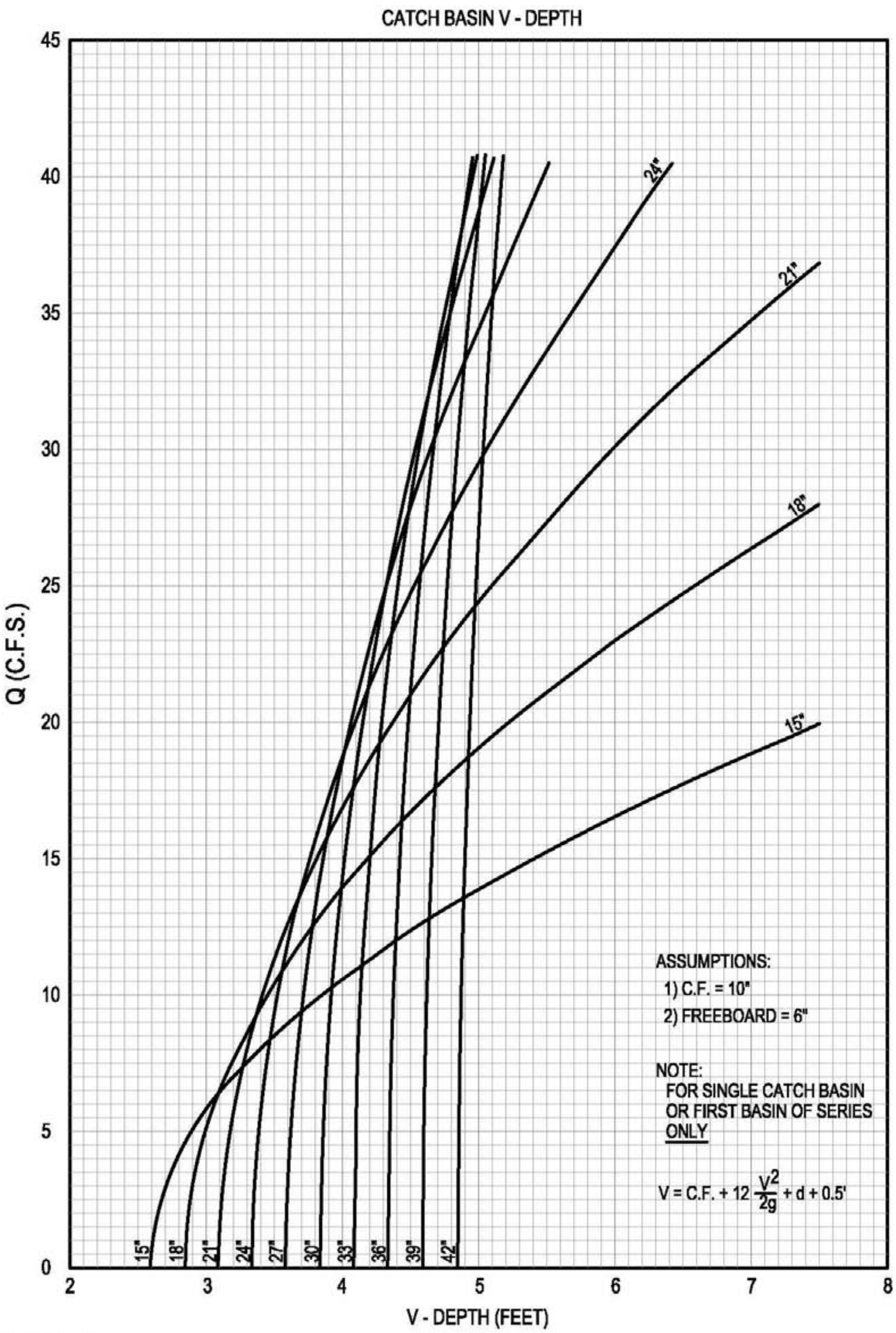

CATCH BASIN V - DEPTH
Q (C.F.S.)
V - DEPTH (FEET)
0
5
10
15
20
25
30
35
40
45
2
3
4
5
6
7
8
15"
18"
21"
24"
27"
30"
33"
36"
39"
42"
24"
21"
18"
15"
ASSUMPTIONS:
1) C.F. = 10"
2) FREEBOARD = 6"
NOTE:
FOR SINGLE CATCH BASIN
OR FIRST BASIN OF SERIES
ONLY
V = C.F. + 12 V²/2g + d + 0.5'

PLATE 22.3 D-9

STORM INLET **CALCULATION SHEET**

Sht___ of___

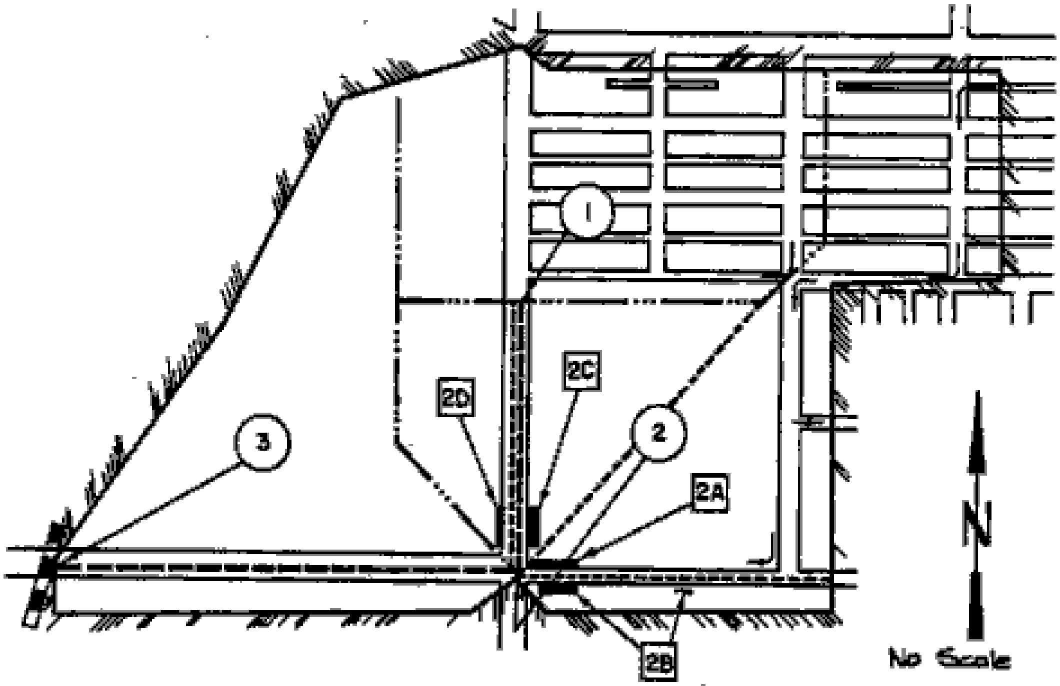
PROJECT ________________ CALCULATED BY __________

DESIGN FREQUENCY ________________ DATE ________________

FLOW DIAGRAM (Indicate street slopes)	Sym.	Drain. Area	Q		Cap. of ½ Street	Gutter "d"	C.B.		Connector Pipe			V
			Total	Inter.			No.	Size	Head	L	Dia.	Depth

PLATE 22.3 D-10

EXAMPLE CATCH BASIN HYDROLOGY PROBLEM



LEGEND

- Major Drainage Area Boundary
- Mainline Sub-Drainage Area Boundaries
- Catch Basin Sub-Drainage Area Boundaries
- Flow Path
- Mainline
- Outlet
- Catch Basins
- ○ Mainline Sub-Drainage Area Numbers
- □ Catch Basin Sub-Drainage Area/ Numbers

MAINLINE HYDROLOGY DATA **

Reach or Sub-Area	Area (Acres) Sub-Area	Area (Acres) Total	Q (c.f.s.) Sub-Area(2)	Q (c.f.s.) Reach
①	45		70	
①-②		45		70
②	70		105	
②-③		115		160
③	50		75	
③-Outlet		165		220

** Provided by L.A.C.F.C.D. Hydraulic Div.

CATCH BASIN HYDROLOGY *

For Mainline Sub Drainage Area No. 2

$A_T = 70$ Acres $Q_p = 105$ c.f.s. $Q_p/A_T = \frac{1.5 \text{ c.f.s.}}{\text{Acre}}$

C.B. Sub Drain Area #	A (Acres)	Q_p/A_T (c.f.s./Acre)	Q_{DES} (c.f.s.)
2A	40 ×	1.5 =	60
2B	5 ×	1.5 =	7.5
2C	15 ×	1.5 =	22.5
2D	10 ×	1.5 =	15

$$Q_{DES} = \frac{Q_p}{A_T} A$$

PLATE 22.3 D-11

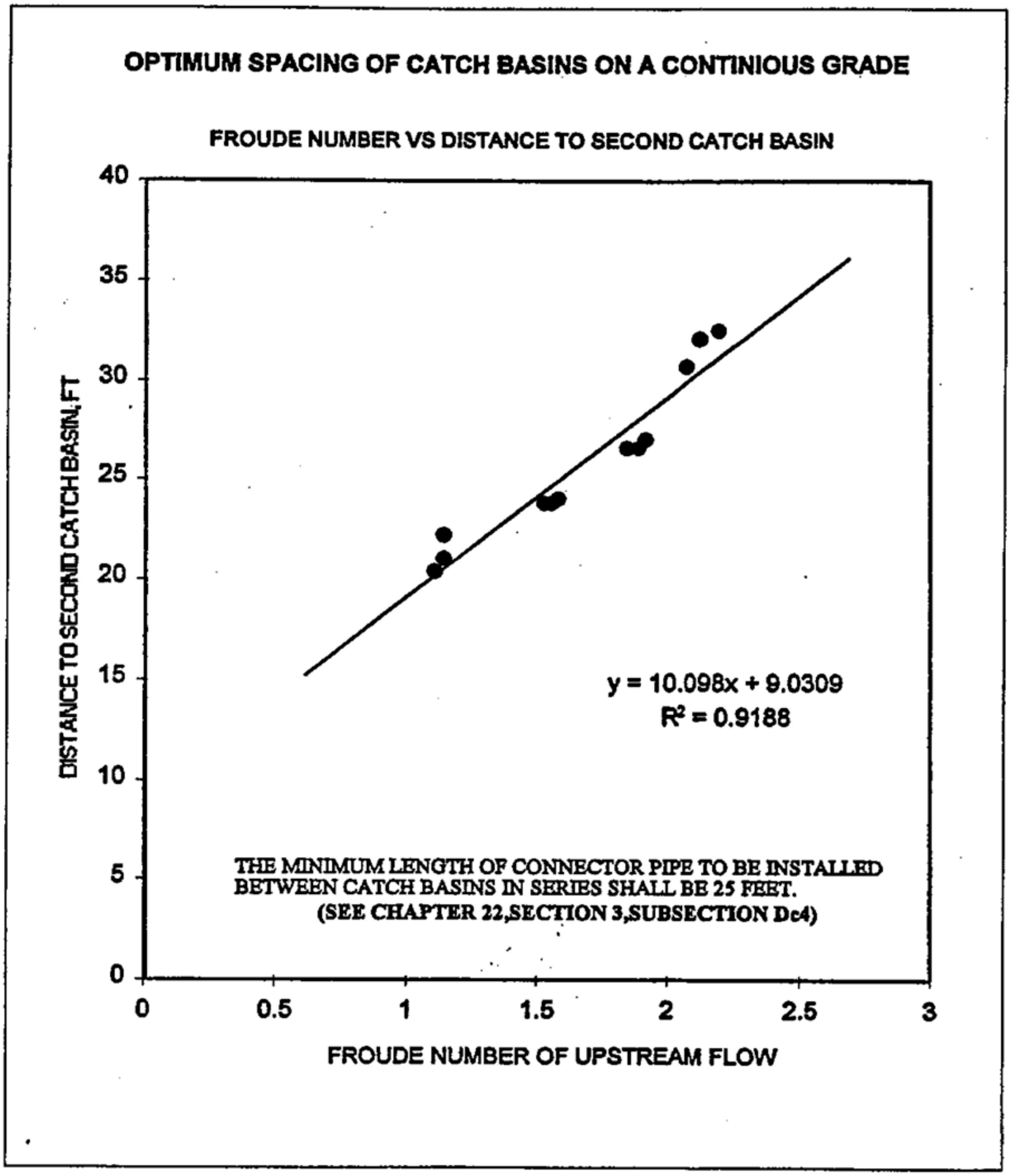
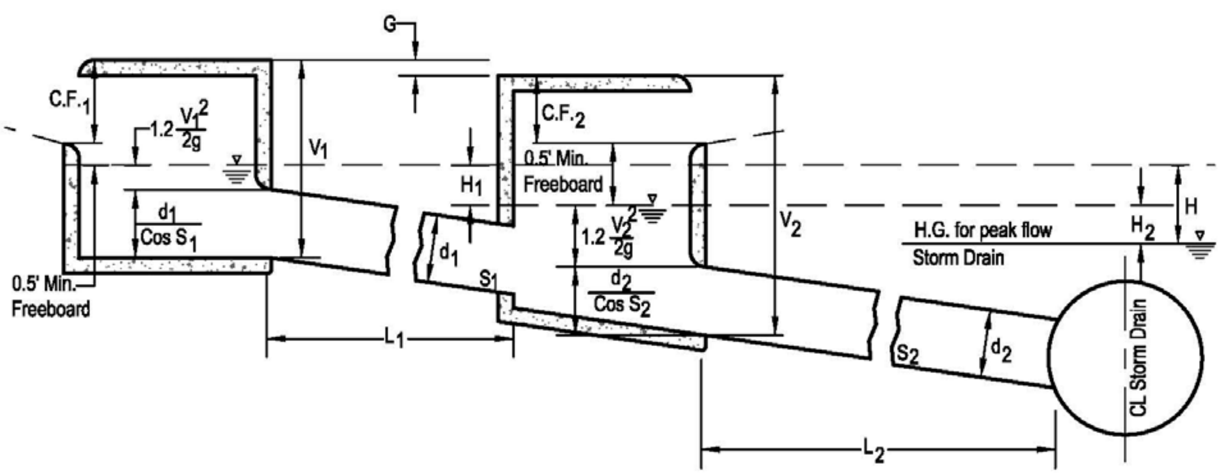


PLATE 22.3 D-12

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.,

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

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:

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

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. Other Criteria

a. 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.

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/SSCAFCA for instructions.

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/SSCAFCA. All storm inlets which must be located outside street property 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.

Storm inlets to be constructed off the paved portion of the roadway but within the street property 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:

1) 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

2) Sufficient storage is available within a combination of public R.O.W., public easement, and nonstructurally 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.

b. Storm Inlets

The selection of type, number, and spacing of storm inlets should be based on Plates 22.3 D-l through 22.3 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 grading. 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 of 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.

c. 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/SSCAFCA.

(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.

E. Street Hydraulics

l. 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 criteria 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 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.)

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 SSCAFCA.

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.

   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/SSCAFCA.

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.

   If flow is likely to cross into the subcritical flow range, then Plate 22.3 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.

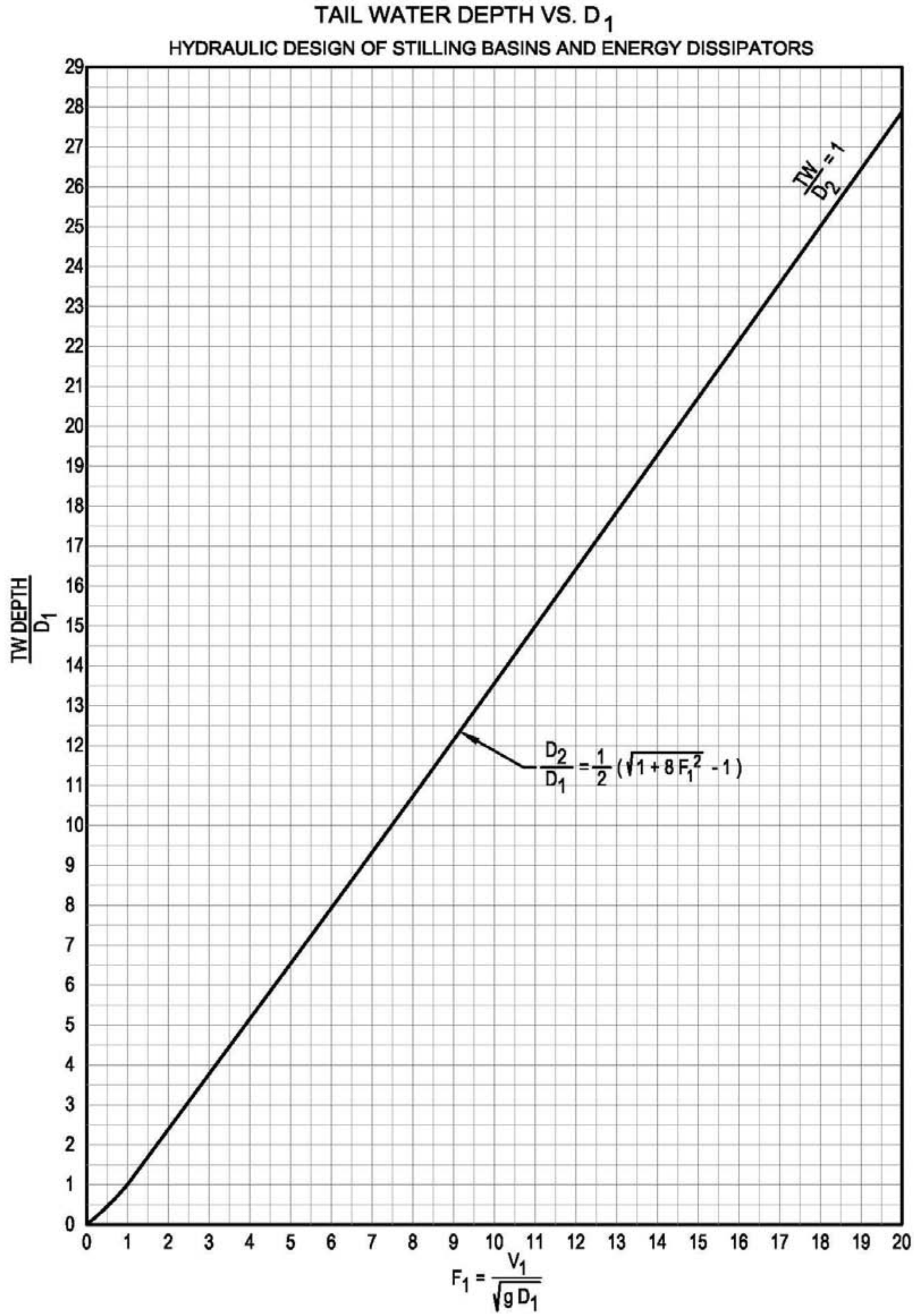


FIGURE5. - RATIO OF TAIL WATER DEPTH TO D_1 (BASIN I)

PLATE 22.3 E-1

LENGTH OF JUMP IN TERMS OF D_1

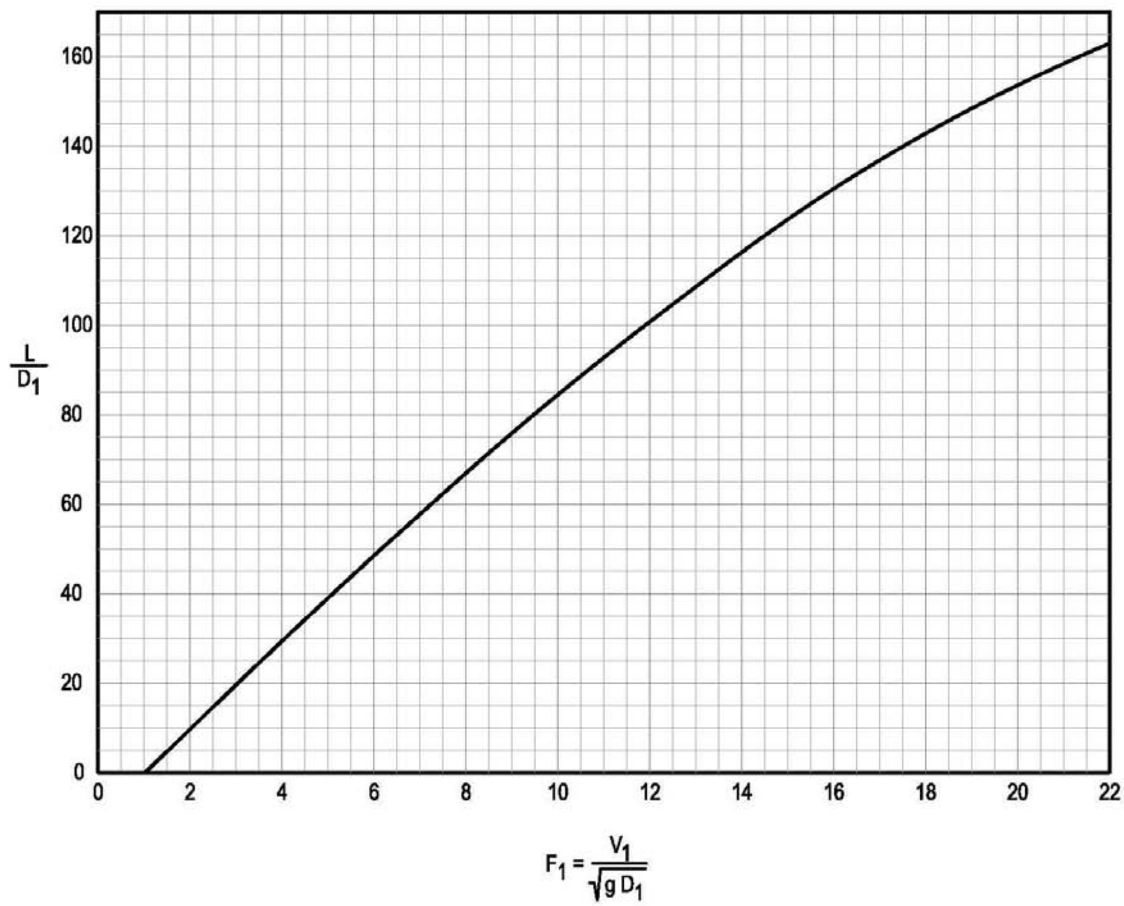


FIGURE 6. - LENGTH OF JUMP IN TERMS OF D_1 (BASIN I)

PLATE 22.3 E-2

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 rip-rapped 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 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

   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

   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

   Berms and levees must be provided with freeboard for the 100-year design flow based on the following guidelines:

   a. For flow depths less than 3.0 feet and not involving a major arroyo; minimum freeboard is 2.0 feet.

b. For flow depths 3.0 feet and greater and, involving a major arroyo; minimum freeboard is 3.0 feet.

c. 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

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:

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

b. 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.

c. 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.).

d. 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/SSCAFCA 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.*

G. Miscellaneous Hydraulic Calculations

1. Hydraulic Jump

a. Location

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.

b. Length

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 D_1 and D_2 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

2. Trashrack Head Loss

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

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

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

where K_{TR} = Trashrack coefficient

A_n = Net area through bars, in ft.^{2}

A_g = Gross area of trashrack and supports (water area without trashrack 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. Side Channel Weirs:

The Los Angeles District Corps of Engineers, as mentioned in Section C-2.5, has developed a side channel spillway inlet. The City or SSCAFCA may require this type of structure for drains outletting into their facilities. The Corps' procedure for designing a side channel spillway is as follows:

a. 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.

b. 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.

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

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

c. Determine the depth of flow in the approach side channel at the upstream end of the spillway.

d. 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 c., above, minus the assumed head on the spillway.

e. Set the side channel invert slope equal to the spillway and the main channel water-surface slopes.

f. 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).

g. 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.

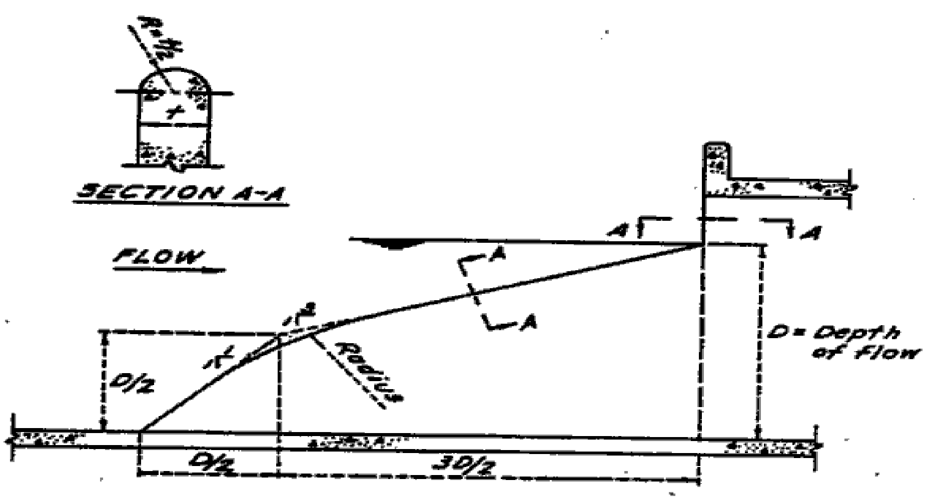
h. If the length between the assumed point at the upstream end of the spillway and this intersection point is equal to the length determined in b., above, the angle at the intersection indicates the required convergence for the side channel.

i. 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.

4. *Pier Extensions:*

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

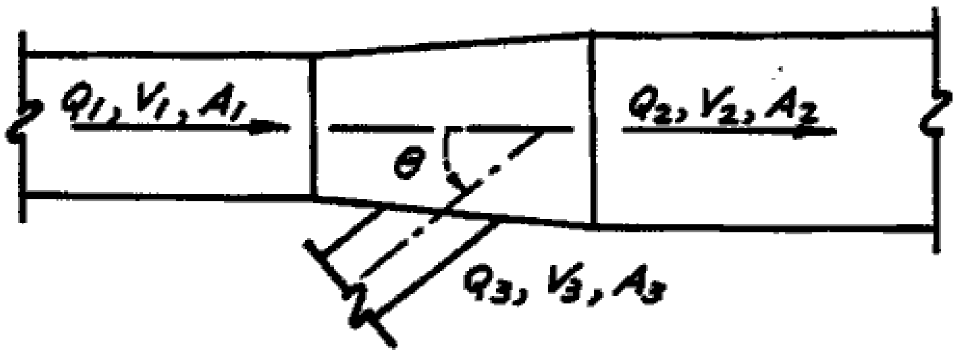
In supercritical flow the addition of a specified width to account for the assumed amount of debris may result in impractical and costly structures. In lieu of assuming additional pier width for debris, the use of streamline pier extensions should be investigated. Unless an unusual quantity of debris 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.



