TABLE 6

VELOCITY HEAD LOSS COEFFICIENTS FOR CLOSED CONDUITS

MANHOLE AT CHANGE IN PIPE DIRECTION		
Description	**Angle**	**Head Loss Coefficient Kj**
	90	1.00
	60	0.80
	45	0.65
Angle	30	0.50
BEND IN PIPES		
Description	**Angle**	**Head Loss Coefficient Kj**
	*90°	0.80
	*60°	0.60
	**45°	0.50
Angle	**30°	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	0.90
	0.84	0.80
	0.85	0.70
	0.86	0.60
	0.88	0.50
	0.90	0.40
	0.92	0.30

* Only as authorized by City Engineer.

** Horizontal curves are the accepted method of construction.

TABLE 7

ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

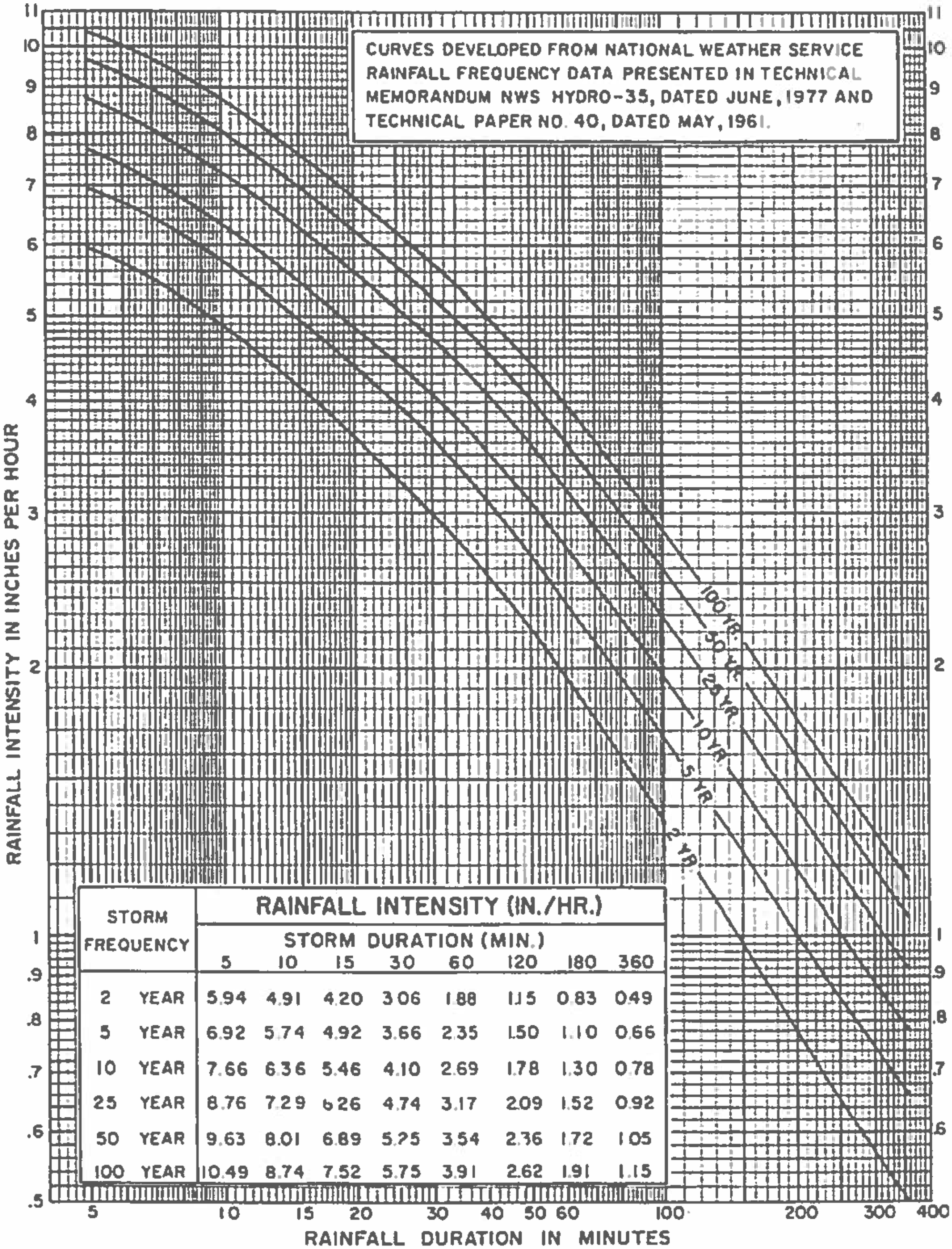
Channel Description	Roughness Coefficient			Maximum Velocity Ft/sec
	Minimum	Normal	Maximum	
MINOR NATURAL STREAMS – TYPE I CHANNEL				
Moderately Well Defined Channel				
• Grass and Weeds, Little Brush	0.025	0.030	0.033	8
• Dense Weeds, Little Brush	0.030	0.035	0.040	8
• Weeds, Light Brush on Banks	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

