IV - CONSTRUCTION PLANS PREPARATION

4.01 GENERAL

This section covers the preparation of drainage construction plans for the City of Farmersville.

4.02 PRELIMINARY DESIGN PHASE

The preliminary design phase shall be complete in sufficient detail to allow review by the City of Farmersville. To complete this phase, all topographic surveys should be furnished to allow establishment of alignment, grades and right-of-way requirements. These may be accomplished by on-the-ground field surveys, by aerial photogrammetric methods, or by use of topographic maps.

Based upon the procedures and criteria outlined in SECTION III, CRITERIA AND DESIGN PROCEDURES, of this manual, the hydraulic design of the proposed facilities shall be accomplished. <u>All calculations shall be made on the appropriate forms and submitted with the preliminary plans</u>.

These plans shall show the alignment, drainage areas, size of facilities and grades.

a) Preliminary Plans

Preliminary storm drainage plans shall include a cover sheet, drainage area map, plan-profile sheets and channel cross sections if required. The proposed improvements shall be drawn on 22-inch by 34-inch sheets.

b) Drainage Area Map

The scale of the drainage area map should be determined by the method to be used in calculating the runoff as discussed in Section III. Generally, a map having a scale of 1" = 200' (showing the street right-of-way) is suitable unless dealing with a large drainage area. For large drainage areas a map having a scale of 1" = 2000' is usually sufficient. When calculating runoff, the drainage area map shall show the boundary of the drainage area contributing runoff into the proposed system. This boundary can usually be determined from a map having a contour interval of 2 to 5 feet. The area shall be further divided into sub-areas to determine flow concentration points or inlet locations.

Direction of flow within streets, alleys, natural and manmade drainage ways and at all system intersections shall be clearly shown on the drainage area map. Existing and proposed drainage inlets, storm sewer pipe systems and drainage channels shall be clearly shown and differentiated on the drainage area map. Plan-profile storm sewer or drainage improvement sheet limits shall also be shown.

The Drainage Area Map should show enough topography to easily determine its location within the City.

All offsite drainage within the natural drainage basin shall be shown and delineated. Runoff calculations including inlet calculations, shall be a part of the drainage area map.

c) <u>Plan-Profile Sheets</u>

Inlets shall be given the same number designation as the area or sub-area contribution runoff to the inlet. The inlet number designation shall be shown opposite the inlet. Inlets shall be located at or immediately downstream of drainage concentration points. At intersections, where possible, the end of the inlet shall be ten feet from the curb radius and the inlet location shall also provide minimum interference with the use of adjacent property. Inlet locations directly above storm sewer lines shall be avoided.

Data opposite each inlet shall include paving or storm sewer stationing at centerline of inlet, size of inlet, type of inlet, number or designation, top of curb elevation and flow line of inlet as shown on the typical plans. Inlet laterals leading to storm sewers, where possible, shall enter the inlet at a 60 degree angle from the street side. Laterals shall be four and one-half feet from top of curb to flow line of inlet unless utilities or storm sewer depth requires otherwise. Laterals shall not enter the corners of inlets. Lateral profiles shall be drawn showing appropriate information including the Hydraulic Gradient.

In the plan view, the storm sewer designation, size of pipe, and length of each size pipe shall be shown adjacent to the storm sewer. The sewer plan shall be stationed at one hundred foot intervals and each sheet shall begin and end with even or fifty foot stationing. All storm sewer components shall be stationed.

The profile portion of the storm sewer plan-profile sheet shall show the existing ground profile along the centerline of proposed sewer, the hydraulic gradient of the sewer, the proposed storm sewer, and utilities which intersect the alignment of the proposed storm sewer. Also shown shall be the diameter of the proposed pipe in inches and the physical grade in percent. Hydraulic data for each length of storm sewer between interception points shall be shown on the profile. This data shall consist of pipe diameter in inches, discharge in cubic feet per second, slope of hydraulic gradient in percent, capacity of pipe in cubic feet per second and velocity in feet per second. Also, the head loss at each interception point shall be shown.

Elevations of the flow line of the proposed storm sewer shall be shown at one hundred foot intervals on the profile. Stationing and flow line elevations shall also be shown at all pipe grade changes, pipe size changes, lateral connections, manholes and wye connections.

4.03 FINAL DESIGN PHASE

During the final design phase, the construction plans shall be placed in final form. All sheets shall be drawn in ink on 22-inch by 34-inch sheets and shall be clearly legible when sheets are reduced to half scale.

Review comments shall be considered, additional data incorporated and the final design and drafting of the plans completed. All grades, elevations, pipe sizes, utility locations, items and quantities should be checked and each plan-profile sheet shall have a bench mark shown.

V - APPENDIX

5.01A DEFINITION OF TERMS

Angle of Flare: Angle between direction of wingwall and centerline of culvert or storm drain outlet.

Backwater Curve: The surface curve of a stream of water.

Conduit: Any closed device for conveying flowing water.

Control: The hydraulic characteristic, which determined the stage-discharge relationship in a conduit.

Critical Flow: The state of flow for a given discharge at which the specific energy is a minimum with respect to the bottom of the conduit.

Entrance Head: The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.

Entrance Loss: Head lost in eddies or friction at the inlet to a conduit, headwall or structure.

Flume: Any open conduit on a prepared grade, trestle or bridge.

Freeboard: The distance between the normal operating level and the top of the side of an open channel left to allow for wave action, floating debris, or any other condition or emergency without overflowing structure.

Headwater: Depth of water in the channel measured form the invert of the culvert inlet.

HEC-1: Computer Program to analyze a Flood Hydrograph. This program is available from the U. S. Army Corps of Engineers.

HEC-2/HEC-RAS: Computer Program to analyze a Water Surface Profile. This program is available from the U. S. Army Corps of Engineers.

Hydraulic Gradient: A line representing the pressure head available at any given point within the system.

Invert: The flow-line of conduit (pipe or box).

Manning's Equation: The uniform flow equation used to relate velocity, hydraulic radius and energy gradient slope.

Open Channel: A channel in which water flows with a free surface.

Rational Formula: The means of relating runoff with the area being drained and the intensity of the storm rainfall.

Soffit: The inside top of the conduit (pipe or box).

Steady Flow: Constant discharge.

Surcharge: Height of water surface above the crown of a closed conduit at the upstream end.

Tailwater: Total depth of flow in the downstream channel measured form the invert of the culvert outlet.

Time of Concentration: The estimated time in minutes required for runoff to flow from the most remote section of the drainage area to the point at which the flow is to be determined.

Total Head Line (Energy Line): A line representing the energy in flowing water. It is plotted a distance above the profiles of the flow line of the conduit equal to the normal depth plus the normal velocity head plus the pressure head for conduits flowing under pressure.

Uniform Channel: A channel with a constant cross section and roughness coefficient.

Uniform Flow: A condition of flow in which the discharge, or quantity of water flowing per unit of time, and the velocity are constant. Flows will be at normal depth and can be computed by the Manning Equation.

Watershed: The area drained by a stream or drainage system.

5.01 B DETENTION SYSTEM DEFINITIONS

Detention Storage: Detention storage facilities are generally designed to control short, high-intensity local storms, as these are the major cause of flooding on small streams (1). Detention storage serves to attenuate the peak flow by reducing the peak outflow to a rate less than the peak inflow, which effectively lengthens the time base of the outflow hydrograph. The total volume of water discharged is the same; it is merely distributed over a long period of time (2). Discharge from detention storage facilities begins immediately at the start of the storm, and the facility is usually completely drained within a day after the storm event.

Retention Storage: Retention storage refers to those facilities where stormwater is collected and stored during the flood event. The stored water is released after the flood event by means of controlled outlet works. Alternatively, the water may be allowed to infiltrate into the ground or evaporate. For maximum effectiveness, the water contained in the retention storage facility must be released or lost before the next flood event occurs (2). In some cases, it may be desirable to maintain a permanent pool within the retention area. Such a facility is termed wet storage.

Conveyance Storage: As stormwater enters and flows in channels, floodplains, drains, and storm sewers, the flow is being stored in transient form and is termed conveyance storage. Conveyance storage is generally obtained by constructing low-velocity channels with large cross-sectional areas.

Upstream Storage: This storage occurs upstream of the design area to be protected. It is intended to contain runoff, which originates upstream and beyond the area to be protected.

Within-Area Storage: This storage occurs in the area to be protected. It is intended to store runoff originating in and around the area to be protected. It is common for such storage to be provided at the development sites.

Downstream Storage: This is storage located downstream from the area to be protected. The general purpose of downstream storage is to manage storm flows from the area to be protected and to control any detrimental downstream effects from development in the protected area.

Rainfall Storage: Rainfall storage refers to the storage of water in the vicinity of the rainfall occurrence or before storm water accumulates significantly (3). This storage classification is similar to "within-area storage" as described above.

Runoff Storage: Runoff storage refers to the storage of larger quantities of water, that have accumulated significantly and have begun to flow in the drainage system. This storage classification is closely related to "upstream storage" and "downstream storage" as described above.

Driveway Storage: This storage method involves the construction of depressed section in the driveway such that runoff from the lot and/or roof may be routed and stored there. A properly designed outlet system will regulate the discharge of this runoff into the drainage system (2).

Cistern/Infiltration: A cistern or tank can be located within the property area to collect runoff from the lot and roof. If local subsurface soil properties and geologic conditions permit, the water can be infiltrated after the storm subsides (2).

Cistern/Irrigation: This method is identical to the "cistern/infiltration" method except that the option is provided for the water in the cistern to be used for an irrigation water supply or to be discharged into the storm sewer system.

Rooftop Storage: This storage method is most applicable to industrial, commercial, and apartment buildings with large flat roofs. Rooftop storage is often an economical and effective alternative. Since it is common for buildings to be designed for snow loads, it is possible to accommodate an equivalent depth of water without significant structural changes. A six-inch depth of water is equivalent to 31.2 pounds per square foot, less than most snow load requirements in the northern United States and Canada (4).

Special roof drains with controlled outlet capacity are typically installed as an integral part of the rooftop storage method. With proper installation of such drains, peak runoff from roofs may be reduced by up to 90 percent (4).

An important consideration for the rooftop storage method would be to provide overflow mechanisms to ensure that the structural capacity of the roof is not exceeded. An additional consideration would be the watertightness of the rooftop.

Parking Lot Storage: Parking lots can be graded to route runoff to desired storage areas or areas of infiltration. If the flow is routed to a storage area, outlet works such as grated inlets or overflow weirs serve to regulate the design flow. Alternatively, the runoff may be routed to grassed or gravel filled areas for infiltration and percolation.

On-Site Ponds: On-site ponds provide for the collected stormwater to be released in a controlled manner by overflow weirs or orifices. When properly designed, on-site ponds can serve the hydraulic function while providing recreational and aesthetic benefits.

Slow-Flow Drainage Patterns: This storage method involves the design of conveyance systems with reduced grades to provide reduced flow velocities. The desired effect is to obtain temporary ponding and a form of transient storage. Slow flow drainage may be augmented by providing controls (e.g., weirs, checks) along channels to create a system of linear reservoirs (2). Use of such controls will provide temporary storage while allowing for a possible increase in infiltration.

Open Space Storage: Open spaces such as parks and recreation fields generally have a substantial area of grass covering and provide increased infiltration opportunities. Such open spaces produce only minimal quantities of runoff. Therefore, open spaces provide excellent opportunities for the temporary storage of storm runoff, provided the primary use of the open space is not altered. This is generally not a problem since recreation areas are seldom used during storm events.

Retention Reservoirs: Retention reservoirs located in a watershed catchment generally represent major storage facilities (2). They are most effective when located in valleys or recessed areas and should have the ability to regulate stream flow. Retention reservoirs maintain a permanent pool in the form of ponds or lakes. As such, they are well suited for water-oriented recreational features.

Detention Reservoirs: Detention reservoirs are generally located on streams and are frequently located above the reaches where there is a continuous flow (2). Since a permanent pool is not maintained, detention reservoirs do not provide opportunities for water-oriented recreation. However, they may be conveniently integrated into a park and open space plan.

Gravel Pits and Quarries: Gravel pits and quarries are located off-channel such that a side-channel spillway is necessary to intercept and direct the peak flow to the pit location. Outfall from such storage facilities must generally be pumped.

5.02 ABBREVIATION OF TERMS AND SYMBOLS

A — Drainage area in acres of tributary watershed. Cross-sectional area of gutter flow in square feet. Cross-sectional area of flow through conduit in square feet.

A_S — Sub-section area in square feet as used on unimproved channel calculations.

b — Bottom width of channel in feet.

c — Runoff Coefficient for use in Rational Formula representing the estimated ratio of runoff to rainfall which is dependent on the slope of the watershed, the land use and the character of soil.

C_O — Street crown height in feet.

C_t	A coefficient related to drainage basin characteristics and used in Unit Hydrograph calculations.
C_p640	Coefficient related to drainage basin characteristics and used in Hydrograph calculations.
c.f.s.	Cubic feet per second.
d	Depth of flow in feet.
d_n	Normal depth of flow in conduit feet.
d_c	Critical depth of flow in conduit feet.
FL	Flow line.
f.p.s.	Feet per second.
g	Gravitational acceleration (32.2 feet per second per second).
H	Depth of flow in feet required to pass a given discharge.
h	Depth of flow in feet.
HW	Headwater elevation or depth above invert at storm drain entrance in feet.
h_o	Vertical distance from downstream culvert flow line to the elevation from which H is measured, in feet.
h_f	Head loss due to friction in a length of conduit in feet.
h_j	Head loss at junction structures, inlets, manholes, etc., due to turbulence in feet.
h_v	Velocity head loss in feet.
I	Intensity, in inches per hour, for rainfall over an entire watershed.
K_b	Head loss coefficient at bridges.
K_e	Coefficient of entrance loss.

K_j	Coefficient for head loss at junctions, inlets and manholes.
L	Length of channel in miles measured along flow line.
L_{ca}	Length of stream in miles from design point to center of gravity of drainage area and used in Unit Hydrograph calculations.
L_i	Length of curb opening inlet in feet.
L_{is}	Initial and subsequent rainfall losses in inches and used in Unit Hydrograph calculations.
n	Coefficient of roughness for use in Manning's Equation.
P	Length in feet of contact between flowing water and the conduit measured on a cross section. (Wetted Perimeter)
Q	Storm water flow in c.f.s.
Q_R	Peak flow in c.f.s. as determined by Rational Method.
Q_u	Peak flow in c.f.s. as determined by Unit Hydrograph Method.
q_p	Peak rate of discharge of the Unit Hydrograph for unit rainfall duration of c.f.s. per square mile.
Q_p	Peak rate of discharge of the Unit Hydrograph in c.f.s.
R	Hydraulic Radius = $\dfrac{\text{Cross section area of flow in sq. ft. (A)}}{\text{Wetted perimeter in ft. (P)}}$
R_T	Total runoff in inches as used in Unit Hydrograph calculations.
S	Slope of street, gutter or hydraulic gradient in feet per foot or percent.
s_c	That particular slope in feet per foot of a given uniform conduit operating as an open channel at which normal depth and velocity equal critical depth and velocity for a given discharge.
S_D	Design storm runoff in inches for a two-hour period.

S_f	Friction slope in feet per foot in a conduit. This represents the rate of loss in the conduit due to friction.
t_c	Time of Concentration in minutes.
t_p	Lag time in hours from the midpoint of the unit rainfall duration to the peak of the Unit Hydrograph.
TW	Tailwater elevation of depth above invert a culvert outlet.
V	Velocity of flow in feet per second.
v	Mean velocity of flow at upstream end of inlet opening in feet per second.
v_c	Critical velocity of flow in a conduit in feet per second.
$\frac{V^2}{2g}$	Velocity head. A measure, in feet, of the kinetic energy in flowing water.
V_1	Upstream Velocity
V_2	Downstream Velocity
W	Street width from face of curb in feet.
WP	Wetted perimeter in feet.
Z	Reciprocal of crown slope, $1/\theta_o$.
θ_o	Crown slope of pavement in feet per foot.
Y	Conveyance factor calculated for unimproved channels.

5.03 BIBLIOGRAPHY

1) Chow, Ven Te, Handbook of Applied Hydrology, McGraw-Hill Book Co., New York, 1964.

2) Chow, Ven Te, Open Channel Hydraulics, McGraw-Hill Book Co., New York, 1959.

3) King, H. W., Handbook of Hydraulics, McGraw-Hill Book Co., New York, 1954, 4th Ed.

4) Corps of Engineers, "Hydrologic and Hydraulic Analysis," Civil Works Construction, Part CXIV, Chapter 5, Supt. of Doc., Washington, D.C.

5) Corps of Engineers, Engineering Manual 1110-2-1405, "Flood Hydrograph Analysis and Computations," Supt. of Doc., Washington, D.C.

6) U. S. Weather Bureau, Rainfall Frequency Atlas of the United States, Technical Paper No. 40, Supt. of Doc., Washington, D.C., May 1961.

7) Texas Highway Department, Hydraulic Manual, Austin, Tex., September 1970.

8) Johns Hopkins University, The Design of Storm Water Inlets, Department of Sanitary Engineering and Water Resources, Baltimore, Maryland, June 1956.

9) Hendrickson, John G., Jr., Hydraulics of Culverts, American Concrete Pipe Association, Chicago, Illinois, 1964.

10) Hydrology Handbook, A.S.C.E., New York, 1949.

11) Design and Construction of Sanitary and Storm Sewers, A.S.C.E., New York, 1960.

12) American Concrete Pipe Association, Design Data, March 1969.

13) Denver Regional Council of Governments, Urban Storm Drainage Manual, March 1969.

14) State Highway Department of Georgia, Manual on Drainage Design for Highways, 1966.

15) City of Waco, Texas, Storm Drainage Design Manual, 1959.

16) City of Fort Worth, Texas, Storm Drainage Criteria and Design Manual, 1967.

17) Horace W. King, Chester O. Wisler, James G. Woodburn, Hydraulics, John Wiley and Sons, New York, 1952, 5th Edition.

18) Portland Cement Association, Handbook of Concrete Culvert Pipe Hydraulics, 1964.

19) Highway Research Board Proceedings, 1946.

20) Department of Commerce Hydraulic Engineering Circular No. 5, Hydraulic Charts for the Selection of Highway Culverts, December 1965.

21) John R. French, National Bureau of Standard Report No. 4444, Hydraulic Characteristics of Commonly Used Pipe Entrances.

22) H. G. Bossy, Hydraulics of Conventional Highway Culverts.

23) Technical Memorandum National Weather Service, Hydro 35, Dated June 1977.

24) Hydraulics of Bridge Waterways, Hydraulic Design Service No. 1, U. S. Department of Transportation, Bureau of Public Roads, 1970.

VI - LIST OF TABLES

TABLE 1

COEFFICIENTS OF RUNOFF AND MINIMUM INLET TIMES

Land Use	Runoff Coefficient C	Minimum Inlet Time In Minutes
Residential	0.6	15
Commercial	0.9	10
Industrial	0.9	10
Multiple Unit Dwelling	0.8	10
Parks	0.4	15
Cemeteries	0.4	15
Pasture	0.4	15
Woods	0.3	15
Cultivated	0.6	20
Shopping Centers	0.9	10
Paved Areas	0.9	10
Schools	0.7	15
Patio Homes	0.6	15
Churches	0.8	10

TABLE 2

COEFFICIENTS "C_t" AND "C_p640"

Drainage Area Characteristics	Approximate Value of "C_t"	Approximate Value of "C_p640"
Sparsely Sewered Area		
Flat Basin Slope (less than 0.50%)	0.65	350
Moderate Basin Slope (0.50% to 0.80%)	0.60	370
Steep Basin Slope (greater than 0.80%)	0.55	390
Moderately Sewered Area		
Flat Basin Slope (less than 0.50%)	0.55	400
Moderate Basin Slope (0.50% to 0.80%)	0.50	420
Steep Basin Slope (greater than 0.80%)	0.45	440
Highly Sewered Area		
Flat Basin Slope (less than 0.50%)	0.45	450
Moderate Basin Slope (0.50% to 0.80%)	0.40	470
Steep Basin Slope (greater than 0.80%)	0.35	490

TABLE 3

MINIMUM SLOPES FOR PIPES
(n = 0.013)

Pipe Diameter (Inches)	Slope (Feet/100 Feet)
18	.180
21	.150
24	.120
27	.110
30	.090
33	.080
36	.070
39	.062
42	.056
45	.052
48	.048

Pipe Diameter (Inches)	Slope (Feet/100 Feet)
51	.045
54	.041
60	.036
66	.032
72	.028
78	.025
84	.023
90	.021
96	.019
102	.018
108	.016

NOTE: Minimum pipe diameter to be used in construction of storm sewers shall be 18-inches unless approved by City or City Engineer.

TABLE 4

MAXIMUM VELOCITIES IN CLOSED CONDUITS

Type of Conduit	Maximum Velocity
Culverts	15 f.p.s.
Inlet Laterals	30 f.p.s.
Storm Sewers	12 f.p.s.

Storm sewers that discharge into open channels shall be at a maximum velocity of 8-feet per second unless channel protection is provided for the reach from the point of discharge until velocity is less than 8-feet per second in the channel. **THIS MAXIMUM VELOCITY MUST BE MAINTAINED IN THE LAST 200-FEET OF STORM SEWER.**

TABLE 5

ROUGHNESS COEFFICIENTS FOR CLOSED CONDUITS

Material of Construction	Recommended Roughness Coefficient "n"
New Monolithic Concrete Conduit	0.015
Concrete Pipe Storm Sewer	
Good Alignment, Smooth Joints	0.013
Fair Alignment, Ordinary Joints	0.015
Poor Alignment, Poor Joints	0.017
Concrete Pipe Culverts	0.012
Monolithic Concrete Culverts	0.012
Corrugated Metal Pipe	0.024
Corrugated Metal Arch Pipe	0.024
Corrugated Metal Pipe with Smooth Liner	0.015

NOTE: Reinforced concrete pipe is the accepted material for construction of storm sewers. The use of other materials for the construction of storm sewers shall have prior approval from the City Engineer. For design of all pipe material an "n" of 0.013 shall be used.

TABLE 6

VELOCITY HEAD LOSS COEFFICIENTS FOR CLOSED CONDUITS

MANHOLE AT CHANGE IN PIPE DIRECTION		
Description	**Angle**	**Head Loss Coefficient Kj**
	90	1.00
Angle	60 45 30	0.80 0.65 0.50
BEND IN PIPES		
Description	**Angle**	**Head Loss Coefficient Kj**
	*90°	0.80
Angle	*60° **45° **30°	0.60 0.50 0.45
ENLARGEMENTS IN PIPE SIZES WITH CONSTANT FLOW		
Description	**Ratio of Upstream Diameter to Downstream Diameter**	**Head Loss Coefficient Kj**
	0.81	1.00
	0.82 0.84 0.85 0.86 0.88 0.90 0.92	0.90 0.80 0.70 0.60 0.50 0.40 0.30

* Only as authorized by City Engineer.