5. Junctions

a. Thompson Equation

The Thompson Equation for junctions is described by the following:



$$\Delta y \cdot A_{avg.} = \frac{Q_2 V_2 - Q_1 V_1 - Q_3 V_3 \cos\theta}{g}$$

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

A_{avg} = average area, in feet^2 = 1/6 ($A_1 + 4A_m + A_2$) or, for practical use 1/2 ($A_1 + A_2$)

A_m = mean area of flow, in feet^2

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 the Los Angeles County Flood Control District Hydraulic Design Manual, March 1982.

In the following compilations:

a. "w", the unit weight of water, has been omitted since it appears in all terms.

b. 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:

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

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$\overline{y}$

$\overline{y}$ = distance to centroid from water surface

$$M = \frac{Q^2}{g*A}$$

CASE 1. OPEN TRAPEZOIDAL CHANNEL

$$M_1 = \frac{Q_1^2}{(b_1 + z_1 D_1)\, g D_1}$$

$$M_2 = \frac{Q_2^2}{(b_2 + z_2 D_2)\, g D_2}$$

$$M_3 \cos \theta = \frac{(Q_2 - Q_1)^2}{A_3 g} (\cos \theta) \qquad \text{where } A_3 = \text{water area at section 3}$$

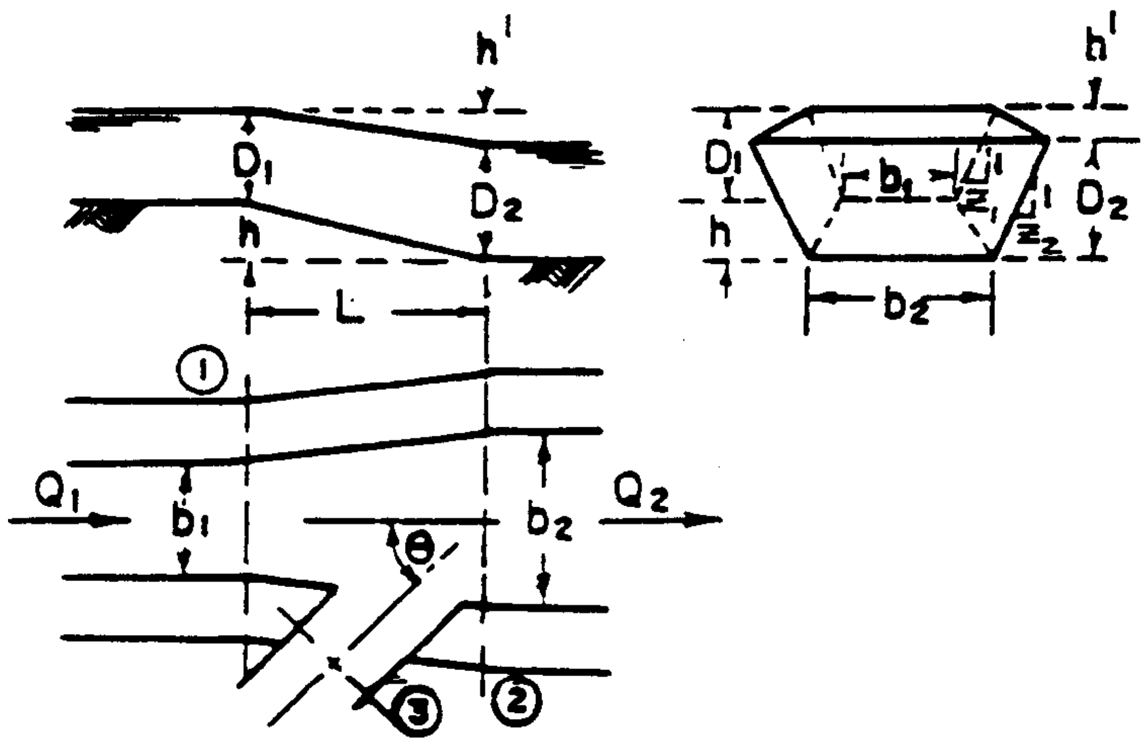
$$P_1 = \frac{D_1^2}{6} \cdot (3b_1 + 2z_1 D_1)$$

$$P_2 = \frac{D_2^2}{6} \cdot (3b_2 + 2z_2 D_2)$$

$$P_i = \left(\frac{b_1 + b_2}{2}\right) h \left[D_1 + \frac{(D_2 - D_1)(b_1 + 2b_2)}{3(b_1 + b_2)} \right]$$

$$P_w = \frac{D_1 + D_2}{4} \left[\frac{b_1 + b_2}{2} (D_1 - D_2) + h' (z_1 D_1 + z_2 D_2) + (b_2 + z_2 D_2) D_2 - (b_1 + z_1 D_1) D_1 \right]$$

$$P_f = \frac{L(s_1 + s_2)}{4} \left[(b_1 + z_1 D_1) D_1 + (b_2 + z_2 D_2) D_2 \right]$$



CASE 2. OPEN RECTANGULAR CHANNEL

$$M_1 = \frac{Q_1^2}{b_1 D_1 g}$$

$$M_2 = \frac{Q_2^2}{b_2 D_2 g}$$

$$M_3 \cos\theta = \frac{(Q_2 - Q_1)^2}{A_3\, g}(\cos\theta)$$

$$P_1 = \frac{b_1 D_1^2}{2}$$

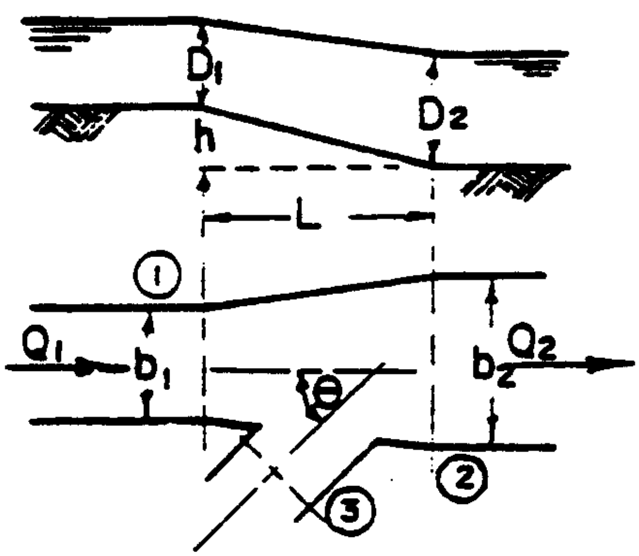
Where A_3 = water area at section 3

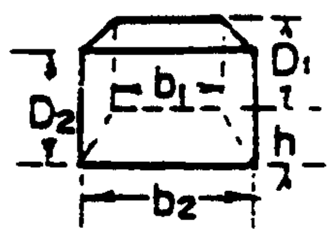
$$P_2 = \frac{b_2 D_2^2}{2}$$

$$P_i = \left(\frac{b_1 + b_2}{2}\right) h \left[D_1 + \frac{(D_2 - D_1)(b_1 + 2b_2)}{3(b_1 + b_2)}\right]$$

$$P_w = \frac{D_1 + D_2}{4}(b_2 - b_1)\left[D_1 + \frac{(D_2 - D_1)(D_1 + 2D_2)}{3(D_1 + D_2)}\right]$$

$$P_f = \frac{L(s_1 + s_2)}{4} \cdot (b_1 D_1 + b_2 D_2)$$





CASE 3. RECTANGULAR BOX UNDER PRESSURE

$$M_1 = \frac{Q_1^2}{b_1 d_1 g}$$

Where A_3 = water area at section 3

$$M_2 = \frac{Q_2^2}{b_2 d_2 g}$$

$$M_3 \cos\theta = \frac{(Q_2 - Q_1)^2}{A_3\, g}(\cos\theta)$$

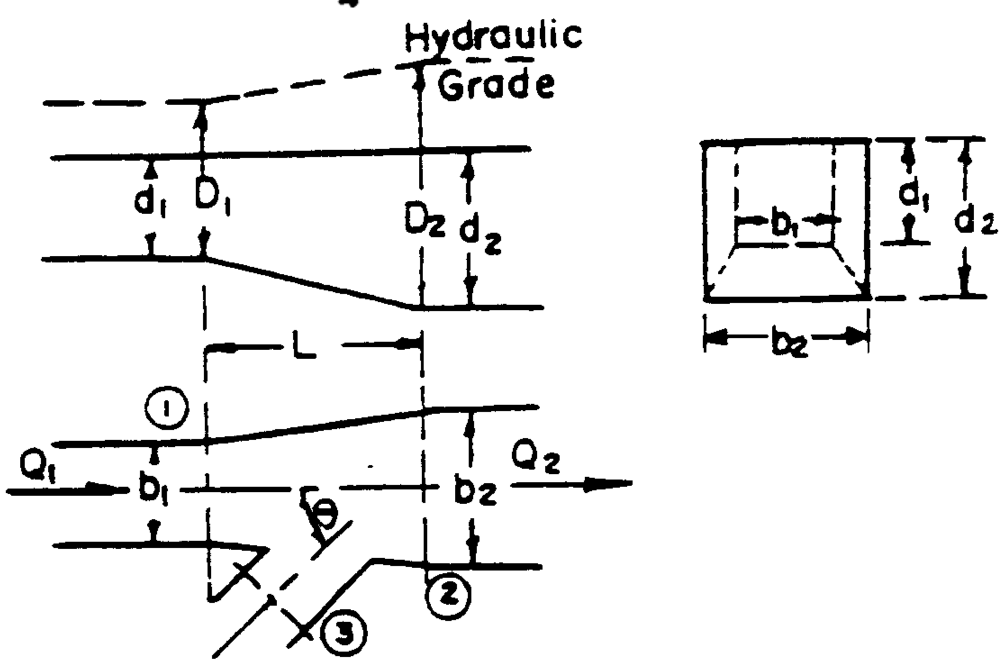
$$P_1 = b_1 d_1\left(D_1 - \frac{d_1}{2}\right)$$

$$P_2 = b_2 d_2\left(D_2 - \frac{d_2}{2}\right)$$

$$P_i = \frac{b_1 + b_2}{2}\ (d_2 - d_1)\left[D_1 + \frac{(D_2 - D_1)\ (b_1 + 2b_2)}{3(b_1 + b_2)}\right]$$

$$P_w = \frac{d_1 + d_2}{4}\ (b_2 - b_1)\left[D_1 + D_2 - \frac{d_1 + d_2}{2}\right]$$

$$P_f = \frac{L(s_1 + s_2)}{4}\ (b_1 d_1 + b_2 d_2), \ldots \text{where } s = \left[\frac{Qn(b+d)^{2/3}}{.936(bd)^{5/3}}\right]^2$$



CASE 4. CIRCULAR CONDUIT UNDER PRESSURE, PIPE INLET

$$M_1 = \frac{Q_1^2}{25.2\ d_1^2}$$

$$M_2 = \frac{Q_2^2}{25.2\ d_2^2}$$

$$M_3 \cos\theta = \frac{(Q_2 - Q_1)^2}{25.2\ d_3^2}\ (\cos\theta)$$

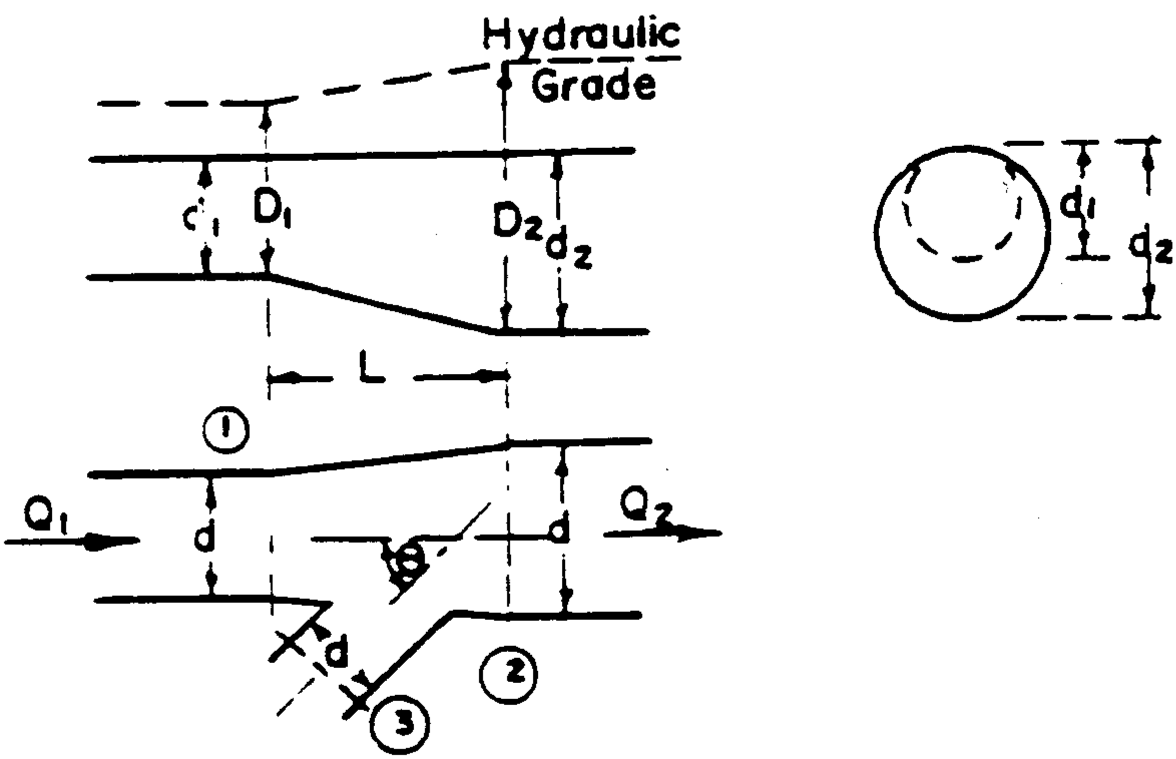
$$P_1 = .784\ d_1^2\ (D_1 - \frac{d_1}{2})$$

$$P_2 = .784\ d_2^2\ (D_2 - \frac{d_2}{2})$$

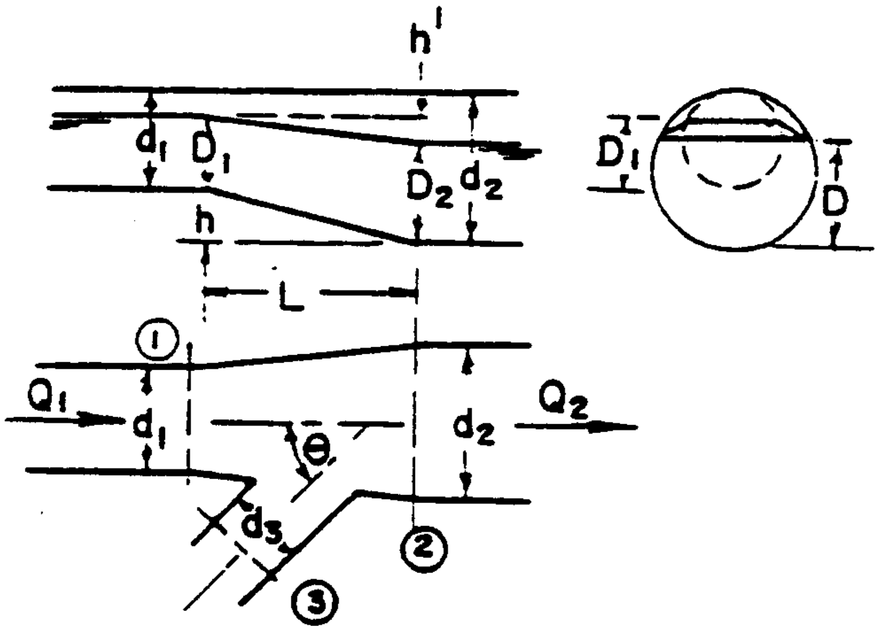
$$P_i = 0$$

$$P_w = .392\left[(d_2^3 - d_1^3) + (d_2^2 - d_1^2)(D_1 + D_2 - d_1 - d_2)\right]$$

$$P_f = .196\ L(s_1 + s_2)\ (d_1^2 + d_2^2), \ldots \text{ where } s = \left(\frac{Qn}{.463\ d^{8/3}}\right)^2$$



CASE 5. CIRCULAR CONDUIT FLOWING PARTIALLY FULL, PIPE INLET



$$M_1 = K_1 \left(\frac{Q_1}{d_1}\right)^2$$

$$M_2 = K_2 \left(\frac{Q_2}{d_2}\right)^2$$

$$M_3 \cos \theta = \frac{(Q_2 - Q_1)^2}{25.2\, d_3^2} (\cos \theta)$$

$$P_1 = C_1\, d_1^3$$

$$P_2 = C_2\, d_2^3$$

$$P_i = o$$

$$^{*}P_w = A_2\bar{y}_2 - A_1\bar{y}_1 + \frac{h'}{2} (A_2 + A_1) + \frac{(h')^2}{12} (T_2 - T_1)$$

$$P_f = \frac{L(s_1 + s_2)}{4} (A_1 + A_2)$$

*WHERE $h' = h + D_1 - D_2$, THE TERM $\frac{(h')^2}{12} (T_2 - T_1)$ IS USUALLY NEGLIGIBLE.

Los Angeles County Flood Control District

FACTORS FOR CIRCULAR CONDUITS FLOWING PARTLY FULL

D = depth of water
d = diameter of conduit

Tabulated Values

$K = \frac{\text{momentum}}{(Q/d)^2}$ $C = \frac{\text{Pressure}}{d^3}$ $F = \frac{\text{Velocity Head}}{(Q/d^2)^2}$

D/d	K	C	F	D/d	K	C	F	D/d	K	C	F	D/d	K	C	F
.00	∞	.0000	∞	.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	.1042	.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	.0307
.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	.2938	.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	.3233	.0276
.17	0.351	.0061	1.982	.42	.0993	.0551	.1585	.67	.0559	.1644	.0496	.92	.0411	.3308	.0272
.18	0.324	.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

F - 03

b. Oblique Waves

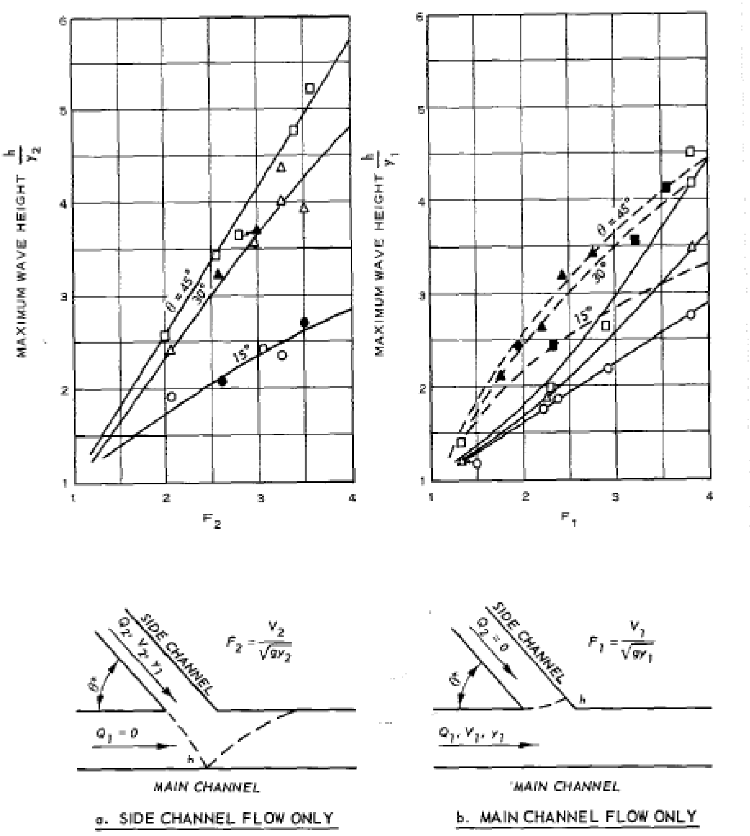
When evaluating junctions, refer to EM 1110-2-1601, Hydraulic Design of Flood Control Channels, 1994 edition, U.S. Army Corps of Engineers for the appropriate methodology. One of the methods from this reference, Plate B-54, is included on the following page.

c. Example Problems

For Implementation of the Thompson equation, please refer to example problems 1 through 6 at the end of this section.

For additional examples and information about junction evaluation, refer to the Los Angeles County Flood Control District Hydraulic Design Manual, March 1982, or to the Office Standard No. 115, Hydraulic Analysis of Junctions, 1968 edition, Storm Drain Design Division, Bureau of Engineering, City of Los Angeles.

*



FOR DESIGN PURPOSES θ SHOULD NOT BE GREATER THAN 12 DEG

NOTE: 1. DATA AND CURVES BASED ON FIGURES 10-12, BEHLKE AND PRITCHETT (1966).

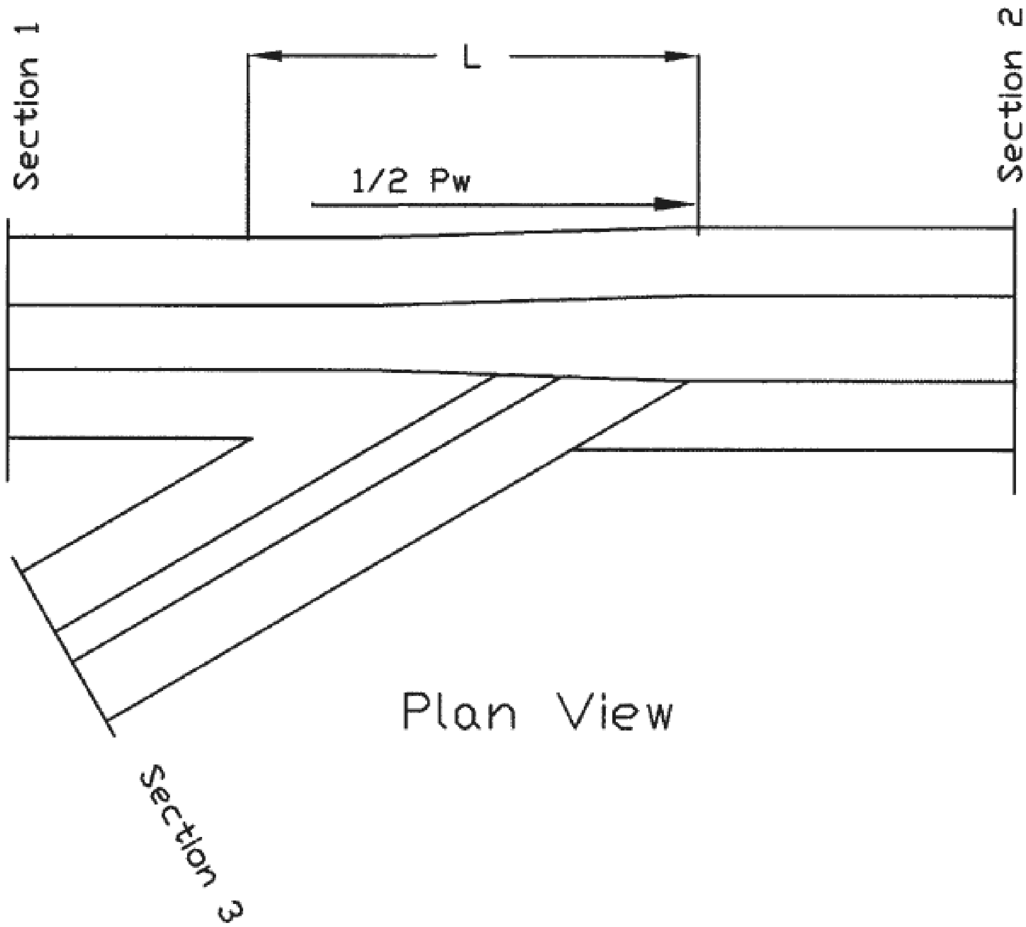
2. □ ○ △ TRAPEZOIDAL CHANNELS
■ ● ▲ RECTANGULAR CHANNELS

**MAXIMUM WAVE HEIGHT
CHANNEL JUNCTION**

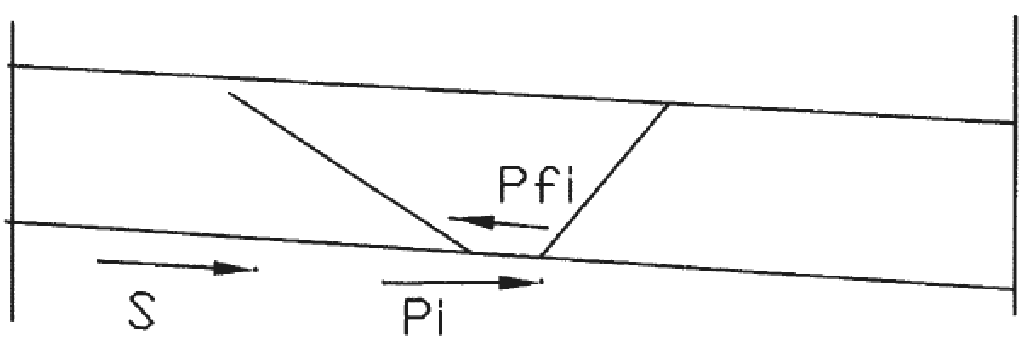
Plate B-54

*

Example Problems 1 - 3
Trapezoidal Junction
With Trapezoidal Side Inlet



Plan View



Profile View

Example Problem # 1

Junction Side flow Less than 10%

Supercritical Trapezoidal Channel with Trapezoidal Side Inlet

Stable Junction

Upsteam Channel			Downstream Channel			Side Channel Outlet		
Section 1			Section 2			Section 3		
Q1=	1,994.0	cfs	Q2=	2,144.0	cfs	Q3=	150	cfs
b1=	15.0	ft.	b2=	15.0	ft.	B3=	5	ft.
SS =	2.0	H:V	SS=	2.0	H:V	SS=	2	H:V
Dn=	3.5	ft.				Dn=	2	ft.
Dc=	6.2	ft.				Angle=	30	deg.
S1=	2.0%		S2=	2%		S inJunc.	2.0%	
D1=	3.5	ft.	D2 =	?	ft.	L=	50	ft.
Fr. 1	2.8					Area=	18	sq. ft.
						Fr.3	1.2	
						Chan S=	0.5%	

Eq. P2 + M2 = P1 + M1 + M3cosΘ + Pw + Pi - Pf

Rearrange and place P2 and M2 on right side to solve near zero difference.