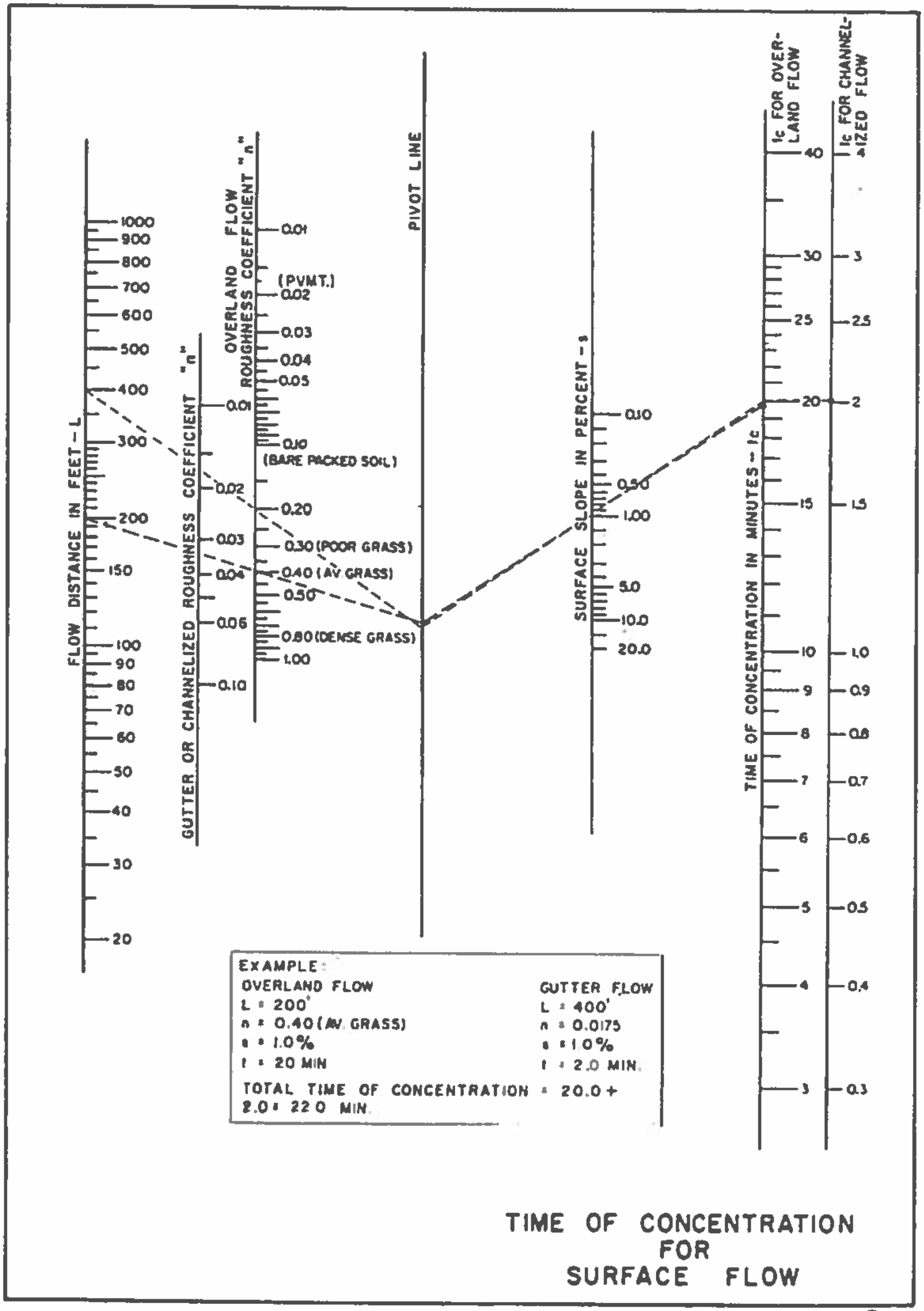
Culvert Discharges On	Maximum Allowable Velocity (f.p.s.)
Earth (Sandy)	6
Earth (Clay)	8
Sodded Earth	8
Rock Gabions (Engineered)	12
Concrete	15
Shale (Lime Stone)	10