** Horizontal curves are the accepted method of construction.

TABLE 7

ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

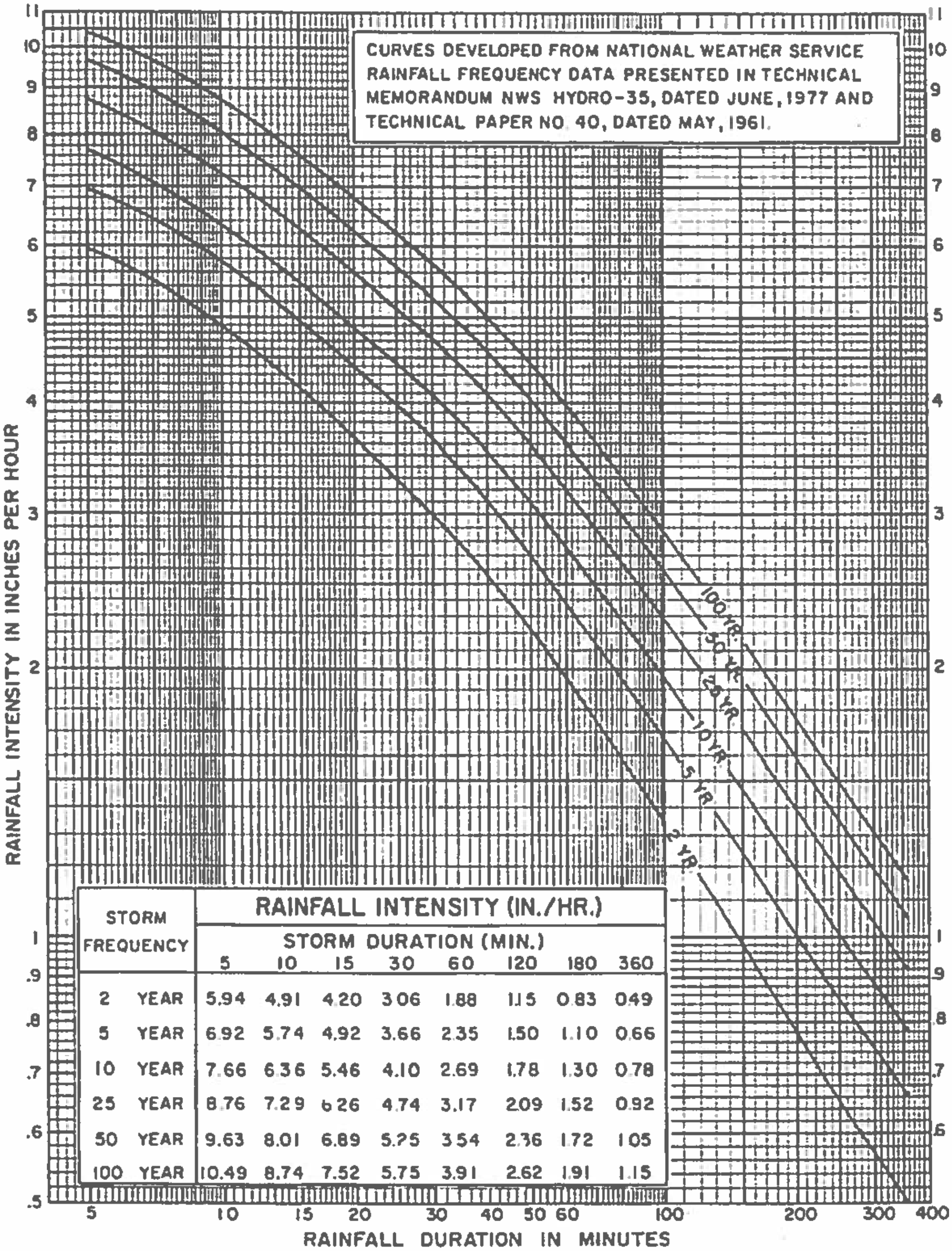
Channel Description	Roughness Coefficient Minimum	Roughness Coefficient Normal	Roughness Coefficient Maximum	Maximum Velocity Ft/sec
MINOR NATURAL STREAMS – TYPE I CHANNEL				
Moderately Well Defined Channel				
• Grass and Weeds, Little Brush	0.025	0.030	0.033	8
• Dense Weeds, Little Brush	0.030	0.035	0.040	8
• Weeds, Light Brush on Banks	0.030	0.035	0.040	8
• Weeds, Heavy Brush on Banks	0.035	0.050	0.060	8
• Weeds, Dense Willows on Banks	0.040	0.060	0.080	8
Irregular Channel with Pools and Meanders				
• Grass and Weeds, Little Brush	0.030	0.036	0.042	8
• Dense Weeds, Little Brush	0.036	0.042	0.048	8
• Weeds, Light Brush on Banks	0.036	0.042	0.048	8
• Weeds, Heavy Brush on Banks	0.042	0.060	0.072	8
• Weeds, Dense Willows on Banks	0.048	0.072	0.096	8
Flood Plain, Pasture				
• Short Grass, No Brush	0.025	0.030	0.035	8
• Tall Grass, No Brush	0.030	0.035	0.050	8
Flood Plain, Cultivated				
• No Crops	0.025	0.030	0.035	8
• Mature Crops	0.030	0.040	0.050	8
Flood Plain, Uncleared				
• Heavy Weeds, Light Brush	0.035	0.050	0.070	8
• Medium to Dense Brush	0.070	0.100	0.160	8
• Trees with Flood Stage below Branches	0.080	0.100	0.120	8
MAJOR NATURAL STREAMS - TYPE I CHANNEL				
The roughness coefficient is less than that for minor stream of similar description because banks offer less effective resistance.				
• Moderately Well Defined Channel	0.025	---	0.060	8
• Irregular Channel	0.035	---	0.100	8
UNLINED VEGETATED CHANNELS - TYPE II CHANNEL				
• Mowed Grass, Clay Soil	0.025	0.030	0.035	8
• Mowed Grass, Sandy Soil	0.025	0.030	0.035	6

TABLE 8

CULVERT DISCHARGE VELOCITIES

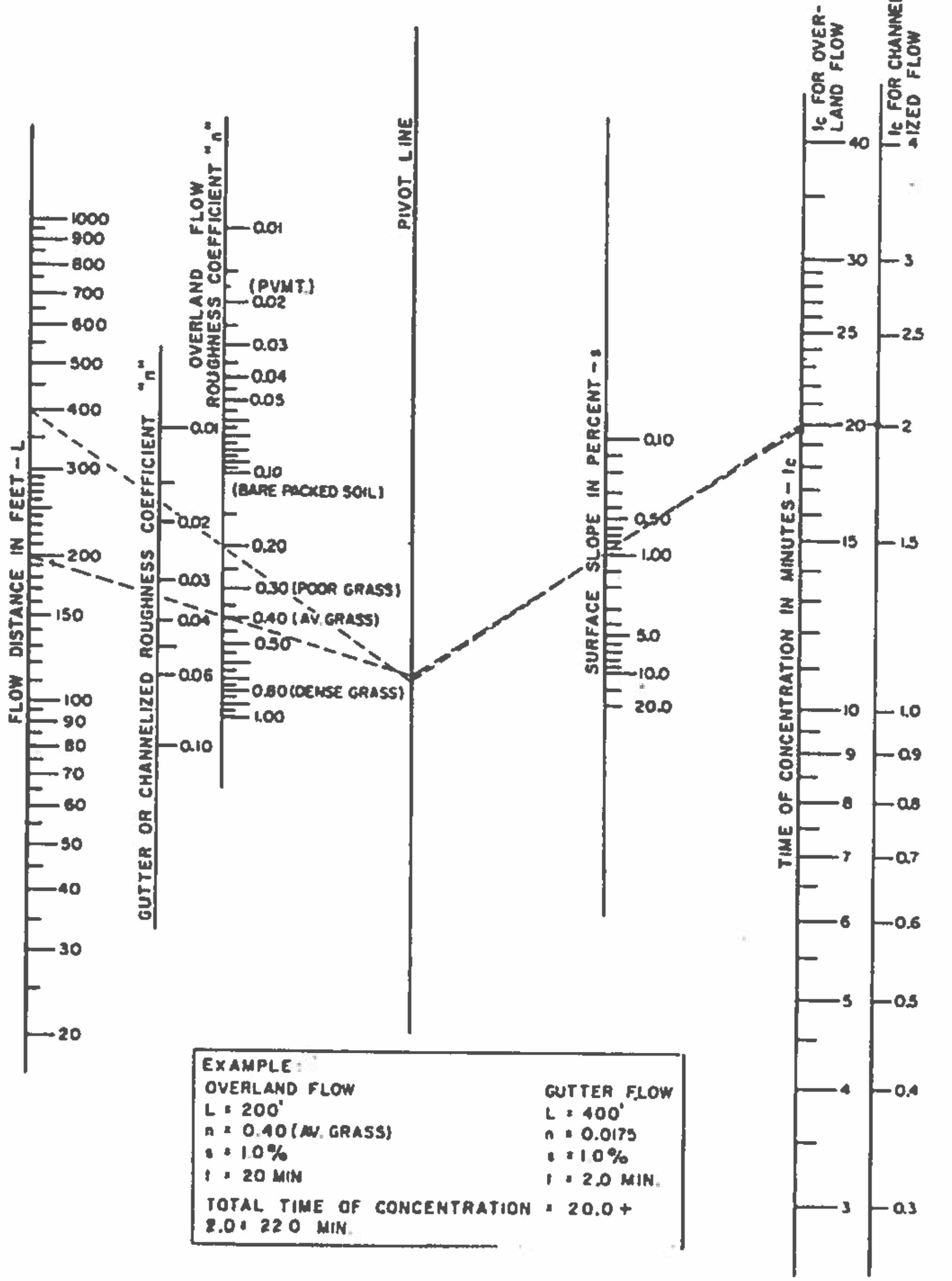
Culvert Discharges On	Maximum Allowable Velocity (f.p.s.)
Earth (Sandy)	6
Earth (Clay)	8
Sodded Earth	8
Rock Gabions (Engineered)	12
Concrete	15
Shale (Lime Stone)	10

VII - LIST OF FIGURES



STORM FREQUENCY	RAINFALL INTENSITY (IN./HR.)							
	STORM DURATION (MIN.)							
	5	10	15	30	60	120	180	360
2 YEAR	5.94	4.91	4.20	3.06	1.88	1.15	0.83	0.49
5 YEAR	6.92	5.74	4.92	3.66	2.35	1.50	1.10	0.66
10 YEAR	7.66	6.36	5.46	4.10	2.69	1.78	1.30	0.78
25 YEAR	8.76	7.29	6.26	4.74	3.17	2.09	1.52	0.92
50 YEAR	9.63	8.01	6.89	5.25	3.54	2.36	1.72	1.05
100 YEAR	10.49	8.74	7.52	5.75	3.91	2.62	1.91	1.15

FIGURE 1



TIME OF CONCENTRATION FOR SURFACE FLOW

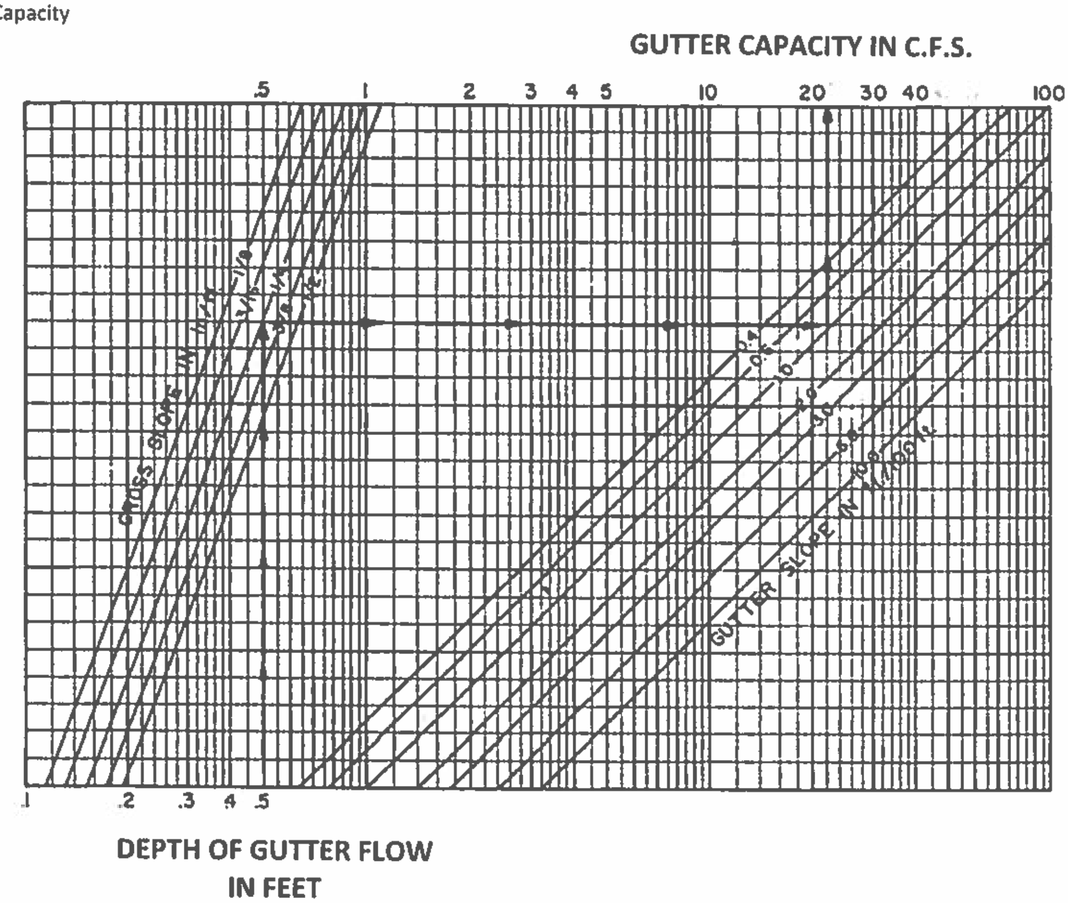
FIGURE 2

EXAMPLE

Known:
Major Thoroughfare, Typce C
Pavement Width = 33'
Gutter Slope = 1.0%
Pavement Cross Slope = ¼"/1'
Depth of Gutter Flow = .5'

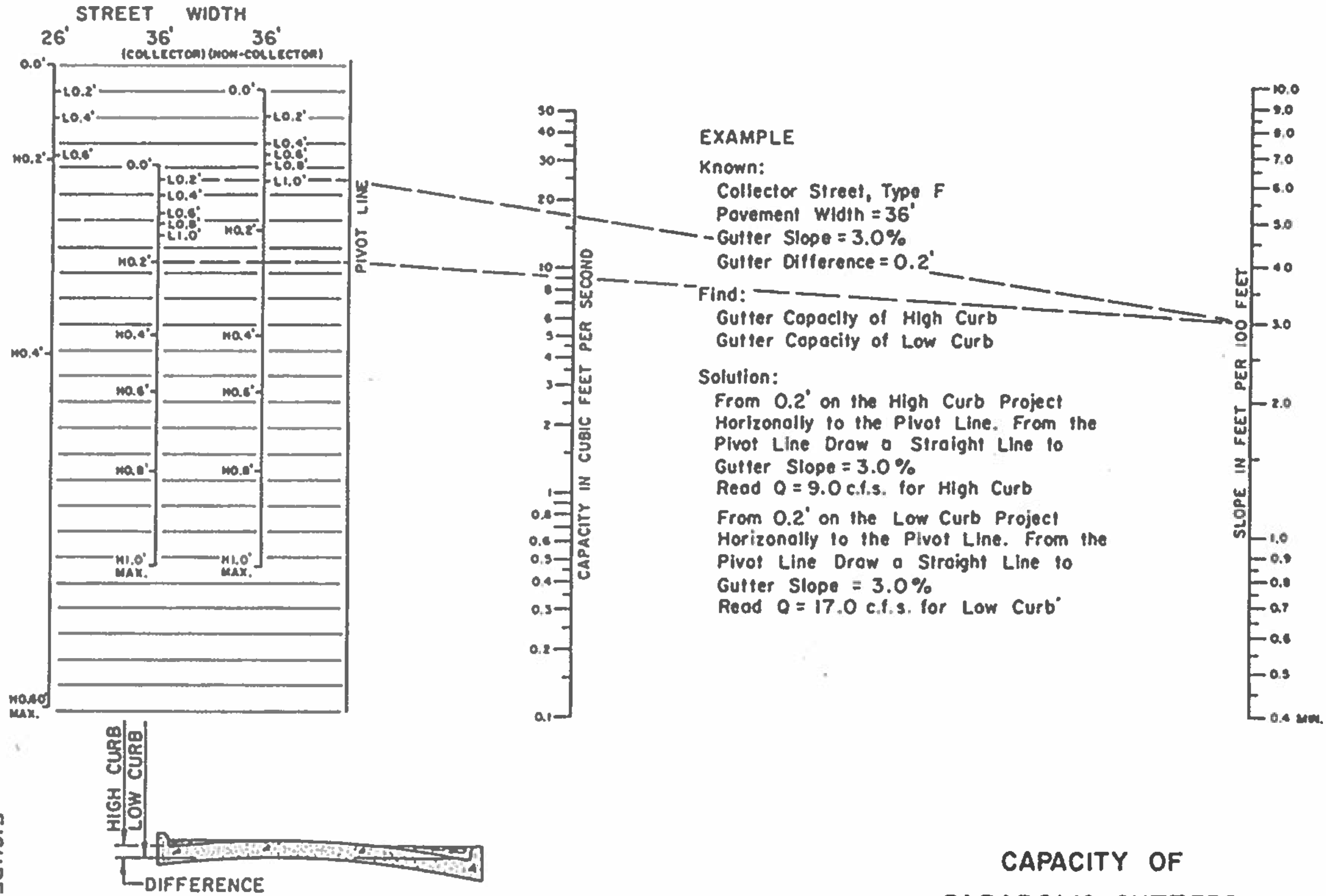
Find:
Gutter Capacity

Solution:
Enter Graph at .5'
Intersect Cross Slope = ¼" /1'
Intersect Gutter Slope = 1.0%
Read Gutter Capacity = 22 c.f.s.



CAPACITY OF TRIANGULAR GUTTERS

FIGURE 3



EXAMPLE

Known:

Collector Street, Type F
Pavement Width = 36'
Gutter Slope = 3.0%
Gutter Difference = 0.2'

Find:

Gutter Capacity of High Curb
Gutter Capacity of Low Curb

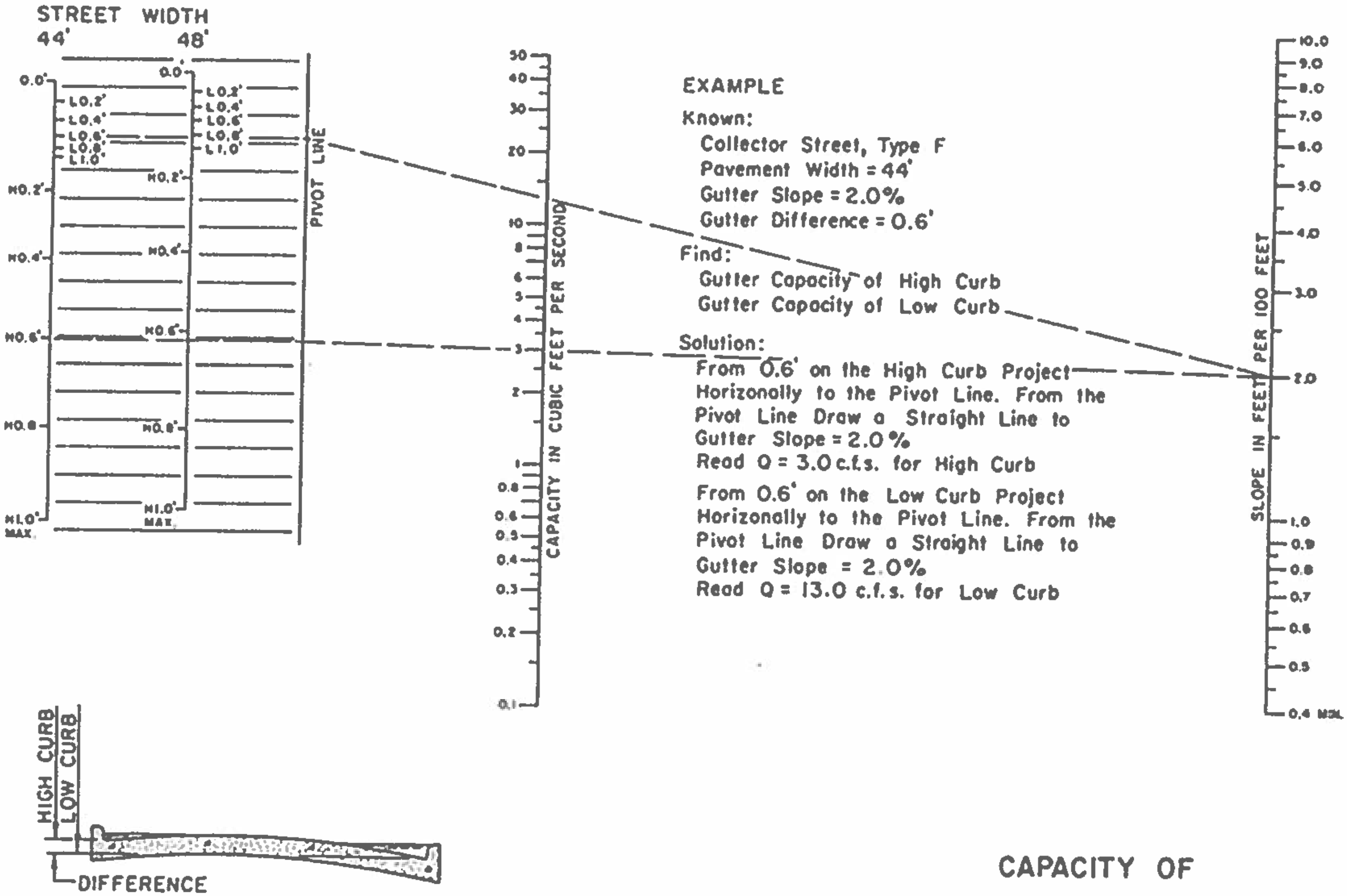
Solution:

From 0.2' on the High Curb Project Horizonally to the Pivot Line. From the Pivot Line Draw a Straight Line to Gutter Slope = 3.0%
Read Q = 9.0 c.f.s. for High Curb

From 0.2' on the Low Curb Project Horizonally to the Pivot Line. From the Pivot Line Draw a Straight Line to Gutter Slope = 3.0%
Read Q = 17.0 c.f.s. for Low Curb'

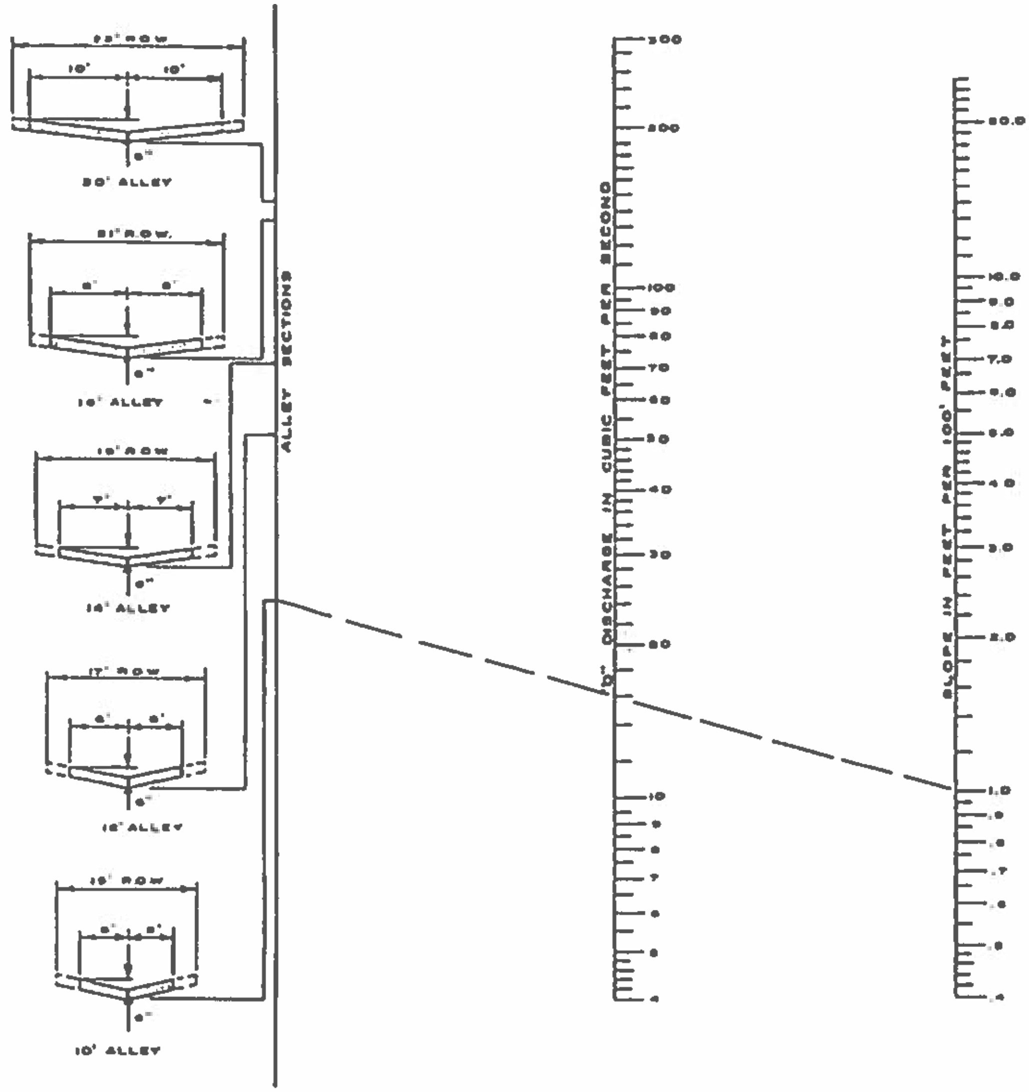
FIGURE 4

CAPACITY OF PARABOLIC GUTTERS (26' & 36' STREET WIDTHS)



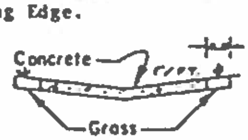
CAPACITY OF
PARABOLIC GUTTERS
(44' & 48' STREET WIDTHS)

FIGURE 5



NOTE:

1. All Alley Capacities Are 2½" Above Paving Edge.



2. The Capacities Obtained From This Nomograph are Based on a Straight Horizontal Alignment. Curved Alignments May Result in Reduced Capacity.