Pi = Longitudinal Component of invert pressure, cubic feet.

Pw = Longitudinal Component of wall pressure, cubic feet.

Fr = Froude Number

Assume the slope through junction

F2 = M2 + P2

F1 = M1 + P1

Pi = Longitudinal Component of invert pressure, cubic feet.

Pw = Longitudinal Component of wall pressure, cubic feet.

Pf = loss due to friction, cubic feet.

Iterate for D2

Trial No.	D2 ft.	F1 cu. ft.	F2 cu. ft.	Pw cu. ft.	M3CosΘ cu. ft.	Pi cu. ft.	Fr. 2	Pf cu. ft.	Convergence Difference	
1	4.0	1,724.1	1714.4	28.1	33.6	56.3	2.4	84.5	43	
2	3.9	1,724.1	1759.1	27.4	33.6	55.5	2.5	83.0	-1	Convergence
3	3.8	1,724.1	1807.2	26.6	33.6	54.8	2.6	81.4	-49	
4	3.7	1,724.1	1858.9	25.9	33.6	54.0	2.7	79.9	-101	

Check Oblique Wave potential due to Side Junction Angle using EM 1110-2-1601, Plate B-54.

With Main Channel Flow & Side Flow Zero, oblique wave potential is 2.7*3.9 = 10.5'

For design, address wall height and freeboard or try different geometry to reduce wave ht.

With Main Flow zero & full side channel flow, minimal oblique wave potential due to low Froude Number

Example Problem # 2

Side flow Greater than 10% (approx. 20%)

Supercritical Trapezoidal Channel with Trap Side Inlet

Unstable, Junction creates hydraulic jump

Upsteam Channel Section 1			Downstream Channel Section 2			Side Channel Outlet Section 3		
Q1=	1,994.0	cfs	Q2=	2,394.0	cfs	Q3=	400	cfs
b1=	15.0	ft.	b2=	15.0	ft.	B3=	20	ft.
SS =	2.0	H:V	SS=	2.0	H:V	SS=	2	H:V
Dn=	5.1	ft.				Dn=	2.8	ft.
Dc=	6.2	ft.				Angle=	45	degrees
S1=	0.5%		S2=	0.5%		S inJunc.	0.5%	
D1=	5.1	ft.	D2 =	?	ft.	L=	50	ft.
Fr. 1	1.4					Area=	29.7	sq. ft.
						Fr.3	1.9	
						Chan S=	1.0%	

Eq. P2 + M2 = P1 + M1 + M3cosΘ + Pw + Pi - Pf

Rearrange and place P2 and M2 on right side to solve near zero difference.

Fr. = Froude Number

Assume the slope through junction

F2 = M2 + P2

F1 = M1 + P1

Pi = Longitudinal Component of invert pressure, cubic feet.

Pw = Longitudinal Component of wall pressure, cubic feet.

Pf = loss due to friction, cubic feet.

Iterate for D2

Trial No.	D2 ft.	F1 cu. ft.	F2 cu. ft.	Pw cu. ft.	M3CosΘ cu. ft.	Pi cu. ft.	Fr. 2	Pf cu. ft.	Convergence Difference	
1	5.5	1,244.3	1582.5	22.5	118.3	19.9	1.50	33.9	-211.5	
2	6.0	1,244.3	1512.7	55.4	118.3	20.8	1.28	36.3	-110.2	
3	6.5	1,244.3	1477.9	94.2	118.3	21.8	1.10	38.8	-38.2	
4	6.9	1,244.3	1471.8	129.6	118.3	22.5	0.98	40.9	2.0	Unstable

Check Oblique Wave potential due to Side Angle using EM 1110-2-1601

Convergence at 6.9' however Froude No. is 1 which is in unstable zone. No solution possible.

Example Problem # 3

Side flow Greater than 10% (approx. 30%)

Supercritical Trapezoidal Channel with Trap Side Inlet

Adjust Example 2 to avoid hydraulic jump

Upsteam Channel Section 1			Downstream Channel Section 2			Side Channel Outlet Section 3		
Q1=	1,994.0	cfs	Q2=	2,394.0	cfs	Q3=	400	cfs
b1=	15.0	ft.	b2=	20.0	ft.	B3=	20	ft.
SS =	2.0	H:V	SS=	2.0	H:V	SS=	2	H:V
Dn=	5.1	ft.	Dn=		ft.	Dn=	2.8	ft.
Dc=	6.2	ft.	Dc=		ft.	Angle=	12	deg.
S1=	0.5%		S2=	1%		S inJunc.	2.0%	
D1=	5.1	ft.	D2 =	?	ft.	L=	50	ft.
Fr. 1	1.4					Area=	29.7	sq. ft.
						Fr.3	1.9	
						Chan S=	1.0%	

Eq. P2 + M2 = P1 + M1 + M3cosΘ + Pw + Pi - Pf

Rearrange and place P2 and M2 on right side to solve near zero difference.

Fr. = Froude Number

Assume the slope through junction

F2 = M2 + P2

F1 = M1 + P1

Pi = Longitudinal Component of invert pressure, cubic feet.

Pw = Longitudinal Component of wall pressure, cubic feet.

Pf = loss due to friction, cubic feet.

Iterate for D2

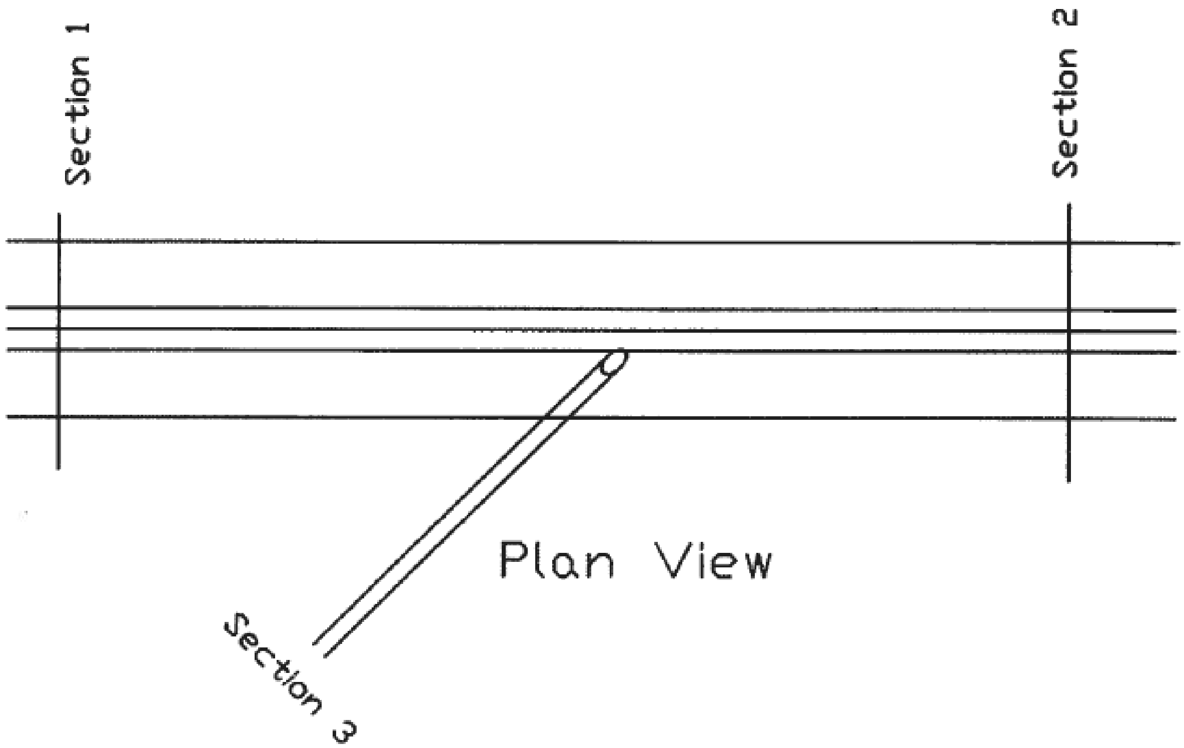
Trial No.	D2 ft.	F1 cu. ft.	F2 cu. ft.	Pw cu. ft.	M3CosΘ cu. ft.	Pi cu. ft.	Fr. 2	Pf cu. ft.	Convergence Difference	
1	5.1	1,244.3	1504.2	117.0	163.6	89.3	1.4	53.0	57.1	
2	4.9	1,244.3	1537.5	112.5	163.6	87.4	1.5	51.5	18.9	
3	4.8	1,244.3	1556.9	110.3	163.6	86.5	1.6	50.7	-2.9	Converges

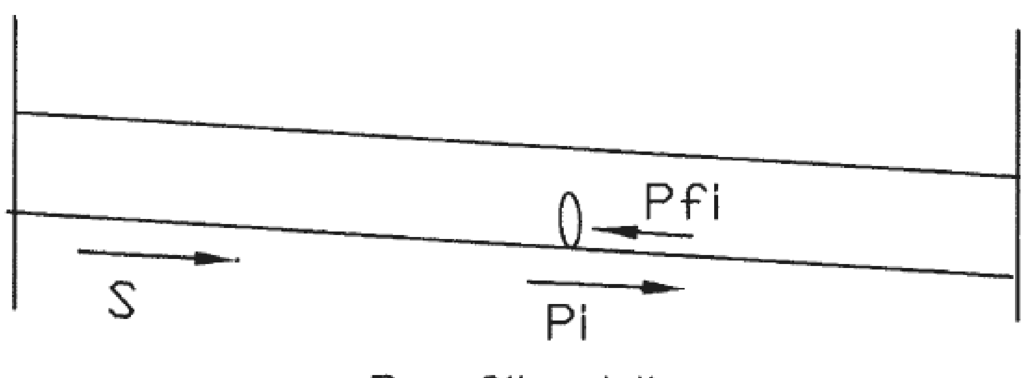
Check Oblique Wave potential due to Side Angle using EM 1110-2-1601

With Side Flow zero oblique wave potential is 1.2*4.8 = 6.1'

With Main Flow zero oblique wave potential is 1.8*2.8 = 5.0'

Example Problems 4 - 6
Trapezoidal Junction
With Pipe Side Inlet





Example Problem # 4											
Side flow Greater less than 10%											
Supercritical Trapezoidal Channel with Pipe Inlet											
Stable Junction											

Upsteam Channel Section 1			**Downstream Channel Section 2**			**Pipe Outlet Section 3**		
Q1=	1,340.0	cfs	Q2=	1,470.0	cfs	Q3=	130	cfs
b1=	10.0	ft.	b2=	10.0	ft.	Dia.=	48	in.
SS =	2.0	H:V	SS=	2.0	H:V			
Dn=	3.6	ft.						
Dc=	5.6	ft.				Angle=	45	deg.
S1=	1.5%		S2=	2%		S inJunc.	0.5%	
D1=	3.6	ft.	D2 =	?	ft.	L=	12	ft.
Fr. 1	2.4					Area=	12.57	sq. ft.
						Pipe S=	0.8%	

Eq. P2 + M2 = P1 + M1 + M3cosΘ + Pw + Pi - Pf

Rearrange and place P2 and M2 on right side to solve near zero difference.

Fr. = Froude Number

Pipe flowing full

F2 = M2 + P2

F1 = M1 + P1

Pi = Longitudinal Component of invert pressure, cubic feet.

Pw = Longitudinal Component of wall pressure, cubic feet.

Pf = loss due to friction, cubic feet.

Iterate for D2

Trial No.	D2 ft.	F1 cu. ft.	F2 cu. ft.	Pw cu. ft.	M3CosΘ cu. ft.	Pi cu. ft.	Fr. 2	Pf cu. ft.	Convergence Difference	
1	3.5	996.5	1217.7	1.5	29.5	3.2	2.7	16.5	-203	
2	4.0	996.5	1054.7	11.6	29.5	3.4	2.1	18.1	-32	
3	4.1	996.5	1029.3	14.8	29.5	3.5	2.0	18.4	-3	Convergence

Check Oblique Wave potential due to Side Angle using EM 1110-2-1601 - Plate B-54

With Side Flow = 0, oblique wave ht. potential is 4.1*1.7 = 7' (conservative as Plate does not exactly apply).

Example Problem # 5

Side flow Greater than 10% (approx. 30%)

Supercritical Trapezoidal Channel with Pipe Inlet

Unstable Junction

Upsteam Channel			Downstream Channel			Pipe Outlet		
Section 1			Section 2			Section 3		
Q1=	1,340.0	cfs	Q2=	1,589.0	cfs	Q3=	249	cfs
b1=	10.0	ft.	b2=	10.0	ft.	Dia.=	48	in.
SS =	2.0	H:V	SS=	2.0	H:V			
Dn=	4.8	ft.	Dn=		ft.			
Dc=	5.7	ft.	Dc=		ft.	Angle=	45	deg.
S1=	0.5%		S2=	0.5%		S inJunc.	0.5%	
D1=	4.8	ft.	D2 =	?	ft.	L=	12	ft.
Fr. 1	1.4					Area=	12.57	sq. ft.
						Chan S=	3.0%	

Eq. P2 + M2 = P1 + M1 + M3cosΘ + Pw + Pi - Pf

Rearrance and place P2 and M2 on right side to solve near zero difference.

Fr. = Froude Number

Pipe flowing full.

F2 = M2 + P2

F1 = M1 + P1

Pi = Longitudinal Component of invert pressure, cubic feet.

Pw = Longitudinal Component of wall pressure, cubic feet.

Pf = loss due to friction, cubic feet.

Iterate for D2

Trial No.	D2 ft.	F1 cu. ft.	F2 cu. ft.	Pw cu. ft.	M3CosΘ cu. ft.	Pi cu. ft.	Fr. 2	Pf cu. ft.	Convergence Difference
1	5.0	781.7	992.5	0.0	108.3	4.4	1.5	7.3	-105
2	5.5	781.7	941.1	0.0	108.3	4.6	1.2	7.8	-54
3	6.0	781.7	918.0	0.0	108.3	4.9	1.0	8.4	-32
4	6.5	781.7	918.8	0.0	108.3	5.1	0.9	9.0	-33

No convergence - hydraulic jump will occur - junction will not remian supercritical

Example Problem # 6										
Side flow Greater than 10% (approx. 20%)										
Supercritical Trapezoidal Channel with Pipe Side Inlet										
Example Problem #5 Revised for Stability										
Upsteam Channel			**Downstream Channel**			**Pipe Outlet**				
Section 1			**Section 2**			**Section 3**				
Q1=	1,340.0	cfs	Q2=	1,589.0	cfs	Q3=	249	cfs		
b1=	10.0	ft.	b2=	10.0	ft.	Dia.=	48	in.		
SS =	2.0	H:V	SS=	2.0	H:V					
Dn=	4.8	ft.								
Dc=	6.0	ft.				Angle=	30	deg.		
S1=	0.5%		S2=	0.5%		S inJunc.	5.0%			
D1=	5.1	ft.	D2 =	?	ft.	L=	20	ft.		
Fr. 1	1.4					Area=	12.57	sq. ft.		
						Pipe S=	3.0%			

Eq. $P2 + M2 = P1 + M1 + M3\cos\Theta + Pw + Pi - Pf$

Rearrange and place P2 and M2 on right side to solve near zero difference.

Fr. = Froude Number

Pipe flowing full

$F2 = M2 + P2$

$F1 = M1 + P1$

Pi = Longitudinal Component of invert pressure, cubic feet.

Pw = Longitudinal Component of wall pressure, cubic feet.

Pf = loss due to friction, cubic feet.

Iterate for D2

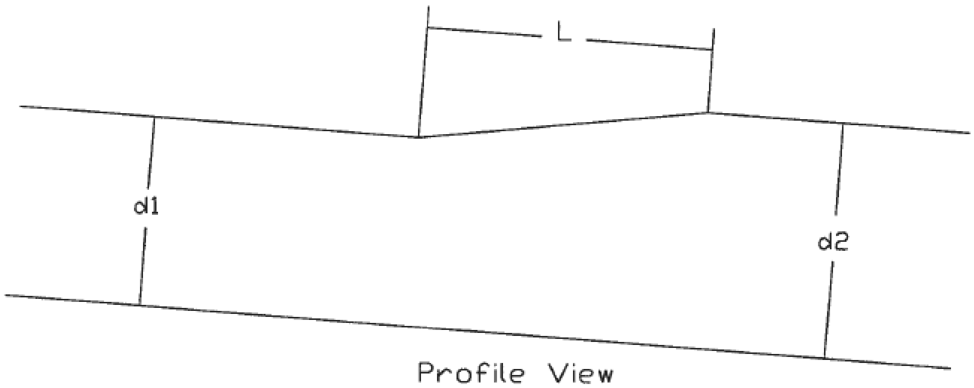
Trial No.	D2 ft.	F1 cu. ft.	F2 cu. ft.	Pw cu. ft.	M3CosΘ cu. ft.	Pi cu. ft.	Fr. 2	Pf cu. ft.	Convergence Difference	
1	4.8	759.8	1022.4	49.0	132.7	74.3	1.6	12.3	-19	
2	4.9	759.8	1006.7	19.4	132.7	75.0	1.5	10.1	-30	
3	5.0	759.8	992.5	22.7	132.7	75.8	1.5	10.2	-12	
4	5.1	759.8	979.6	26.0	132.7	76.5	1.4	10.3	5	Convergence

Check Oblique Wave potential due to Side Angle using EM 1110-2-1601, Plate B-54

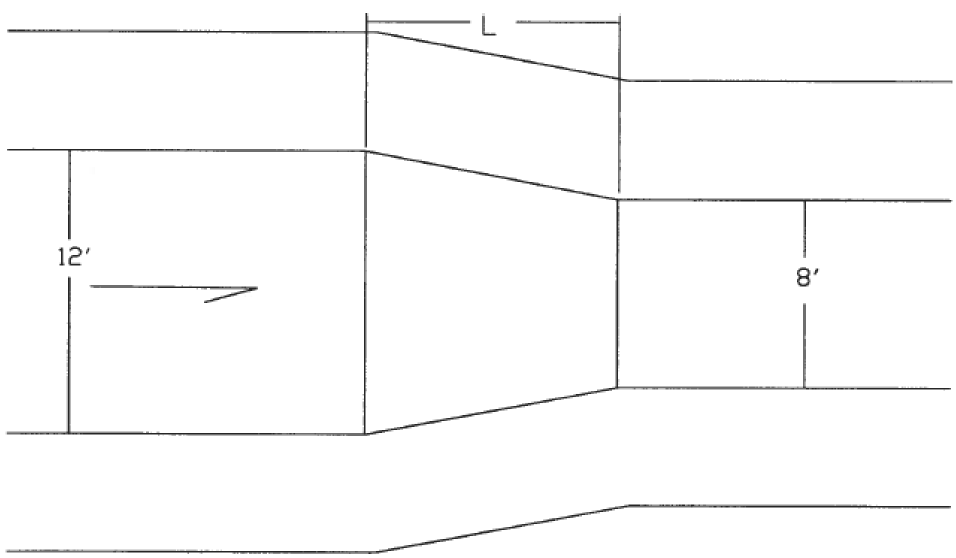
With Side Flow = 0, oblique wave ht. potential is 4.1*1.7 = 7' (conservative as Plate does not exactly apply).

With Main Flow zero, oblique wave potential 3.1*2.3 = 7.1' (estimate based on equivalent channel)

Example Problem 7
Supercritical Flow Transition



Profile View



Plan View

Q = 200 cfs
Slope = 1 %

2:1 side slopes
n= 0.015

Determine the minimum length L to ensure that a hydraulic jump does not occur through the transition and that the transition angle is small enough so that oblique waves are negligible.

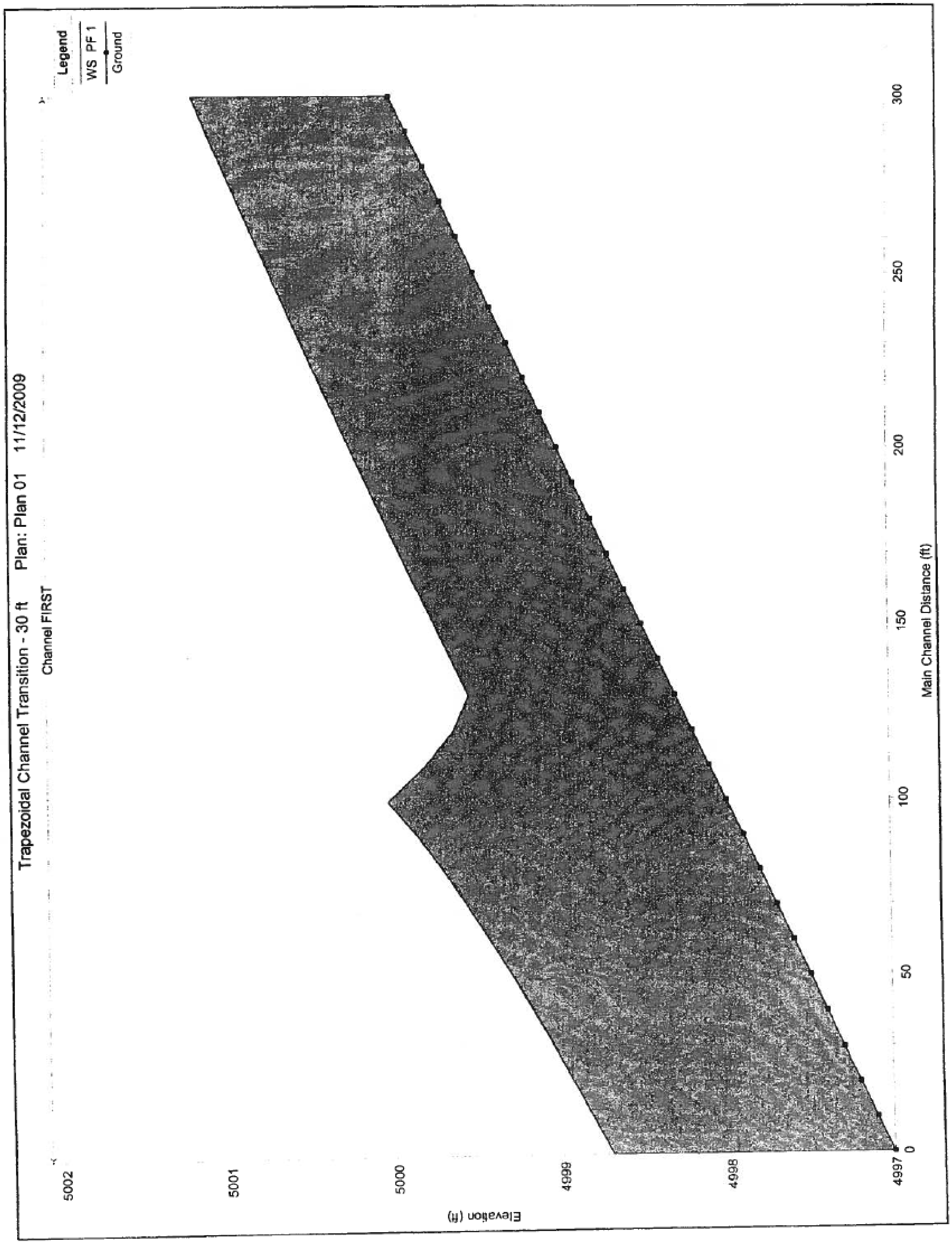
Example 7

HEC-RAS Run

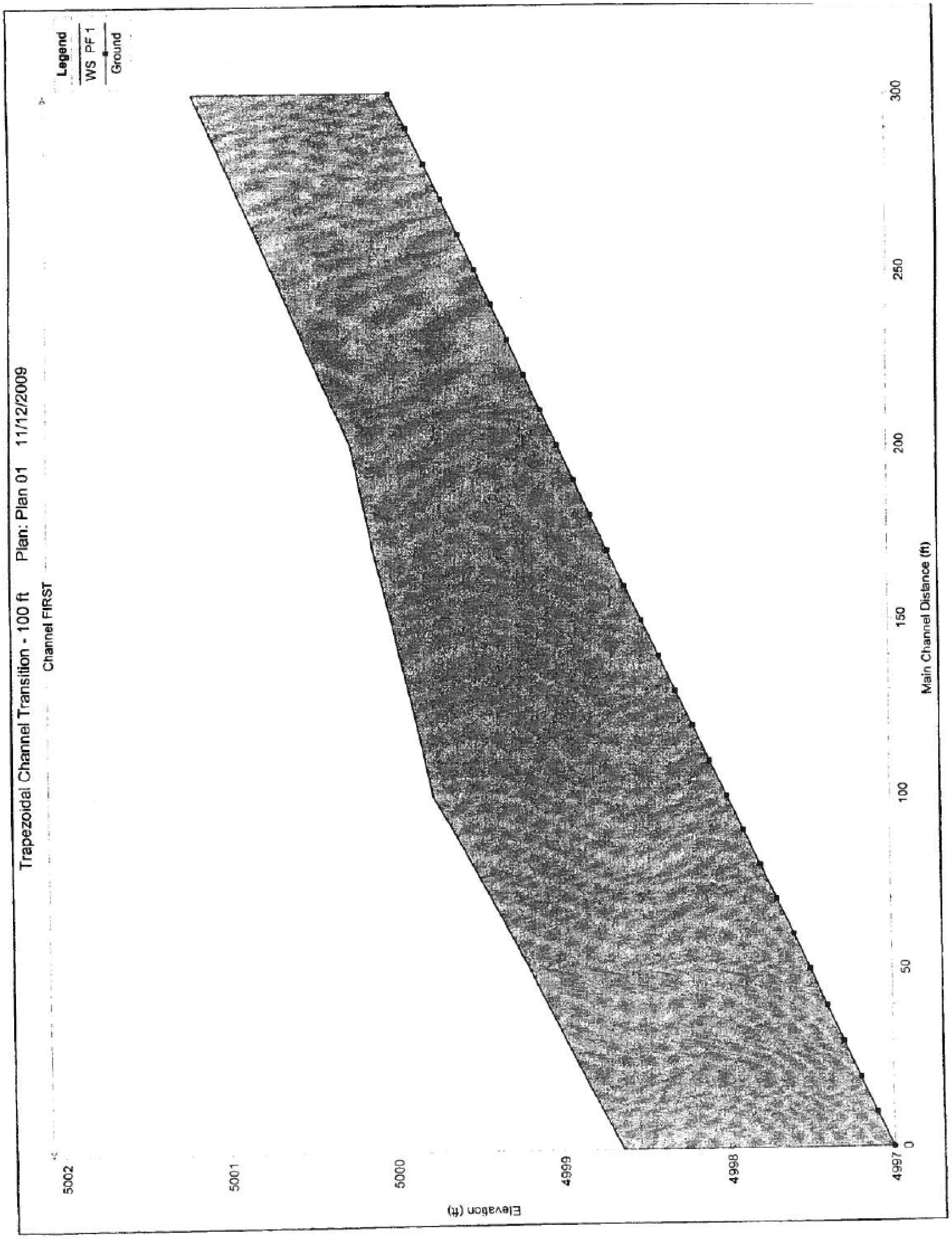
Bottom Width Transition 12' to 8'