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

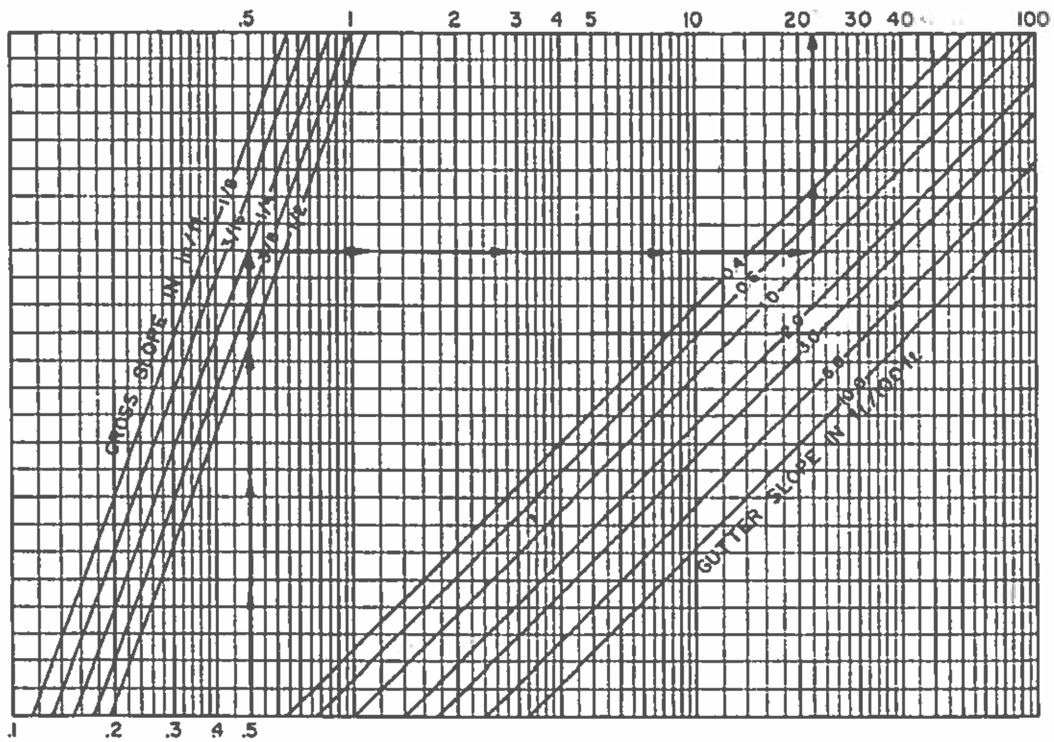
EXAMPLE

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.