EXAMPLE

KNOWN:
Alley width = 10'
Alley depression = 5"
Gutter Slope = 1.0%

FIND:
Gutter Flow (Q)

SOLUTION:
Connect the 10' alley section with slope = 1.0%. Read Q = 16 c.f.s

CAPACITY OF ALLEY SECTIONS

Average n = 0.020
Revised: Feb. 1981

FIGURE 6

STORM DRAIN INLETS

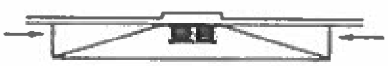
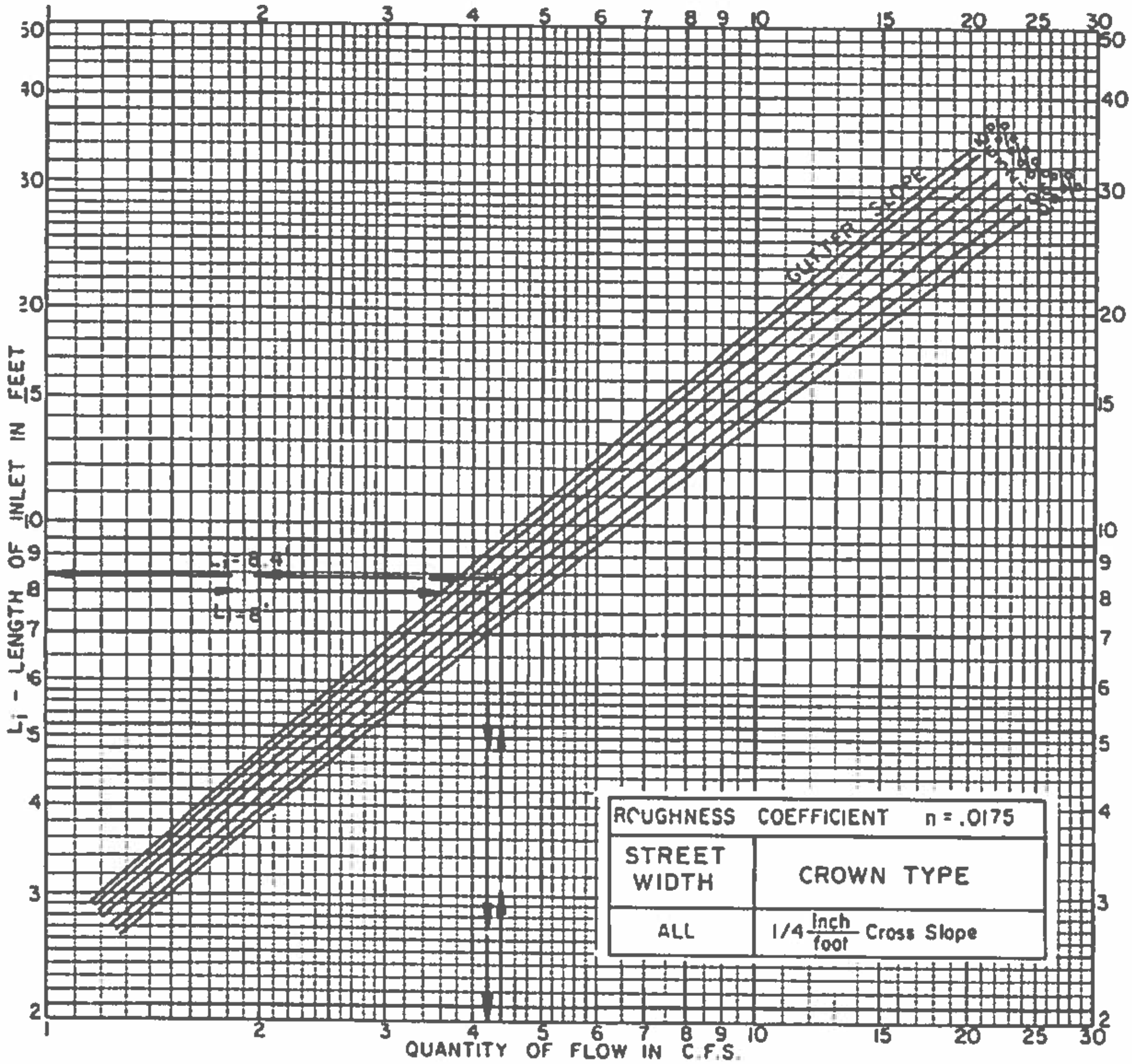
INLET TYPE	INLET DESCRIPTION	AVAIL. INLET SIZES	WHERE USED	DESIGN CURVES
I	 STANDARD CURB OPENING INLET ON GRADE	4' 6' 8' 10' 12' 14'	26' LOCAL STREET, TYPE H 36' COLLECTOR STREET, TYPE F ALLEY	FIGURES 8 THROUGH 12
IA	 STANDARD CURB OPENING INLET AT LOW POINT	4' 6' 8' 10' 12' 14'	26' LOCAL STREET, TYPE H 36' COLLECTOR STREET, TYPE F ALLEY	FIGURE 13
II	 RECESSED CURB OPENING INLET ON GRADE	4' 6' 8' 10' 12' 14'	44' COLLECTOR STREET, TYPE F 48' SECONDARY STREET, TYPE E 2-24' MAJOR STREET, TYPE D 2-33' MAJOR STREET, TYPE C 2-36' MAJOR STREET, TYPE B 2-36' MAJOR STREET, TYPE A	FIGURES 8 THROUGH 12
IIA	 RECESSED CURB OPENING INLET AT LOW POINT	4' 6' 8' 10' 12' 14'	44' COLLECTOR STREET, TYPE F 48' SECONDARY STREET, TYPE E 2-24' MAJOR STREET, TYPE D 2-33' MAJOR STREET, TYPE C 2-36' MAJOR STREET, TYPE B 2-36' MAJOR STREET, TYPE A	FIGURE 13
III	 COMBINATION INLET ON GRADE	4' 6' 8'	COMBINATION INLETS TO BE USED WHERE SPACE BEHIND CURB PROHIBITS OTHER INLET TYPES	FIGURES 14 THROUGH 16
IIIA	 COMBINATION INLET AT LOW POINT	4' 6' 8'	COMBINATION INLETS TO BE USED WHERE SPACE BEHIND CURB PROHIBITS OTHER INLET TYPES	FIGURE 20
IV	 GRATE INLETS	2 GRATE 3 GRATE 4 GRATE 6 GRATE	GRATE INLETS TO BE USED WHERE SPACE RESTRICTIONS PROHIBIT OTHER INLET TYPES OR AT LOCATIONS WITH NO CURB.	FIGURES 16, 17, 18, 19 & 21
V	 DROP INLET	2x2' 3'x3' 4'x4'	OPEN CHANNELS	FIGURE 22

FIGURE 7



EXAMPLE

Known:
- Pavement Width = 24'
- Gutter Slope = 2.0 %
- Pavement Cross Slope = 1/4"/1'
- Gutter Flow = 4.4 cfs

Find:
- Length of Inlet Required (L_i)

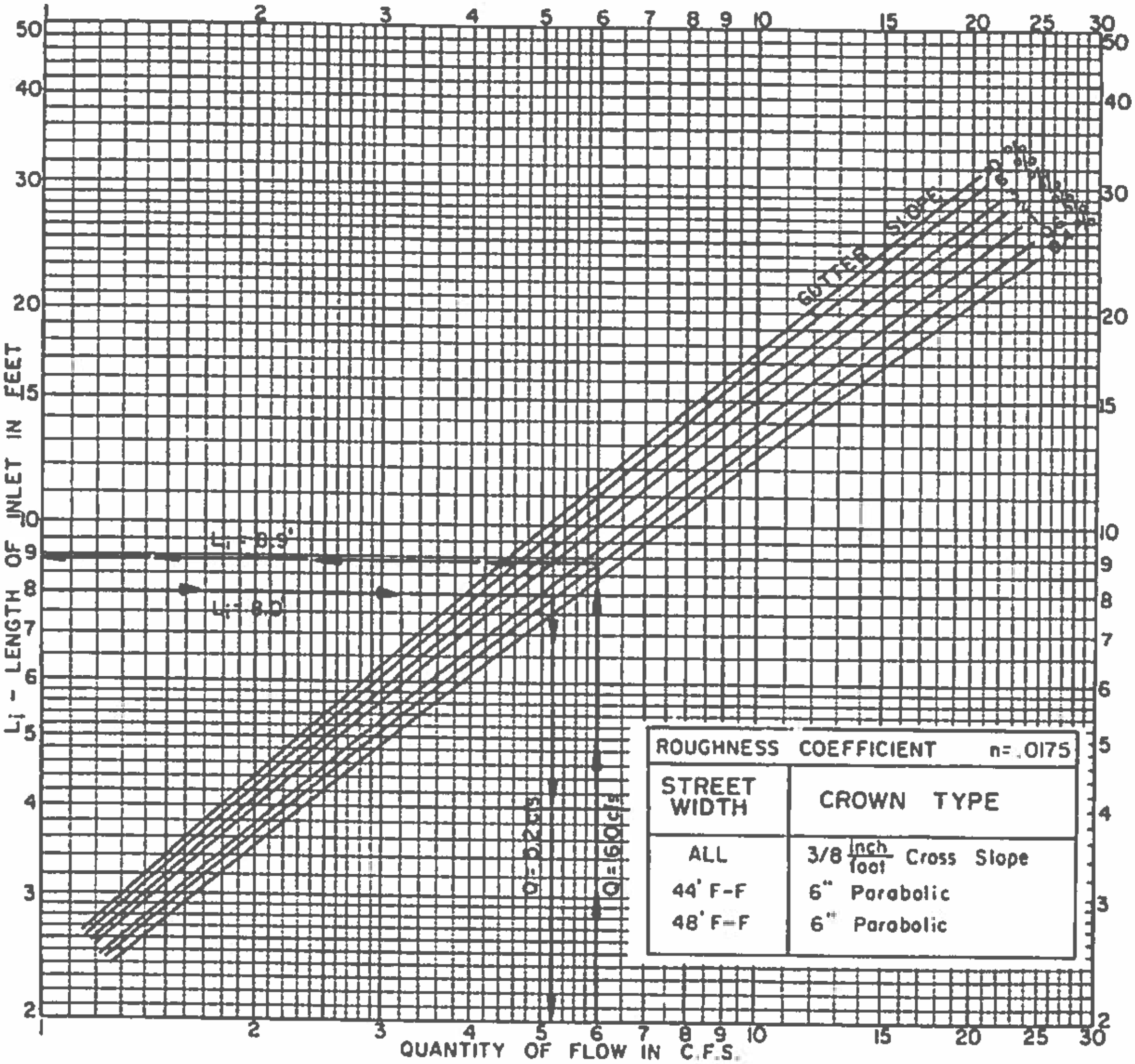
Solution:
- Enter Graph at 4.4 cfs
- Intersect Slope = 2.0 %
- Read L_i = 8.4'

Decision:
1. Use 10' Inlet
   No Flow Remains in Gutter
2. Use 8' Inlet
   Intercept Only Part of Flow

Use 8' Inlet
Enter Graph at L_i = 8'
Intersect Slope = 2.0%
Read Q = 4.2 cfs
Remaining Gutter Flow =
4.4 cfs − 4.2 cfs = 0.2 cfs

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 8



EXAMPLE

Known:

Pavement Width = 44'
Gutter Slope = 0.6 %
6" Parabolic Crown
Gutter Flow = 6.0 cfs

Find:

Length of Inlet Required (L_i)

Solution:

Enter Graph at 6.0 cfs
Intersect Slope = 0.6 %
Read L_i = 8.9'

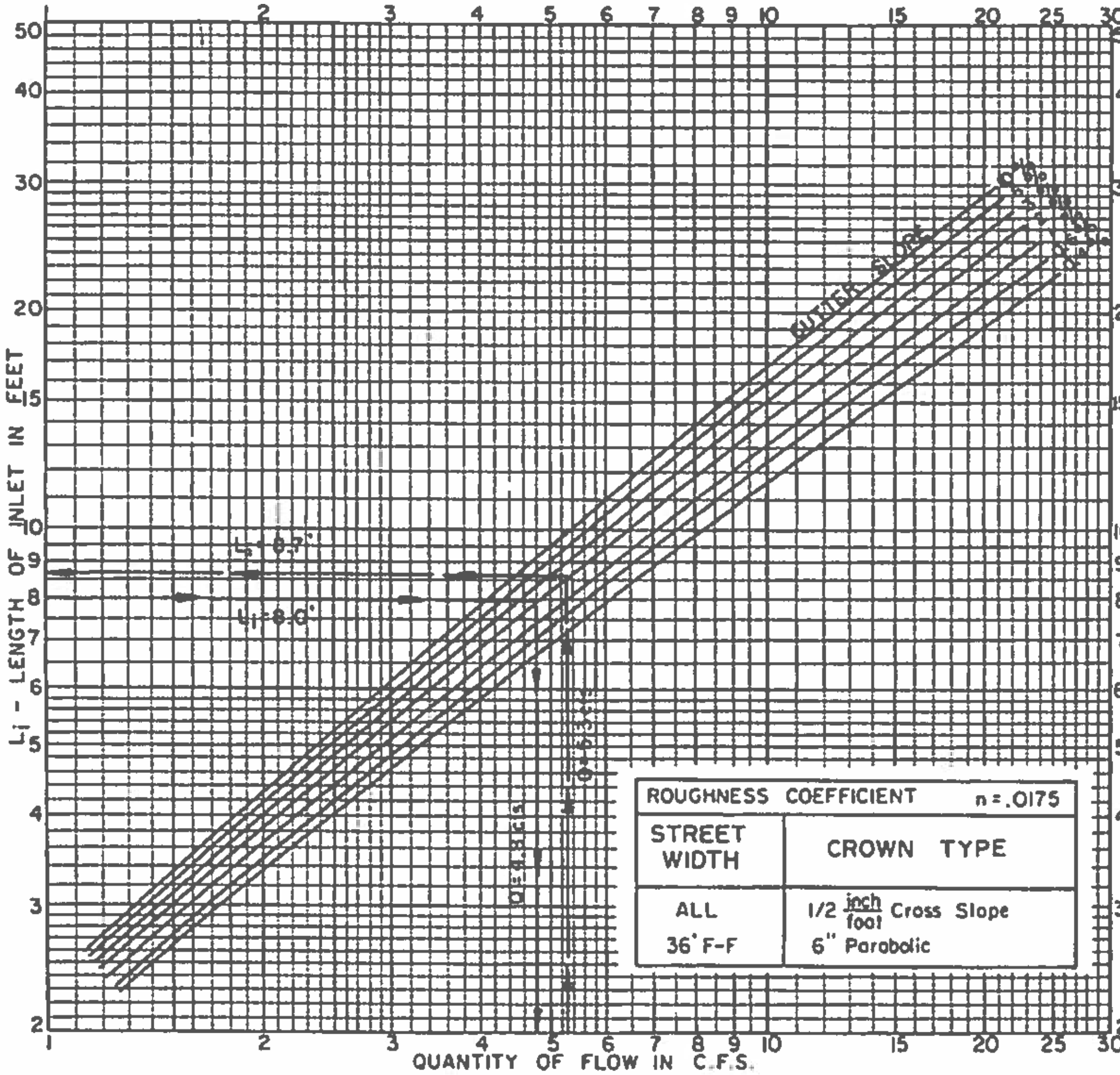
Decision:

1. Use 10' Inlet
   No Flow Remains in Gutter
2. Use 8' Inlet
   Intercept Only Part of Flow

Use 8' Inlet
Enter Graph at L_i = 8'
Intersect Slope = 0.6 %
Read Q = 5.2 cfs
Remaining Gutter Flow =
6.0 cfs – 5.2 cfs = 0.8 cfs

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 9



ROUGHNESS COEFFICIENT	n = .0175
STREET WIDTH	CROWN TYPE
ALL	1/2 inch/foot Cross Slope
36' F-F	6" Parabolic

EXAMPLE

Known:
- Pavement Width = 36'
- Gutter Slope = 2%
- 6" Parabolic Crown
- Gutter Flow = 5.3 cfs

Find:
- Length of Inlet Required (L_i)

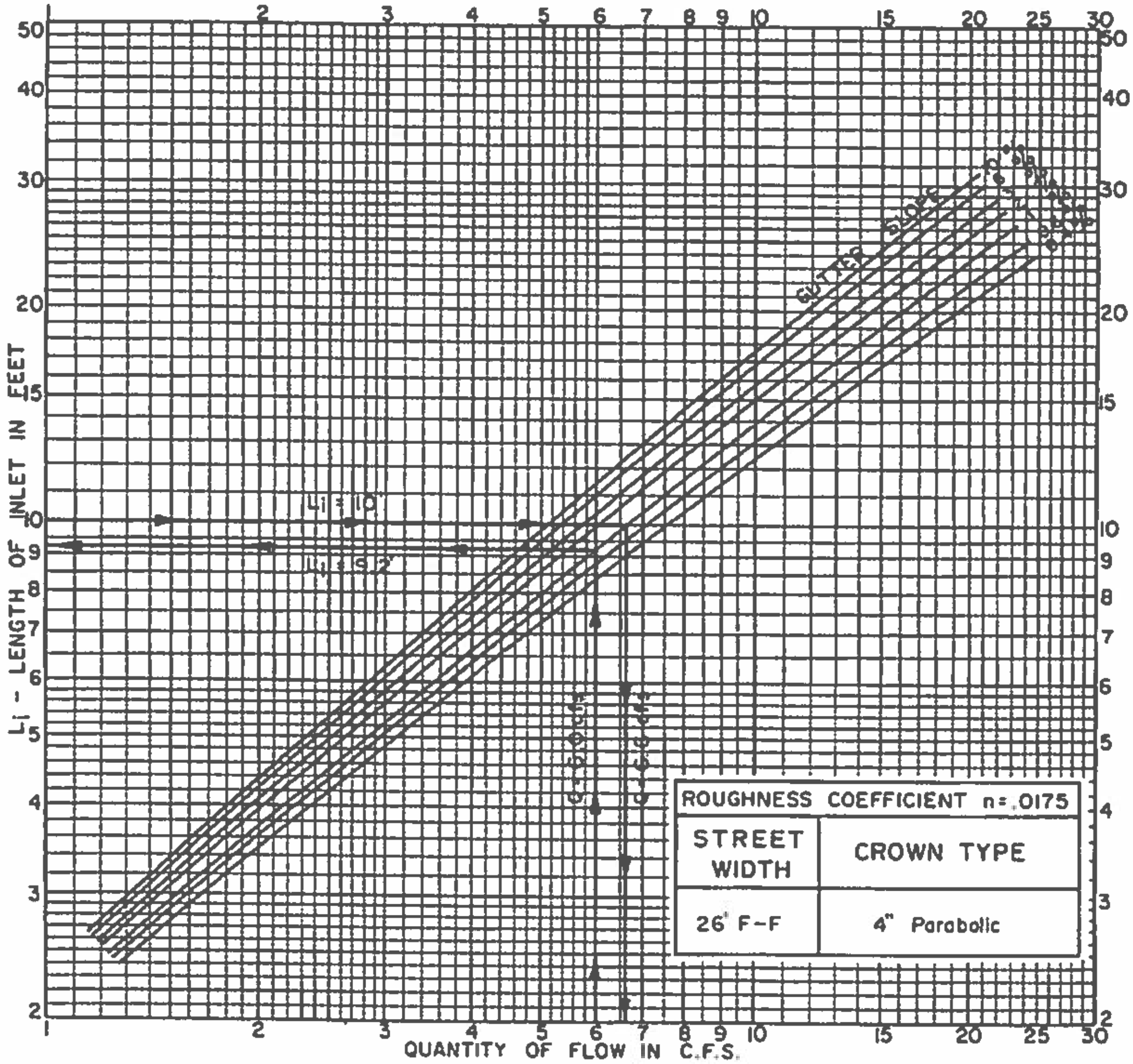
Solution:
- Enter Graph at 5.3 cfs
- Intersect Slope = 2%
- Read L_i = 8.7'

Decision:
1. Use 10' Inlet
   No Flow Remains in Gutter
2. Use 8' Inlet
   Intercept Only Part of Flow

Use 8' Inlet
Enter Graph at L_i = 8'
Intersect Slope = 2%
Read Q = 4.8 cfs
Remaining Gutter Flow =
5.3 cfs - 4.8 cfs = 0.5 cfs

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 10



EXAMPLE

Known:
- Pavement Width = 26'
- Gutter Slope = 1%
- 4" Parabolic Crown
- Gutter Flow = 6.0 cfs

Find:
- Length of Inlet Required (L_i)