30' Transition from Sta. 200 to Sta. 230

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude No.
400	200	5000.00	5001.18	5001.88	5003.49	0.01	12.64	16.99	16.73	2.05
390	200	4999.90	5001.10	5001.78	5003.35	0.01	12.49	17.19	16.78	2.01
380	200	4999.80	5001.00	5001.68	5003.22	0.01	12.38	17.36	16.82	1.99
370	200	4999.70	5000.91	5001.58	5003.09	0.01	12.28	17.51	16.85	1.97
360	200	4999.60	5000.82	5001.48	5002.98	0.01	12.23	17.59	16.87	1.95
350	200	4999.50	5000.72	5001.38	5002.86	0.01	12.17	17.67	16.89	1.94
340	200	4999.40	5000.63	5001.28	5002.75	0.01	12.13	17.74	16.91	1.93
330	200	4999.30	5000.53	5001.18	5002.64	0.01	12.08	17.81	16.93	1.92
320	200	4999.20	5000.44	5001.08	5002.53	0.01	12.04	17.88	16.94	1.91
310	200	4999.10	5000.34	5000.98	5002.42	0.01	12.00	17.93	16.96	1.9
300	200	4999.00	5000.24	5000.88	5002.31	0.01	11.97	17.98	16.97	1.89
290	200	4998.90	5000.14	5000.78	5002.21	0.01	11.97	17.98	16.97	1.89
280	200	4998.80	5000.04	5000.68	5002.11	0.01	11.97	17.98	16.97	1.89
270	200	4998.70	4999.94	5000.58	5002.01	0.01	11.97	17.98	16.97	1.89
260	200	4998.60	4999.84	5000.48	5001.91	0.01	11.97	17.98	16.97	1.89
250	200	4998.50	4999.74	5000.38	5001.81	0.01	11.97	17.98	16.97	1.89
240	200	4998.40	4999.64	5000.28	5001.71	0.01	11.97	17.98	16.97	1.89
230	200	4998.30	4999.54	5000.18	5001.61	0.01	11.97	17.98	16.97	1.89
220	200	4998.20	4999.63	5000.19	5001.44	0.01	11.30	19.40	16.40	1.66
210	200	4998.10	4999.81	5000.23	5001.28	0.01	10.35	21.73	16.16	1.4
200	200	4998.00	5000.03	5000.28	5001.22	0.00	9.51	24.45	16.11	1.18
190	200	4997.90	4999.85	5000.18	5001.17	0.00	9.97	23.22	15.80	1.26
180	200	4997.80	4999.70	5000.08	5001.11	0.00	10.32	22.37	15.59	1.32
170	200	4997.70	4999.56	4999.98	5001.06	0.01	10.60	21.73	15.42	1.37
160	200	4997.60	4999.42	4999.88	5000.99	0.01	10.84	21.20	15.29	1.42
150	200	4997.50	4999.29	4999.78	5000.93	0.01	11.06	20.75	15.17	1.46
140	200	4997.40	4999.17	4999.68	5000.87	0.01	11.25	20.37	15.06	1.49
130	200	4997.30	4999.04	4999.58	5000.80	0.01	11.44	19.99	14.96	1.53
120	200	4997.20	4998.93	4999.48	5000.73	0.01	11.55	19.79	14.91	1.55
110	200	4997.10	4998.81	4999.38	5000.65	0.01	11.66	19.59	14.86	1.57
100	200	4997.00	4998.70	4999.28	5000.57	0.01	11.77	19.40	14.80	1.59


Trapezoidal Channel Transition - 30 ft Plan: Plan 01 11/12/2009
Channel FIRST
Legend
WS PF 1
Ground
Elevation (ft)
5002
5001
5000
4999
4998
4997
Main Channel Distance (ft)
0
50
100
150
200
250
300

Example 7										
HEC-RAS Run										
Trapazoid, 2:1 SS, Bottom Width Transition 12' to 8'										
100' Transition from Sta. 200 to Sta. 300										
River Sta	**Q Total**	**Min Ch El**	**W.S. Elev**	**Crit W.S.**	**E.G. Elev**	**E.G. Slope**	**Vel Chnl**	**Flow Area**	**Top Width**	**Froude**
	(cfs)	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft/ft)**	**(ft/s)**	**(sq ft)**	**(ft)**	**No.**
400	200	5000.00	5001.18	5001.88	5003.49	0.01	12.64	16.99	16.73	2.05
390	200	4999.90	5001.10	5001.78	5003.35	0.01	12.49	17.19	16.78	2.01
380	200	4999.80	5001.00	5001.68	5003.22	0.01	12.38	17.36	16.82	1.99
370	200	4999.70	5000.91	5001.58	5003.09	0.01	12.28	17.51	16.85	1.97
360	200	4999.60	5000.82	5001.48	5002.98	0.01	12.23	17.59	16.87	1.95
350	200	4999.50	5000.72	5001.38	5002.86	0.01	12.17	17.67	16.89	1.94
340	200	4999.40	5000.63	5001.28	5002.75	0.01	12.13	17.74	16.91	1.93
330	200	4999.30	5000.53	5001.18	5002.64	0.01	12.08	17.81	16.93	1.92
320	200	4999.20	5000.44	5001.08	5002.53	0.01	12.04	17.88	16.94	1.91
310	200	4999.10	5000.34	5000.98	5002.42	0.01	12.00	17.93	16.96	1.90
300	200	4999.00	5000.24	5000.88	5002.31	0.01	11.97	17.98	16.97	1.89
290	200	4998.90	5000.20	5000.81	5002.18	0.01	11.76	18.40	16.79	1.82
280	200	4998.80	5000.15	5000.75	5002.07	0.01	11.59	18.77	16.60	1.76
270	200	4998.70	5000.11	5000.68	5001.96	0.01	11.44	19.13	16.42	1.70
260	200	4998.60	5000.05	5000.62	5001.88	0.01	11.38	19.33	16.21	1.66
250	200	4998.50	5000.00	5000.56	5001.80	0.01	11.33	19.53	16.01	1.63
240	200	4998.40	4999.95	5000.50	5001.72	0.01	11.28	19.74	15.81	1.59
230	200	4998.30	4999.90	5000.44	5001.66	0.01	11.28	19.86	15.61	1.57
220	200	4998.20	4999.85	5000.38	5001.59	0.01	11.28	20.00	15.41	1.55
210	200	4998.10	4999.81	5000.33	5001.53	0.01	11.28	20.14	15.22	1.52
200	200	4998.00	4999.76	5000.28	5001.48	0.01	11.30	20.28	15.04	1.50
190	200	4997.90	4999.64	5000.18	5001.41	0.01	11.48	19.93	14.95	1.53
180	200	4997.80	4999.52	5000.08	5001.33	0.01	11.58	19.73	14.89	1.56
170	200	4997.70	4999.41	4999.98	5001.25	0.01	11.69	19.53	14.84	1.58
160	200	4997.60	4999.30	4999.88	5001.18	0.01	11.79	19.35	14.79	1.59
150	200	4997.50	4999.19	4999.78	5001.10	0.01	11.89	19.18	14.75	1.61
140	200	4997.40	4999.08	4999.68	5001.02	0.01	11.98	19.02	14.70	1.63
130	200	4997.30	4998.97	4999.58	5000.94	0.01	12.07	18.87	14.66	1.65
120	200	4997.20	4998.86	4999.48	5000.86	0.01	12.15	18.74	14.63	1.66
110	200	4997.10	4998.75	4999.38	5000.77	0.01	12.23	18.61	14.59	1.68
100	200	4997.00	4998.64	4999.28	5000.69	0.01	12.30	18.49	14.56	1.69
Continue iteration to determine the minimum transition length in accordance with Section 3.C.1										


Trapezoidal Channel Transition - 100 ft Plan: Plan 01 11/12/2009
Channel FIRST
Legend
WS PF 1
Ground
Elevation (ft)
5002
5001
5000
4999
4998
4997
Main Channel Distance (ft)
0
50
100
150
200
250
300

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. Methods found in items C.7 and C.8 in the Bibliography at the end of Section 22.3 shall be used in sediment transport analyses.

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.

<u>CHANNEL STABILITY WORKSHEET - A</u>

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			

CHANNEL STABILITY WORKSHEET - 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	Aggradation	Degradation
Sediment Particle Size...	Aggradation	Degradation
Streambed Material Size	Aggradation	Degradation
Channel Vegetation...	Aggradation	Degradation

1. Channels

a. Earthwork

The following shall be compacted to at least 90% of maximum density as determined by ASTM D-1557 (modified Proctor):

(1) The 12 inches of subgrade immediately beneath concrete lining (both channel bottom and side slopes).

(2) Top 12 inches of maintenance road (either as subgrade or finished roadway if unsurfaced).

(3) 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.

(4) All fill material.

b. Concrete

(1) All concrete channels shall be continuously reinforced.

(2) All exposed concrete drainage structures shall be tinted with San Diego Buff or a color approved by the City Engineer/SSCAFCA.

(3) Materials

(a) Cement type: ILA or I-IILA

(b) Minimum cement content: 5.5 sacks/c.y.

(c) Maximum water-cement ratio: 0.53 (6 gals. per sack)

(d) Maximum aggregate size: 1 ½ inches

(e) Air content range: 4-7%

(f) Maximum slump: 3 inches

(g) Minimum compressive strength (f_c): 3500 psi @ 28 days

(h) 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.

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

(4) Lining Section

(a) Bottom width - 10 feet minimum

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

(c) Concrete lining thickness

All concrete lining shall have a minimum thickness of 8 inches.

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.

(d) Concrete Finish

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 timed finish, but it must be preapproved by SSCAFCA. Precautions shall be taken to guard against excessive working or wetting of finish.

(e) Concrete Curing

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

(f) Steps

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.

(5) Joints

(a) 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.

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

(c) All joints shall be designed to prevent differential displacement and shall be watertight.

(d) Construction joints are required at the end of a day's run, where lining thickness changes.

(6) Reinforcing Steel for Continuously Reinforced Channels

(a) Ratio of longitudinal steel area to concrete area not including additional thickness of sacrificial concrete

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

(b) Ratio of transverse steel area to concrete area not including additional thickness of sacrificial concrete

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

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

(c) 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.)

2. 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/SSCAFCA. 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.

BIBLIOGRAPHY

22.3 Hydraulics

A. Weirs and Orifices

1. King and Brater: Handbook of Hydraulics, McGraw Hill Book Company, Inc., New York, Fifth Edition 1963

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

3. Streeter: Fluid Mechanics, McGraw Hill Book Company, Inc., New York, Fifth Edition

B. Closed Conduits

1. Los Angeles County Flood Control District Design Manual - Hydraulic, P.O. Box 2418 Los Angeles, California 90054 Rev. 1973.

C. Channels

1. Chow: Open Channel Hydraulics, McGraw Hill Book Company, Inc., New York, 1959

2. U.S. Army Corps of Engineers:- Hydraulic Design of Flood Control Channels EM 1110-2-1601,. Office of the Chief of Engineers, Washington, D.C. 20314, 1970

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

4. Morris and Wiggert: Applied Hydraulics in Engineering, the Ronald Press Company Second Edition, l972

5. U.S. Department of the Interior, Bureau of Reclamation: Hydraulic Design of Stilling Basins and Energy Dissipaters, U.S. Government Printing Office, Washington, Fourth Printing, Revised 1973

6. U.S.D.A Soil Conservation Service: Planning and Design of Open Channels, Technical Release No. 25, Washington, D.C., October, 1971

7. U.S.D.A Soil Conservation Service:. Sedimentation, National Engineering Handbook, Section 3, Chapter 4, Washington, D.C., 1971

8. Simons, Li and Associates: Design Guidelines and Criteria - Channels and Hydraulic Structures on Sandy Soil, P.O. Box 1816 Ft. Collins, Colorado, 80522, 1981

9. Los Angeles County Flood Control Authority, Design Manual Hydraulic P.O. Box 2418 Los Angeles, California 90054 Rev. 1973.

10. Albuquerque Metropolitan Arroyo Flood Control Authority Draft Design guide for Trapezoidal Concrete Flood Control Channels, Rev. April, 1982.

D. Storm Inlets

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

E. Street Hydraulics

1. See Reference C-1

2. See Reference C-4

F. Berms and Levees

1. See Reference C-6

2. See Reference C-7

3. See Reference C-8

G. Sediment & Erosion Control

1. SSCAFCA's Sediment and Erosion Design Guide prepared by Mussetter Engineering, Inc. dated November 2008. Available at www.sscafca.com.

Section 4. CHANNEL TREATMENT SELECTION GUIDELINES

A. General

The selection of a treatment type or of a combination of treatment types for a channel within the Rio Rancho/SSCAFCA 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:

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.

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.

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.

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.

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.

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.

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.

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 drainage and flood control facilities.

Section 5. DESIGN GRADING AND EROSION CONTROL

A. Slope Criteria

Earthen slopes shall conform 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/SSCAFCA approved means.

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 SSCAFCA's Executive Engineer in writing.

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/SSCAFCA. 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 insure 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.

D. Grading in a Floodplain

No grading 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.

E. Violations As To Construction Or Site Alteration

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

(A) Prior to approval of an infrastructure list/preliminary plat, building permit or development plan by SSCAFCA, if the grading or site alteration is related to a proposed subdivision;
(B) Prior to approval of a drainage plan or report, or a determination by the City Engineer/SSCAFCA that no such plan or report is required;

(C) 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; or
(D) Prior to the submittal of a construction schedule for the proposed drainage infrastructure improvements/grading.
(E) Prior to the issuance of any permits required pursuant to this section.
(F) Prior to submittal of financial guarantees required by the City/SSCAFCA.
(G) Prior to:
- Submittals and review of Storm Water Pollution Prevention Plan
- Filing and activation of Environmental Protection Agency Notice of Intent
- Installation of Best Management Practices per Storm Water Pollution Prevention Plan
- USACE 404 permit approval, if required.

F. Erosion and Stormwater Pollution Control

All grading within the City of Rio Rancho/SSCAFCA area 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/SSCAFCA. All grading shall conform with EPA Stormwater Regulations. See Section 9 of this chapter 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/SSCAFCA 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 SSCAFCA’s Drainage Policy/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/SSCAFCA policies.

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 SSCAFCA's jurisdiction are highly erosive requiring special attention during the design, construction and post construction phases of development.

2. METHODOLOGY
   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
   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 shall be determined from the sediment bulking factors as defined in the hydrologic analysis procedures in this DPM will be the minimum volume of sediment generation considered in evaluating downstream capacity.

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

H. Pond/Dam Design (City/SSCAFCA Maintained Facilities)

1. 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.

2. 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.

3. 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 Executive Engineer.

4. 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 insure 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.

5. 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.

6. MINIMUM POND SIZE:

   In order for a pond to be publicly maintained by SSCAFCA, it must be a minimum of two (2) acre-feet.

7. FENCING:

   a. Detention ponds will require five (5) strand barbless wire fencing with wooden posts in accordance with SSCAFCA Standard Details.

8. 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 SSCAFCA 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.

9. 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.

10. FREEBOARD- All ponds shall have a minimum of one (1') foot of freeboard.

11. IN-POND SEDIMENT STORAGE- An evaluation shall be performed to insure sufficient in pond storage of sediment deposited during a 100 year event will not affect the functional capability of the structure.

12. SEDIMENT STOCK PILE AND TRANSPORT PROVISION- An evaluation shall be performed to determine how sediment and debris shall be removed from the facility and transported offsite.

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. SSCAFCA approval is required.

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/SSCAFCA.
12. A signature block for approval by either the City Engineer's/SSCAFCA'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 SSCAFCA's ROW are not allowed without SSCAFCA's approval.

Section 6. RIGHTS-OF-WAY, EASEMENTS AND COVENANTS

A. Rights-of-Way - Introduction

Land necessary for permanent drainage, flood control, erosion control or major arroyos must be dedicated in fee simple to SSCAFCA. SSCAFCA may grant an easement to the City for joint operation and maintenance of drainage facilities and for sole operation and maintenance of quality of life amenities and other City owned infrastructure. SSCAFCA will require sole dedication of drainage right-of-way without a City easement for all high hazard drainage facilities. Easements benefiting SSCAFCA may be considered for temporary access, construction, and unique purposes; temporary use of questionable land areas (that could revert to a land owner) or for uses adjacent and ancillary to those for flood control and drainage management (e.g.: joint recreation or landscaping).

Note: both easements and rights-of-way can be "dedicated" for a use or purpose by statutory enactment (a plat map) or conveyed by a document (deed or grant of easement). A "covenant" is a document, usually separate from a dedication that can be used for guaranteeing continuing action by one of the parties (e.g. required maintenance or insurance coverage on dedicated property). Also, some forms of dedication instruments are subject to the provisions of the Minimum Standards for Surveyors (NMAC 12.8.2.) and may require separate staking, recording of survey documents and limitations or conditions of metes and bounds legal descriptions. The value of all dedicated ROW and granted easements to SSCAFCA must be provided to satisfy federal auditing requirements.

B. Fee Simple ROW

1. Dedication Language (statutory, upon plat creation, acceptance and recordation):

The real estate shown and described in this plat is dedicated 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 the Southern Sandoval County Arroyo Flood Control Authority, 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.

2. Conveyance Language (documentary):

The Owner (or "Grantor", etc.) hereby grants (or hereby conveys) to Southern Sandoval County Arroyo Flood Control Authority, a political subdivision of the State of New Mexico, the following described property…

Note: documentary conveyances are usually prepared by an attorney or Registered Land Surveyor, for consideration and prior acceptance by SSCAFCA, and then recorded as a deed in fee simple or easement.

C. Easements

Easements for drainage, flood control and erosion control facilities may be acceptable in rare, special occasions as long as a clear written and approved agreement exists with SSCAFCA as to other acceptable uses of the easements and no permanent facilities are constructed within them. The use of an easement may require an accompanying covenant governing the permitted uses and clearly assigning the continuing responsibilities of the parties using said easement. High hazard structures can only be constructed on publicly owned property dedicated or conveyed in fee simple title to SSCAFCA.

1. Grant of Easement to SSCAFCA (include this language on all plats and as separate instrument, if documentary):

The Grantor hereby grants to SSCAFCA, a non-exclusive easement upon, over, under and across _________ (the "Easement Property"). SSCAFCA shall use the Easement Property solely for the access, construction, operation and maintenance of storm water drainage facilities. This easement shall be perpetual in duration; except that if at any time in the future the Easement Property should cease to contain a drainage facility, this easement shall terminate.

Note: A termination shall be effected upon recordation of a Termination of Easement document signed and acknowledged by SSCAFCA and all other easement grantees.

2. Grant of Easement to the City of Rio Rancho (Reference City DPM):

This easement is appurtenant to SSCAFCA's Easement Property referred to above.

The City shall maintain all City owned improvements within the Easement Property including, but not limited to, recreational facilities, open space, grass, landscaped areas, irrigation facilities, fences, City utility lines, retaining/landscape walls, all recreation and public access trails including asphalt bike trails, drop/surface inlets, storm drainage laterals, roads, roadway crossings, including the underlying culverts/structures and all drainage facilities, except those regional drainage facilities hereinabove identified as the responsibility of SSCAFCA.

Note: Easements that are not contiguous to existing platted lot or tract lines may require a legal description prepared by a surveyor and staked, physical corner monuments. A separate "plat", filed in public records as a "Plat of Survey" may also be required.

3. Sample Language

a. Drainage Facilities and/or Detention Areas Maintained by Lot Owner

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

The lot owners agree to defend, indemnify, and hold harmless, SSCAFCA, the City, and their 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 as provided for herein or for the lot owner’s failure to construct, maintain, or modify the drainage facilities specified herein.

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*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/SSCAFCA and plans and specifications approved by the City/SSCAFCA in accordance with the drainage report entitled _________________________, submitted by _____________________ on, ________________________ and approved by the City/SSCAFCA on __________________, together with the amendments approved on _________________, which report and amendments are on file in the offices of the City and/or SSCAFCA.

b. Dedication of Drainage Easements: Owner Constructs and City/SSCAFCA Maintains

A perpetual easement on the areas designated on this plat as “drainage easements” or “detention areas” are hereby dedicated to the City of Rio Rancho/SSCAFCA for the purpose of permitting the conveyance of storm water runoff and for the purpose of maintaining, operating, removing, and replacing storm water drainage facilities or 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 the City/SSCAFCA. No obstructions may be placed in said easement areas which would prevent ingress and egress by maintenance vehicles or which would prevent said vehicles traveling on said drainage way for maintenance purposes.

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

c. Grant of Drainage Easement Sample Language

This grant of easement 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 called the “City” and the Southern Sandoval County Arroyo Flood Control Authority, a political subdivision of the State of New Mexico hereinafter called “SSCAFCA”

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 to the City of Rio Rancho/SSCAFCA a perpetual easement over and across a portion of Grantor’s property for the purpose of permitting the flow, retention, conveyance, and discharge of storm water runoff and for the purpose of constructing and maintaining storm water detention facilities and any appurtenances thereto, such as SWPPP installations or for storm water detention facility.

3. The easement and right-of-way land is more particularly described as follows:

(Note: the possible requirement of a metes and bounds legal description.)

4. Grantor shall construct drainage facilities in the easement in accordance with standards prescribed by the City and plans and specifications approved by the City Engineer/SSCAFCA Executive Engineer.

5. Possible Additional Language: in accordance with standards prescribed by the City/SSCAFCA and plans and specifications approved by the City/SSCAFCA in accordance with the drainage report entitled __________________, submitted by ______________________ on __________, and approved by the City/SSCAFCA on ________________ together with the amendments approved on _______________, which report and amendments are on file in the office of the City Engineer/SSCAFCA.

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

7. In the event that the Grantor should fail to construct the drainage facilities contemplated herein or fail to adequately and properly maintain the easement and any facilities constructed thereon, the City/SSCAFCA or its agents, at any time following fifteen (15) days written notice to the property owner, may enter upon said property to perform the necessary construction or maintenance. The cost of performing such construction or maintenance shall be paid by the owner. In the event the property owner fails to pay the costs of such construction or maintenance within thirty (30) days after written demand for payment is made for the City/SSCAFCA. The City/SSCAFCA may file a lien therefore against the real property described in paragraph 1above.

8. No fence, wall, planting, building or other obstruction may be placed or maintained in the easement without the written approval of the City/SSCAFCA 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 City/SSCAFCA. Any violation of this provision will be promptly corrected upon notice to the property owner from the City/SSCAFCA and if not corrected promptly, the City/SSCAFCA shall have the right to remove or otherwise correct such violation and assess the cost to the property owner as provided in paragraph 6 above.

9. This easement to the City/SSCAFCA is permanent in nature for the uses and purposes set forth herein unless the City/SSCAFCA releases said easement in writing and it is recorded with the County Clerk.

10. The obligations of the Grantor set forth herein shall be binding upon the Grantor and Grantor's, heirs, successors and assigns.

11. The City/SSCAFCA 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/SSCAFCA, 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 specified herein. The Grantor further agrees to maintain general liability insurance on the property easement in an amount not less than $500,000.

12. The written notices provided for herein shall be sent by first class mail to:

The Grantor may change said address by notice in writing sent by, certified or registered mail, return receipt requested to the City Engineer, 3200 Civic Center Circle, Rio Rancho, New Mexico 87144 and to the Executive Engineer, SSCAFCA 1041 Commercial Street SE, Rio Rancho, New Mexico 87124.

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

City of Rio Rancho	GRANTOR
By:________________________	______________________
Title: ________________________	______________________

SSCAFCA

By: ________________________

Title: ________________________

D. Drainage Covenants

Occasionally, a developer of a property will choose to employ a drainage scheme that requires installation and maintenance of drainage features on the developer's property or other properties. In those instances where such drainage features must be perpetually maintained to minimize possible damage to other properties or to public properties, the City may require the developer enter into a covenant assuring maintenance of such facilities. There are four (4) types of covenants which are discussed below.

Covenants are to run with the land. They generally require the owner of the land to maintain features to City/SSCAFCA standards and allow the City's/SSCAFCA's entrance upon the property to inspect drainage features for such maintenance as needed. A typical example of such drainage covenant and instructions for the use of the covenant are presented in the DPM.

The following is a brief description of the four types of drainage covenants the City/SSCAFCA may require the developer to enter into:

1. **Private Facility Drainage Covenant –** for a privately owned, privately maintained facility, which places maintenance and inspection responsibility on the property owner(s). For example, a cutoff wall to protect property adjacent to an unlined arroyo.

2. **Drainage Covenant (no public easement) –** for a privately owned, privately maintained facility whose non-function or failure to perform, will cause damage to others. For example, a large detention pond in a shopping center. The maintenance responsibilities lie with the owner. The City/SSCAFCA, however, have the right to inspect periodically and to enforce proper maintenance.

3. **Agreement and Covenant –** for a privately maintained facility which is within the City's/SSCAFCA's property (right-of-way or easement). The City/SSCAFCA have the right to inspect and to enforce proper maintenance. For example, phased developments that require temporary retention ponds and/or sediment ponds.

4. **Private Facility Drainage Covenant and Reservation of Private Drainage Easement** – for a privately owned, privately maintained facility which places maintenance and inspection responsibility on the property owner(s). For example, a pond used in common by more than one property owner.