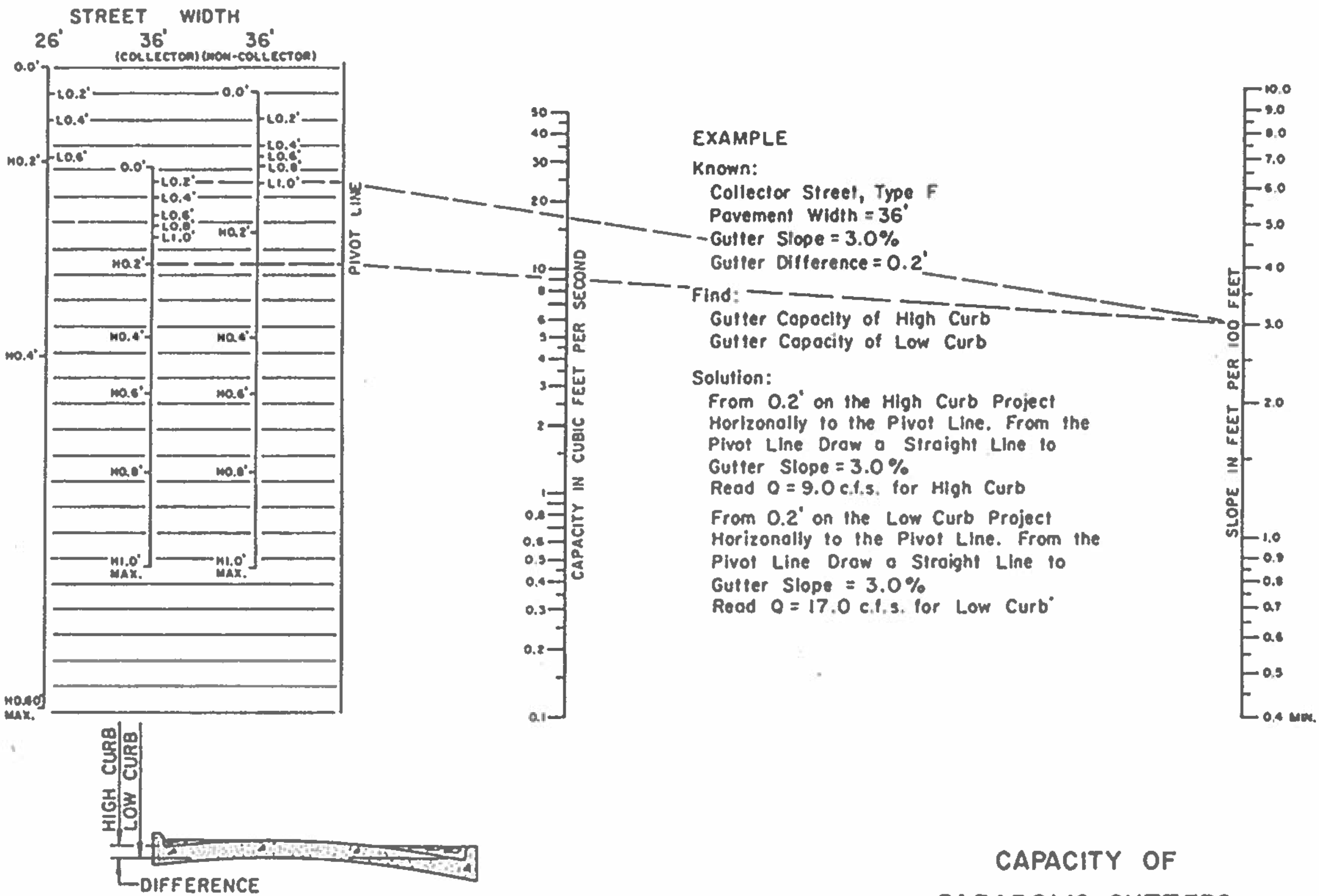
GUTTER CAPACITY IN C.F.S.