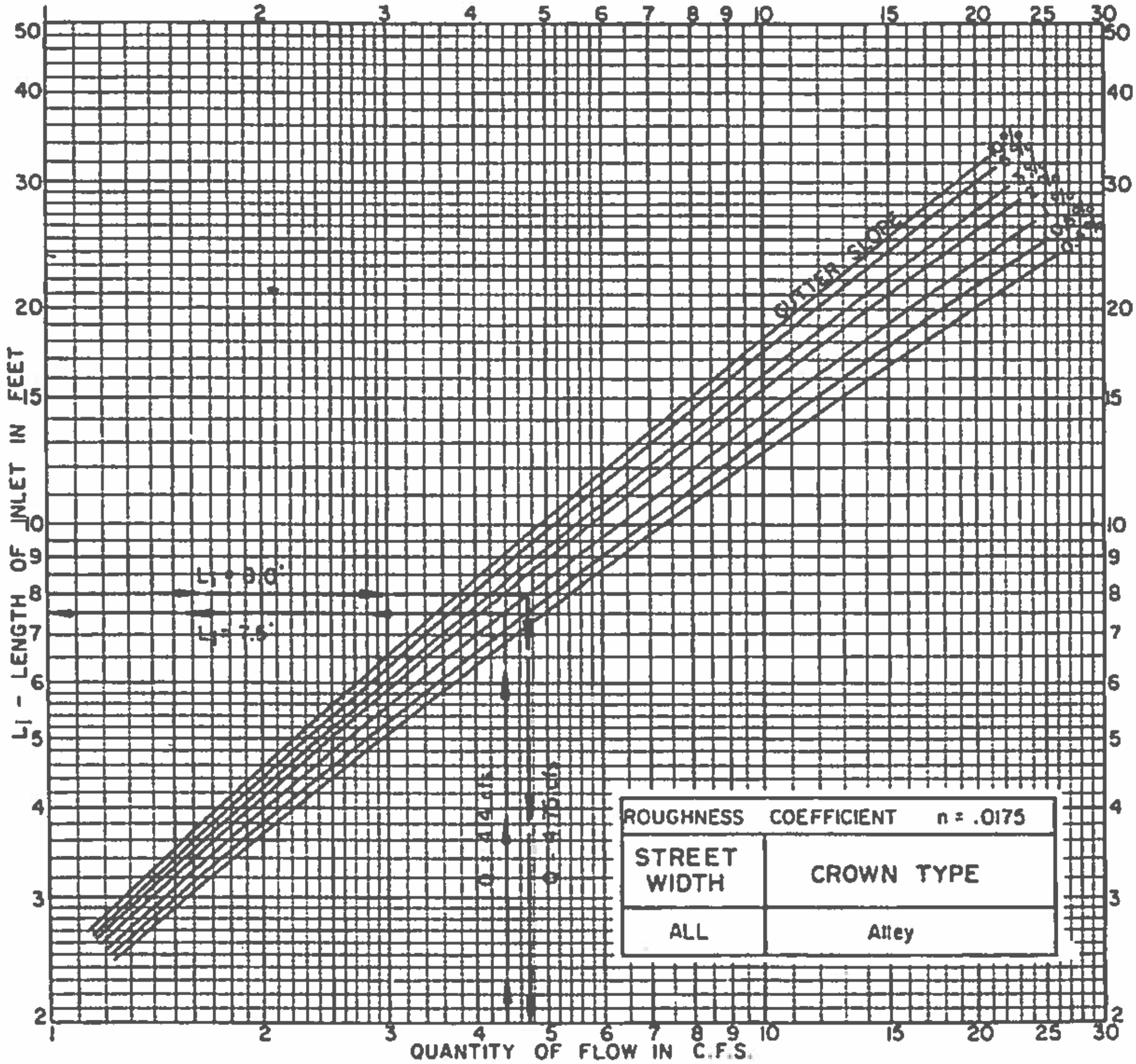
Solution:
- Enter Graph at 6.0 cfs
- Intersect Slope = 1%
- Read L_i = 9.2'

Decision:
1. Use 10' Inlet
   No Flow Remains in Gutter
2. Use 8' Inlet
   Intercept Only Part of Flow

Use 10' Inlet
Enter Graph at L_i = 10'
Intersect Slope = 1%
Read Q = 6.6 cfs
No Flow Remains in Gutter

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 11



EXAMPLE

Known:
Pavement Width = 16'
Gutter Slope = 1%
Pavement Cross Slope = 1/4"/1'
Gutter Flow = 4.4 cfs

Find:
Length of Inlet Required (L_i)

Solution:
Enter Graph at 4.4 cfs
Intersect Slope = 1%
Read L_i = 7.5'

Decision:
1. Use 8' Inlet
No Flow Remains in Gutter
2. Use 6' Inlet
Intercept Only Part of Flow

Use 8' Inlet
Enter Graph at L_i = 8'
Intersect Slope = 1%
Read Q = 4.75 cfs
No Flow Remains in Gutter

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES ON GRADE

FIGURE 12

EXAMPLE

Known:

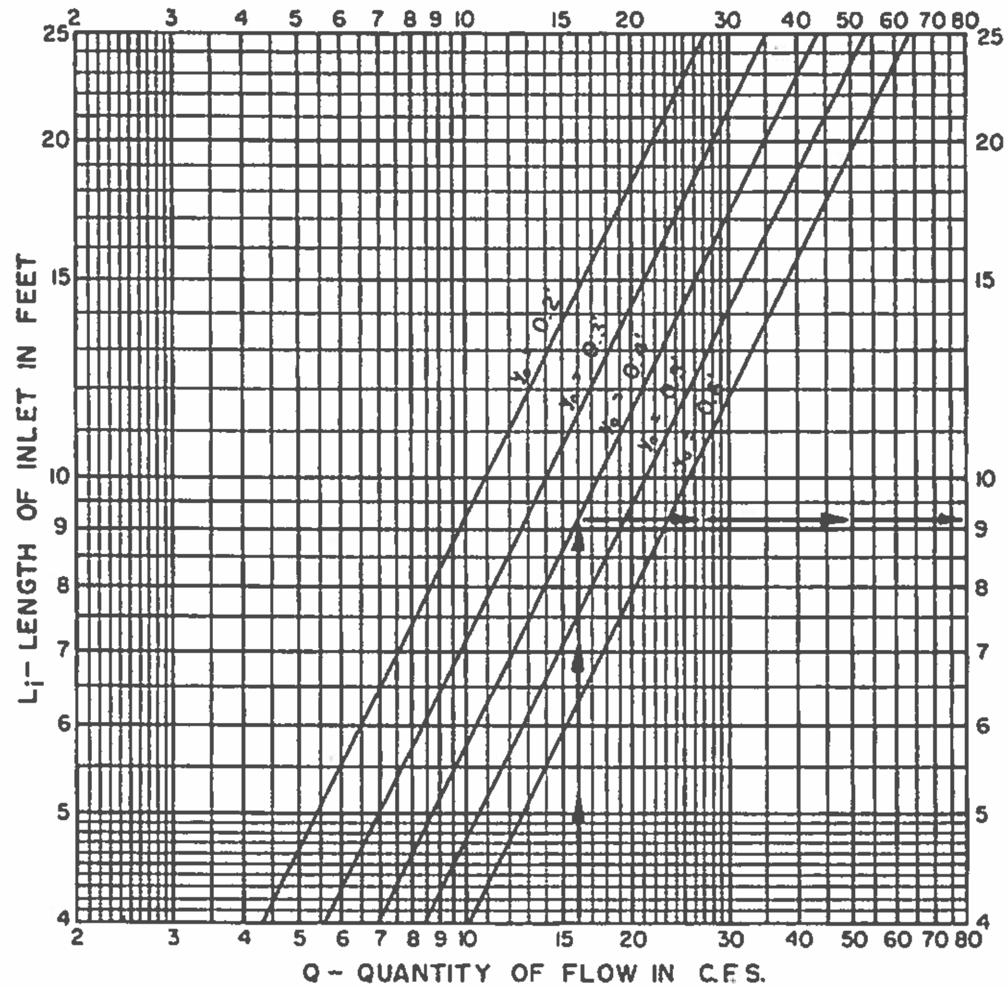
Quantity of Flow = 16.0 c.f.s.
Maximum Depth of Flow Desired in Gutter At Low Point (y_o) = 0.4'

Find:

Length of Inlet Required (L_i)

Solution:

Enter Graph at 16.0 c.f.s.
Intersect y_o = 0.4'
Read L_i = 9.2'
Use 10' Inlet



ROUGHNESS COEFFICIENT n = .0175	
STREET WIDTH	CROWN TYPE
ALL	Streight and Parabolic

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES AT LOW POINT

FIGURE 13

EXAMPLE

Known:

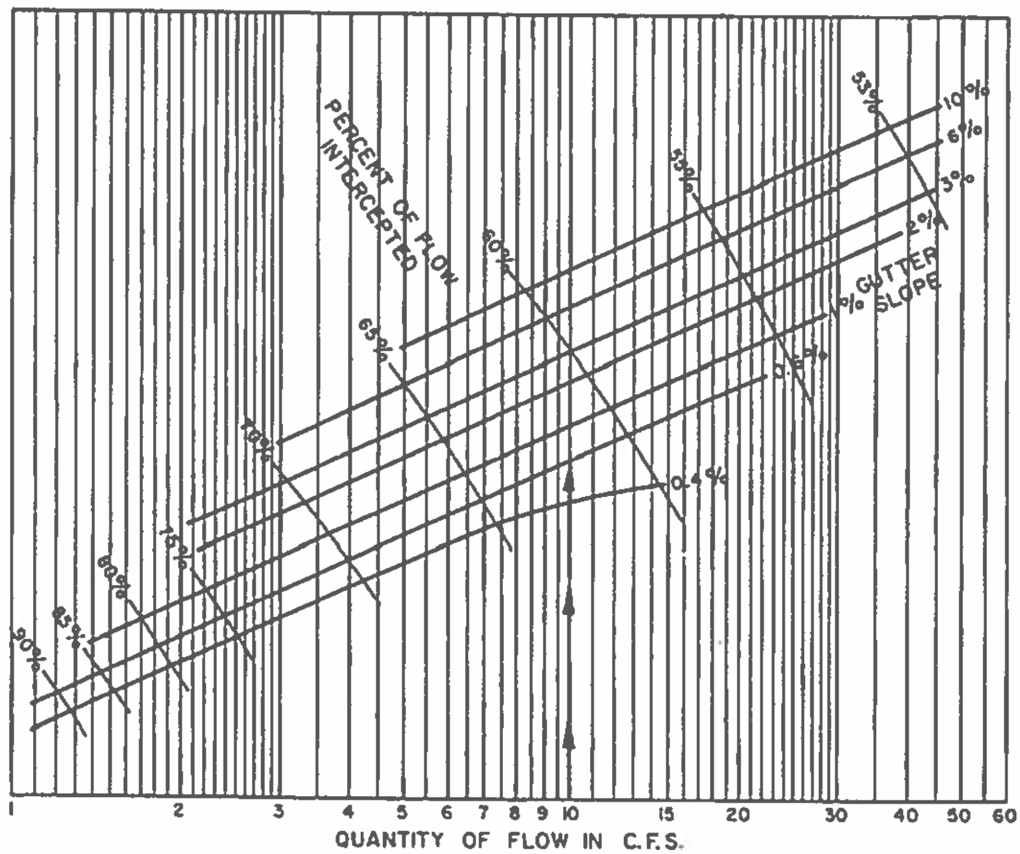
Quantity of Flow = 10.0 c.f.s.
Gutter Slope = 0.6 %

Find:

Capacity of Two Grate Combination Inlet

Solution:

Enter Graph at 10.0 c.f.s.
Intersect Slope = 0.6%
Read Percent of Flow Intercepted = 62 %
62 % of 10.0 c.f.s. = 6.2 c.f.s. as Capacity of Two Grate Combination Inlet
Remaining Gutter Flow = 10.0 c.f.s − 6.2 c.f.s. = 3.8 c.f.s.



TWO GRATE COMBINATION INLET CAPACITY CURVES ON GRADE

FIGURE 14

EXAMPLE

Known:

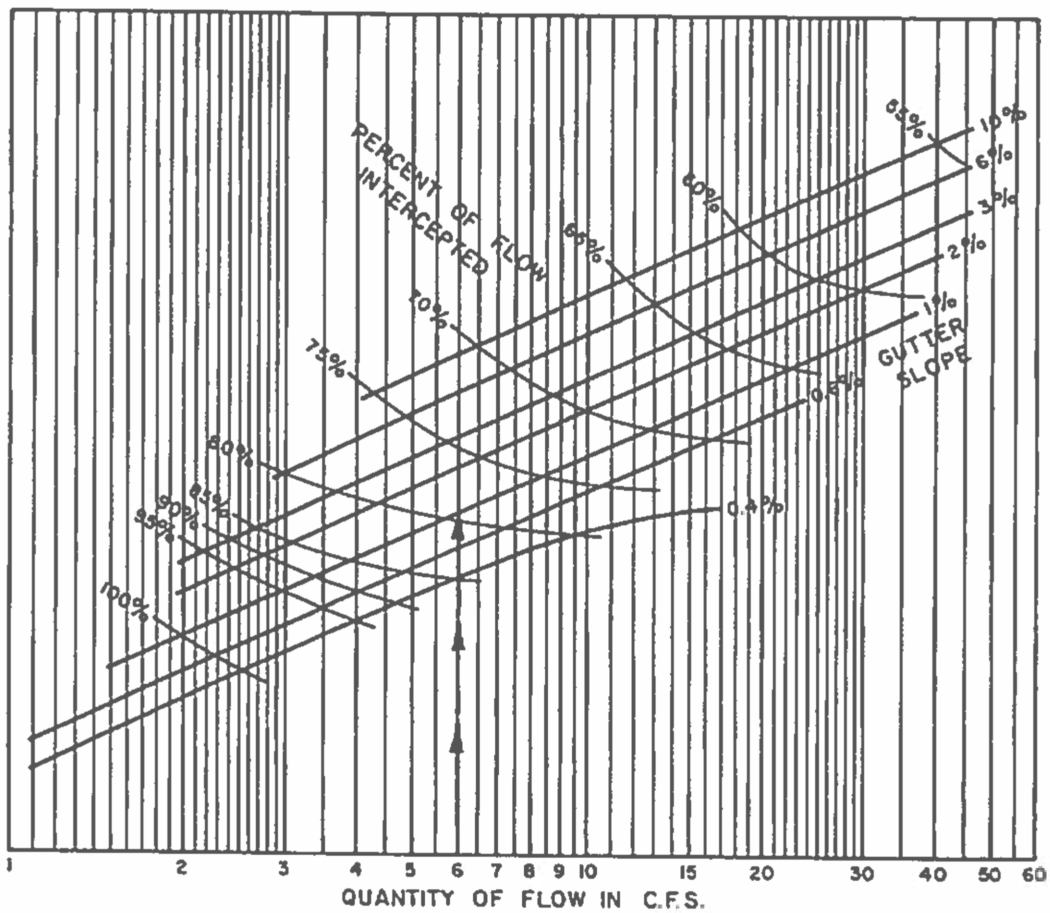
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0 %

Find:

Capacity of Four Grate Combination Inlet

Solution:

Enter Graph at 6.0 c.f.s.
Intersect Slope = 1.0 %
Read Percent of Flow Intercepted = 79 %
79 % of 6.0 c.f.s. = 4.7 c.f.s. as Capacity of Four Grate Combination Inlet
Remaining Gutter Flow = 6.0 c.f.s. − 4.7 c.f.s. = 1.3 c.f.s.



FOUR GRATE COMBINATION INLET
CAPACITY CURVES
ON GRADE

FIGURE 15

EXAMPLE

Known:

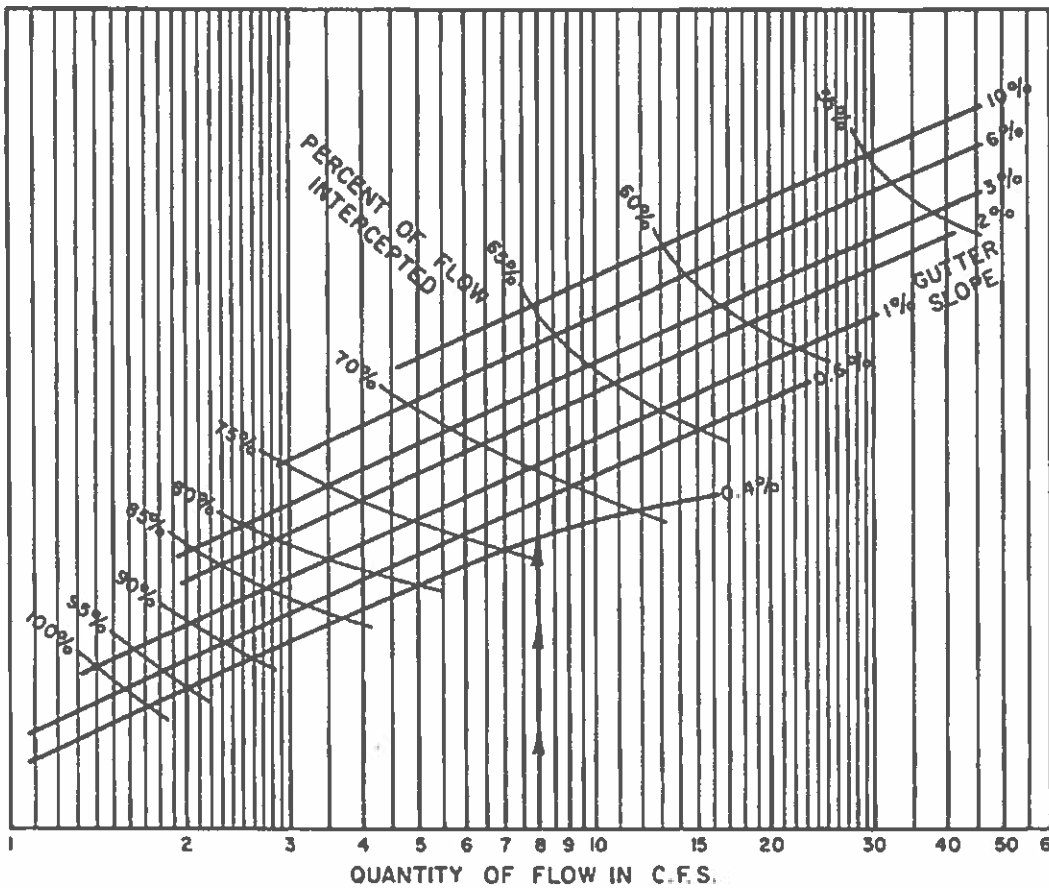
Quantity of Flow = 8.0 c.f.s.
Gutter Slope = 0.4%

Find:

Capacity of Three Grate Inlet

Solution:

Enter Graph at 8.0 c.f.s.
Intersect Slope = 0.4%
Read Percent of Flow
Intercepted = 74%
74% of 8.0 c.f.s. = 5.9 c.f.s.
as Capacity of Three Grate Inlet
Remaining Gutter Flow =
8.0 c.f.s. – 5.9 c.f.s. = 2.1 c.f.s.



THREE GRATE INLET AND
THREE GRATE COMBINATION INLET
CAPACITY CURVES
ON GRADE

FIGURE 16

EXAMPLE

Known:

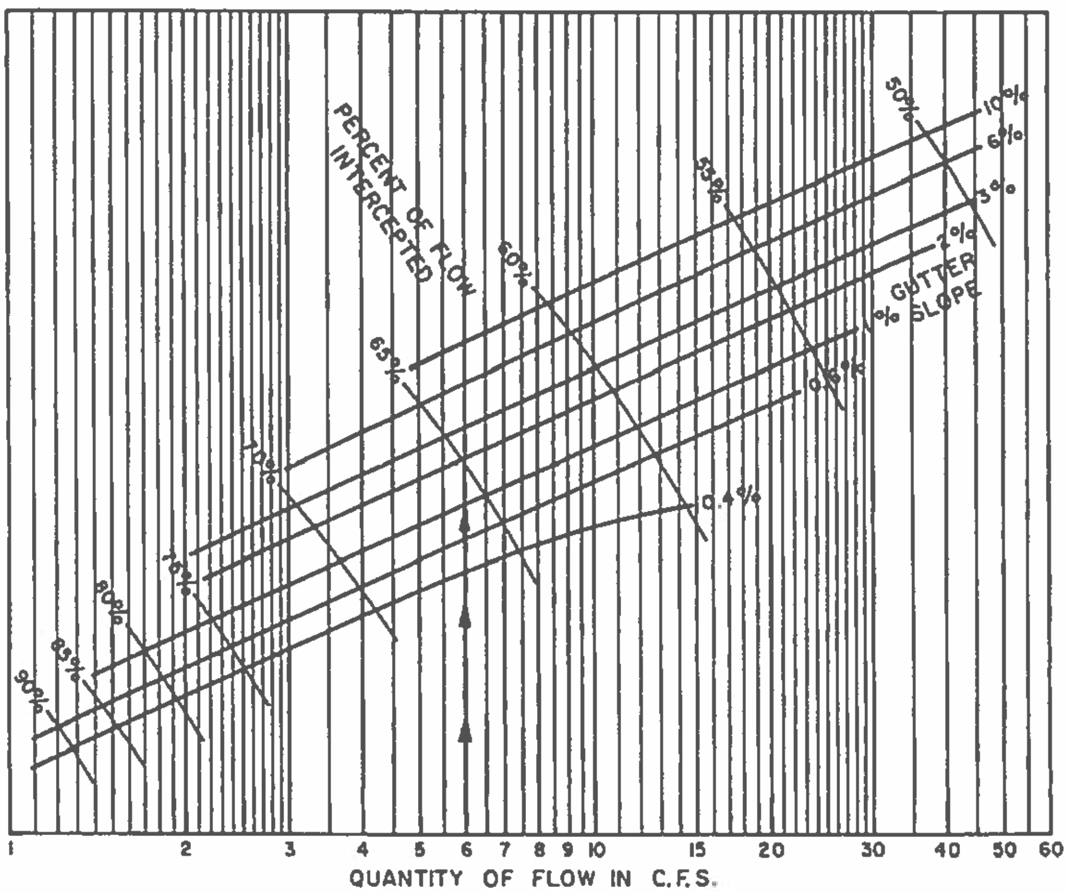
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

Find:

Capacity of Two Grate Inlet

Solution:

Enter Graph at 6.0 c.f.s.
Intersect Slope = 1.0%
Read Percent of Flow
Intercepted = 66%
66% of 6.0 c.f.s. = 4.0 c.f.s.
as Capacity of Two Grate Inlet
Remaining Gutter Flow =
6.0 c.f.s. − 4.0 c.f.s. = 2.0 c.f.s.