5. **Drainage Covenant Sample Language**

This Drainage Covenant, between [state the name of the present real property owner exactly as shown on the real estate document conveying title to the present owner and state the legal status of the owner, for example, "single person," "husband and wife," "corporation of the State of X," "partnership"]
("Owner"):____
____
[his, her, their, or its] heirs, executors, successors, assigns and transferees, whose address is
____
____
and the Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) is entered into as of the date Owner signs this or any Easement benefiting SSCAFCA to the subject property as attached.

Recital. Owner is the owner of certain real property located at [give general description, for instance, subdivision, lot and block or street address]:
____ in Sandoval County, New Mexico (the "Property").

Pursuant to City and County ordinances, regulations and other applicable laws, the Owner is required to construct and maintain certain drainage facilities on the Property, and the parties wish to enter into this agreement to establish the obligations and responsibilities of the parties.

Description and Construction of Drainage Facilities. Owner shall construct the following "Drainage Facility" within the Property at Owner's sole expense in accordance with the standards, plans and specifications approved by SSCAFCA:

____

____

The Drainage Facility is more particularly described in the attached Exhibit A.

The Owner shall not permit the Drainage Facility to constitute a hazard to the health or safety of the general public.

Maintenance of Drainage Facility. The Owner shall maintain the Drainage Facility at Owner's cost in accordance with the approved Drainage Report and plans.

Right of Entry. SSCAFCA/City have the right to enter upon the Property at any time and perform whatever inspection of the Drainage Facility it deems appropriate, without liability to the Owner.

Demand for Removal, Construction or Repair. SSCAFCA/City may send written notice ("Notice") to the Owner requiring the owner to construct, remove or repair the Drainage Facility within ____30____ days ("Deadline") from the receipt of the Notice, as provided in Section 11, and the Owner shall comply promptly with the requirements of the Notice. The Owner shall perform all required work by the Deadline, at Owner's sole expense.

Failure to Perform by Owner and Emergency Work by SSCAFCA/City. If the Owner fails to comply with the terms of the Notice by the Deadline, or if City/SSCAFCA determines that an emergency condition exists, City/SSCAFCA may perform the work itself. The County, City or SSCAFCA then may assess the Owner for the cost of the work and for any other expenses or damages which result from Owner's failure to perform. The Owner agrees promptly to pay the amount assessed. If the Owner fails to pay the assessment within thirty (30) days after the party gives the Owner written notice of the amount due, the County or City may impose a lien against Owner's Property for the total resulting amount plus interest.

Liability for Repair after Notice or as a Result of Emergency. City/SSCAFCA shall not be liable to the Owner for any damages resulting from City/SSCAFCA's repair, removal or maintenance following notice to the Owner as set forth in this agreement or in an emergency unless the damages are the result of the reckless conduct or gross negligence of City/SSCAFCA.

Indemnification. As a part of the consideration for this grant, subject to the provisions of the New Mexico Tort Claims Act and all other applicable New Mexico laws, City/SSCAFCA agrees to save Owner harmless from any and all liability arising from City/SSCAFCA's negligent use of the Drainage Facility.

The Owner hereby agrees to hold harmless, indemnify and defend

SSCAFCA, Sandoval County or the City, its officers, agents and employees from and against any and all liability, suits, actions, claims, damages, costs of defense and fees arising out of or resulting from the acts or conduct of the Owner and/or any of Owner's employees, agents, or officers relating in any manner whatsoever to this agreement.

Provided, however, such indemnity shall not extend to liability, claims, damages, losses or expenses, including attorney's fees, arising out of the preparation or approval of maps, drawings, opinions, reports, surveys, change orders, designs or specifications by the indemnitee, or the agents or employees of the indemnitee, or the giving of or the failure to give directions or instructions by the indemnitee, where such giving or failing to give directions or instructions is a primary cause of bodily injury to persons or damage to property.

Cancellation of Agreement and Release of Covenant. This agreement may be cancelled and Owner's covenants released by City/SSCAFCA mailing to the Owner notice of its intention to record a Cancellation and Release with the Sandoval County Clerk. The Cancellation and Release shall be effective thirty (30) days from the date of mailing the notice to the User unless a later date is stated in the notice or in the Cancellation and Release. After the effective date, the County will record the Cancellation and Release with the Sandoval County Clerk.

Assessment. Nothing in this agreement shall be construed to relieve the Owner, his heirs, assignees, transferees and successors from an assessment against Owner's Property for improvements to the Property under a duly authorized and approved Special Assessment District or applicable law. The Parties specifically agree that the value of the (Drainage Facility) will not reduce the amount assessed by the City or County.

Notice. For purposes of giving formal written notice to the Owner, Owner's address is:

____

____

____

Notice may be given to the Owner either in person or by mailing the notice by regular U.S. mail, postage paid. Notice will be considered to have been received by the Owner within six (6) days after the notice is mailed if there is not actual evidence or receipt. The Owner may change Owner's address by giving written notice or change by certified mail, return receipt requested, to SSCAFCA and any other parties to this instrument.

Term. This agreement shall continue until cancelled and released by City/SSCAFCA as set forth above.

Binding on Owner's Property. The covenants and obligations of the

Owner set forth herein shall be binding on Owner, and the Grantor's heirs, assigns, transferees and successors and shall constitute covenants running with the Owner's land until released by SSCAFCA.

Entire agreement. This agreement contains the entire agreement of the parties and supersedes any and all other agreements or understandings, oral or written, whether previous to the execution hereof or contemporaneous herewith.

Changes to agreement. Changes to this agreement are not binding unless made in writing, signed by both parties.

Construction and Severability. If any part of this agreement is held to be invalid or unenforceable, the remainder of the agreement will remain valid and enforceable if the remainder is reasonably capable of completion.

Captions. The captions to the sections or paragraphs of this agreement are for reference and convenience purposes only and shall not affect the meaning or interpretation of any of its provisions.

OWNER:	SSCAFCA:
By: ___________________________	By: _________________________
Its: ___________________________	Its: _________________________
Dated: ________________________	Dated: ______________________

State of New Mexico)
) SS
COUNTY OF __________________)

The foregoing instrument was acknowledged before me this __________ day of ________________, 20_____, by [name of person signing]: ______________________ __________________________________, [Title or capacity, for instance, "President" or "Owner"]: __________________________________ of [name of the entity which owns the Property if other than the individual signing, for instance, the name of the corporation, partnership, or joint venture]: ____________________________________.

____
Notary Public
My commission expires: _________________________

E. Encroachment Agreements

Occasionally the grading scheme for an approved drainage plan will employ the construction of a retaining wall or other drainage/grading structure outside the periphery of a private property, encroaching into public property. Although such encroachments are discouraged, it is recognized that certain circumstances will require installations of this type. In such event the City/SSCAFCA normally requires an encroachment agreement with the developer. The encroachment agreement, which runs with the land, allows the developer to install some semi-permanent features on public property meeting criteria established in the DPM. The developer is required to assure the City/SSCAFCA that such features will be removed in a timely manner if required by the City/SSCAFCA or, alternatively, that the City/SSCAFCA will be empowered to remove such encroachments, with the cost of such removal charged to the owner of the property. A standard encroachment agreement together with instructions for the preparation of same can be obtained by contacting the City/SSCAFCA.

F. Joint-Use, Shared Maintenance and Common-Area Considerations.

In certain instances, adjacent development may provide for recreation opportunities or special uses of SSCAFCA owned rights-of-way. An example could be an adjacent Planned Unit Development or Condominium project where a regime for maintenance is assured and an opportunity for joint-use of land is presented.

If such opportunities are presented, each use must be considered independently and be secured by binding agreements. Consideration should include:

- Right of access, vehicular movements (large equipment) and inspections.
- Hold-harmless to SSCAFCA (and City or County) for regular maintenance if the joint-party fails to perform, as well as for emergency repairs.
- Removal or rehabilitation of installations (including landscaping) that impede or diminish the effectiveness of any provision of the approved Drainage Management Plan.
- Insurance on the land areas (general liability) in an amount not less than $500,000 and including SSCAFCA as an additional named insured.
- Rodent and pest control (particularly rip-rap).
- Operation and maintenance of Storm Water Pollution Prevention Plan (SWPPP) devices.
- Potential LOMR, CLOMR and LOMA filings with FEMA for floodplain designations.
- In the event of disputes, with eviction by SSCAFCA should full compliance not occur.
- A drainage covenant (see following).
- SSCFACA shall normally maintain all fences and gates (usually 5-strand wire and locked pipe-rail gates). A separate covenant may be required for this and other items of ongoing maintenance.

1. Drainage Covenants (separate or included in the grant of easement):

A drainage covenant may be used and may be required, in addition to dedicated easements, where joint-use of land is considered and where a granted easement calls for provisions which include responsibilities of the land owner such as on-going maintenance, re-vegetation or rehabilitation after minor storm events. See Section D.

2. Homeowner's Association, Maintenance Association or common-area regime:

In most contemporary developments that have common-areas, an Association is formed binding upon the owners of the common development. In such documents, SSCAFCA would review the instruments concurrent with the development's approvals and recommend provisions to protect its interests in the negotiated agreements. Suggested language to be considered is provided in Section E, following.

3. Suggested language for inclusion in the documents:

Special provisions for Drainage and Floodwater Control. There are planned uses within the Common Areas for purposes of offsite and onsite stormwater conveyance and management, including construction and maintenance of facilities such as channels, drop structures, pedestrian crossings, pipes, culverts, access roads and the like. The land area for these stormwater conveyances include ________________. The intent of the Declarant is to convey, by easement or otherwise, surface rights to the land area for these facilities to the Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) and/or the City of Rio Rancho or Sandoval County.

Within the designated Common Areas SSCAFCA has an implied easement to the extent of the natural floodplain and an actual easement where platted and so designated on those instruments. Until such grant and acceptance of these facilities for permanent maintenance, the Association shall undertake periodic and regular maintenance of the facilities, including, but not limited to reconstruction, landscape replacement, earth removal and replacement, temporary dikes, berms and channels and continuing the level of stormwater protection to _______PROJECT___________ and others downstream. The level of maintenance shall be in accordance with the requirements of SSCAFCA.

The costs of such maintenance, until acceptance by SSCAFCA and/or the County (including the necessary insurance coverage for catastrophic events) shall be borne by the Developer or Association in the same manner and fashion as periodic maintenance of other common areas including provisions for capital improvement.

Vehicular Access. Vehicular access is allowed on the Common Areas by the Declarant, the Association, approved maintenance personnel for utilities, SSCAFCA, the County (and other approved contractors and public entities). Without express, written permission from the Association, no other vehicular access is allowed to any owner or to the public except for vehicles on paved, designated areas or for bicycles on designated routes and to accommodate handicapped citizens. No off-road or all terrain vehicle traffic is permitted.

4. Acknowledgements, Format for instruments following signatures:

APPROVED AS TO FORM:

____
Chief Administrative Office

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: ________________________

APPROVED AS TO FORM

____
Executive Engineer, SSCAFCA

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: ___________________

G. Land-Areas; Configuration Criteria.

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

1. **Surface Facilities:**

The entire facility must be included in the dedicated area as well as any slopes, maintenance roads, turn arounds or other necessary appurtenances. The dedicated area may not be less than 10 feet wide.

2. **Underground Facilities**:

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

W = 2 x Di + 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 may be placed within the easement to allow for stockpiling of material.

Drainage Rights-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 bollards or pipe / steel tube gates.

3. **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:

Underground utility lines will be allowed in and adjacent to arroyos when appropriately permitted. SSCAFCA values the natural environment and desires to protect and maintain the wildlife and plant habitat along the arroyos. As a result, SSCAFCA is performing planning work to identify selected arroyos to be kept in their natural state. Arroyos such identified shall have no sewer line or other utility development in or adjacent to the arroyo.

SSCAFCA supports the Quality of Life Master Plan for Watershed Park. To accomplish the Master Plan’s objective of creating an open space network of joint use improvements, Watershed Park amenities shall be provided as replacement value to the public for the intrusion caused by the utility construction. The types of amenities required shall be determined on a case-by-case basis.

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 the Watershed Park amenities associated with the utility.

4. **Utilities**

All utilities in an SSCAFCA facility require an easement granted by SSCAFCA 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 SSCAFCA Executive Director or their designee.

H. Criteria for Vacating SSCAFCA's Rights-of-Way/Easements

1. Rights-of-Way/Easements
    a. Approved by SSCAFCA Board
    b. Compensation for right-of-way being vacated based on appraisal or land exchange.
    c. Naturalistic improvements constructed by party requesting the vacation. (O&M costs must be equal or less)
2. Vacated area shall be replatted or identified by recording a statement with the County Clerk identifying the property vacated.

I. Vacation Procedure for Rights-of-Way and Easements

Step l: Pre-Application Discussion

Discussion of the proposed vacation with the SSCAFCA staff is recommended prior to application filing. The purpose of the discussion is to review City/SSCAFCA policies and procedures applicable to the proposal so that incomplete, inadequate, and inappropriate applications are avoided. City staff may be included in this discussion.

The discussion should:

- review the appropriateness of the request as related to various applicable plans, policies, and ordinances including the Zoning Code and/or Subdivision Ordinance.
- determine all appropriate procedures/information needed to obtain approval.
- determine a preliminary schedule/time frame for approval.
- determine a filing date for the application if appropriate.
- outline preliminary direction from staff based upon the information submitted and discussed.
- prepare a written summary of the requirements/procedures to obtain approval.

SSCAFCA and the applicant will sign a written summary of the meeting. Copies of the written summary are given to the applicant/agent and City/SSCAFCA.

Step 2: Application for a public hearing with SSCAFCA Board of Directors

Submit a letter to the Executive Engineer with all the required information determined at the pre-discussion meeting. The Executive Engineer will advise applicant the date of the public hearing.

Step 3: SSCAFCA Public Hearing

The public hearing gives the general public and area residents the opportunity to discuss and speak for or against the request and to elicit additional information which may have a bearing on the request. The applicant or agent must be present at the hearing to speak on behalf of the request and respond to questions.

Outcome:

A decision by the SSCAFCA Board may be deferred if additional information or additional public notice is deemed necessary.

The SSCAFCA Board decision on the request may be to:

- approve,
- approve with conditions, or
- deny.

The applicant and other interested parties receive a Letter of Notification of the decision along with any conditions imposed. The decision is final.

Step 4: Compliance with Conditions

A normal condition of approval requires SSCAFCA to dispose of all public right-of-way declared surplus through the vacation process. Generally all utility and drainage easements are retained unless otherwise specified in the Board's decision.

The applicant must also prepare and record a replat which incorporates the vacated right-of-way with adjacent property. Under special circumstances other instruments of conveyance, such as a deed, may be appropriate.

Any conditions must be met within the time period established by SSCAFCA. SSCAFCA may grant an extension by written request. However, all conditions must be met within one (1) year from the date of the original decision.

Section 7 PROCEDURES FOR DRAINAGE SUBMITTALS

A. Procedures for Drainage Submittals

INTRODUCTION

This section presents procedures for making drainage submittals. General criteria established by the City/SSCAFCA for review of those submittals are also presented.

Submittal Preparation

Guidelines for preparation of drainage submittals are presented in DPM Chapter 22, Section 7. The material and information required for a complete submittal can be determined by referring to the appropriate section in the DPM.

Approval Procedures

The following are procedures and guidelines established by the City/SSCAFCA for the review of drainage submittals.

1. All Drainage Submittals and follow-up correspondence should be submitted to the City/SSCAFCA. For record keeping purposes a Drainage Information Sheet (DIS) must be provided with the subject transmittal. The latest version can be obtained from the City/SSCAFCA. All Drainage submittals required for building permit, preliminary plat, site development plan, sector plan, grading plan approvals, etc, must be processed through the City's/SSCAFCA's Offices.

2. Upon receipt of a drainage submittal the City/SSCAFCA will assign a file number, and the submittal will be logged in for review. The submittal will be added to a list that identifies its status in the review process.

3. Correspondence related to drainage submittals must reference the file number assigned by the City's/SSCAFCA's Office upon submittal. These file numbers shall also be referenced on all re-submittals. The use of the file number facilitates the processing and tracking of drainage submittals and related correspondence.

4. Drainage submittals that do not include a DIS, vicinity map, legal description, engineer's seal for Drainage, date and other major items identified on the appropriate DPM format guideline will not be accepted. Only after the information is deemed complete will a submittal be accepted for review.

5. It is the policy of the City's/SSCAFCA's Offices to make responses to new submittals, resubmittals, and follow-up correspondence as soon as possible but not more than thirty calendar days after a complete submittal has been received by that office.

6. All revisions made to a particular submittal must be signed, sealed and dated by the Engineer of Record for all drainage submittals with revisions clearly noted. Resubmittals must be accompanied with the agency's original comments.

7. Approved drainage submittals are in effect for a period of one year (provided no significant changes have occurred which may alter the original submittal) from the date of approval. After one year, if no significant development has taken place, a resubmittal will be required and must reflect all changes in conditions and/or City/SSCAFCA requirements since the date of last approval.

8. Questions concerning the preceding items should be directed in writing to the City's/SSCAFCA's Offices.

Flood Hazard Certification

Compliance with the requirements of the Flood Hazard Prevention Ordinance is required of every applicant for subdivision, site development plan and/or building permit approval. Compliance is achieved by either demonstrating that the proposed project does not lie within a designated flood hazard area or by demonstrating adequate flood-proofing as required by the ordinance or by removing the site from a flood hazard area through the FEMA map revisions process.

Development Within Flood Hazard Areas For Building Permits

If the site is determined at the time of building permit application to lie within a Flood Hazard Area as shown on the Federal Emergency Management Agency (FEMA) maps on file with the City, then the City/SSCAFCA will determine if flood-proofing is required. Prior to final approval of building occupancy, certification by a registered professional surveyor or engineer as appropriate must be made so that these flood-proofing requirements have been met.

Development Within Flood Hazard Areas For Subdivisions And/Or Site Plan Approvals

If any improvements are proposed which modify the existing floodplain boundary, an application for a Conditional Letter of Map Change (CLOMC) shall be submitted to the City Floodplain Administrator to be forwarded to FEMA. A Letter of Map Change (LOMC) must be obtained from FEMA after construction is complete. When a CLOMC has been issued by FEMA, a portion or all of the SIA (Subdivision Improvement Agreement) and financial guarantees may be released prior to the LOMC being issued by FEMA. Submittal of a copy of the LOMC from FEMA is required for release of the balance of the financial guarantees and SIA's when issuance is a condition of release.

The following floodplain note must be placed on the plat if a LOMC has not been issued by FEMA: "Portions of the subject property lie within a designated area of special Flood Hazard as shown on the most recent National Flood Insurance Program's "Flood Insurance Rate Map. Until such time that a LOMC is issued by FEMA, flood insurance may be required."

Drainage Facilities Construction Agreement and Financial Guarantee

Section 9C of SSCAFCA's Drainage Policy states that "if the construction of such (drainage) facilities is a condition of plat approval or building permit issuance, then financial guarantees of such construction satisfactory to the City/SSCAFCA shall also be provided as a prerequisite." In those instances where financial guarantees are required, the developer enters into an agreement with the City assuring the construction of such facilities. The form of agreement and the nature of acceptable financial guarantee is dependent on the circumstances involved.

Forms and Certificates

Current copies of forms and certificates such as the drainage information sheet can be obtained from the Development Service Department (DSD), SSCAFCA or through SSCAFCA's website at www.sscafca.com.

CONFERENCE RECAP

DRAINAGE FILE/ZONE ATLAS PAGE NO. ______________ DATE: ____________

PLANNING DIVISION NOS: EPC _________________ DRB __________________
SUBJECT: ____

STREET ADDRESS (IF KNOWN)
____

SUBDIVISION NAME: _______________________ BLOCK: __________ LOT: __________

TYPE OF PROJECT

____ PRELIMINARY PLAT ____ FINAL PLAT

____ SITE DEVELOPMENT PLAN ____ BUILDING PERMIT

____ (OTHER)_________________ ____ ROUGH GRADING

ATTENDEES

WHO	REPRESENTING
____________________	_________________________
____________________	_________________________
____________________	_________________________

FINDINGS:

____

____

____

____

The undersigned agrees that the above findings are summarized accurately and are only subject to change if further investigation reveals that they are not reasonable or that they are based on inaccurate information.

SIGNED: ____________________________ SIGNED: ____________________________

TITLE: ______________________________ TITLE: ______________________________

DATE: ______________________________ DATE: _______________________________

***NOTE**PLEASE PROVIDE A COPY OF THIS RECAP WITH THE DRAINAGE SUBMITTAL**

DRAINAGE INFORMATION SHEET

PROJECT TITLE: ______________________________________ RIO RANCHO CASE #: _____________________
SSCAFCA File #: ____
LEGAL DESCRIPTION: ____
PROPERTY ADDRESS:____

ENGINEERING FIRM: _____________________________________ CONTACT: _______________________
ADDRESS: _______________________________________ PHONE: ___________________________
CITY, STATE: ____________________________________ ZIP CODE: ________________________

OWNER: ____ CONTACT: _______________________
ADDRESS: _______________________________________ PHONE: ___________________________
CITY, STATE: ____________________________________ ZIP CODE: ________________________

ARCHITECT: ____ CONTACT: _______________________
ADDRESS: _______________________________________ PHONE: ___________________________
CITY STATE: _____________________________________ ZIP CODE: ________________________

SURVEYOR: ____ CONTACT: _______________________
ADDRESS: _______________________________________ PHONE: ___________________________
CITY, STATE: ____________________________________ ZIP CODE: ________________________

CONTRACTOR: ____ CONTACT: _______________________
ADDRESS: _______________________________________ PHONE: ___________________________
CITY, STATE: ____________________________________ ZIP CODE: ________________________

CHECK TYPE OF SUBMITTAL:

_____ DRAINAGE REPORT
_____ DRAINAGE PLAN 1st SUBMITTAL
_____ DRAINAGE PLAN RESUBMITTAL
_____ GRADING PLAN
_____ EROSION CONTROL PLAN
_____ ENGINEER'S CERTIFICATION (HYDROLOGY)
_____ CLOMR/LOMR
_____ ENGINEERS CERTIFICATION (SITE PLAN)
_____ OTHER

CHECK TYPE OF APPROVAL SOUGHT:

_____ PRE-DESIGN CONFERENCE
_____ SIA/FINANCIAL GUARANTEE RELEASE
_____ PRELIMINARY PLAT APPROVAL
_____ S. DEV. PLAN FOR SUB'D APPROVAL
_____ S. DEV. PLAN FOR BLDG. PERMIT APPROVAL
_____ FINAL PLAT APPROVAL
_____ FOUNDATION PERMIT APPROVAL
_____ BUILDING PERMIT APPROVAL
_____ CERTIFICATE OF OCCUPANCY (PERM.)
_____ CERTIFICATE OF OCCUPANCY (TEMP.)
_____ GRADING PERMIT APPROVAL
_____ PAVING PERMIT APPROVAL
_____ WORK ORDER APPROVAL
_____ REQUEST FINAL APPROVAL
_____ OTHER (SPECIFY)

DATE PRE-DESIGN CONFERENCE HELD:
____

DATE SUBMITTED: ______________________________ BY: ____

Requests for approvals of Site Development Plans and/or Subdivision Plats shall be accompanied by a drainage submittal. The particular nature, location and scope to the proposed development defines the degree of drainage detail. One or more of the following levels of submittal may be required based on the following:

1. **Conceptual Grading and Drainage Plan:** Required for approval of Site Development Plans greater than five (5) acres and Sector Plans.

2. **Drainage Plans:** Required for building permits, grading permits, paving permits and site plans less than five (5) acres.

3. **Drainage Report:** Required for subdivision containing more than ten (10) lots or constituting five (5) acres or more.

(A) Fees

The consultant should be advised that FEMA has a cost for reviewing private development projects to recover their engineering review and processing associated with the issuance of Conditional Letters of Map Amendments (CLOMA's), Conditional Letters of Map Revision (CLOMR's), Letters of Map Revisions (LOMR's), and Letters of Map Amendments (LOMA's).

FEMA's current fee schedule may be obtained from the City Floodplain Administrator. All fees may be subject to change by FEMA.

Prior to preparing information for a map revision or amendment, it is recommended that a pre-design meeting be initiated with the City Floodplain Administrator to discuss your request. At this meeting, specific information relating to your CLOMA, LOMA, CLOMR or LOMR will be identified. All submittals must be made on current FEMA Forms. All submittals will be sent to FEMA by the City/County Floodplain Administrator.

(B) Letter of Map Amendment (LOMA)

The purpose of a LOMA is to provide an administrative procedure whereby FEMA will review the scientific or technical submissions of an owner or lessee of property who believes his property has been inadvertently included in designated A, AO, AE, AH, A99, VE, or V Zones, as a result of the transposition of the curvilinear line to either street or to other readily identifiable features. The necessity for this is due in part to the technical difficulty of accurately delineating the curvilinear line on a FIRM map. These procedures shall not apply when there has been any alteration of topography since the effective date of the FIRM map, which shows the property within an area of special flood hazard.

Any owner or lessee of property (applicant) who believes his property has been inadvertently included in a designated A, AO, AE, AH, A99, VE or V Zones on a FIRM map, may submit scientific or technical information to the City Floodplain Administrator to be forwarded to FEMA for review.

(C) Conditional Letter of Map Revision (CLOMR)

A Conditional Letter of Map Revision is FEMA's comment on the effectiveness or impacts of a proposed flood control project or flood plain modification. It is based on FEMA's review of the proposed project and states that if the proposed project is built as designed, it would be cause for a Letter of Map Revision. The CLOMR does not revise the FEMA flood maps.

(D) Letter of Map Revision (LOMR)

If land development involves the reclamation of a floodplain or floodway, it is recommended that you contact the City Floodplain Administrator to discuss the specific requirement for a LOMR. The criteria for LOMR's will be per FEMA's latest revision of The National Flood Insurance Program and Related Regulation.

Revisions to effective NFIP maps are most often requested because of physical changes that have taken place in the flood plain. Such changes include, but are not limited to, the construction of new bridges, culverts, levees, or channel improvements and the grading and filling normally associated with development (including the placement of fill to elevate individual structures above the BFE).

Occasionally, revisions will be requested because the analyses used to develop the data shown on the effective NFIP are found to contain errors, or because a requester believes that the use of alternative methodologies or better data will provide results that are more accurate than those obtained from the original FEMA analyses.