DEPTH OF GUTTER FLOW IN FEET

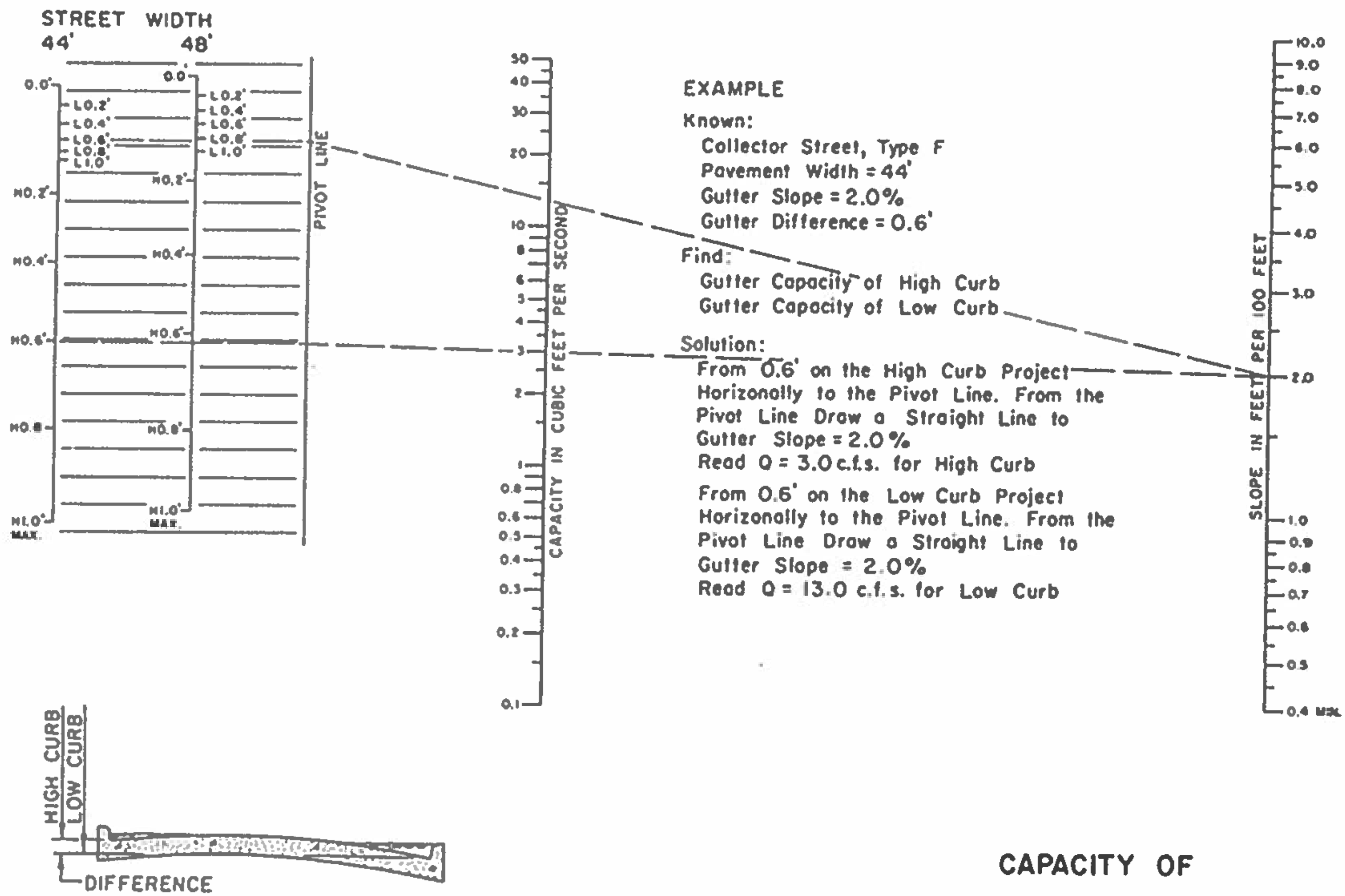
CAPACITY OF TRIANGULAR GUTTERS

FIGURE 3



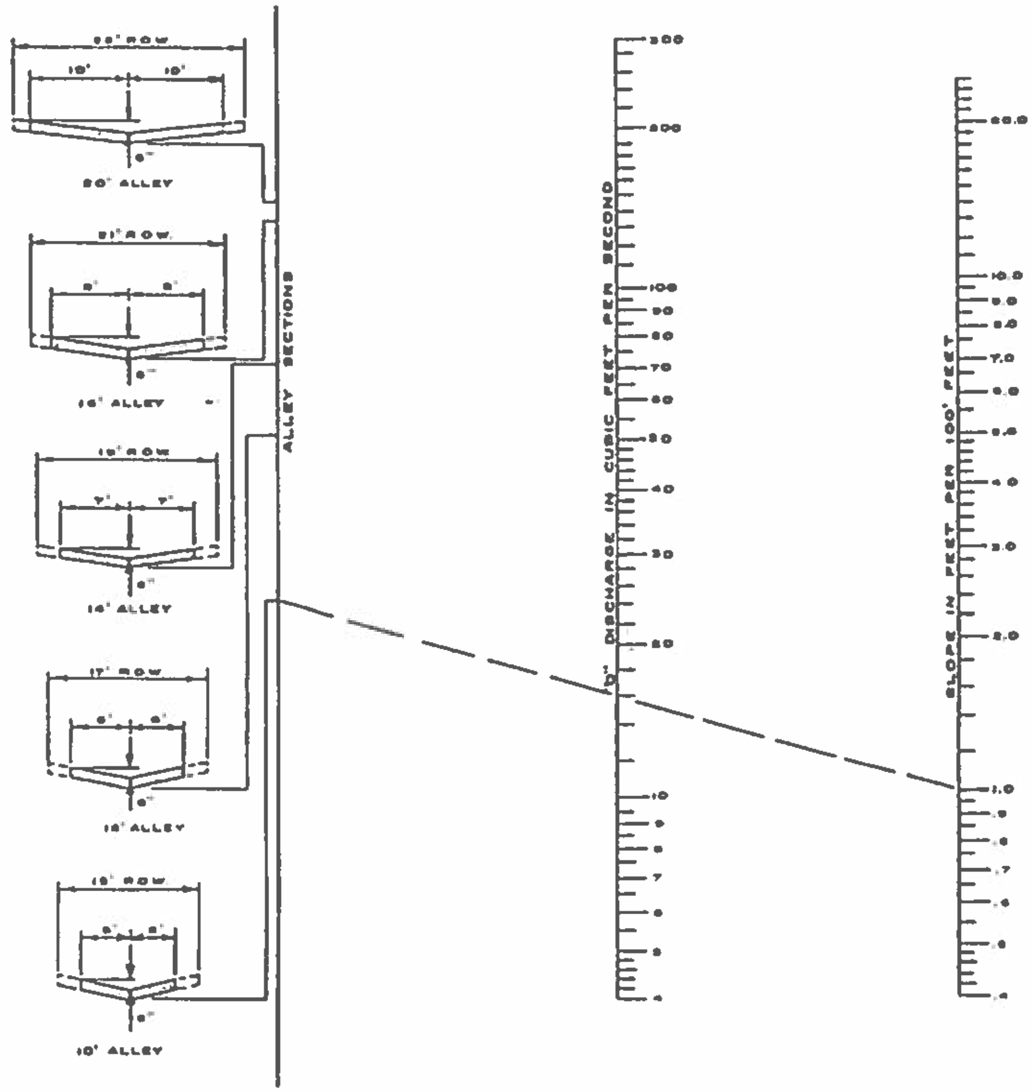
CAPACITY OF
PARABOLIC GUTTERS
(26' & 36' STREET WIDTHS)

FIGURE 4



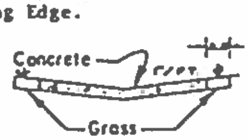
CAPACITY OF PARABOLIC GUTTERS (44' & 48' STREET WIDTHS)