TWO GRATE INLET CAPACITY CURVES ON GRADE

FIGURE 17

EXAMPLE

Known:

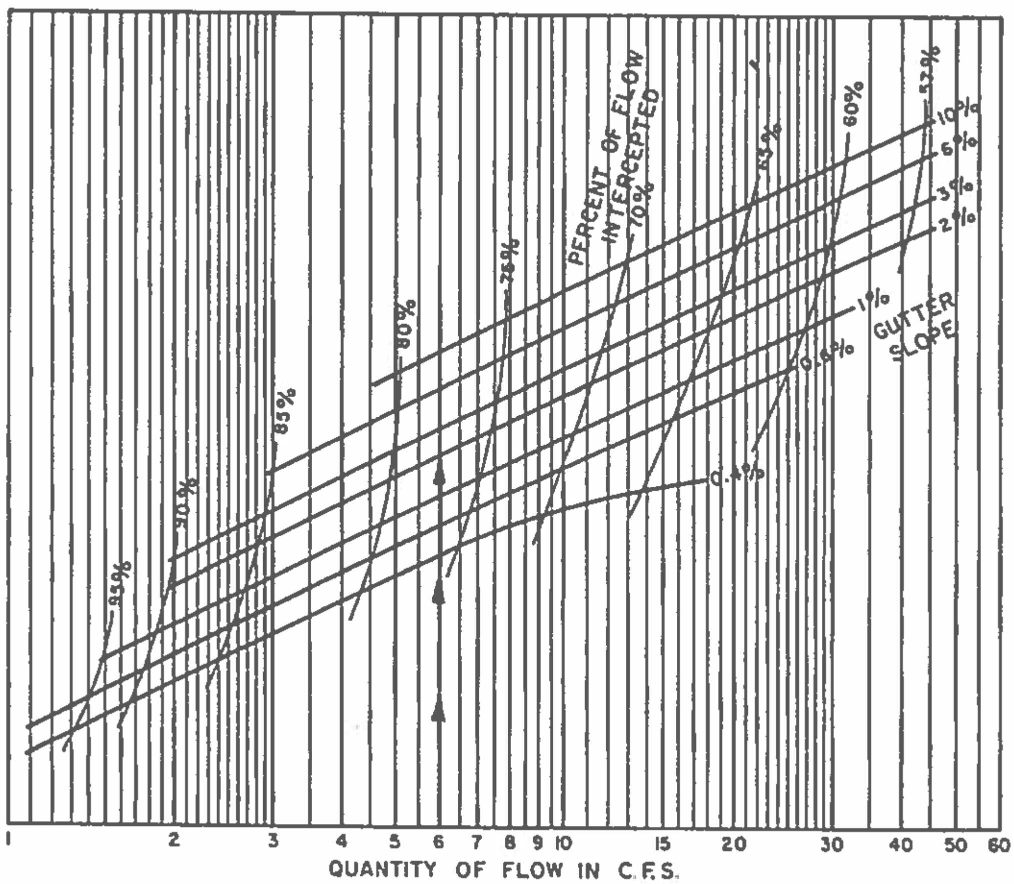
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

Find:

Capacity of Four Grate Inlet

Solution:

Enter Graph at 6.0 c.f.s.
Intersect Slope = 1.0%
Read Percent of Flow Intercepted = 77%
77% of 6.0 c.f.s. = 4.6 c.f.s. as Capacity of Four Grate Inlet
Remaining Gutter Flow = 6.0 c.f.s. – 4.6 c.f.s. = 1.4 c.f.s.



FOUR GRATE INLET
CAPACITY CURVES
ON GRADE

FIGURE 18

EXAMPLE

Known:

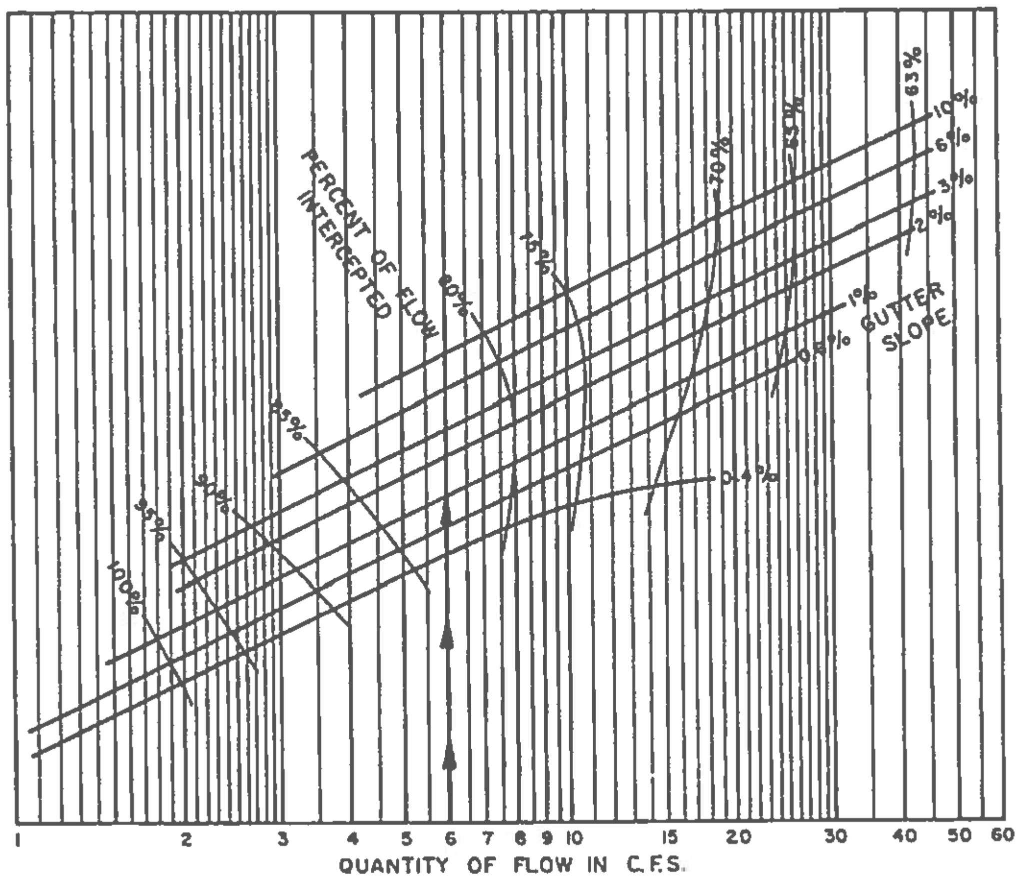
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

Find:

Capacity of Six Grate Inlet

Solution:

Enter Graph at 6.0 c.f.s.
Intersect Slope = 1.0%
Read Percent of Flow
Intercepted = 82 %
82 % of 6.0 c.f.s. = 4.9 c.f.s.
as Capacity of Six Grate Inlet
Remaining Gutter Flow =
6.0c.f.s. − 4.9 c.f.s. = 1.1 c.f.s.



SIX GRATE INLET
CAPACITY CURVES
ON GRADE

FIGURE 19

EXAMPLE

Known:

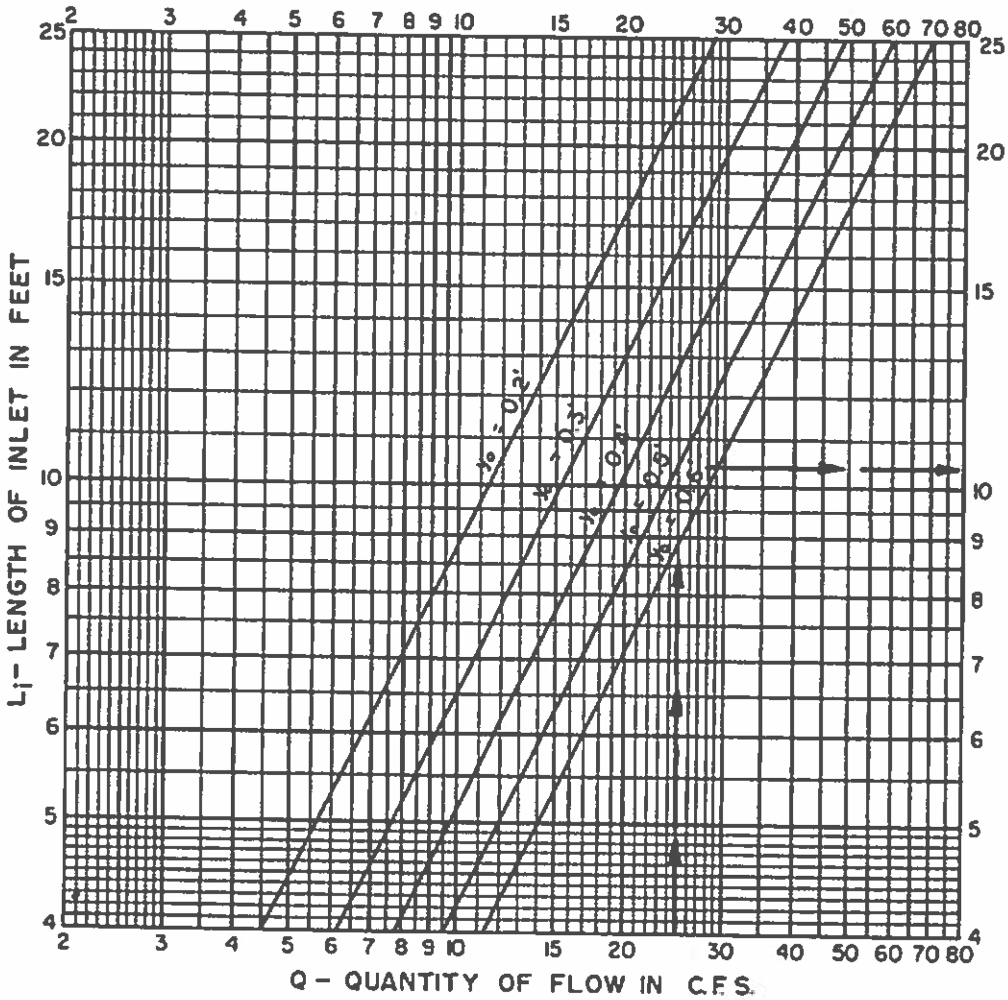
Quantity of Flow = 25.0 c.f.s.
Maximum Depth of Flow Desired
At Low Point (y_o) = 0.5'

Find:

Length of Inlet Required (L_i)

Solution:

Enter Graph at 25.0 c.f.s.
Intersect y_o = 0.5'
Read L_i = 10.4'
Use 12' Inlet



ROUGHNESS COEFFICIENT n = .0175	
STREET WIDTH	CROWN TYPE
ALL	Straight and Parabolic

COMBINATION INLET CAPACITY CURVES AT LOW POINT

FIGURE 20

EXAMPLE

Known:

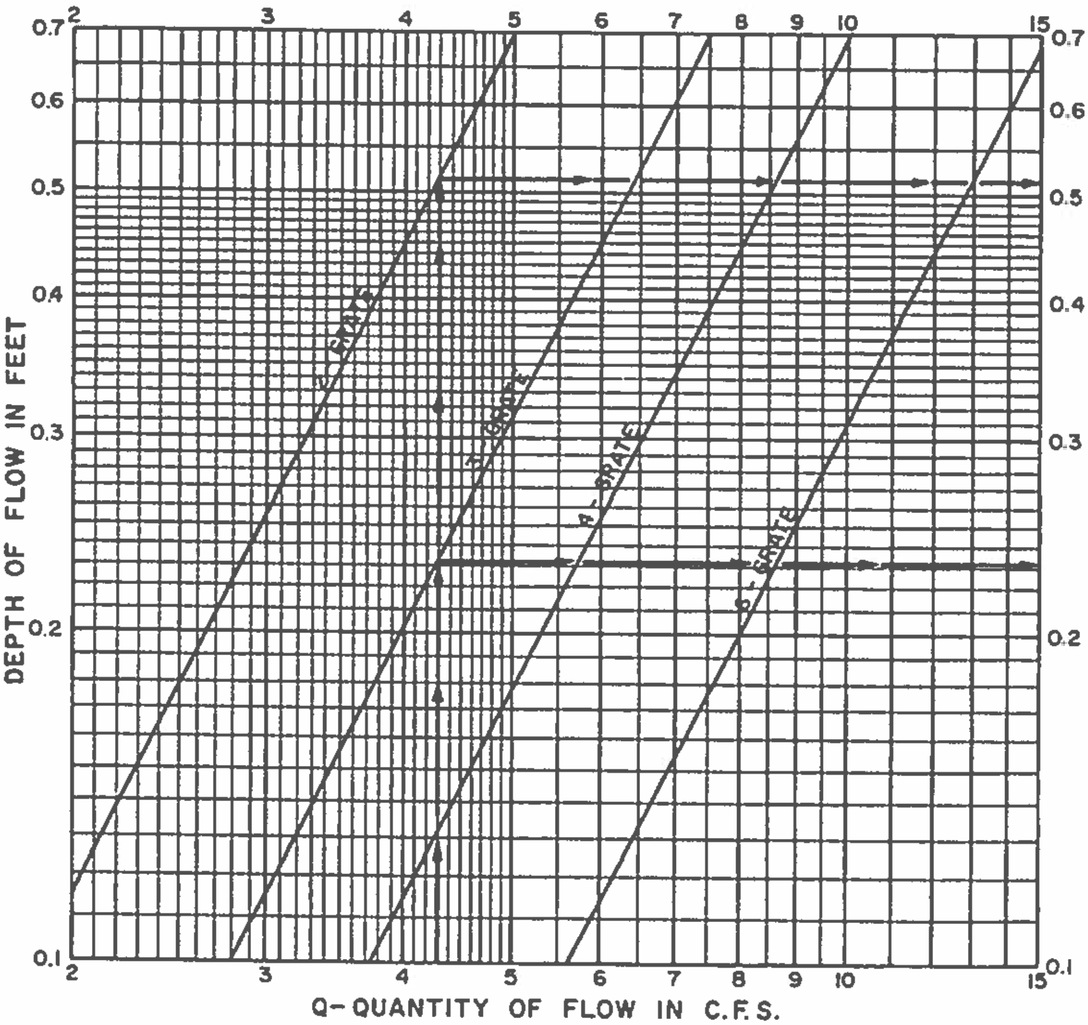
Quantity of Flow = 4.3 c.f.s.
Maximum Depth of Flow Desired at Low Point = 0.3'

Find:

Inlet Required

Solution:

Enter Graph at 4.3 c.f.s.
Intersect 3-Grate at 0.23'
Intersect 2-Grate at 0.51'
Use 3-Grate



GRATE INLET
CAPACITY CURVES
AT LOW POINT

FIGURE 21

EXAMPLE

Known:

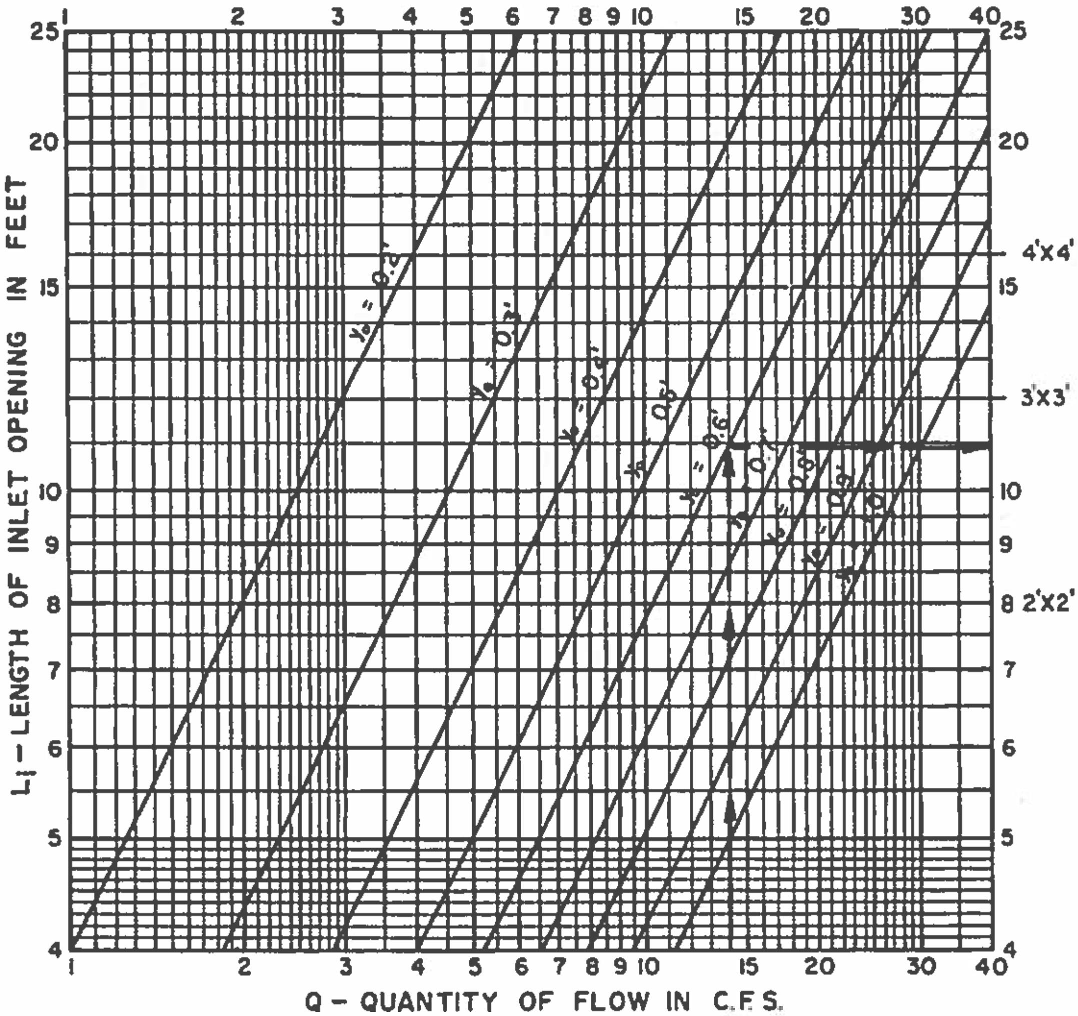
Quantity of Flow = 14.0 c.f.s.
Maximum Depth of Flow Desired
(y_o) = 0.6'

Find:

Length of Inlet Opening Required (L_i)

Solution:

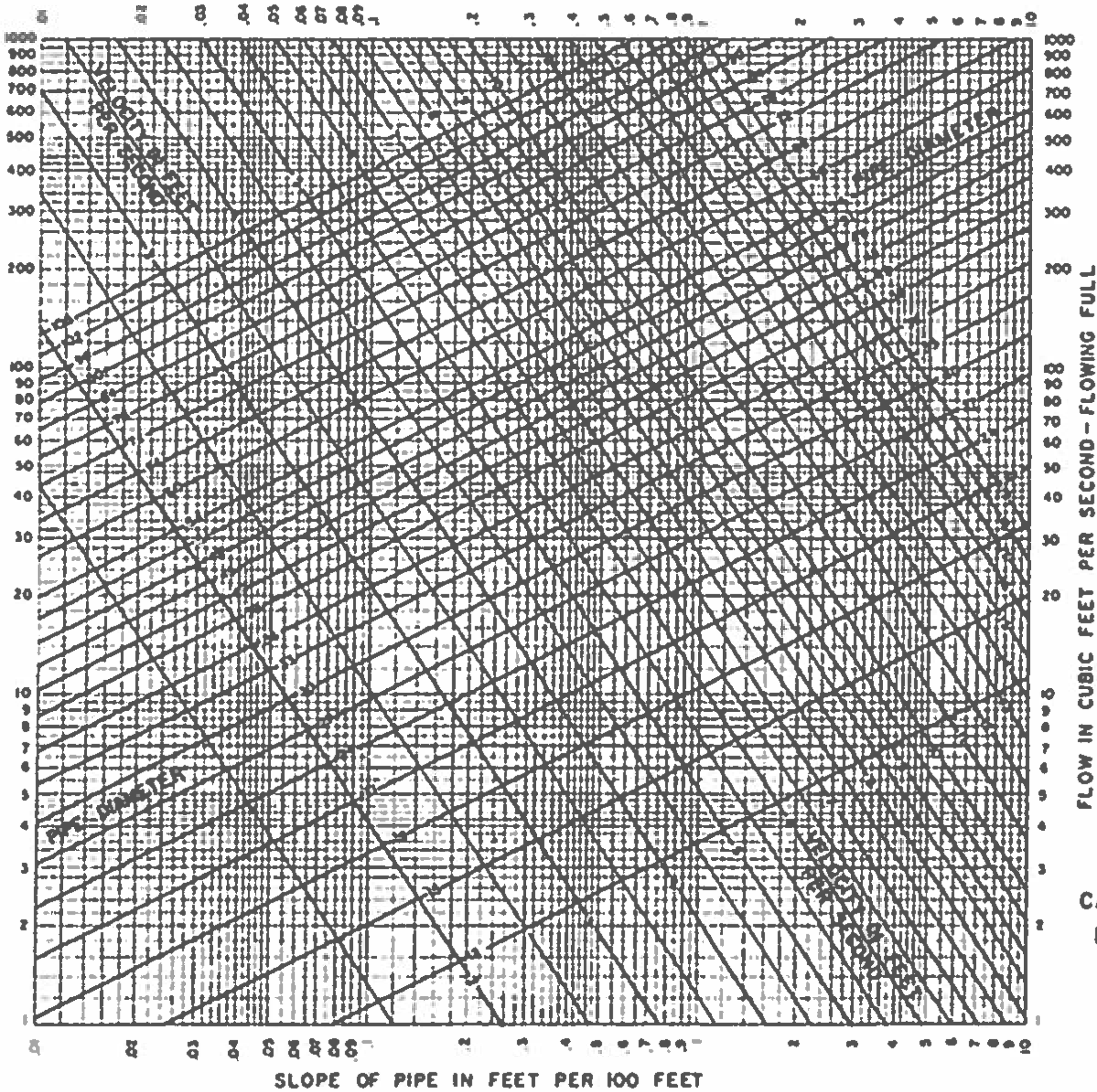
Enter Graph at 14.0 c.f.s.
Intersect y_o = 0.6'
Read L_i = 10.9'
Use 12' of Inlet; 3'x3'



Standard Drop Inlet Sizes:
2'x2'; Li = 8'
3'x3'; Li = 12'
4'x4'; Li = 16'

DROP INLET CAPACITY CURVES AT LOW POINT

FIGURE 22



A GRAPHICAL SOLUTION OF MANNING'S EQUATION

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

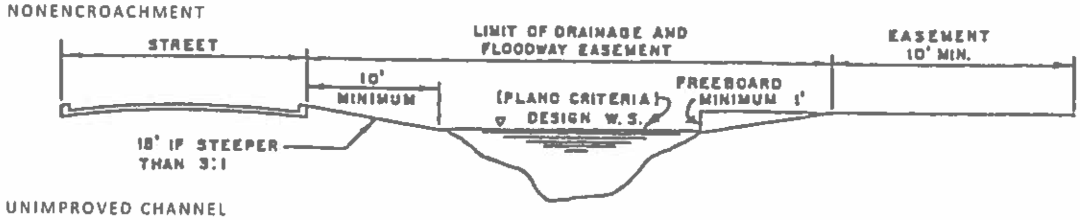
$$n = 0.013$$

CAPACITY OF CIRCULAR PIPES FLOWING FULL

FIGURE 23

CREEKS MAY REMAIN IN OPEN NATURAL CONDITION IF:

(1) THEY COMPLY WITH THE SUBDIVISION ORDINANCE;
(2) TREE COVERAGE IS ADEQUATE TO BE ACCEPTABLE TO THE CITY
(3) UNSANITARY OR UNACCEPTABLE DRAINAGE CONDITIONS DO NOT EXIST IN THE CREEK;
(4) APPROVED BY THE CITY



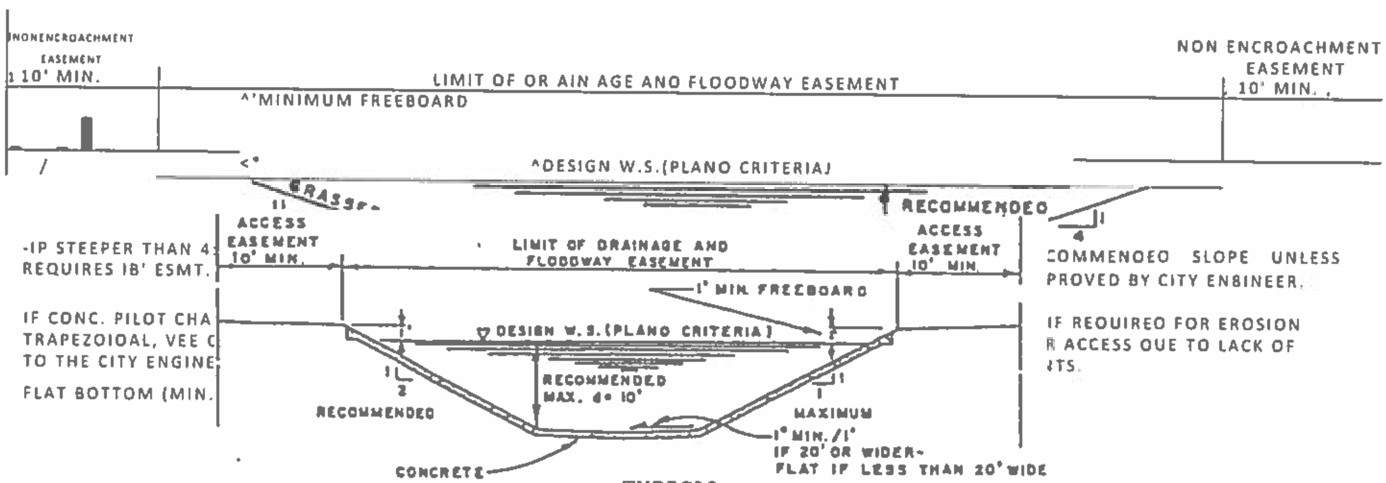
TYPE I - NATURAL

TYPE III - LINED

NOTE: TYPE I OR II - IF STEEPER THAN 3:1 SLOPE ABOVE DESIGN W.S., THE NON-ENCROACHMENT ESMT. SHALL BE 15 FEET WIDE TO PROVIDE A STABLE ACCESS ESMT., IF ACCESS HAS NOT OTHERWISE BEEN PROVIDED.