The typical required submittal for map revisions because of physical changes is as follows:

a. General description of the changes (dam, diversion channel, detention basin, etc.)
b. Construction plans for as-built condition, if applicable.
c. New hydrologic analysis accounting for the effects of the changes.
d. New hydraulic analysis using the new flood discharge values resulting from the hydrologic analysis.
e. Revised delineations of the flood plain boundaries or floodway.

All requests to FEMA must be accompanied by the latest NFIP forms. Two sets of the required data must be submitted to the City Floodplain Administrator. The Administrator will forward the submittal to FEMA for the map revision. The consultant should be aware that FEMA may request additional data or fees prior to releasing a LOMR.

B. Procedure for Storm Drainage Infrastructure Allocation

A. Introduction

This section provides the procedure for the allocation of drainage infrastructure improvements that are generated by and attributable to new development.

B. Purpose

The purpose of this Procedure is to provide an equitable cost distribution method for drainage improvements that allows for the installation of public drainage facilities with new development and a mechanism to provide for the Cost Allocation to and payment of those facilities by the properties that are seeking development approval and benefit from the facilities.

C. Generally

1. The City/SSCAFCA acknowledges that new development may construct drainage facilities that benefit other property within a drainage basin. The provisions of this Procedure provide the manner in which such facilities may be constructed by an applicant and the method to allocate the Cost to benefited property owners.

2. This Procedure is intended to complement and supplement the Subdivision Ordinance, Erosion Control; Storm Drainage Ordinance and the Flood Hazard Prevention Ordinance of the City, SSCAFCA Drainage Policy and shall be administered in concert therewith. Pursuant to the City Erosion Control Ordinance and SSCAFCA Drainage Policy, all properties proposed for development must provide for the management and conveyance of storm runoff from a fully developed upstream drainage basin.

3. Administration and enforcement of this Procedure may be delegated to the City Engineer.

D. Infrastructure Allocation Drainage Management Plan (Allocation Plan)

1. Any new development which requires the construction of public drainage facilities that service more than a single platted parcel of land may prepare an Allocation Plan. An Allocation Plan shall be required to support a request for the Cost Allocation of the cost of drainage facilities to benefiting properties. Generally, the Allocation Plan shall (1) define the extent and limits of the drainage basin to be served by the drainage facilities to be constructed; (2) determine the drainage and water quality facilities necessary to collect, control and convey storm water runoff based on the design storm generated within the drainage basin; (3) identify a drainage outfall for the drainage facilities proposed for construction; (4) define the benefited area; and (5) include a Preliminary Cost Allocation Map and a Preliminary Cost Allocation Table. The Preliminary Cost Allocation Table and Preliminary Cost Allocation Map may be prepared based on existing or proposed platting of lands within the benefited area. Previous studies, reports and/or plans may be utilized in preparation of the Allocation Plan, as accepted by the City/SSCAFCA.

2. The Allocation Plan shall include a current estimate of the total calculated cost of constructing the drainage facilities, including the anticipated costs for engineering studies and design, surveying, planning, Federal Emergency Management Agency Map revisions and amendments construction, construction management, observation and administration, easement, right-of-way and property acquisition, and other incidental costs which can be anticipated. The City's estimated Unit Prices Contract Items, latest edition, shall be used whenever possible.

3. The Allocation Plan shall be prepared and/or amended by or under the direct supervision of a professional engineer registered in the State of New Mexico and competent in the areas of surface water hydrology and hydraulics. The design work referenced above shall be performed in accordance with the City/SSCAFCA Ordinances, Policies and DPM.

4. The Allocation Plan shall be based upon fully developed conditions, [excepting properties excluded under paragraph G (9)] taking into consideration the current elements of the applicable City land use master plan(s), or other reasonable land use models, as they relate to the benefited area, and other relevant known factors, such as changes in zoning or development trends not reflected on the master plan(s).

5. The Allocation Plan shall specifically identify and address, but not be limited to, the following:

a. land use assumptions

b. the benefited area, drainage basin and benefit

c. undeveloped and developed conditions and assumptions which shall be illustrated by a definitive table establishing the specific discharge rate for each property and volume

d. hydrology/hydraulic analysis

e. phasing

f. required drainage facilities and associated infrastructure

g. all costs for the drainage facilities and associated infrastructures

h. current conditions

i. anticipated sources of funding independent of the Cost Allocations

j. required right-of-way

k. how cost allocations are established (methodology)

l. all properties within the benefited area (preliminary Cost Allocation Map)

m. preliminary Cost Allocations to properties, and identify "excluded" or benefited properties that shall not be allocated (if any)

n. a cost allocation Table

o. a cost allocation Map

6. Neither the City/SSCAFCA or any other owner or developer of land in the benefited area shall subsequently construct a drainage facility that does not comply with an approved Allocation Plan.

E. Review and Approval Procedure

1. **Pre-Application Meeting.** It shall be mandatory that a pre-application meeting occur prior to initiating any of the following steps. Upon request, the City/SSCAFCA shall schedule a meeting with the applicant to discuss general Allocation Plan procedures and the merits of the proposed Allocation Plan.

2. **City/SSCAFCA Review and Approval**

a. The Applicant shall submit a draft Allocation Plan to the City/SSCAFCA for preliminary review and comment. The final Allocation Plan shall be approved by the City Engineer at a public hearing after notice in a newspaper of general circulation at least 15 days prior to the hearing prior to initiation of any subsequent steps in these procedures.

b. The approved Allocation Plan shall be on file at the City Engineer's office and open to public inspection.

F. Establishing Cost Allocations

1. The method for determining the Cost Allocation associated with each property within the benefited area shall be set forth in the Allocation Plan, in accordance with this section. The Cost Allocation shall be determined by multiplying the total costs of the drainage facilities by a Cost Allocation Factor.

2. The Cost Allocation Factor may be calculated by: (1) a proportion of individual parcel area to the total area of the Benefited Area, (2) a proportion of the designed discharge or runoff volume for the property as set forth in the Allocation Plan to the total designed discharge or runoff volume of the public drainage facility to be constructed as set forth in the Allocation Plan, or (3) of a cost sharing matrix which takes into account such factors as property size, designed discharge, floodplain removed, partial basin Cost Allocation, allocation of downstream capacity, ponds reclaimed, frontage, prudent line changes and other factors.

3. The method or combination of methods selected for establishing Cost Allocations shall be approved by the City/SSCAFCA and used in preparing the Cost Allocation Table.

4. The total calculated cost of the drainage facilities to be constructed shall consist of all costs, including, but not limited to, engineering, surveying, planning, Federal Emergency Management Agency Map revisions and amendments, the acquisition of easements, rights-of-way or other property, environmental permitting and mitigation and construction.

5. The cost allocation or the required drainage infrastructure identified by the Allocation Plan for each new development shall be identified on the approved infrastructure list for the new development, and shall be required as a condition to final plat final site plan approval, or building permit approval.

6. All money collected through this procedure shall be due at the time of final plat approval or final site plan approval.

7. All money collected through the implementation of this Procedure shall be maintained by the City Engineer in a segregated account clearly identifying the payer and the drainage facility within the benefited area for which the payment was made. All money collected through this procedure shall be used to construct the infrastructure as shown on the approved Allocation Plan.

8. In the event that the drainage basin extends outside the City's municipal limits, the benefited area may also extend beyond those limits provided that the benefited property owners outside the City's municipal limits consent to participation.

9. The exclusion of properties from Cost Allocation shall be subject to the following conditions and qualifications.

a. Properties within the Drainage Basin that will not benefit from the drainage facilities shall be identified in the Allocation Plan but excluded from Cost Allocation. For example, such excluded properties may not reasonably drain to the drainage facilities to be constructed, or which have already been developed with permanent stand alone drainage systems and would receive no benefit from the proposed drainage facilities.

b. Permanent Open Space within the Drainage Basin shall be identified in the Allocation Plan but excluded from Cost Allocation. The cost that would have been allocated to the open space will be distributed in accordance with paragraph G (2) to the remaining benefited properties.

c. Public right-of-way shall not be subject to Cost Allocation.

d. The Applicant may choose to exclude property within the benefited area, provided that (1) such exclusion does not increase the Cost Allocations of other properties, or (2) the applicant submits written verification that all of the other allocated properties have agreed to accept the excluded property's Cost Allocation in an equitable or agreed upon manner.

e. Property owned by the United States of America, the State of New Mexico or any other property owned by an entity not subject to the jurisdiction of the City's Planning and Development regulations include ROW owned by SSCAFCA shall not be subject to Cost Allocation.

f. Excluded properties, as approved by the City, shall be limited to existing condition discharge.

G. Design of Drainage Facilities

1. After the City/SSCAFCA has approved the Allocation Plan and the applicant is ready to proceed with his development, the applicant shall have the drainage facilities designed by a professional engineer in accordance with the DPM and the approved infrastructure list. The construction plans and specifications shall be submitted to the City/SSCAFCA for review and, if acceptable, approval.

2. Construction cost/quantity estimates shall be prepared and approved in accordance with applicable policies of the City/SSCAFCA and prepared in such a manner that the total cost for Allocation Plan items alone can be determined.

3. The construction plans shall not necessarily be limited to Allocation Plan item construction only.

H. Construction and Inspection of Facilities

1. Upon approval of the construction plans and specifications by the City/SSCAFCA, completion of applicable competitive bidding, and acquisition of the necessary easements, rights-of-way, environmental mitigation and permitting, or other necessary property interests, the applicant shall cause the drainage facilities to be installed, at the applicant's expense, strictly in accordance with the approved plans and specifications.

2. Prior to construction, the applicant or applicant's contractor shall obtain approval from the City/SSCAFCA, complying with all procedures and practices normally required to obtain same,

including but not limited to applicable bonds, subdivision improvement agreements, construction contracts, insurance certificates and fees.

3. Construction inspection, surveying and testing shall be performed in accordance with applicable City/SSCAFCA policies.

4. Changes to Allocation Plan related construction items shall be allowed during construction, provided the City/SSCAFCA approves the field change in writing as being substantially in conformance with the approved Allocation Plan.

5. If the change varies by 10% or more of the original estimated Allocation Plan cost, the Allocation Plan shall be amended and resubmitted by the applicant to the City/SSCAFCA for reapproval.

6. Financial guarantees shall be withheld until such time as the Allocation Plan is amended to reflect as-constructed changes and conditions.

I. Temporary or Phased Drainage Facilities

1. Temporary facilities and phased construction of drainage facilities are only allowed and/or required on a case-by-case basis as determined by the City/SSCAFCA. The level of protection to be provided by temporary or phased facilities shall be determined by considering:

a. the likelihood and consequences of a failure;

b. length of time until permanent facilities shall be in place;

c. the acceptance of maintenance responsibilities and legal liabilities;

d. the provision of substantially complete plans of all required permanent allocation plan infrastructure.

All costs of approved temporary or phased facilities shall be included in the Cost Allocations, as approved by the City/SSCAFCA, and to the extent that the temporary facilities benefit the area.

2. Under phased construction of drainage facilities where the developer is not required by the approved Allocation Plan to install an amount of infrastructure equal to or exceeding his ultimate Cost Allocation to support the development of his phase, the developer installing the drainage facilities shall: (1) install infrastructure equal in cost to the developer's required Cost Allocation, as determined by the completed Allocation Plan improvements without phasing, or (2) pay cash or post a suitable financial guarantee acceptable to the City in an amount equal to the difference between the cost of drainage facilities constructed and the developer's required Cost Allocation, as determined under the completed Allocation Plan improvements without phasing.

J. Updating Allocation Plan and Cost Allocations

1. Allocation Plan and the Cost Allocations shall be updated with each subsequent development or as required by the City/SSCAFCA.

2. As determined by the City Engineer/SSCAFCA, the Allocation Plan shall be reviewed and/or updated to reflect changed conditions within the drainage basin.

K. Appeals; SSCAFCA Executive Committee

1. Any applicant aggrieved by a decision at to actions of the Executive Engineer or absence of such decision, may appeal such decision to the Executive Committee of SSCAFCA. Such appeal shall be made by notice of appeal in writing addressed to the Chairperson of the Executive Committee and delivered to SSCAFCA within 30 days after the date the decision was mailed to the applicant. The Chairperson of the Executive Committee shall notify the applicant and the Executive Committee Members of the date, time, and place of the appeal hearing at least five day prior to the hearing date. Such hearing shall be conducted not earlier than ten days no later than 30 days after the filing of the notice of appeal. At the hearing, the Executive Committee may consider such facts, exhibits , and engineering principles as may be presented by the appellant or the Executive Engineer or his designee, or of which the members may have knowledge or experience, and may affirm, reverse or modify the decision appealed from, and attach as condition to their decision such requirements as in their opinion may be necessary or appropriate in compliance with the policies of §§ 1 et seq. to safeguard persons and property from storm water runoff. Each decision of the Executive Committee shall be in writing and shall state reasons therefore. A copy of the decision shall be promptly mailed to the applicant and to the Executive Engineer and City Engineer.

2. The Executive Engineer or applicant aggrieved by any decision of the Executive Committee may appeal such decision to the SSCAFCA Board of Directors. Such appeal shall be requested by notice of appeal in writing addressed to the Chairman of the SSCAFCA Board of Directors within 30 days after the date a copy of the decision was mailed to the applicant. Such appeal shall be heard after notice at the first available meeting of the SSCAFCA Board of Directors. The SSCAFCA Board of Directors may affirm, reverse, or modify the decision of the Executive Committee. A copy of the decision shall be promptly mailed to the applicant and to the Executive Engineer and City Engineer.

L. Appeals; City Of Rio Rancho City Council

M. Application

1. This Procedure shall apply to and be required of new development projects requesting platting, site plan and building permit approvals that, prior to the effective date of this Procedure, have not received preliminary plat (and such approval has not expired) and for which the construction of public drainage facilities are required. At the request of the Developer, development projects that have proceeded beyond preliminary plat approvals may be considered for review and application of this Procedure upon approval of the City/SSCAFCA. Where phasing of drainage facility construction is planned, the provisions of this Procedure shall be applied only to that phase of

construction, or phases identified in an approved Allocation Plan, which has not been completed nor commenced.

2. For development projects for which a drainage submittal to the City/SSCAFCA has already been made, the applicant shall have the option of proceeding with a standalone project independent of the Allocation Plan or conform to this Procedure.

3. This procedure shall be promulgated as an administrative rule change to the Development Process and shall become applicable to new development 30 days after the approved rule change is promulgated.

Section 8. SUPPLEMENTARY MATERIALS FOR DRAINAGE SUBMITTALS

A. Drainage Submittal Format

1. *INTRODUCTION*

A Drainage Submittal is generally in the form of either a Conceptual Grading and Drainage Plan, Drainage Report or Grading and Drainage Plan. All drainage submittals shall include a cover letter explaining the purpose of the submittal and clearly identify the action being requested from SSCAFCA. Quite often, the terms are used interchangeably. The following are definitions of these three types of submittals:

2. *CONCEPTUAL GRADING AND DRAINAGE PLAN*

Conceptual Grading and Drainage Plans are a graphic representation of existing and proposed grading, drainage, flood control, erosion control and stormwater pollution prevention information. The information should be of sufficient detail to determine project feasibility. The purposes of this plan are to check the compatibility of the proposed development within grading, drainage, floodplain, erosion control and stormwater pollution prevention constraints as dictated by on-site physical features as well as adjacent properties, streets, alleys and channels. Modifications to the comprehensive plans and the development of area plans, sector plans, site development plans and landscaping plans on tracts of five (5) acres or more are appropriate applications of conceptual grading and drainage plans.

3. *DRAINAGE REPORT*

A Drainage Report is a comprehensive analysis of the drainage management, flood control, erosion control and stormwater pollution prevention constraints on and impacts resulting from the proposed platting, development or construction of a particular project. Drainage Reports are required for subdivisions containing more than 10 lots or comprising more than 5 acres, platting or construction proposed within a designated flood hazard area, and for platting or development proposed adjacent to a major arroyo.

4. *GRADING AND DRAINAGE PLAN*

A Drainage Plan is a comparatively short, yet comprehensive, presentation for small, non-complex development submittals. Drainage Plans are often combined with or accompany the detailed Grading Plan, and address both onsite and offsite drainage management, flood control, erosion control and stormwater pollution prevention. Drainage Plans are required for the approval of Building Permits, Site Development Plans, and Landscape Plans for the development of projects 5 acres or less in size.

The Format presented below provides for a logical and comprehensive treatment of the topics relevant to the review and analysis of a complete Drainage Submittal. The Format is presented in outline form for simplicity. In addition, each submittal shall include the following information:

1. Project Name
2. Name of Engineering Firm
3. Engineer's Seal (signed and dated)
4. Appropriate completed check list

NOTE: The following Outline is intended as a guide for the preparation of Drainage Submittals. Some items may not be applicable, while other items may require a more in-depth treatment or may have been overlooked in the preparation of the Outline.

A pre-design conference is required for projects where the scope may be difficult to define, the constraints and conditions somewhat unique, or the drainage solution non-traditional.

B. Drainage Report Outline

I. EXECUTIVE SUMMARY

A. Provide a brief yet comprehensive discussion of the following:

1. General project location
2. Development concept for the site
3. Drainage concept for the site (include relevant #'s as appropriate)
4. How offsite flows will be handled
5. How onsite flows will be handled and discharged
6. Downstream capacity and how determined
7. Impacts on or requirements of other jurisdictions

B. Identify all approvals being requested in conjunction with this submittal, such as:

1. Zone Change
2. Subdivision Plat
3. Site Plan for Subdivision
4. Site Development Plan for Building Permit

5. Building Permit

6. Sidewalk Culverts, Drain Line through Curb, Drain Line to Existing Storm Inlet

7. Grading Permit

8. Paving Permit

9. DPM Design Variance

10. CLOMR, LOMR or LOMA

11. USACE 404 Permit

II. INTRODUCTION

A. Narrative description of project scope

1. Provide more detail than presented in the Executive Summary (combine with Executive Summary for non-complex projects)

B. Project requirements

1. Discuss and reference required infrastructure and associated infrastructure list

2. Platting and/or easements

3. Approvals by and/or coordination with other Agencies and/or entities

C. Attachments (when applicable)

1. Infrastructure List (draft, preliminary, amended or approved)

2. Preliminary or Final Plat

3. Easement Documents

4. Drainage Covenants

5. Approval Letters

III. PROJECT DESCRIPTION

A. Location

1. Discuss relationship of the site to the following:

a. Well known landmarks

b. Municipal limits

c. City Zone Atlas page and reference

d. Other jurisdictional boundaries

e. Previously approved Drainage Management Plans, Drainage Reports, Plans or studies including watersheds, basins, drainage ways, etc. as defined therein

2. Provide copy of Zone Atlas page, or equivalent, with the site location superimposed

B. Legal Description

1. Identify the current legal description(s) of the land which comprises the site

2. Identify the proposed legal description(s), when applicable, of the land which comprises the site

3. Include a copy of existing and/or proposed platting as an attachment in cases where its inclusion will lend clarity or facilitate the review

C. Flood Hazard Zone

1. Identify proximity of site to a designated Flood Hazard Zone

2. Provide reference to the above referenced Flood Hazard Zone

3. Identify whether or not the site drains to, or has an adverse impact upon, a designated Flood Hazard Zone

4. Include a copy of the relevant FEMA Flood Insurance Rate Map (FIRM) or Flood Boundary and Floodway Map with the site clearly identified along with all affected Flood Zones

5. Identify portion of designated Flood Hazard Zone to be revised or amended when CLOMR, LOMR or LOMA approval requested

IV. BACKGROUND DOCUMENTS

A. Planning History

1. Reference and discuss relevant Planning and Zoning actions, plans or studies

2. Verify and/or demonstrate compatibility with the above actions, plans and studies

B. Drainage History and Related Documents

1. Reference and discuss relevant Drainage Management Plans, Drainage Plans, Reports and Studies

2. Reference applicable Hydrology Files.

3. Discuss status of above referenced Plans, Reports and Studies

4. Describe compatibility with or deviation from the above referenced Plans, Reports and Studies

5. Describe the location of site with respect to previously defined watersheds or drainage basins

6. Provide copies of pertinent data from above referenced Plans, Reports and/or Studies when applicable

V. EXISTING CONDITIONS

A. Site Investigation

1. Describe by text or clearly show graphically the following:

   a. onsite drainage patterns

   b. onsite drainage facilities

   c. point(s) of discharge

   d. drainage basin(s) boundaries

   e. offsite drainage facilities

   f. offsite drainage patterns including offsite flow conditions

   g. condition and status of adjacent properties (e.g. developed, undeveloped, under construction, etc.)

   h. condition and status of adjacent right-of-way (e.g. developed, undeveloped, under construction, etc.)

   i. presence of any other relevant features

B. Site Evaluation

1. Discuss the significance and impacts of the following:

   a. onsite drainage facilities

   b. offsite drainage facilities

   c. point(s) of discharge

   d. drainage basin(s) boundaries

   e. offsite flow conditions

   f. proximity to designated flood hazard zone(s)

   g. presence of any other relevant features or conditions which may impact or be impacted by the development of the property or project

2. Form of Analysis

   a. Most situations - most submittals require both qualitative and quantitative analyses

   b. Unique situations - for some cases, such as infill sites, a qualitative analysis by itself may be appropriate. Examples of appropriate qualitative analysis criteria are:

      (1.) a comparison of the runoff generated by the proposed development to that generated by the overall drainage basin with respect to the impacts of the anticipated increase

      (2.) impacts on downstream flood plains

      (3.) potential offsite problems which may or may not be attributed to this development

      (4.) anticipated impact(s) and/or precedent to be set on the development of the remaining infill sites by following the same drainage concept

3. Downstream Capacity

   The evaluation of downstream capacity shall include, but not be limited to, the following:

   a. Assumptions

      (1.) fully developed watershed

      (2.) ability to accept and safely convey runoff generated from the 100-year design storm

b. Hydraulic capacity

(1.) channel

(2.) crossing structure

(3.) storm inlet and/or entrance conditions

(4.) storm drain

(5.) street and/or alley

c. Storage capacity

(1.) Detention pond/reservoir

(2.) Retention pond

(3.) Flood zone

d. Stability

(1.) Channel/arroyo

(2.) Natural slope

(3.) Cut/fill slope

e. Existing publicly owned ROW and Easements

VI. DEVELOPED CONDITIONS

A. Onsite

1. Discuss the following as applicable:

a. proposed development/construction

b. impacts on existing drainage patterns

c. impacts on existing drainage basins

d. impacts on existing onsite facilities

e. identification of offsite flow conditions

f. compatibility/compliance with previously approved and/or adopted Plans, Reports and Studies

g. sediment bulking and transport

h. aggradation and/or degradation potential

i. impacts on designated flood hazard zones

j. required private drainage improvements

k. required infrastructure

l. required easements

m. phasing and future improvements

n. ownership, operation and maintenance responsibilities

o. stormwater pollution potential during construction and post construction

2. Evaluate and/or quantify the following:

a. capacity and freeboard of existing onsite facilities

b. capacity and freeboard of proposed onsite facilities

c. impacts on designated flood hazard zones

d. impacts on existing drainage patterns and drainage basin boundaries

e. impact of offsite flows on the proposed development

f. erosion potential and erosion setback requirements

g. phased system capacities and ability to function as a standalone system

h. emergency overflow spillway conditions

B. Offsite

1. Discuss the following:

a. impacts on existing drainage basins and/or watersheds

b. impacts on existing offsite facilities and downstream capacity

c. compatibility/compliance with previously approved and/or adopted Plans, Reports and Studies

d. impacts on designated flood hazard zones

e. required improvements to insure runoff from development can be properly conveyed to a publicly owned arroyo or Storm Sewer System

f. required easements to insure runoff from development can be properly conveyed to a publicly owned arroyo or Storm Sewer System

g. right-of way dedications to insure runoff from development can be properly conveyed to a publicly owned arroyo or Storm Sewer System

h. phasing and future improvements

i. ownership, operation and maintenance responsibilities

j. concurrence and/or approval from affected property owners for offsite grading or construction activities

2. Evaluate and/or quantify the following:

a. capacity of existing offsite facilities

b. capacity of proposed offsite facilities

c. impacts on downstream designated flood hazard zones

d. impacts on downstream drainage basins and/or watersheds

e. downstream capacity

NOTE: Any excess downstream capacity, based on a fully developed watershed, will be allocated by SSCAFCA

VII. GRADING PLAN

A. Description

1. Reference the Grading Plan when included as an attachment to the Drainage Submittal

2. Describe elements of the Plan and how those elements relate to the Existing and Developed Conditions sections of the submittal discussed above

3. Discuss and reference all other supporting drawings provided in support of the Drainage Submittal

B. Content

1. Refer to Grading Plan Checklist that follows

VIII. CALCULATIONS

A. Description

1. Provide narrative description of the calculations performed to support the analyses and evaluations discussed above

2. Discuss and reference calculations for Existing, Developed and Future hydrology

3. Discuss and reference hydraulic calculations demonstrating capacity and/or adequacy of existing and proposed facilities

4. Provide sample calculations, tables, charts, etc. as necessary to support the calculations and results discussed above

5. Reference computer software, documents, circulars, manuals, etc. used to produce the calculations and results discussed above

IX. CONCLUSION

A. Summary of proposed drainage management strategy

B. Justification of rationale for discharge of developed runoff from site

C. Summary of proposed drainage improvements

D. Identification of DPM design variances being requested

E. Identification of required Drainage Covenants

F. Identification of ownership, operation and maintenance responsibilities

The following check list must be completed and submitted

with the drainage report.