NOTE: A PARALLEL STREET IS RECOMMENDED ON AT LEAST ONE SIDE OF TYPE I CHANNELS IF THE DRAINAGE AND FLOODWAY IS DEDICATED TO PUBLIC USE.

NOTE: NO ENCROACHMENTS SHALL BE PERMITTED IN ACCESS EASEMENTS.

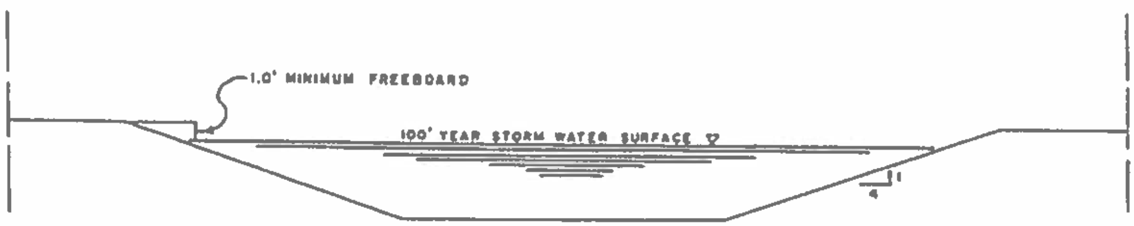


TYPICAL

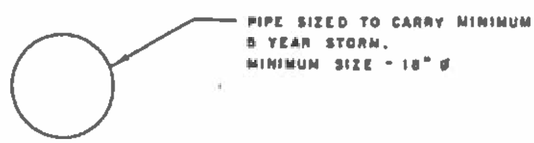
WHEN CHANNEL IS DESIGNED USING PEAK DISCHARGE FLOWS FROM THE FLOOD INSURANCE STUDY, FREEBOARD MAY BE DELETED.

OPEN CHANNEL TYPES

OPEN CHANNEL WITH PILOT PIPE
ALTERNATIVE TYPE II



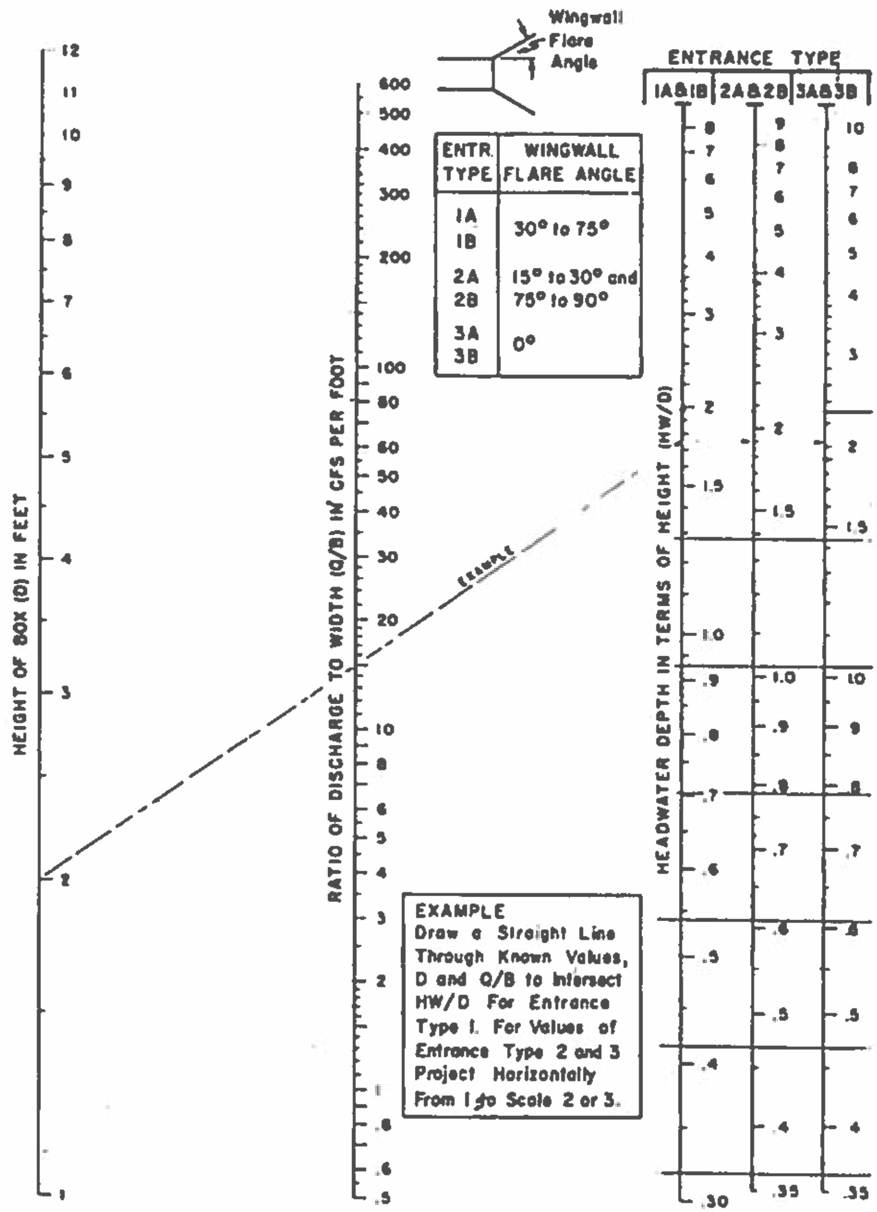
NOTE: Bank slopes and non-encroachment easement requirements same as for Type II.



NOTE: There are conditions due to the excessive capacity of the open ditch section where a pilot pipe carrying less than a five-year storm may be used if approved by the City Engineer.

ALTERNATE OPEN
CHANNEL TYPE II

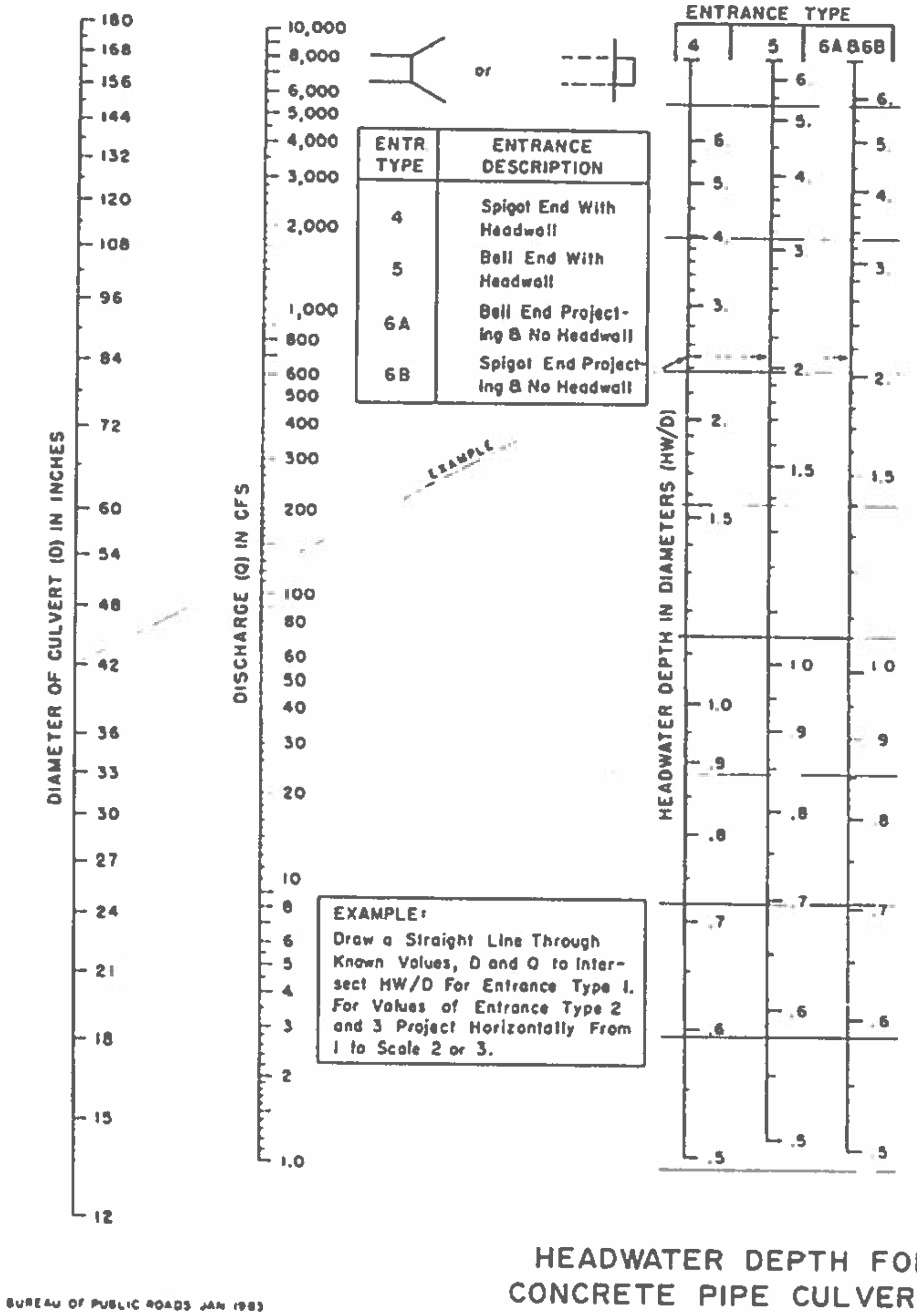
FIGURE 24(B)



BUREAU OF PUBLIC ROADS JAN 1963

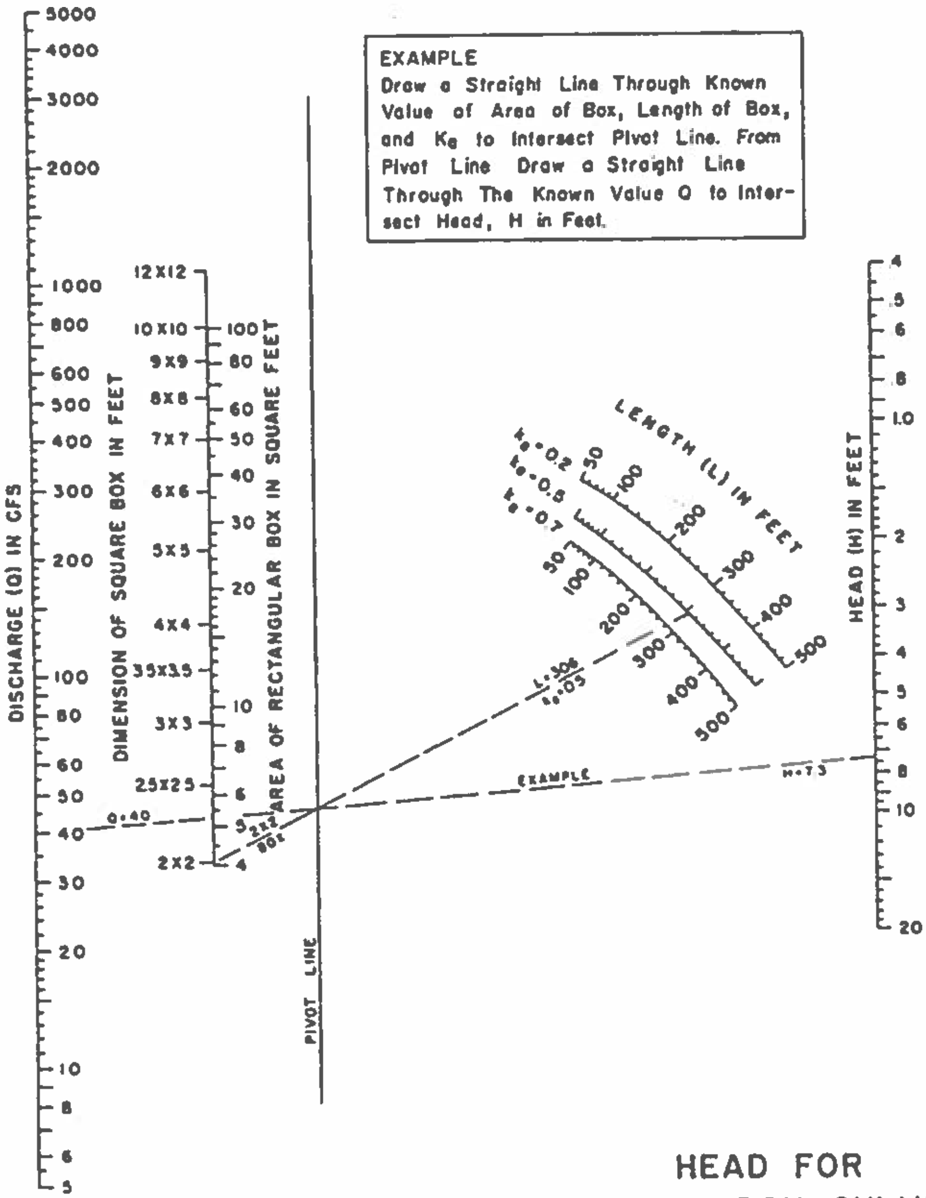
HEADWATER DEPTH FOR CONCRETE BOX CULVERT WITH INLET CONTROL

FIGURE 25



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

FIGURE 26

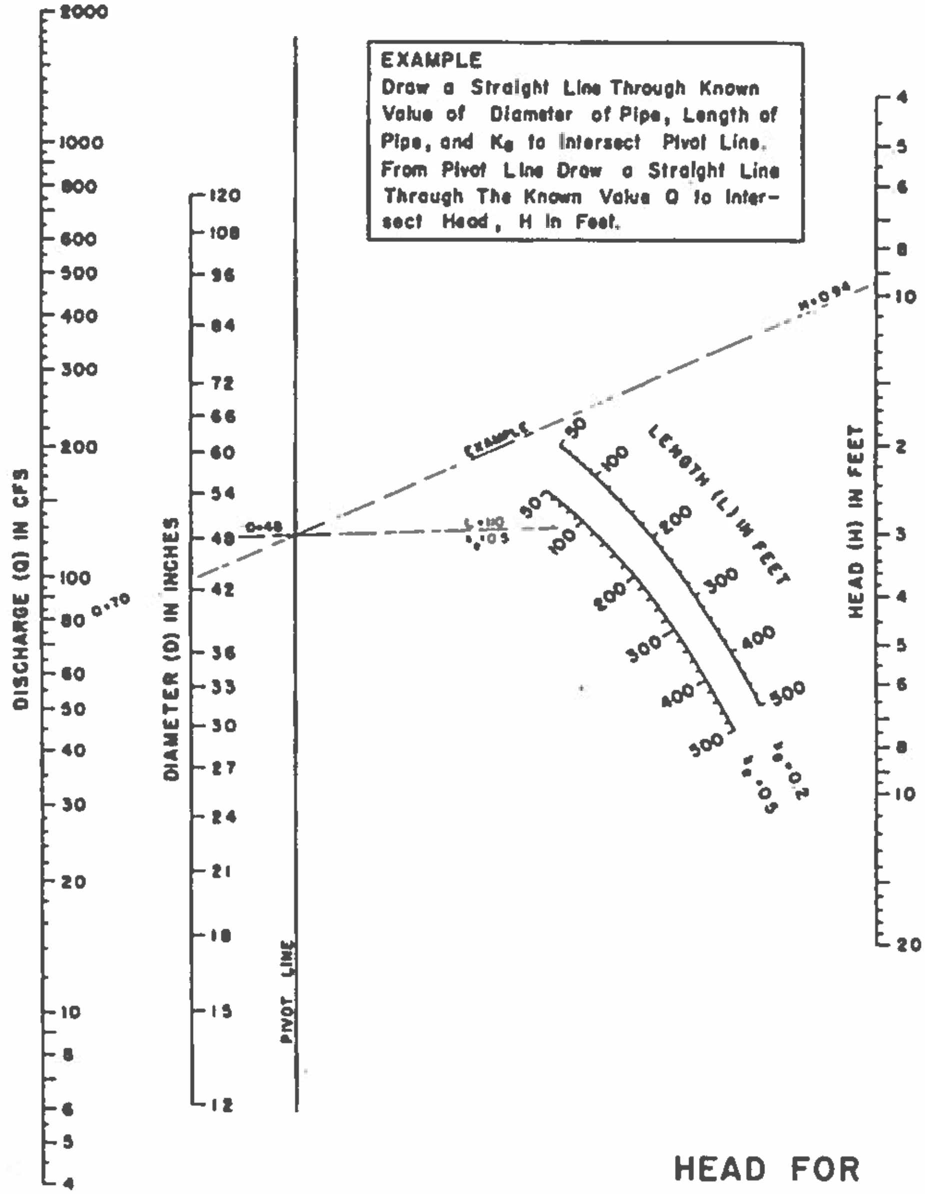


HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL

n = 0.012

BUREAU OF PUBLIC ROADS JAN 1963

FIGURE 27



HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

BUREAU OF PUBLIC ROADS JAN 1963

FIGURE 28

EXAMPLE

Known:

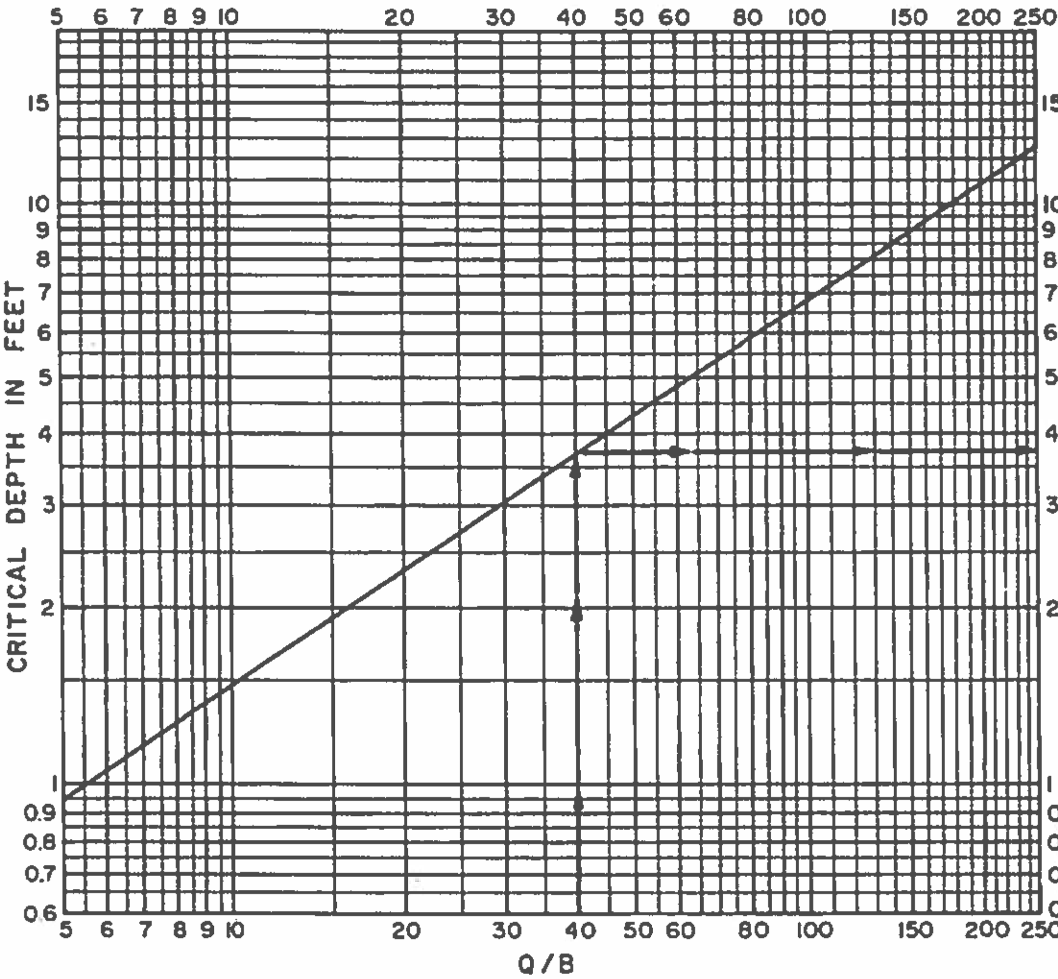
Discharge = 200 c.f.s.
Width of Conduit = 5'
Q/B = 40

Find:

Critical Depth

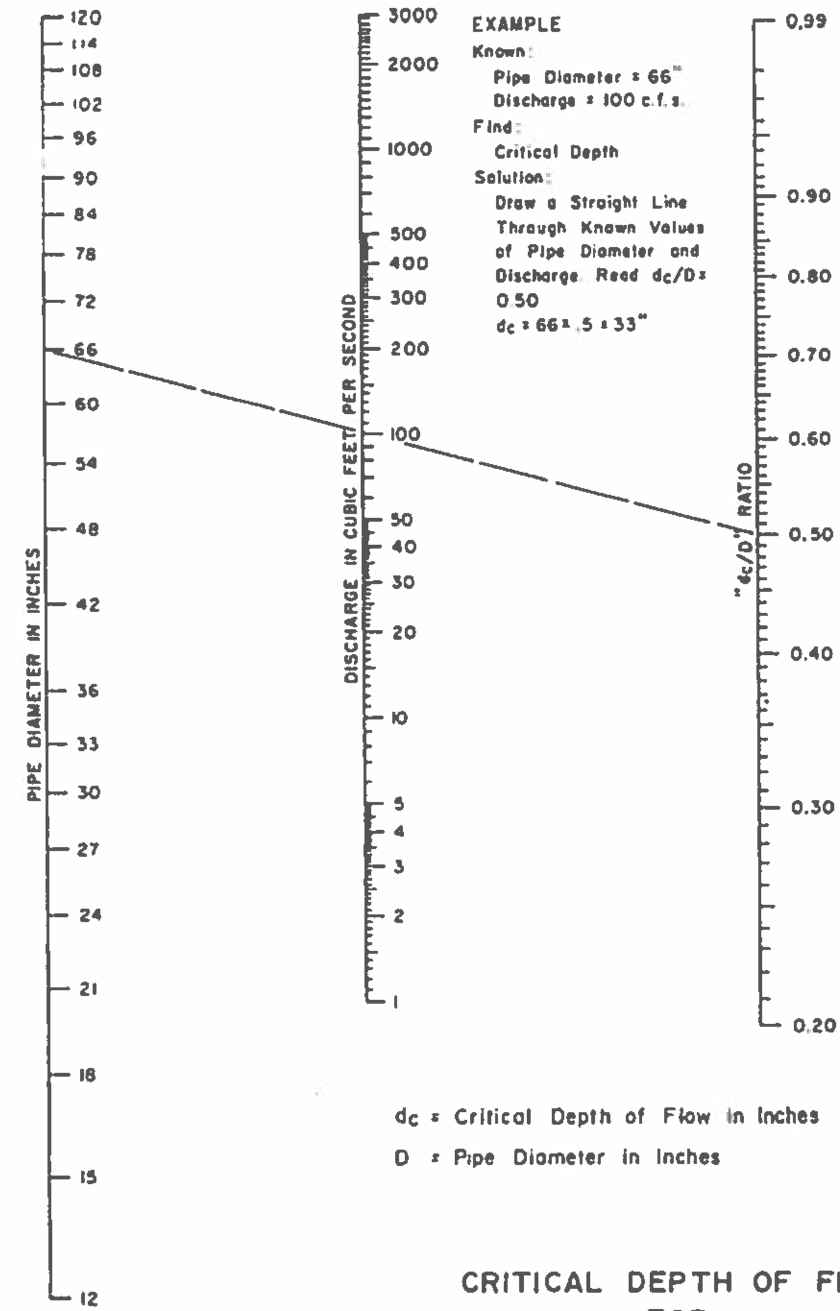
Solution:

Enter Graph at Q/B = 40
Intersect Critical Depth
at 3.7



CRITICAL DEPTH
OF FLOW FOR
RECTANGULAR CONDUITS

FIGURE 29



CRITICAL DEPTH OF FLOW
FOR
CIRCULAR CONDUITS

TEXAS HIGHWAY DEPARTMENT

FIGURE 30

VIII - LIST OF FORMS

<u>**Form**</u>

NOTE: A copy of each applicable form must be submitted with the drainage plans to the City to review. Final plans must include these forms in the drainage plans.

STORM WATER RUNOFF CALCULATIONS - FORM "A"

Column 1	Location of the drainage structure for which the runoff calculation is being made or a design point on an open channel.

Columns 2 thru 6 are to be used in calculating runoff by the Rational Method.

Column 2	Obtained from TABLE 1, or FIGURE 2
Column 3	Using the appropriate Design Storm Frequency, and the Time of Concentration in Column 2, the Intensity is obtained from FIGURE 1.
Column 4	Size of the drainage area tributary to the point of design shown in Column 1.
Column 5	Taken from TABLE 1 and is a weighted composite value if several different zoning districts fall within the drainage area.
Column 6	Column 3 multiplied by Columns 4 and 5.

Columns 7 thru 19 are to be used in calculating runoff by the Unit Hydrograph Method.

Column 7	Taken from TABLE 2.
Column 8	Measured distance along the stream course from the upper-most limit of the drainage area to the point of design shown in Column 1.
Column 9	Measured distance along the stream course from the point of design shown in Column 1 to the measured center of gravity of the drainage area.
Column 10	A computed value using the values shown in Columns 7, 8 and 9.
Column 11	Taken from TABLE 2.
Column 12	Column 11 divided by Column 10.

Column 13 Size of the drainage area tributary to the plant of design shown in Column 1.

Column 14 Column 12 multiplied by Column 13.

Column 15 Using the appropriate Design Storm Frequency and a duration of two hours, this value is obtained from FIGURE 1.

Column 16 Obtained by multiplying the value in Column 15 times two.

Column 17 Constant value of 1.11 inches for the Farmersville geographic area.

Column 18 Result of subtracting Column 17 from Column 16.

Column 19 Column 14 multiplied by Column 18.

Column 20 The flow used for design depends on the size of the drainage area. If the size of the drainage area is less than 600 acres, Q_R should be entered. If the drainage area is larger than 600 acres and smaller than 1200 acres, the larger of the two flows (Q_R and Q_U) should be entered. If the drainage area is larger than 1200 acres, Q_U should be entered.

FORM "A"

STORM WATER RUNOFF CALCULATIONS

	DESIGN FLOW (Q_R) BY RATIONAL METHOD					DESIGN FLOW (Q_U) BY UNIT HYDROGRAPH METHOD													
Drainage Basin	Time of Concentration (minutes)	Intensity "I" (in./hr.)	Drainage Area "A" (Acres)	Runoff Coefficient "C"	Design "Q" = C*I*A	Coefficient "C_t"	Length "L" (miles)	Length "L_{ca}" (miles)	Log Time "t_p"= $C_t(L*L_{ca})^3$ (hours)	Coefficient C_p640	Peak unit Flow "q_p" = (C_p640/t_p) (c.f.s./sq.mi.)	Drainage Area "A" (sq.mi)	Peak Flow "Q_p" = q_p*A (c.f.s.)	Intensity "I" at 2-hours (in./hr.)	Design Storm "S_D" = 2*I (inches)	Initial and Subsequent Losses "L_{IS}" (inches)	Total Runoff "R_T" = S_D-L_{IS} (inches)	Design Flow "Q_U" = R_T*Q_p (c.f.s)	FLOW USED FOR DESIGN
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

INLET DESIGN CALCULATIONS - FORM "B"

Column 1	Drainage subbasin area designation.
Column 2	Design Storm Frequency is same as the Design Storm Frequency of the storm sewer.
Column 3	Time of concentration for each inlet is taken from TABLE 1, or FIGURE 2.
Column 4	Using the time of concentration and the Design Storm Frequency, rainfall intensity is taken from FIGURE
Column 5	Runoff Coefficient is taken from TABLE 1 according to the zoning of the drainage area.
Column 6	Area drained by the specific inlet. Care should be taken to keep the drainage area flow separate into the appropriate street gutters.
Column 7	Product of Column 4 multiplied by Columns 5 and 6.
Column 8	Inlet number or designation. The first inlet shown is the most upstream.
Column 9	Construction plan station of the inlet.
Column 10	If there is any flow that was not fully intercepted by an upstream inlet, it should be entered here.
Column 11	Sum of columns 7 and 10.
Column 12	Gutter flow depth.
Column 13	Roughness coefficient. Use a value of n = 0.0175
Column 14	Street gutter slope to be used in selecting the proper size inlet.

Column 15 Crown type of the street on which the inlet is located.

Column 16 Crown slope as determined by crown type.

Column 17 Capacity of the street gutter, in which the inlet is located, from either FIGURES 3, 4, 5 or 6. The total gutter flow shown in Column 11 is in excess of the value in Column 17 the inlet should be moved upstream. If it is substantially less than the value in Column 17, an investigation should be made to see if the inlet could be moved downstream.

Column 18 Calculated using Columns 11 and 12 and FIGURES 8 thru 22.

Column 19 Selected size of the inlet taken from COLUMN 18.

Column 20 Inlet type taken from FIGURE 7.

Column 21 Calculated using values from Columns 12, 15 and FIGURES 8-22.

Column 22 If the selected inlet does not intercept all of the gutter flow, the difference between the two values should be entered here and in Column 10 of the inlet that will intercept the flow.

FORM "B"
INLET DESIGN CALCULATIONS

	Area Runoff Q = C*I*A						Inlet										Selected Inlet				
Drainage Subbasin	Design Storm Frequency (yr.)	Time of Concentration (min.)	Intensity "I" (in./hr.)	Runoff Coefficient "C"	Drainage Area "A" (Acres)	Design Flow (Q from FORM A)	No.	Location	Carry-Over From Upstream Inlet (c.f.s.)	Total Gutter Flow (c.f.s.)	Gutter Flow Depth (ft.)	Roughness Coefficient "n"	Gutter Slope (ft./100 ft.)	Crown Type	Crown Slope (ft./100 ft.)	Gutter Capacity (c.f.s.)	Length Required (ft.)	Length Selected (feet)	Type	Inlet Capacity	Carry-Over To Downstream Inlet (c.f.s.) (c.f.s.)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

STORM SEWER CALCULATIONS - FORM "C"

Column 1	Upstream station of the section of conduit being designed. Normally, this would be the point of a change in quantity of flow, such as an inlet, or a change in grade.
Column 2	Downstream station of the section of conduit being designed.
Column 3	Distance in feet between the upstream and downstream stations.
Column 4	Drainage sub-area designation from which flow enters the conduit at the upstream station.
Column 5	Area in acres of the drainage sub-area entering the conduit.
Column 6	Runoff coefficient, obtained from TABLE 1, based on the characteristics of the subdrainage area.
Column 7	Column 5 multiplied by Column 6.
Column 8	Obtained by adding the value shown in Column 7 to the value shown immediately above in Column 8.
Column 9	This time in minutes is transposed from Column 19 on the previous line of calculations. The original time shall be equal to the time of concentration as shown on TABLE 1 or FIGURE 2, whichever value has been used.
Column 10	Design Storm Frequency.
Column 11	Using the time at the upstream station shown in Column 9 and the Design Storm Frequency shown in Column 10, this value is taken from FIGURE 1.
Column 12	Column 8 multiplied by Column 11.
Column 13	Roughness coefficient for Manning's formula from TABLE 5.

Column 14 Designed pipe slopes with minimum values selected from TABLE 3.

Column 15 Pipe diameter required based on values from Column 12, 13 & 14.

Column 16 Utilizing the values in Columns 12 and 17, a conduit size should be selected. In the case of concrete pipe, FIGURE 23 may be used.

Column 17 This slope should be computed from the profile of the ground surface. Normally, the hydraulic gradient will have a slope approximately the same as the proposed conduit and will be located above the inside crown of the conduit.

Column 18 Calculated using the values in Columns 13, 14 and 16.

Column 19 Velocity in the selected conduit based on the values in Columns 12, 16 and 17. Taken from FIGURE 23 for concrete pipe.

Column 20 Calculated using value from Column 19.

Column 21 Calculated using Column 3 and Column 17.

Column 22 Head loss coefficient is selected from Table 6.

Column 23 Calculation is made utilizing appropriate equations from section 2.26.

Column 24 Calculation is based on the values of Columns 3 and 19.

Column 25 Sum of Columns 9 and 24.

Column 26 Special design comments may be entered here.

FORM "C"
STORM SEWER CALCULATIONS

Runoff Collection Point (Inlet or Manhole)			Incremental Drainage Area																						
Upstream Station	Downstream Station	Distance Between Collection Points "L"	Area No.	Drainage Area "A" (Acres)	Runoff Coefficient "C"	Incremental "CA"	Accumulated "CA"	Time at Upstream Station (minutes)	Design Storm Frequency (yrs.)	Intensity "I" (inches/hr.)	Storm Water Runoff "Q" (c.f.s.)	Roughness Coefficient "n"	Design Slope (ft/ft)	Computed Storm Size Diameter (inch)	Selected Storm Sewer Size (inch)	Hydraulic Gradient Slope "S" (ft/ft)	Storm Pipe Capacity "Qcap" (c.f.s.)	Velocity In Sewer Between Collection Points "V" (f.p.s.)	Velocity Head = $V^2/2g$	Friction Head Loss L*S	Head Loss Coefficient Kj	Velocity Head Loss of Upstream Station (feet)	Flow Time in Sewer = L/(V*60) (minutes)	Time of Downstream Station (minutes)	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

WATER SURFACE PROFILE CALCULATIONS - FORM "D"

Column 1	At each point where a water surface elevation is desired, a cross section must be obtained. The sections are numbered and subdivided according to the assigned roughness coefficient.
Column 2	Known or assumed water surface elevation at the particular section.
Column 3	Distance along the channel between sections.
Column 4	Area of sub-section calculated from plotted cross sections.
Column 5	Wetted perimeter of each sub-section exclusive of the water interfaces between adjacent sub-sections.
Column 6	Column 4 divided by Column 5. (Hydraulic Radius)
Column 7	Column 6 raised to 2/3 power.
Column 8	Roughness coefficient for Manning's formula from TABLE 7.
Column 9	Column 4 multiplied by 1.486 and the product divided by Column 8.
Column 10	Column 9 multiplied by Column 7.
Column 11	The total flow shown in the upper left of the calculation form divided by Column 10 and squared, which is the friction slope.
Column 12	Average friction slope between sections.
Column 13	Column 12 multiplied by Column 3.
Column 14	Flow in each individual sub-section. Varies directly with the conveyance factor shown in Column 10. The sum of the values must equal the total flow.

Column 15 Column 14 divided by Column 4.

Column 16 Column 15 squared.

Column 17 Column 16 multiplied by Column 14.

Column 18 Sum of the values in Column 17 of a particular section divided by twice the acceleration of gravity and multiplied by the total flow.

Column 19 Algebraic difference in velocity heads between sections.

Column 20 Eddy losses are calculated as 10 percent of the value of Column 19 when such value is positive and 50 percent of the absolute value of Column 19 when such value is negative.

Column 21 Sum of Column 13, Column 19 and Column 20.

Column 22 The sum of the value shown in Column 2 for the previous section and the value in Column 21. If the elevations calculated for subsequent sections do not agree within a reasonable limit with the assumed elevations shown in Column 2 for that particular section, then the assumed elevations for such section must be revised and the section properties recomputed until the desired accuracy is obtained. An accuracy of +0.3 feet is considered a reasonable limit.

FORM "D"

WATER SURFACE PROFILE CALCULATIONS

Section and Subsection	Known or assumed W.S. Elevation	Distance Between Sections "L" (feet)	Subsection Area "A_s" (sq/ft)	Subsection Wetted Perimeter "WP" (feet)	Subsection Hydraulic Radius "R" = A/(WP)	$R^{2/3}$	Subsection Roughness Coefficient	(1.486*A)/n	Conveyance Factor "Y" = ((1.486*A)/n)*$R^{2/3}$	Friction Slope "S_f" = $(Q_T/Y)^2$ (ft/ft)	Avg. S_f Between Sections (ft/ft)	Friction Head Loss Between Sections "h_f" = Avg. S_f L (feet)	Subsection Flow "Q_s" (c.f.s.)	Subsection Velocity "V_s" = Q_s/A_s (f.p.s.)	V_s^2	$V_s^2*Q_s$	Weighted Velocity Head "h_v" = $(\Sigma V_s^2*Q_s)/(2*g*Q_T)$ (feet)	Velocity Head Loss "$h_v\Delta$" = $h_{v1}-h_{v2}$ (feet)	Eddy Losses "E_l" = .10*(+$h_v\Delta$) or .5*(-$h_v\Delta$) (feet)	Total Loss "ΔH" = h_f+($h_v\Delta$)+E_l (feet)	WATER SURFACE ELEVATION
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

OPEN CHANNEL CALCULATIONS - FORM "E"

Column 1	Downstream limit of the section of channel under consideration.
Column 2	Upstream limit of the section of channel under consideration.
Column 3	Type of channel as shown in FIGURE 24 is entered here.
Column 4	Flow in the section of channel under consideration.
Column 5	Roughness coefficient of the channel cross-section taken from TABLE 7.
Column 6	Slope of the channel that is most often parallel to slope of the hydraulic gradient.
Column 7	Square root of Column 6.
Column 8	Calculation is made using the values in Columns 4, 5 and 7.
Column 9	Assumed width of the bottom width of the channel.
Column 10	Assumed depth of flow.
Column 11	Assumed slope of the sides of the channel.
Column 12	Areas of flow that are calculated based on Columns 9, 10 and 11.
Column 13	Wetted perimeter calculated from Columns 9, 10 and 11.
Column 14	Value is calculated from Columns 12 and 13.
Column 15	Column 14 raised to 2/3 power.
Column 16	Product of Column 13 times Column 15.

When the value of Column 16 equals the value of Column 8 the channel has been adequately sized. When the value of Column 16 exceeds the value of Column 8 by more than five percent then the channel width or depth should be decreased and another trial section analyzed.

Column 17 Calculation is based on the values of Columns 4 and 12.

Column 18 Calculation is based on Column 17.

Column 19 Remarks concerning the channel section analyzed may be entered.

NOTE: Form "E" should be used only to size open channels. Form "D" should be used to calculate stream profile.

FORM "E"
OPEN CHANNEL CALCULATIONS

CHANNEL STATION		Channel Type	Flow "Q" (c.f.s.)	Roughness Coefficient "n"	Slope "S" (ft./ft.)	"$S^{1/2}$"	$(Q*n)/(1.486*S^{1/2})$	Width "b" (feet)	Depth "d" (feet)	Side Slope	Area "A" (sq. ft.)	Wetted Perimeter "WP" (feet)	Hydraulic Radius "R" = A/WP (feet)	$R^{2/3}$	$A*R^{2/3}$	Velocity V = Q/A (f.p.s.)	Velocity Head $V^2/(2*g)$	REMARKS
From	To																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

HYDRAULIC DESIGN OF CULVERTS, FORM "F"

Columns 1 through 10 deal with selection of trial culvert size and are explained as follows:

Column 1 Total design discharge, Q, passing through the culvert divided by the allowable maximum velocity gives trial total area of culvert opening.

Column 2 Culvert width should be reasonably close to the channel bottom width, W, downstream of the culvert.

Column 3 Lower range for choosing culvert depth is trial area of culvert opening, Column 1, divided by channel width, Column 2.

Column 4 Allowable headwater obtained from FORM F_b.

Column 5 Trial depth, D, of culvert corresponding to available standard sizes and between the numerical values of Columns 10 and 12.

Columns 6, 7 and 8 are solved simultaneously based on providing a total area equivalent to the trial area of opening in Column 1.

Column 6 Number of culvert openings.

Column 7 Inside width of one opening.

Column 8 Inside depth of one opening if culvert is box structure or diameter if culvert is pipe.

Column 9 Column 6 multiplied by Column 7 and Column 8.

Column 10 Total discharge divided by number of openings shown in Column 6.

Columns 11 through 15 (Inlet Control) and 16 through 27 (Outlet Control) deal with Headwater Calculations which verify hydraulics of trial culvert selected and are explained as follows:

Column 11 Obtained from FORM F_b.

Column 12 When the allowable headwater is equal to or less than the value in Column 8, enter Case I. When the allowable headwater is more than the value in Column 8, enter Case II.

Column 13 Column 10 divided by Column 7.

Column 14 Obtained from FIGURE 25 for box culverts or FIGURE 26 for pipe culverts.

Column 15 Column 14 multiplied by Column 8.

Column 16 Obtained from FORM Fb.

Column 17 Obtained from FIGURE 27 for box culverts and FIGURE 28 for pipe culverts.

Column 18 Tailwater depth obtained from FORM F_b.

Column 19 S_o, culvert slope, multiplied by culvert length, L, both obtained from FORM F_b.

Column 20 Sum of Columns 17 and 18 minus Column 19.

Column 21 Obtained from FIGURE 27 for box culverts and FIGURE 28 for pipe culverts.

Column 22 Critical depth obtained from FIGURE 29 for box culverts and FIGURE 30 for pipe culverts.

Column 23 Sum of Columns 22 and 8 divided by two.

Column 24 Tailwater depth obtained from FORM F_b.

Column 25 Enter the larger of the two values shown in Column 23 or Column 24.

Column 26 Previously calculated in Column 19 and may be transposed.

Column 27 The sum of Columns 21 and 25 minus Column 26.

Column 28 Enter the larger of the values from Column 15, Column 20 or Column 27. This determines the controlling hydraulic conditions of the particular size culvert investigated.

Column 29 When the Engineer is satisfied with the hydraulic investigations of various culverts and has determined which would be the most economical selection, the description should be entered.

SUPPLEMENTAL FORM "F_a"

USED TO DETERMINE VALUES IN FORM "F_b"

Culvert Location:	This is a word description of the physical location.
Length:	The actual length of the culvert.
Total Discharge, QT:	This is the flow computed on FORM "A".
Design Storm Frequency:	Obtained from TABLE 1 and used on FORM "A".
Roughness Coefficient, n:	Obtained from TABLE 5.
Maximum Velocity:	Obtained from TABLE 4.
Tailwater:	This is the design depth of water in the downstream channel and is obtained in connection with the channel design performed on FORM "D" or FORM "E".
D. S. Channel Width:	This is the bottom width of the downstream channel obtained from the calculations on FORM "E". The culvert should be sized to approximate this width whenever possible.
Entrance Description:	This is a listing of the actual condition as shown in the "Culvert Entrance Data" shown on the calculation sheet.
Roadway Elevation:	The elevation of the top of curb at the upstream end of culvert.
U. S. Culvert F. L.	The flow line of the culvert at the upstream end.
Difference:	The difference in elevations of the roadway and the upstream flow line.
Required Freeboard:	The vertical distance required for safety between the upstream design water surface and the roadway elevation or such other requirements that may occur because of particular physical conditions.
Allowable Headwater:	This is obtained by subtracting the freeboard from the difference shown immediately above.
D.S. Culvert F.L.	The flow line elevation of the downstream end of the culvert.
Culvert Slope, So:	This is the physical slope of the structure calculated as indicated.