EXHIBIT 8-1

DRAINAGE REPORT CHECKLIST

NOTE: This document is intended as an aid in preparing Drainage Reports located in southern Sandoval County. This checklist was developed by the Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA). This document is not intended to be all inclusive, and does not limit the extent of the information, calculations, and exhibits that may be necessary to properly evaluate the intended land use. **This checklist must be included with all drainage report submittals.**

General Information:

Date: ________________ File Name or No. ____
Project Name: ____
Proposed Land Use: ________________________________ Zoned: ___________________________
Location: ____________________________ Acreage: _____________ No. of Lots: ________________
Legal Description: ____
FIRM Community Panel No: _______________________________ SFHA: ○ Yes ○ No
Engineering Firm: ____
Project Manager: ____
Telephone No: ______________________________ Fax No: ________________________________
Address: ____
Email: ____

Drainage Report Contents General Format

The following items must be included in order to initiate review:

1. Project Name and Legal Description
2. Engineer's Seal, Signature and Date
3. Typed, Bound, Legible Report
4. Pertinent portions of all referenced information/reports
5. Drainage Report Checklist

Engineer's Signature: ____ Date: _______________

(seal)

Introduction			
Description	**Yes (included)**	**Not Applicable**	**Reviewer's Notes**
Type of approval sought (i.e. zone change, subdivision plat, vacation, site plan, paving or grading permit, variance)			
Complete summary of study intent, resultant Drainage Management Plan for the site**.** Describe how all off- and on-site flows are dealt with and how they leave the site, with respect to downstream capacity, historic and/or existing and full development condition flows.			
Location and Project Description			
Vicinity Map			
Copy of Preliminary or Final Plat			
Phasing Description			
Discussion of jurisdictions affected			
Watershed Name			
Site investigation Summary (describe if any grading has occurred since topography shown on plan, existing off- and on-site drainage facilities, etc.)			
References and Drainage / Planning History			
Description	**Yes (included)**	**Not Applicable**	**Reviewer's Notes**
Floodplain Information & Map (show property location on copy of effective FEMA Flood Insurance Rate Map (FIRM)			
References - Planning History, Zoning			
SSCAFCA/Master Planning Info. (facility design over 500 cfs or adjacent to SSCAFCA facility will require SSCAFCA approval)			
Drainage Basin Description			
Description	**Yes (included)**	**Not Applicable**	**Reviewer's Notes**
Off-site Flow Description & Map (with topo, flow patterns, and Q100)			
Existing Site Condition and Drainage Facilities Description			
Soils, Geology, Land Treatments			
Existing and proposed zoning and land use			
On-site Flow Description & Map (with topo, flow patterns, Q100 pre and post development, V100 pre and post development at analysis points)			
Hydrology			
Description	**Yes (included)**	**Not Applicable**	**Reviewer's Notes**
Discussion of Hydrologic Model / Methodology (must use current version of AHYMO or equivalent hydrologic modeling program i.e. HEC-HMS)			
Modeling Schematic			
Rainfall Distribution 2-yr. / ___hr. or ____day 10-yr. / ___hr. or ____day (req'd for street design) 100-yr. /___hr. or ____day			
Land Treatment allocations (%) Pre-development / post-development			
Time to Peak Calculations			
Emergency Spillway Design			
Spillway Flood Return Period ___-yr./___hr. or ____day			

Channel Routing (must use Muskingum-Cunge procedure)			
Reservoir Routing			
Hydrology Cont.			
Description	**Yes (included)**	**Not Applicable**	**Reviewer's Notes**
Elevation-Area-Volume-Discharge data and calculations			
Detention Pond Flood Routing Summary Table A*			
Hydrologic Summary Table B (main analysis points)*			
Sediment Yield/Sediment Transport (aggradation/degradation analysis)			
Input File (paper & digital)			
Output File (paper & digital)			
Existing and Proposed Development Site Plan			
State Engineer's Office Approval (dams in excess of 50 acre feet of storage or 25' of embankment height)			
**Blank Summary Tables are attached to this checklist for inclusion in the consultant's report*			
Hydraulics			
Description	**Yes (included)**	**Not Applicable**	**Reviewer's Notes**
Discussion of Hydraulic Model(s) and Methodology			
Parameters for Model(s) / Methodology			
Storm Sewer Hydraulics and Storm Inlet Capacity Calculations (must be submitted)			
Street Capacity Calculations (10-year and 100-year)			
Arroyo, Channel, Culvert, Bridge Capacity Calculations			
Arroyo / Channel stability addressed			
Scour Calculations			
Superelevation Calculations			
Floodplain/Floodway Discussion & Calculations			
Freeboard and levee criteria addressed			
Comparison of historic/existing/fully developed condition peak discharge rates and runoff volumes with respect to existing and proposed drainage infrastructure capacities.			
Verification and discussion of downstream capacity			
Miscellaneous			
Description	**Yes (included)**	**Not Applicable**	**Reviewer's Notes**
Pertinent portions of all referenced information			
Soils investigation			
Structural calculations for retaining walls in excess of 3' in height, sealed by Structural Engineer			
Letter for permission to grade on adjacent parcels from parcel's owner			
Operations / Maintenance requirements ownership/easements and ROW			
All weather access addressed			
Conclusions			
Compliance with local criteria			
Compliance with SSCAFCA criteria			
Compliance with City of Rio Rancho DPM (Sections 22.2 through 22.8) and SSCAFCA criteria			

C. Grading and Drainage Plan Checklist

The following checklist is intended as a guide for preparing a Grading and Drainage Plan to accompany a drainage report or plan. Some items may not be applicable to your particular project; some items may require more detail. A Pre-design Conference is recommended to define scope and project specific requirements.

GENERAL INFORMATION:

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

2. Drafting Standards: (Reference City of Rio Rancho Standards)

   A. North Arrow

   B. Scales - recommended engineer scales:

      (1) 1" = 20' for sites less than 5 acres

      (2) 1" = 50' for sites 5 acres or more

   C. Legend - see City of Rio Rancho D.P.M. Manual, Volume 2, for recommended standard symbols

   D. Plan drawings size: 24" x 36"

   E. Notes defining property line, asphalt paving, sidewalks, planting areas, ponding areas, project limits, and all other areas whose definition would increase clarity

3. Vicinity Map

4. Benchmark - location, description and elevation

   A. Control survey vertical datum

   B. Permanently marked temporary benchmark located on or very near site

5. Flood Insurance Rate Map (FIRM)

6. Legal Description

EXISTING CONDITIONS

1. On-site:

   A. Existing Contours - vertical intervals for contour maps shall not exceed the following:

      (a) One foot intervals for slopes under 1% with sufficient spot elevations at key points to adequately show the site's topography

      (b) Two feet for slopes between 1% and 5%

      (c) Five feet for slopes in excess of 5%

   B. Spot elevations adequately showing conditions on-site.

   C. Contours and spot elevations extending a minimum of 25' beyond property line.

   D. Identification of all existing structures located on-site or on adjacent property extending a minimum of 25' beyond property line with particular attention to retaining and garden walls.

   E. Identification of all existing drainage facilities located on-site or on adjacent property.

   F. Pertinent elevation(s) of structures and facilities defined in A, B and C should be based on the NAVD 88.

   G. Indication of all existing easements and rights-of-way on or adjacent to the site with dimensions and purpose shown.

   H. Existing top of curb and flow line elevations with NAVD 88 designation.

   I. The location of Special Flood Hazard Area Boundaries from the latest FEMA maps must be overlaid on the existing site map (enlarged to site plan scale), when applicable.

2. Off-site:

   A. Contributing Area - delineation of off-site contributing watersheds and/or drainage basins on ortho-topo area maps or equivalent mapping at a preferable scale of 1" =200' or 1" = 500'. Watershed and Basin designations shall match those used in the hydrology calculations.

   B. Existing easements and rights-of-way including ownership and purpose.

PROPOSED CONDITIONS

1. On-site:

   A. Proposed improvements superimposed onto the existing conditions,

B. Proposed Grades

Proposed grades shall be adequately depicted by contours and/or spot elevations conforming with the following minimum criteria:

(1) Contours - vertical intervals for contour maps shall not exceed the following:

(a) One foot intervals for slopes under 1% (with supplemental spot elevations as appropriate to adequately illustrate the proposed grading of the site).

(b) Two feet for slopes between 1% and 5%.

(c) Five feet for slopes in excess of 5%.

(2) Spot Elevations - supply spot elevations at the following:

(a) Key points and grade breaks

(b) Critical locations

(c) Pad elevations

C. Indication of all proposed easements and rights-of-way on or adjacent to the site with dimensions and purpose identified.

D. City Engineer approved street and/or alley grades when site abuts a dedicated unpaved street or alley. In the event that approved grades are not available, provide preliminary street and/or alley grades.

E. Internal contributory drainage areas, including roof areas, outlined on plan.

F. Flow lines defined by arrows and spot elevations with NAVD 88 designation, as appropriate for clarity.

G. Pond(s) 100 year water surface elevation outlined and indicated on plan.

H. Finish building floor elevation(s) or pad elevation(s) with complete NAVD 88 designation, when applicable.

I. Elevations along property lines including relationship to adjacent top of curb.

J. Details of ponds, inverts, rundowns, curb cuts, water blocks, emergency spillways, retaining walls, pond outlets, safety fences, slopes, and all other significant drainage structures with contours, cross-sections and spot elevations. All cross-sections must be drawn to a standard engineering scale and adequately dimensioned.

K. Phasing,

L. Proposed construction of private storm drain improvements within public right-of-way and/or easement including identification of the public entity having ownership.

M. Proposed contours superimposed over existing contours adequately demonstrating changes in grade especially at the property line.

N. Identification of any required offsite grading.

O. Specifications for the proposed grading and/or soil compaction.

P. Erosion Control and Stormwater Pollution Prevention Plans. See Erosion Control and Stormwater Pollution Prevention Plans Checklist.

2. Off-site:

   A. Definition, location, and configuration of required drainage facilities.

   B. Rights-of-way and easements needed to accommodate (A) above.

GRADING AND DRAINAGE PLAN NOTE REGARDING BOUNDARY SURVEYS:

This is not a boundary survey; data is shown for orientation only. The boundary information depicted by this plan is based upon the (boundary survey, plat, etc.) prepared by ________________________, NMPS no. ________, dated ___/___/______. Topographic survey information is based upon a topographic survey prepared by ___________________________ on ___/___/______, NMPS no. ________.

The following check list must be completed and submitted

with the Grading & Drainage Plan.

EXHIBIT 8-2
GRADING AND DRAINAGE PLAN CHECKLIST

A grading and drainage plan is required for Building Permits, Site Development Plans, Landscaping Plans and for developments involving less than 5 acres

Note: This document is intended as an aid in preparing Grading and Drainage Plans for projects located in Southern Sandoval County. This checklist was developed by the Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA). This document is not intended to be all inclusive, and does not limit the extent of the information, calculations, and exhibits that may be necessary to properly evaluate the intended land use. **This checklist must be included with all grading and drainage plan submittals.**

General Information:

Date: ________________File Name or No. ____
Project Name: ____
Proposed Land Use:________________________________Zoned:___________________________
Location:___________________________Acreage:____________ No. of Lots:________________
Legal Description:____
FIRM Community Panel No: _____________________________________SFHA: Yes No
Engineering Firm:____
Project Manager:____
Telephone No: ____________________________ Fax No: _________________________________
Address: ____
Email: ____

Engineer's Signature:____Date:_______________

(seal)

Grading and Drainage Plan Checklist

Description	Yes (Included)	Not Applicable	Reviewer's Notes
Signature Block for Approvals			
Sheet Size: 24" x 36"			
Scale: 1" = 20' for sites less than 5 acres 1" = 50' for site greater than 5 acres			
Bar Scale			
North Arrow			
Vicinity Map			
Legend (reference DPM Tables 27.3a – 27.3d for recommended standard symbols)			
Local Drafting Standards (reference DPM, Chapter 27)			
Project Name			
Professional Engineer's Seal, signature, and date			
Legal Description			
Site Address			
Basis of Bearings			
Benchmark and Datum (above mean sea level)			
Site Benchmark			
Right-of-way lines and dimensions Existing and Proposed			
Easement lines and dimensions Existing and Proposed			
Property Line location, bearings and dimensions existing and proposed			
Limits of existing floodplain based on effective Flood Insurance Rate Map: include a copy of the FIRM and provide reference to Panel number			
Phase lines			
Street Names			
Street dimensions			
Utility Locations Existing and Proposed			
Septic Tank and Leach Field locations			
Retaining and garden wall locations for all walls within 25' of the subject property			
Proposed wall locations and details			
Existing contours encompassing the subject property and 25' beyond boundaries at the following intervals: 1' for slopes less than 1% 2' for slopes between 1% and 5% 5' for slopes greater than 5%			
Existing and proposed spot elevations at critical locations, including: Top of curbs at returns, flow lines, street crowns, lot lines, and all grade breaks. Spot elevations must be provided in sufficient intervals to detail existing and proposed drainage patterns, slopes and transitions			
Daylight proposed contours to existing			
Verify no cross-lot drainage			
Minimum finished floor elevations			
Flow Arrows			

D. Erosion Control and Stormwater Pollution Prevention Plans Checklist

Use this checklist to prepare a plan for the mitigation of damages due to stormwater pollution, soil erosion and deposition. All grading of 1.0 acre or more or 500 cubic yards and any grading within or adjacent to a watercourse defined as a major facility during the months of June, July, August, or September shall provide for erosion control and the safe passage of the 100-year design storm runoff during the construction phase. A Stormwater Pollution Prevention Plan shall be provided for all grading of 1.0 acre or more.

NOTE: *The following checklist is intended to be used as a guide for preparing the plan to meet any or all drainage requirements. Some items may not be applicable to your particular project; some items may require more detail. A Pre-design Conference is required to define the scope and specific requirements.*

1. Provide the corresponding information for the following phases of development:

   A. Rough grading

      1. Grading plan with limits of soil disturbance outlined.

      2. Erosion protection and stormwater pollution prevention practices indicated.

      3. Supporting data, calculations, references and details drawn to scale or adequately dimensioned.

      4. Erosion control and stormwater pollution prevention notes:

         a. The contractor is to ensure that no soil erodes from the site onto adjacent property or public right-of-way. This should be achieved by implementing Best Management Practices (BMPs) to protect the soil from wind, and water erosion.

         b. During the months of June, July, August or September, any grading within or adjacent to a watercourse defined as a major facility shall provide for erosion control and safe passage of the 100-year design storm runoff during the construction phase.

         c. Contractor shall conform to all City, County, State and Federal dust control and stormwater pollution prevention requirements and is responsible for preparing and obtaining all necessary applications, permits and approvals.

         d. All graded areas which do not receive a final surface treatment will be revegetated in accordance with New Mexico APWA Standard Specification 1012 and the Landscape Specifications.

e. Contractor shall obtain and abide by a Grading Permit from the City of Rio Rancho. The cost for required construction dust and erosion control measures shall be incidental to the project cost.

B. Phased development

1. Grading plan with limits of soil disturbance outlined for each phase of development and numbered in sequential order of events.

2. Erosion protection and stormwater pollution prevention procedures indicated for each phase.

3. Supporting data, calculations, references and details drawn to scale or adequately dimensioned.

C. Construction and permanent phase

1. Grading plan with limits of soil disturbance outlined.

2. Erosion protection and stormwater pollution prevention practices indicated.

   a. Project owner and the owner's contractor shall complete federal EPA Notice of Intent (NOI) prior to commencement of any construction project disturbing 1.0 or more acres of land area.

   b. Stormwater Pollution Prevention Plans and accompanying federal EPA administrative procedures shall meet the guidelines and procedures outlined in the current edition of the New Mexico Department of Transportation Stormwater Management Guidelines for Construction and Industrial Activities Manual.

3. Supporting data, calculations, references and details drawn to scale or adequately dimensioned.

The following check list must be completed and submitted

with the Erosion Control & Storm Water Pollution Prevention Plan.

EXHIBIT 8-3

EROSION CONTROL & STORMWATER POLLUTION PREVENTION PLAN CHECK LIST

An erosion control plan is required for all grading of 1 acre or more or 500 cubic yards or more and any grading within or adjacent to a watercourse defined as a major facility during the months of June, July, August or September. The plan shall provide for erosion control and safe passage of the 100-year 6-hour design storm runoff during the construction phase.

Instructions - Fill out <u>all that is applicable</u> and relevant, submit this checklist with the Erosion Control Plan and or the Grading and Drainage Plan

Date: ___________________
Erosion Control Plan Name:____
____
Consultant / Designers Name:____
Consultant / Designers Telephone Number:______________________________________

<u>Erosion Control Plan General Format / Checklist:</u>

Item and Description	**Consultant** (put "Y" yes or "NA" not applicable	**Reviewer** (put "Y" yes adequate or comment or reference a "footnote" for review letter
GENERAL		
1. Title Block with Project Title		
2. Designers Signature and Date	______	___________________
ROUGH GRADING		
1. Grading Plan with limits of soil disturbance outlined	______	___________________
2. Erosion Protection Indicated	______	___________________
3. Supporting data, calculations, references and details drawn to scale or adequately dimensioned	______	__________________
4. Erosion control notes:	______	___________________
a. The contractor is to ensure that no soil erodes		

from the site onto adjacent property or public right-of-way. This should be achieved by wetting the soil to protect it from wind erosion and by installation of berms per detail this sheet. ______ ________________

b. At all time, but especially during the months of June, July, August or September, any grading within or adjacent to a watercourse defined as a major facility shall provide for erosion control and safe passage of the 100-yr. 6-hour design storm runoff during the construction phase. ______ ________________

c. Contractor shall conform to all City, County, State and Federal dust control requirements and is responsible for preparing and obtaining all necessary applications and approvals. ______ ________________

d. All graded areas which do not receive a final surface treatment will be revegetated in accordance with New Mexico APWA Standard Specification 1012 and the Landscape Specifications ______ ________________

e. Contractor shall obtain and abide by a Topsoil Disturbance Permit from the local jurisdiction. The cost for required construction dust and erosion control measures are incidental to construction. ______ ________________

PHASED DEVELOPMENT

1. Grading Plan with limits of soil disturbance outlined for each phase of development and numbered in sequential order of events. ______ ________________

2. Erosion protection indicated for each phase. ______ ________________

3. Supporting data, calculation, references and detail drain to scale or adequately dimensioned. ______ ________________

CONSTRUCTION AND PERMANENT PHASE

1. Grading Plan with limit of soil disturbance outlined. ______ ____________________

2. Erosion protection indicated. ______ ____________________

3. Supporting data, calculations, references and detail drawn to scale or adequately dimensioned. ______ ____________________

E. Engineer’s Certification Checklist for Non-Subdivision Development

Use this checklist when certifying compliance with an approved drainage report or drainage plan for public, commercial and multi-residential buildings requiring a Certificate of Occupancy building permit or grading and paving projects. Engineer must revise the original drawing as approved with the following information which shall serve as minimum criteria for evaluation. This is merely a guide. The level of detail necessary for presentation and verification is a function of the specific plan being evaluated. The engineer's certification must be approved prior to the release of the issuance of a Certificate of Occupancy, or acceptance (by the City) of the completed work.

1. Completed Information Sheet - see Information Sheet.

2. Provide as-built finished floor and/or pad

3. Provide as-built spot elevations on the property line and/or limits of phase development (points of significant grade changes) to demonstrate compliance with the approved drainage report or drainage plan.

4. Provide copies of construction approval from the appropriate government agencies for construction within their right-of-ways and/or easements.

5. Outline the as-built drainage basin(s) (including roof areas) supported with sufficient spot elevations and roof drain locations.

6. Provide as-built elevations and dimensions for the following structures:

    A. Pond(s) (include as-built volume calculations)

    B. Pipe inlet(s) and outlet(s) (include as-built capacity calculations)

    C. Rundown(s) (including the required inlet dimensions)

    D. Spillway(s) (including the required outlet dimensions)

    E. Channel(s)

    F. Flowlines

    G. Erosion control and stormwater pollution prevention structure(s)

    H. Temporary drainage, erosion control and stormwater pollution prevention facilities required for phased development

    I. Retaining and/or garden wall(s)

J. Other features critical to the drainage scheme.

7. Professional Certification

   A. Engineer's stamp dated and signed accompanied with a statement indicating substantial compliance with the approved drainage report and/or deficiencies with recommended corrections.

   B. The surveying associated with the certification must be performed by a professional engineer and/or surveyor in accordance with the "New Mexico Engineering and Surveying Practice Act" as amended and any standards adopted by the State Board of Registration.

ENGINEER'S CERTIFICATION CHECKLIST FOR SUBDIVISIONS

Use this checklist when certifying compliance with an approved drainage report or grading and drainage plan for subdivisions when required for the release of financial guarantees associated with an executed Subdivision Improvement Agreement (SIA). Engineer must revise the approved drawing with the following information, which shall serve as minimum criteria for evaluation. This is merely a guide. The level of detail necessary for presentation and verification is a function of the specific plan being evaluated. The engineer's certification must be approved prior to the release of the SIA and/or financial guarantees.

1. Completed Information Sheet - see <u>Information Sheet</u>.

2. As-Built Information:

   A. Pad elevations

   B. Top of Curb Elevations at critical locations

   C. Property corner elevations at each lot

   D. Horizontal and vertical data for storm drains (public and private)

   E. Horizontal and vertical data for retaining walls

3. As-Built Analysis

   A. Statement and verification that all grades inside the subdivision do not deviate by more than 18" of the approved grades within 50 feet of the subdivision's perimeter.

   B. Statement and verification of street, storm drain and channel hydraulic capacities.

   C. Statement and verification of pond capacities.

   D. Statement of as-built elevation tolerances with respect to the feature being analyzed.

4. Other Approvals

   A. When necessary or appropriate, provide documentation of acceptance or construction approval from other affected governmental agencies or property owners.

5. Clearly State the origin and Date(s) of As-Built Data

6. Supplemental Information

   A. Provide details as necessary to illustrate as-built conditions for instances in which the as-constructed work materially deviates from the as approved design.

   B. Provide calculations to demonstrate and/or verify that all deviations satisfy the intent of the approved design.

7. Professional Certification

   A. Engineer's stamp dated and signed accompanied with a statement indicating substantial compliance with the approved drainage report and/or deficiencies with recommended corrections.

   B. The surveying associated with the certification must be performed by a professional engineer and/or surveyor in accordance with the "New Mexico Engineering and Surveying Practice Act" as amended and any standards adopted by the State Board of Registration.

DRAINAGE CERTIFICATION WITH SURVEY WORK BY PROFESSIONAL SURVEYOR

DRAINAGE CERTIFICATION

I, ________________, NMPE ___, OF THE FIRM ________________, HEREBY CERTIFY THAT THIS PROJECT HAS BEEN GRADED AND WILL DRAIN IN SUBSTANTIAL COMPLIANCE WITH AND IN ACCORDANCE WITH THE DESIGN INTENT OF THE APPROVED PLAN DATED _______. THE RECORD INFORMATION EDITED ONTO THE ORIGINAL DESIGN DOCUMENT HAS BEEN OBTAINED BY ________________, NMPS ___, OF THE FIRM ________________. I FURTHER CERTIFY THAT I HAVE PERSONALLY VISITED THE PROJECT SITE ON _______ AND HAVE DETERMINED BY VISUAL INSPECTION THAT THE SURVEY DATA PROVIDED IS REPRESENTATIVE OF ACTUAL SITE CONDITIONS AND IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF. THIS CERTIFICATION IS SUBMITTED IN SUPPORT OF A REQUEST FOR _____________________________.

(DESCRIBE ANY EXCEPTIONS AND/OR QUALIFICATIONS HERE IN A SEPARATE PARAGRAPH)

(DESCRIBE ANY DEFICIENCIES AND/OR CORRECTIONS REQUIRED HERE IN A SEPARATE PARAGRAPH)

THE RECORD INFORMATION PRESENTED HEREON IS NOT NECESSARILY COMPLETE AND INTENDED ONLY TO VERIFY SUBSTANTIAL COMPLIANCE OF THE GRADING AND DRAINAGE ASPECTS OF THIS PROJECT. THOSE RELYING ON THIS RECORD DOCUMENT ARE ADVISED TO OBTAIN INDEPENDENT VERIFICATION OF ITS ACCURACY BEFORE USING IT FOR ANY OTHER PURPOSE.

____

XXXXXXXXXXXXXXX, NMPE XXXX

(SEAL)

____

DATE

DRAINAGE CERTIFICATION WITH VERIFICATION BY ENGINEER OF RECORD

DRAINAGE CERTIFICATION

I, ________________, NMPE ___, OF THE FIRM ________________, HEREBY CERTIFY THAT THIS PROJECT HAS BEEN GRADED AND WILL DRAIN IN SUBSTANTIAL COMPLIANCE WITH AND IN ACCORDANCE WITH THE DESIGN INTENT OF THE APPROVED PLAN DATED _______. THE RECORD INFORMATION EDITED ONTO THE ORIGINAL DESIGN DOCUMENT HAS BEEN OBTAINED BY ME OR UNDER MY DIRECT SUPERVISION AS SUPPLEMENTAL DATA TO THE ORIGINAL TOPOGRAPHIC SURVEY PREPARED BY ________________________, NMPS ________, OF THE FIRM ___________________________, AND IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF. THIS CERTIFICATION IS SUBMITTED IN SUPPORT OF A REQUEST FOR _____________________________.

(DESCRIBE ANY EXCEPTIONS AND/OR QUALIFICATIONS HERE IN A SEPARATE PARAGRAPH)

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____

XXXXXXXXXXXXXXX, NMPE XXXX

(SEAL)

____

DATE

F. Procedures for Development Review and Approval

This procedure is for development, design, and approval of infrastructure improvement plans. This process is for Private Development projects.

PROCEDURE: INFRASTRUCTURE DESIGN DEVELOPMENT

Pre-Design Phase

For complex projects, this phase shall begin with a pre-design meeting with City/SSCAFCA staff.

***Step 1*: Application for Pre-Design Conference**

Submit a letter to City/SSCAFCA requesting a pre-design meeting.

Application Materials:

- Two (2) copies of Sketch Plat/Plan (if available, a Preliminary Plat and Findings may be substituted).
- A copy of the Conceptual Drainage and Grading Plan.
- The cost of the land being dedicated or the cost of the easement being granted.

Note: If a developer or designer does not have all required submittals available, the developer may still apply for a Pre-Design Conference with SSCAFCA. However, the outcome of the conference will be a limited instruction, pending receipt of the remaining required submittals. A second Pre-Design Conference may be conducted, if requested by the applicant or required by SSCAFCA due to project scope.

Outcome:

- Reviews application material for completeness. If insufficient, developer is notified of additional requirements.
- Schedules the Pre-Design Conference with City/SSCAFCA.
- Assigns the project number, unless previously assigned.
- Starts project file.

***Step 2*: Pre-Design Conference**

The Pre-Design Conference allows the developer, consulting engineer, and other City/SSCAFCA staff to discuss detailed design requirements, the consulting engineer's approach to implementing drainage infrastructure requirements, construction phasing for partial acceptance, and the subsequent design and review procedures.