FORM "Fb"
CULVERT DESIGN CALCULATIONS

CULVERT ENTRANCE DATA

CONCRETE BOX CULVERT (Wingwall Flare Angle; Entrance Edge)

Type	Flare Angle	Edge	K_e
1A	30° to 75°	Square	0.4
1B	30° to 75°	Round	0.3
2A	15° to 30° & 75° to 90°	Square	0.5
2B	15° to 30° & 75° to 90°	Round	0.3
3A	0° (Extension to Sides	Square	0.7
3B	0° (Extension of Sides)	Round	0.5

CONCRETE PIPE

Type	Entrance Description	K_e
4	Spigot End With Headwall	0.5
5	Bell End with Headwall	0.2
6A	Bell End Projecting With No Headwall	0.3
6B	Spigot End Projecting With No Headwall	0.6

Culvert Location:

______________ Length, L

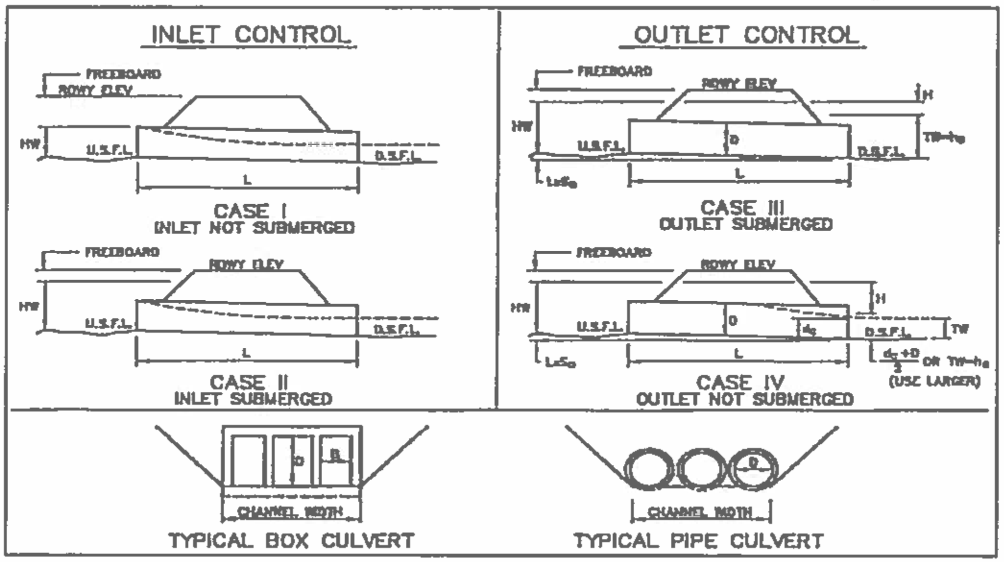
Total Discharge, Q______________ Design Storm Freq. ______________

Roughness Coeff., n______________ Max. Vel. ______________

Tailwater:______________ D.S. Channel Width: ______________

Entrance Description: ______________

Rdwy. Elev.	U.S. Culv. F.L.
U.S. Culv. F.L. ______	D.S. Culv. F.L.
Difference: ______	Difference:
Reqd. Freeboard: ______ Ft.	Culv. Slope, S_o = Diff. Ft. / Length Ft.
Allow. Headwater: ______ Ft.	S_o =



FORM "F"
CULVERT DESIGN CALCULATIONS

TRIAL CULVERT										HEADWATER CALCULATION																	Greater Controlling Headwater	SELECTED CONDUIT SIZE
		Depth Range D.R.			Possible Culvert Sizes					Inlet Control (See Figures 25 & 26					Outlet Control (See Figures 27, 28, 29 & 30													
																Case III: HW = H+TW-L*S, (feet)				Case IV: HW = H+h,-L*S, (feet)								
																					h_o = (d, D)/2 or h_o = TW (use larger)							
Trial Area of Opening T-A = Q/V (sq. ft.)	Channel Width "W" (feet)	(T-A)/W	Allowable Headwater (feet)	Trial Depth "D" (feet)	Number of Culvert Openings	Culvert Width "B" (feet)	Culvert Depth "D" (feet)	Culvert Area "A" (sq. ft.)	Q for Each Opening	Entrance Type	Inlet Control Case	Q/B	HW/D	HW	Entrance Coefficient K_e	"H" (feet)	"TW" (feet)	L*S, (feet)	"HW" (feet)	"H" (feet)	d (feet)	(d+D)/2 (feet)	TW (feet)	h_o (feet)	L*S, (feet)	"HW" (feet)		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

BRIDGE DESIGN CALCULATIONS - FORM "G"

Column 1	Obtained from FORM A.
Column 2	Obtained from FORM A.
Column 3	Depth of flow in downstream channel.
Column 4	Assume an average velocity that is less than the maximum allowable velocity and more than 4 feet per second. Maximum velocities are equal to those specified for open channels.
Column 5	Total flow thru bridge divided by Column 4.
Column 6	Column 5 divided by Column 3.
Column 7	Selected bridge length utilizing standard span lengths.
Column 8	Calculated from bridge and channel geometrics.
Column 9	Total flow through bridge divided by Column 8.
Column 10	Selected head loss coefficient based upon specific conditions.
Column 11	Calculated utilizing values in Columns 8 and 9

FORM "G"
BRIDGE DESIGN CALCULATIONS

Design Flow (c.f.s.)	Velocity in Downstream Channel "V_c" (f.p.s.)	Depth of Flow in Downstream Channel "D_c" (feet)	Trial Velocity through Bridge "V_T" (f.p.s.)	Trial Opening Area "A_T" = Q/V_T (sq. ft.)	Trial Length of Opening "L_T" = A_T/D_c	Actual Length of Opening "L" (feet)	**Actual Area of Opening Below Highwater "A" (sq. ft.)**	Actual Velocity through Bridge "V" = Q/A (f.p.s.)	Head Loss Coefficient "K_b"	"h_1" = $(K_b*V^2/(2*g))$
1	2	3	4	5	6	7	8	9	10	11

CITY OF FARMERSVILLE

Farmersville

MANUAL

FOR THE DESIGN OF

WATER AND SANITARY SEWER LINES

Adopted________________

By Ordinance #________________

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TABLE OF CONTENTS

I – GENERAL

This manual is intended to aid and assist private engineers in the layout and design of sanitary sewers and water lines to definite standards and to obtain uniformity in the plans. It is recognized that each addition has its individual challenges and that no fixed rules will apply to all cases; therefore, final acceptance of all or any part of any plan's rests with the City Engineer or authorized representative of the City of Farmersville.

A. Submittal: On completion of the plan and preliminary engineering of a subdivision, it will be to your advantage to bring or send two copies along with a contour map and preliminary water and sewer layout to the City, whereby a check can be made as to the general layout and availability of water and sewer. If problems arise as to the availability of water and sewer, it may be necessary to have a meeting with the developer and discuss the problems.

B. Preliminary Check: When the engineering plans are complete, submit three sets of legible prints. Every attempt will be made to review plans within three weeks.

C. Final Check: When the plans are returned to you after preliminary check, the final plans must be submitted with the marked-up set. Three sets of legible prints will need to be submitted.

D. Final Approval of Plans: Before you request approval of the plans, check the following:

1) The plans must be complete and correct.

2) The approved plat must have been submitted.

3) The street grades and storm sewer plans must have been submitted and approved.

4) The plans must be signed and sealed by a Professional Engineer licensed in the State of Texas, who is responsible for the design.

5) All fees and other monies due must be paid in full.

6) Contractor's insurance must be in correct form.

7) Three sets of complete engineering plans are required for City use. There should be additional approved plans available for Contractors and Engineering Consultants use during construction of the improvements. The City Representative will only recognize those plans with the "approved" stamp.

8) Upon completion of construction and prior to acceptance of that construction by the City, one set of mylars and one set of prints of the record drawings must be submitted to the City.

E. All work and materials shall be in accordance with the latest editions of the City of Farmersville Design Manuals, Ordinances, Standard Construction Details, Standard Specifications, and the North Central Texas Council of Governments (NCTCOG) Public Works Construction Standards. Should a conflict be found between the two publications, the City of Farmersville Design Manuals, Ordinances and Standards shall take precedence.

In the event that an item is not covered by the City of Farmersville Design Manuals, Ordinances, or Standards; the NCTCOG Public Works Construction Standards shall apply. Notification in writing by the contractor shall be made to the engineer of record, City inspector and the City of the issue. The City of Farmersville shall make the final decision regarding all construction materials, methods, and procedures specified in construction plans. Reference to all documents contained in the project specifications shall refer to the latest edition of each document or the version adopted by the City Council.

F. Special Provisions are City of Farmersville Special Provisions to the Specifications.

G. Inspection of construction activities shall be conducted by staff of the City of Farmersville under direction of the city Engineer or authorized representative. The City inspector shall observe and check the construction in sufficient detail to satisfy himself that the work is proceeding in general conformance with the standards and specifications for the project, but he will not be a guarantor of the Contractor's performance. The City will not accept any development until City staff has approved all construction. The developer shall be responsible for any additional expense to the City for inspection that is necessary after normal business hours, or when the improvements will be privately owned. The City will establish the rate for compensation and other expenses.

The developer will be responsible for furnishing the original reproducible engineering drawings corrected to show any revised construction conditions to the City before any improvements will be accepted. All public works improvements must be accepted by the City before any City Building permits will be issued.

II - WATER MAINS

In general, water mains are placed on the north and west sides of a street, as shown in the Standard Construction Details, or otherwise as directed by the City Engineer. Where applicable, line sizes will comply with the Water Distribution System Master Plan and shall be adequate to convey a fire flow. Fire flow analysis will be required on lines that are questioned by City staff. Starting pressures shall be obtained from the nearest junction node as stated in the City's Water Distribution Master Plan computer printouts or shall be provided by the City.

A. Minimum 8-inch pipe required in residential areas.

B. Minimum 12-inch pipe required on commercial, retail and industrial areas.

C. The length of live water dead-end mains shall not exceed 150 feet. A 2-inch blow-off valve will be required at the end of the main.

D. No water main shall be located closer than 5-feet from any tree or structure.

E. Crosses shall not be used without permission from the City Engineer or authorized representative.

F. Water Main Specifications:

1) City mains shall have a minimum diameter of 8-inches, unless a larger line size is required by the Comprehensive Plan, Water Master Plan or to meet fire protection needs as determined by analysis. All water lines shall meet the requirements of AWWA and NCTCOG under the following specifications:

Line Size	NCTCOG Item	AWWA Standard	Description
8" thru 12"	2.12.20	C900 DR18	PVC
Greater than 12" Pipe	2.12.5	C301 & C303	Reinforced Concrete Cylinder Pipe
	2.12.20	C905 DR18	PVC
	2.12.8	C151 Class 50	Ductile Iron Pipe

2) All mains supplying fire sprinkler systems outside of utility easements shall be minimum 200-PSI working pressure and U.L. listed.

3) All water pipe shall be designed for a working pressure of 150-PSI unless otherwise directed by the City Engineer or authorized representative.

G. Valves 12-inches and under shall be placed on or near street property lines not over 800 feet apart in residential, duplex and apartment districts and not over 500 feet apart in all other districts: and in such a manner as to require preferably two, but not more than three valves to shut down each City block, or as may be required to prevent shutting off more than one fire hydrant. On cross-feed mains without services, a maximum of four valves shall be used to shut down each block. Also, valves shall be placed at or near the ends of mains in such manner that a shutdown can be made for a future main extension without causing loss of service on the existing main. Main line valves shall be placed at all fire hydrant leads. The location of valves larger than 12-inches will be as approved by the City Engineer or authorized representative. Valves 12-inches and under will be Gate Valves meeting requirements of AWWA C500 or AWWA C509 (NCTCOG Item 2.13.1) with non-rising stems. Valves over 12-inches will be Butterfly Valves meeting requirements of AWWA C504 (NCTCOG Item 2.13.4). All valves over 14-inches shall be provided with a valve vault over the valve operator assembly to provide ease of access for routine maintenance.

H. Fire Hydrants

A sufficient number of fire hydrants shall be installed to provide hose stream protection for every point on the exterior wall of the building with the lengths of hose normally attached to the hydrants. There shall be sufficient hydrants to concentrate the required fire flow, as recommended by the publication "GUIDE FOR DETERMINATION OF REQUIRED FIRE FLOW" published by the Insurance Service Office, around any building with no hose line exceeding the distances hereinafter established and with an adequate flow available from the water system to meet this required flow. In addition, the following guidelines shall be met or exceeded:

1) SINGLE FAMILY AND DUPLEX RESIDENTIAL - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between intersections at a maximum spacing of 500 feet between fire hydrants as measured along the route that fire hose is laid by a fire vehicle.

2) MULTIFAMILY RESIDENTIAL - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between intersections at a maximum spacing of 400 feet as measured along the length of the centerline of the roadway, and the front of any structure at grade shall be no further than 500 feet from a minimum of two fire hydrants as measured along the route that a fire hose is laid by a fire vehicle.

3) OTHER DISTRICTS - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between intersections at a maximum spacing of 300 feet as measured along the length of the centerline of the roadway, and the front of any building at grade shall be no farther than 300 feet from a minimum of two fire hydrants as measured along the route that the fire hose is laid by a fire vehicle.

4) PROTECTED PROPERTIES - Fire hydrants required to provide a supplemental water supply for automatic fire protection systems shall be within 100 feet of the Fire Department connection for such system.

5) BUILDINGS FIRE SPRINKLED - An 8-inch fire line stub-out with valve shall be provided for all buildings to be sprinkled. A smaller stub-out can only be used with Fire Department approval.

6) Fire hydrants shall be installed along all fire lane areas as follows:

a. <u>Non-Residential Property or Use</u>

- Within 150 feet of the main entrance.
- Within 100 feet of any Fire Department connection.
- At a maximum intermediate spacing of 300 feet as measured along the length of the fire lane.

b. <u>Apartment. Townhouse' or Cluster Residential Property or Use</u>

- Within 100 feet of any Fire Department connection.
- At maximum intermediate spacing of 400 feet as measured along the length of the fire lane.

7) Generally, no fire hydrant shall be located closer than 50-feet to a non-residential building or structure unless approved by the Engineering and Fire Departments.

8) In instances where access between the fire hydrant and the building that it is intended to serve may be blocked, extra fire hydrants shall be provided to improve the fire protection. Railroads, divided thoroughfares, expressways and blocks that are subject to buildings restricting movement, and other man-made or natural obstacles are considered as barriers.

I. Fire Hydrant Restrictions

1) All required fire hydrants shall be of the national standard 3-way breakaway type no less than 5¼-inches in size and shall conform to the provisions of the latest AWWA Standard C502 and shall be placed upon water mains of no less than 8-inches in size. Fire hydrants shall have a bury depth of five feet.

2) Valves shall be placed on all fire hydrants leads. Valves shall be flanged by mechanical joint.

3) Required fire hydrants shall be installed so the breakaway point will be no less than 2-inches, and no greater than 6-inches above the grade surface.

4) Fire hydrants shall be located a minimum of 2-feet and a maximum of 6-feet behind the curb line, based on the location of the sidewalk. The fire hydrant shall not be in the sidewalk.

5) All required fire hydrants placed on private property shall be adequately protected by either curb stops or concrete posts or other methods as approved by the City Engineer and Fire Chief and shall be in easements. Maintenance of such stops or posts to be the responsibility of the landowner on which the said fire hydrant is placed.

6) All required fire hydrants shall be installed so that the steamer connection will face the fire lane or street, or as directed by the Fire Department.

7) Fire hydrants, when placed at intersections or access drives to parking lots, when practical, shall be placed so that no part of the fire truck will block the intersection or parking lot access when connections to the fire hydrant are made.

8) Fire hydrants, required by this article, and located on private property, shall be accessible to the Fire Department at all times.

9) Fire hydrants shall be located at street or fire lane intersections, when feasible.

10) A Blue Stimsonite, Fire-Lite reflector (or approved equal) shall be placed in the center of the drive lane on the side of the fire hydrants.

11) In non-residential developments an 8-inch lead will be required on all fire hydrants that are located more than 50-feet from the looped main.

J. Four-inch mains used for hydrant supply in existing construction shall be replaced with new construction and dead-ends shall be eliminated where practical. Six-inch lines shall be connected so that not more than one hydrant will be between intersecting lines and not more than two hydrants on an eight-inch main between intersecting lines.

K. The minimum cover to the top of the pipe must vary with the valve stem. In general, the minimum cover below the top of the street subgrade should be as follows: 6-inch and smaller, 3.5 feet; 8-inch, 4.0 feet: 12-inch, 4.5 feet to 5 feet; 16-inch, 5.0 feet to 5.5 feet. Lines larger than 16-inch shall have a minimum of 6 feet of cover, or sufficient cover to allow water and sewer and other utilities to go over the large main. Increase the cover as required for water lines to be constructed along county-type roads commonly built with a high crown about the surrounding property, to allow for future paving grade and storm sewer changes.

L. A service with a meter box is constructed from the main to a point just behind the curb line, usually in advance of paving. The location of the meter box is at or near the center of the front of the lot to be served. On multiple apartments and business properties, the Owner or Architect usually specifies the desired size and location. Minimum requirements for water service sizes are as follows:

1) One-inch copper services are required to serve all residential lots including townhouse lots and patio homes. Separate services shall be provided for each of the family units.

2) The size of apartment, condominium, or multi-family services will depend on the number of units served with a minimum of one meter per building.

3) Fittings shall include mega-lugs and shall be polywrapped.

M. A domestic service connection shall not be allowed on fire hydrant leads.

III – SANITARY SEWERS

A. Sizes and grades for sanitary sewer lines shall be based on serving the proposed development and all upstream areas in the drainage basin at full development. The minimum size for sanitary sewer mains shall be 8-inches. Design calculations for sizing lines shall be included in the plans, along with drainage area map. If feasible, sewers shall be placed in streets or as shown in the City Standard Construction Details. Sewers are usually located in the center of residential streets. Each addition has its challenges; therefore, no fixed rules will apply to all cases regarding the location of sanitary sewers.

B. Minimum cover shall be 3.5 feet; exceptions authorized by the City Engineer or authorized representative shall have concrete protection. In general, the minimum depth for sewer to serve given property with a 4-inch lateral shall be 3-feet plus 2% times the length of the house lateral (the distance from the sewer to the center of the house). Thus, for a house 135 feet from the sewer, the depth would be 3-feet plus 2% x 135 feet = 3.0 plus 2.7 = 5.7 feet. The depth of the flow line of the sewer should then be at least 5.7 feet below the elevation of the ground at the point where the service enters the house. Profiles of the ground line 20-feet past the building line will be required to verify that this criterion is met. On lines deeper than 12 feet, a parallel sewer line will be required when laterals are to be attached. This requirement should be discussed with the City Engineer.

C. Sewage flow shall be computed in accordance with Appendix "A", with the exceptions, as required by the City Engineer. Pipes should be placed on such a grade that the velocity when flowing full is not less than two feet or more than 6-feet per second. Minimum grades shall be as follows:

Size	Minimum Slope
8"	0.35%
10"	0.26%
12"	0.22%
15"	0.16%
18"	0.12%
21"	0.10%
24"	0.09%

D. All grades shall be shown to the nearest 0.01%. Grades shall be evenly divisible by 4, and if practical, they should be even, such as: 0.20%, 0.40%, 0.60%, and 1.00%, etc., in order to facilitate field computations. When the slope of a sewer changes, a manhole will be required. No vertical curves will be allowed. Horizontal curves (pulling pipe not joints) with a minimum 200-foot Radius to match change in street direction will be allowed as approved by the City Engineer, but will not be allowed across residential single family and duplex lots.

E. The sizes and locations of manholes, wyes, bends, tap connections, cleanouts, etc., shall be approved by the City Engineer. In general, manholes shall be placed at all four-way connections and three-way connections. The diameter of a manhole constructed over the center of a sewer should vary with the size of the sewer. For 6", 8", and 10" sewers, the manhole shall be 4.0-foot minimum diameter; for 12", 15", 18", 21", 24" and 27" - 5.0-foot minimum diameter; 30" and 36" - 6-foot minimum diameter. In Flood Plains, sealed manholes are to be used to prevent the entrance of storm water. Manholes in flood plains shall be vented as required by TCEQ. Manholes shall be placed on the ends of all lines. Drop manholes shall be required when the inflow elevation is more than 18-inches above the outflow elevation. Construct manholes at each end of lines that are installed by other than open cut and at each end of aerial crossing lines. Sewer mains and water mains shall be not less than nine feet apart as measured from outside to outside of pipe and shall meet all Texas Commission on Environmental Quality.

F. LATERALS: The sizes and locations of laterals shall be as approved by the City Engineer. In general, for single family dwellings, the lateral size shall be 4" minimum; for multiple units, apartments, local retail and commercial - 6" minimum; for manufacturing and industrial, the size should be 8" or larger as required. House laterals usually come out 10 feet downstream from the center of the lot and shall have a 10-foot lateral separation from the water service. Manholes will be required on 6-inch and larger laterals where they connect to the main line. Laterals will not be attached to sewer mains that are deeper than 12 feet. A minimum of one lateral per building shall be required. Also, a minimum of one lateral per residential lot shall be required. Duplexes shall have two laterals.

G. Railroad, State Highway and creek crossings, etc., shall be as approved by the City Engineer or authorized representative. The developer is responsible for obtaining permits from the Railroad Company and from the Texas Department of Transportation and for ensuring that construction meets all the permit requirements.

H. The developer's Engineer shall furnish all line and grade stakes for construction. All property lines and corners must be properly staked to insure correct alignment. Monuments must be set at the corners of the property as shown in the Standard Construction Details. The City will not be liable for improper alignment or delay of any kind caused by improper or inadequate surveys by the developer or by interference of other utilities.

I. In order to provide access for sewer lines for cleaning, manholes shall be so located that 250 feet of sewer rod can reach any point in the line. This means that manhole spacing shall be a maximum of 500 feet.

J. No sewer line shall be located nearer than five feet from any tree or structure.

K. No sanitary sewer in alleys unless approved by the City Engineer.

L. Sewer Lines Specifications:

1) All sewer lines shall be PVC and meet the requirement of ASTM and NCTCOG under the following specifications:

Pipe Diameter	NCTCOG Item	ASTM Standard
6" thru 15"	2.12.14	D3034/SDR 35 D3350/PE 345434C
15" thru 48"	2.12.13	F679 F794 F949 F1803 D3350/PE 345434C

2) Sewer pipe shall conform to the Specifications and/or Special Provisions.

M. Lift Stations (Shall be only as approved by the City Engineer or Authorized Representative). Refer to the City Standard Details for Lift Stations.

1) Lift station design shall be in full conformance to TCEQ Regulations, latest revision. Letter approval from the TCEQ must be provided at time of Preliminary Engineering plan submittal. Flows shall be as calculated by this manual.

2) The current rules can be obtained at:
www.tceq.texas.gov

IV - FORM OF PLANS

A. Plans shall be clear, legible, and neatly drawn on bordered sheets, full size shall be 22" x 34". Initial copies submitted for review and approval shall be provided at ½ the full size on 11" x 17" sheets. Each sheet shall clearly display the Texas Professional Engineer's seal of the Engineer under whose direction the plans were designed. A title block in the lower right-hand corner shall be filled in to include: (l) project name; (2) Engineer's name, address, and telephone number.

B. The plan sheet should be drawn so that the north arrow points to the top or to the right side of the sheet. It is important that the plan show sufficient surrounding streets, lots, and property lines so the existing water and sewer may be adequately shown and so that proper consideration may be given to future extensions. Proposed water and sewer lines shall be stubbed out to the addition extremities in order that future extensions may be made with a minimum of inconvenience. Unless it would make the plan very difficult to read, both water and sewer lines should be shown on the same sheet. The lines on the profile sheet shall be drawn in the same direction as on the plan. Lettering shall be oriented to be read upward or from left to right.

C. On large additions or layouts requiring the use of more than six sheets (total of plan & profile), key sheets may be required on a scale of 1" = 400' or 1" = 1000', as designated by the City Engineer. They shall show the overall layout with the specific project clearly indicated with reference to individual sheets.

D. The use of "off-standard" scales will not be permitted. A plan shall be drawn to scales of 1" = 20', or 1" = 40'. Plans for water and sewer that do not involve great detail should be drawn on a scale of 1" = 50'. Plans in and along creeks, heavily wooded sections, streets with numerous utilities, or as may be required to produce a clean and legible drawing, shall be drawn on plan-profile sheets or separate plan and profile sheets on a scale 1" = 40'. If the plan is in an extremely congested area, a scale of 1" = 20' may be necessary. All profiles shall be drawn on a vertical scale (1" = 4') as required for clarity, and the horizontal scale shall be the same as for the plan unless otherwise directed by the City Engineer.