Partial Acceptance: When application for design and construction of public infrastructure improvements is made, the developer indicates on the application if partial acceptance of the proposed construction will be requested. Partial acceptance will be a topic for discussion at the Pre-Design Conference. Each subdivision for which partial acceptance of improvements is requested will be examined at the Pre-Design Conference to determine what parts, if any, can function adequately without the remaining parts. These will be designated the "stand alone" parts. If no "stand alone" parts can be determined, then the infrastructure improvements cannot be partially accepted. If "stand alone" parts are identified, the developer may achieve partial acceptance of the infrastructure improvements for these parts by.

(a) Dividing the entire subdivision into projects for each of the "stand alone" parts (each project will have its own separate pre-construction), or

(b) Assuring construction of required infrastructure in accordance with Section 9 of SSCAFCA's Drainage Policy.

The financial guarantee option selected by the developer during the Pre-Design Conference will be made a part of the Pre-Design Conference minutes. The minutes will also indicate the requirement (prior to acceptance of "stand alone" parts by the City/SSCAFCA) that the developer or agent must provide to the City/SSCAFCA all data, such As-Built drawings, GASB 34/35 information, etc., necessary for the City/SSCAFCA operation and maintenance of the improvements being accepted. Warranty will commence at the time a Certification of Completion and Acceptance Letter is issued by the City/SSCAFCA. If bonding is used, written acceptance will not occur until the bond is obtained by the developer for the City's/SSCAFCA's benefit.

Outcome:

- Minutes of the meeting are prepared delineating the items discussed and agreements reached for the signature of the participants.

Design and Review Phase

Step 3*: *Design Development

Consulting engineer prepares plans according to guidelines of the Pre-Design Conference, incorporating any required materials into the infrastructure design. Construction Plans and Specifications must be prepared in accordance with current Standard Specifications unless otherwise approved by the City/SSCAFCA.

Step 4*: *Preliminary Design Review by SSCAFCA

Submit material to the Development Services Division (DSD). The DSD will route plans to SSCAFCA for review and comment.

Outcome:

- SSCAFCA will review plans for completeness and notifies the DSD of any missing items/information before scheduling a review by SSCAFCA staff.

- SSCAFCA reviews plans for quality and content. If the submittal is unacceptable, areas of major concern are identified and the submittal is returned to the City Engineer/Consulting Engineer for corrections.

***Step 5*: Incorporation of Comments and Preparation of Final Plans and Estimate Sheet**

The Consulting Engineer must either incorporate the SSCAFCA review comments into the proposed final plans or propose acceptable alternatives. City /SSCAFCA must review and approve all proposed alternatives. The Consulting Engineer prepares an estimate of the quantities of materials and associated costs for the project.

***Step 6*: Review of Final Plans and Estimate Sheet**

DSD submits final drawings with all corrections (with redlines) as required and all additional reports, technical studies and related documents to SSCAFCA. The complete package of required submittals must be received prior to SSCAFCA signing the final plans.

Outcome:

- SSCAFCA signs plans if the plans comply with all of their requirements.

CONSTRUCTION PHASE:

Pre-Construction Phase

During this phase, all arrangements required to complete the construction contract between the developer and the contractor, or City/SSCAFCA and contractor, are identified.

***Step 1*: Contract Documentation**

Complete the necessary documents and submit to SSCAFCA.

Submittal Requirements:

Developer Provides:

- Copy of the subdivision approval agreement and financial guarantee

- Copy of construction contract with licensed contractor reflecting work detailed on approved plans and engineers estimate
- Insurance certificate
- Performance/Warranty Bond (or equal) and Labor and Material Payment Bond
- Other items if applicable:
- Copy of necessary easements
- Copy of State Highway Department permits
- Copy of SWPPP and USEPA Stormwater NOI
- Copy of utility company encroachment permits
- Copy of USACE 404 permit
- MRGCD approval and License Agreements
- Approval of other entities or utilities as necessary for project scope
- Reproducible copy of recorded plat for plan set as required
- Construction Schedule
- Material Testing Schedule

Outcome:

- SSCAFCA verifies that scope of work on contract is same as shown on the approved engineers estimate and plan set.

***Step 2*: Contractor Obtains Permits**

The contractor must obtain all the required City permits before release of the work order.

***Step 2A*: Progress Inspections**

For each inspection listed below a request shall be made by contractor to SSCAFCA 48 hours in advance.

1. Preconstruction meeting
2. After construction staking and storm water quality best management practices have been completed and prior to any earthwork
3. Concrete/shotcrete placement

a. Final subgrade is prepared PRIOR TO ANY REBAR/STEEL BEING PLACED
b. Final placement of rebar/steel PRIOR TO CONCRETE/SHOTCRETE
c. First placement of concrete/shotcrete

4. Placement of storm drain pipe (Water truck and compaction equipment must be on-site during placement
   a. Staking complete and prior to excavation
   b. Final subgrade preparation
   c. Placement of pipe prior to backfill
   d. Placement of lateral connection to mainstem
   e. Completion of pipe
5. Outlet/inlet structures
   a. Construction staking complete
   b. Final subgrade
   c. Form and rebar
   d. Concrete/shotcrete
   e. Rip rap
6. Channel Construction
   a. Construction staking complete
   b. Subgrade preparation complete
   c. Rebar installation
   d. Concrete/shotcrete placement
   e. Inlet placement

***Step 3*: Interim Inspection**

NOTE: PARTIAL ACCEPTANCE...If partial acceptance is being requested per conditions of the Pre-Design Conference, (Step 2), the following steps and instructions generally apply except that "Final Acceptance" is identified as "Partial Acceptance". Under partial acceptance, a financial guarantee may be reduced, however the agreement cannot be released until all required drainage infrastructure on the approved Infrastructure List is completed and accepted. If the drainage infrastructures come under the jurisdiction of the Office of the State Engineer (OSE), the following items must be provided by the developer prior to final acceptance by SSCAFCA/City:

1. Written approval by OSE
2. Transfer of ownership to SSCAFCA
3. Transfer of all documents required by OSE

INITIATING ACTION

SSCAFCA Inspector and contractor shall conduct an interim inspection to determine if the work is ready for final inspection. Contractor will contact SSCAFCA seven (7) working days in advance to schedule an inspection.

Outcome:

- If project is ready for final inspection, the developer's construction inspector schedules final inspection seven (7) working days in advance with SSCAFCA Inspector.

- If project is not ready for final inspection, contractor must complete necessary work prior to requesting final inspection.

***<u>Step 4</u>*: Completion of Record Drawings**

Record Drawings and applicable data must be furnished to the SSCAFCA Inspector prior to the final inspection. If not available, final inspection will be delayed until they are available. Information required on the Record Drawings are detailed below.

RECORD DRAWING INFORMATION

A. Record Drawings with elevations, finished contours and dimensions for the following improvements:

- Permanently marked benchmark based on NAVD 88 and located on or very near the facility
- Pond(s) (include as-built volumes, e.g., 100 year water surface elevation, and flow information)
- Pipe inlet(s) and outlet(s) (include as-built capacity calculations)
- Rundown(s) (including the required inlet dimension)
- Graphic depiction of complete storm drainage system on 1 sheet. Size of sheet to be agreed upon with SSCAFCA
- Spillways(s) (including the required outlet dimensions)
- Channel(s)
- Flowlines
- Erosion control and stormwater pollution prevention structure(s)
- Temporary drainage, erosion control and stormwater pollution prevention facilities required for phased development
- Retaining and/or garden wall(s)
- Other features critical to the drainage facility
- Cost of drainage improvements proposed for maintenance
- Operation and maintenance schedule and pictures taken during the construction

B. All testing results

C. Professional Certification (See Section 7 for standard certification language):

(1) Engineer's stamp dated and signed accompanied with a statement indicating substantial compliance with the approved construction drawings and/or deficiencies with recommended corrections.

(2) The surveying associated with the certification must be performed by a professional engineer and/or surveyor in accordance with the "New Mexico Engineering and Surveying Practice Act" as amended and any standards adopted by the State board of Registration.

***Step 5*: Final Inspection (applies to partial or entire acceptance)**

INITIATING ACTION

- Developer/Engineer contacts SSCAFCA's Construction Inspector and requests a final inspection. SSCAFCA's Senior Drainage Engineer and Executive Engineer must be invited to attend the Final Inspection.

- Responsible party (See Step 4) completes Record Drawings or furnishes red-line marked up prints to SSCAFCA showing Record Drawings conditions. A hard copy of the Record Drawings must be provided to the City/SSCAFCA at the time a final inspection is requested.

Note: A water test may be required at the final inspection to verify drainage system operation.

Outcome:

- SSCAFCA schedules final inspection with the contractor, consulting engineer, developer, and all City staff concerned with the project.

- At final inspection, a list of discrepancies (punch list) is prepared by the consulting Engineer, or inspecting agency, which is given to the contractor for correction. A copy is sent to the developer, SSCAFCA, and City staff concerned with the project.

- If both, SSCAFCA and the Engineer, find the constructed facility to be sufficient to function properly, a certificate of substantial completion can be issued.

INITIATING ACTION

Contractor:

- Completes work on punch-list items within 30 days.

- Notifies SSCAFCA inspector and all affected parties when ready for verification.

Outcome:

SSCAFCA inspector verifies that discrepancies are corrected.

INITIATING ACTION

Contractor sends SSCAFCA Inspector final quantities sheet and invoices.

Outcome:

SSCAFCA prepares a Letter of Infrastructure Construction Completion after receiving the following:

- Final quantities sheet
- Invoices from the contractor
- Copy of recorded plat and/or copy of recorded easement
- Revised Record Drawings (One hard copy) including a reproducible mylar and electronic file copy (e.g.) an Auto-Cad/PDF file in a format acceptable to SSCAFCA submitted on a compact disc (CD)
- Copy of all test results, construction pictures and copy of certifications on a compact disc (CD)
- Submittal of a performance bond in accordance with Section 11 of SSCAFCA's Drainage Policy.
- Final quantities sheet, cost of drainage improvements (including the cost of the land) and invoices from the contractor.
- A letter from owner/developer/engineer requesting acceptance from the Executive Engineer for warranty period to begin.

Upon acceptance by SSCAFCA the one year warranty period commences for the structure. The developer/contractor shall be responsible for O&M during the warranty period. Before SSCAFCA takes over responsibility for O&M there will be a post warranty inspection to insure that the structure condition is as designed and that there are no outstanding issues.

Note: All storm water management measures and facilities shall be maintained by the owner of the property or a homeowners association, unless a dedication of the storm water management system has been required and accepted by SSCAFCA/City, in which case, the City/SSCAFCA shall be responsible for maintenance after the warranty period ends.

Section 9. MISCELLANEOUS

A. Maintenance Standards

1. General:

All drainage control, flood control and erosion control facilities both public and private shall be regularly 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/SSCAFCA Standard Tube Gate.

2. Publicly Maintained Facilities:

Every effort shall be taken to operate and maintain publicly owned and maintained facilities to be functional and operate as designed recognizing the constraints of public funding. SSCAFCA reserves the right to schedule O&M as its purview.

3. Privately Maintained Facilities:

Every effort shall be taken to operate and maintain privately owned and maintained facilities to be functional and operate as designed recognizing the constraints of public funding. SSCAFCA reserves the right to schedule O&M as its purview.

The owner shall regularly maintain 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 after ½" of rain to insure the water quality flow capacity features are functioning as designed.

Privately owned drainage control, flood control 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.

B. Utilities in SSCAFCA ROW

Underground utilities will be allowed in and adjacent to arroyos when properly designed and appropriately permitted.

A. <u>Engineering Design Criteria for Underground Utilities in and Adjacent to Arroyos</u>

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.

B. <u>Engineering Design Criteria for Gravity Sewer Lines in Arroyos</u>

a. Design Capacity Criteria

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

b. 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

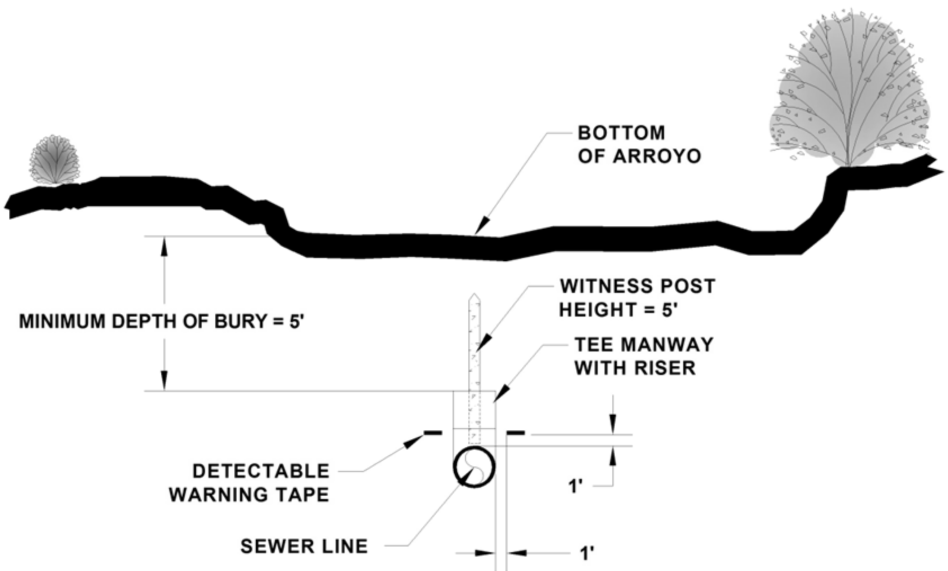
   a. Place the utility in the bottom of the existing arroyo where practical. This will minimize disturbance to existing habitat and vegetation.

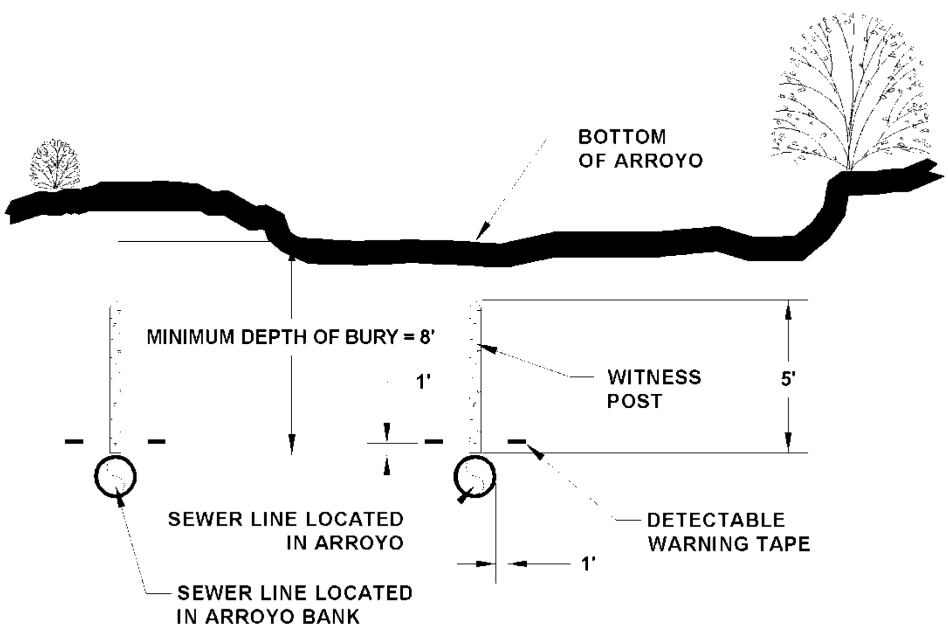
2) Vertical Location

   a. Place the utility at a depth below the existing arroyo bottom equal to or greater than the SAS erosion control zone. Under no circumstances shall the utility be placed less than 8-feet below the bottom of the arroyo.

      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.



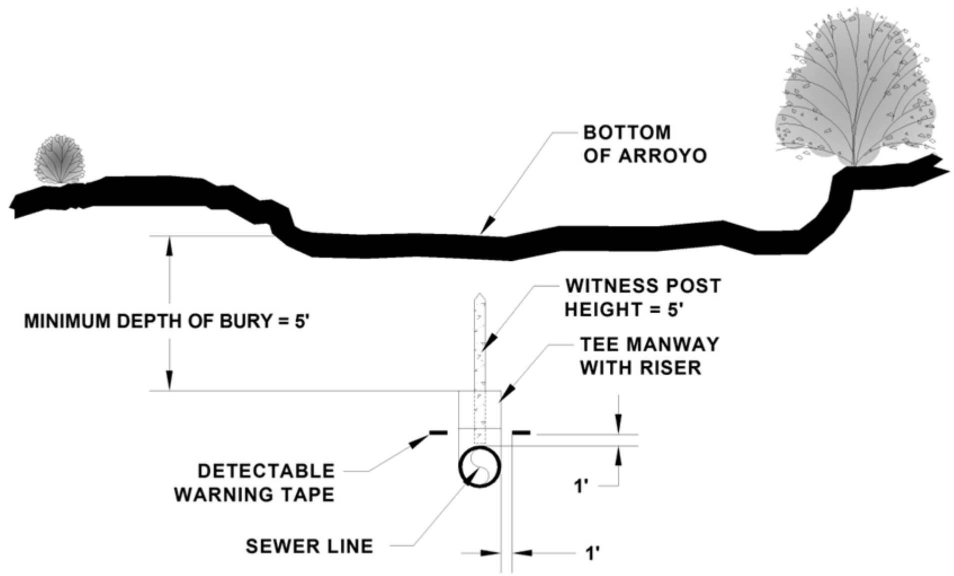


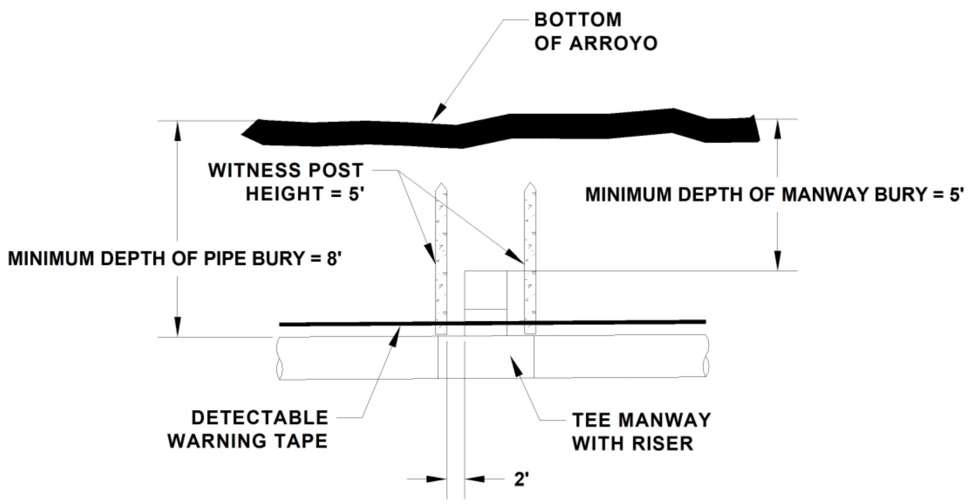
3. Manway Criteria

1) Manways must be located in the arroyo bottom and buried. Manholes in arroyos are not acceptable. All manways must be accessible by a 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.

4. 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.

5. 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.

C. <u>Engineering Design Criteria for Gravity Sanitary Sewer Lines Crossing Arroyos</u>

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.

1. 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. 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.

2. 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 SSCAFCA standard language for warning signs.

2) Trails shall have signage notifying users 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. 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:

    a. Fencing

    b. Trail head step-through gates

    c. Access gates for operations and maintenance

2) 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

4. Protection and Restoration of Existing Wildlife Habitat and Existing Vegetation

Maintain wildlife habitat and existing vegetation to the maximum extent practicable.

1) Provide for the protection of existing wildlife habitat and existing vegetation in the design and construction of the utility.

2) Limit construction work zone areas to minimize disturbance to existing wildlife habitat and existing vegetation.

3) Re-vegetate all disturbed areas not in arroyo bottom.

4) Restore disturbed habitat as appropriate.

5. 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.

C. Watershed Park/Quality of Life Plan

Development that encroaches or is adjacent to a Lateral Erosion Envelope (LEE) must:

A. Comply with Watershed Parks/Quality of Life Plan and consider inclusion of Quality of Life amenities acceptable to SSCAFCA and the City of Rio Rancho.

B. Dedicate in fee simple the LEE Line to SSCAFCA.

C. The type of amenities required shall be determined on a case-by-case basis approved by the Executive Engineer.

D. Lateral Erosion Envelope

Encroachment into the LEE Line will require the following:

A. Update the existing Lee Line Study

B. Identify the drainage improvements required to reduce the LEE Line

C. 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, the methodology for prorating cost outlined in Section 10 of this chapter can be used.

D. Provide construction plans for the required drainage improvements and the Watershed Management Park Plan amenities.

E. Dedicate to SSCAFCA without compensation the required drainage rights-of-way/easements for the proposed drainage improvements, LEE Line and the Watershed Management Plan amenities.

F. If the proposed LEE Line reduction is in the SSCAFCA right-of-way and/or easement, a vacation request to the SSCAFCA Board will be required.

Section 10. STORM WATER POLLUTION CONTROL

A. General

As an EPA requirement, structural, environmental controls must be included to minimize the discharge of storm water pollutants from areas of new development and significant redevelopment both during and after construction.

The following section was created in an effort to ensure that, to the maximum extent practicable, new development and projects that require drainage plans do not increase pollutant loads from the development project site. The measures outlined in this section are to be in accordance with approved Storm Water Management Plans.

B. Applicability

While all development shall address water quality, some Priority Project categories have been developed to address the more serious development categories that historically have the potential to generate serious storm water pollution problems during and after construction. All new development and projects that require drainage plans and that fall into one of the following Priority Project categories are subject to Structural Treatment Control Best Management Practices (BMPs) requirements:

- Retail, Warehouse and Office Developments in excess of 0.5 acres site size
- Automotive Repair Shops
- Restaurants
- Gas Stations/Fueling Facilities
- Dumpster, Compactor and Waste Collection and Storage Pads on all commercial and industrial sites
- Residential developments with more than 10 residential units, excluding single family housing subdivisions

C. Structural Treatment Control Best Management Practices

All Priority Projects shall consider, incorporate and implement storm water Structural Treatment Control BMPs into the project design to comply with the Minimum Storm Water Quality Control Measures shown in Table 16-1.

A Structural Treatment Control BMP is an engineered system designed, constructed and maintained to remove pollutants from urban runoff. Pollutant removal is achieved by simple gravity settling of particulate pollutants, filtration, screening, biological uptake, media adsorption or other physical, biological or chemical process. Examples of typical drawings and details for Structural Treatment Control BMPs are shown in the respective agency's Storm Water Management Plans under separate cover.

D. Criteria for Designing Structural Treatment Control BMPs

1. Treat the runoff from the "water quality storm event" (0.6 in. of precipitation within a six-hour period).

2. a. For sites 40 acres or smaller, the following approximate methods may be used:

   i. The Storm Water Quality Treatment Rate (SWQR) is the peak rate of flow from the water quality storm event as a function of the percentage of impervious land use (Land Use Category D) shown on Table 10-2. Treatment of the initial storm runoff at rates equal to or greater than the SWQR provides treatment of the SWQV.

   ii. The Storm Water Quality Treatment Volume (SWQV) is the treatment volume from the water quality storm event as a function of the percentage of impervious land use (Land Use Category D) shown on Table 10-2.

   b. For sites larger than 40 acres, site hydrology in accordance with the City of Rio Rancho/SSCAFCA Development Process Manual (DPM), using the water quality storm event, is used to determine the runoff rate and volume.

3. Provide bypass or overflow capacity to convey the flood control design discharge, even if the BMP structures and components are completely full or plugged.

4. Gross Pollutant Control (AMAFCA/Albuquerque)*

   a. Gross pollutant material consists of both surface floatables and submerged buoyant neutral items such as saturated paper, tumbleweeds, etc. Therefore, gross pollutant structural treatment control BMPs must address both surface and subsurface gross pollutants and floatable debris;

   b. To the extent practical, prevent trapped and collected pollutant materials being re-introduced into the runoff during subsequent runoff events, including events larger than the water quality design storm;

   c. To the extent practical, retain the trapped pollutants out of low flows and nuisance flows to prevent leaching of water quality constituents from the trapped debris;

   d. Design the facilities for ease of maintenance; and

e. Identify the maintenance plan and responsible party to maintain adequate gross pollutant capacity. It is recommended that the facility be cleaned following each storm event.

f. Commercial and industrial sites must provide and operate and maintain BMP facilities on-site.

g. Commercial and industrial site BMPs shall address failure of the system such that no pollution is discharged off-site.

5. Examples of standard details for BMPs and guidance documents for storm water pollution control can be found on the COA Website at www.cabq.gov/storm-drainage-design.

*Reference: AMAFCA/Albuquerque MS4 Gross Pollutant Study, Draft dated August, 2004, prepared by ASCG for AMAFCA and the City of Albuquerque.

TABLE 10-1. MINIMUM STORM WATER QUALITY CONTROL MEASURES FOR PRIORITY PROJECTS

Priority Projects	**Control of Liquids from Dumpster Areas[(1)]**	**Control of Gross Pollutants and Floatable Trash**	**Control of Oil from Vehicle Parking Areas**
Residential developments with more than 10 residential units		x	
Automotive repair facilities	x	x	x
Gas stations/fueling facilities	x	x	x
Restaurants	x	x	
Retail and office developments larger than 0.5 acres	x	x	
Dumpster and compactor pads[(1)]	x	x	

NOTES:

(1) Isolate and discharge to sanitary sewer. Design discharge for 100 year event.

<u>TABLE 10-2.</u> WATER QUALITY STORM EVENT RUNOFF RATE AND VOLUME AS A PERCENT OF IMPERVIOUS AREA FOR 40-ACRE AND SMALLER SITES			
Percent Impervious (%D)	Runoff Depth (inches)	Runoff Rate (cfs/ac)	Runoff Volume (cubic feet/ac)
0	0	0	0
20	0.09	0.5	327
40	0.18	0.8	653
60	0.27	1.2	980
80	0.36	1.35	1037
100	0.46	1.5	1670

NOTES:

(1) Water Quality Storm Event – 0.6 inches precipitation, all zones. It is assumed that approximately 0.14” will infiltrate leaving 0.46” of actual run-off to be treated for Water Quality purposes.

(2) Assumes pervious area evenly divided between Land Uses B and C.

(3) Interpolate for site-specific impervious area.

(4) Calculated from DPM Chapter 22, Section 2, Part A.