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

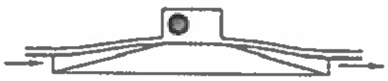
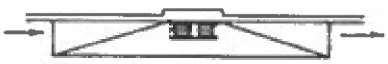
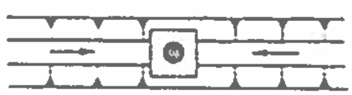
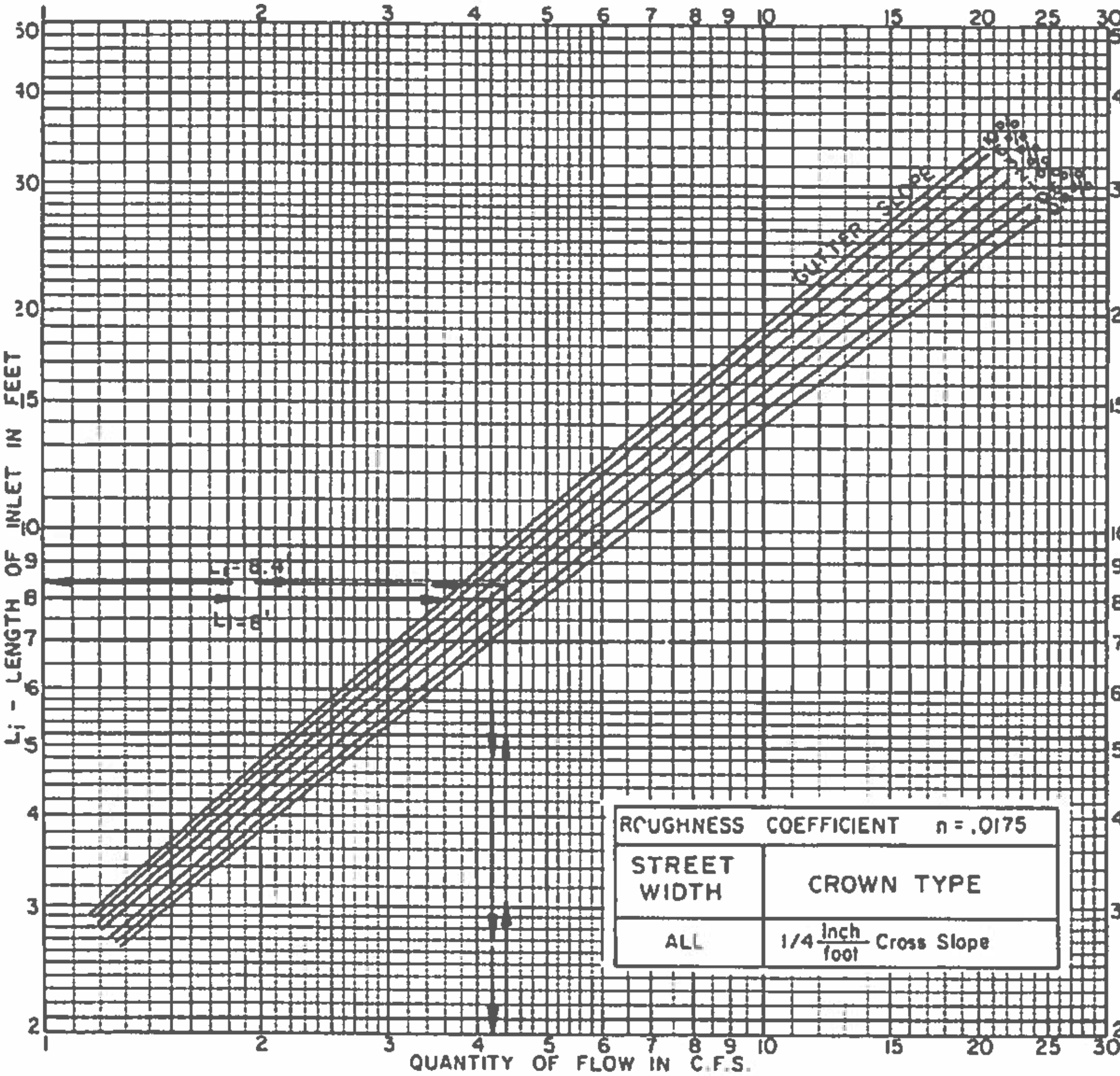
INLET TYPE	INLET DESCRIPTION	AVAIL. INLET SIZES	WHERE USED	DESIGN CURVES
I	 STANDARD CURB OPENING INLET ON GRADE	4' 6 8' 10' 12 14'	26' LOCAL STREET, TYPE H 36' COLLECTOR STREET, TYPE F ALLEY	FIGURES 8 THROUGH 12
IA	 STANDARD CURB OPENING INLET AT LOW POINT	4' 6' 8' 10' 12' 14'	26' LOCAL STREET, TYPE 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	2'x2' 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

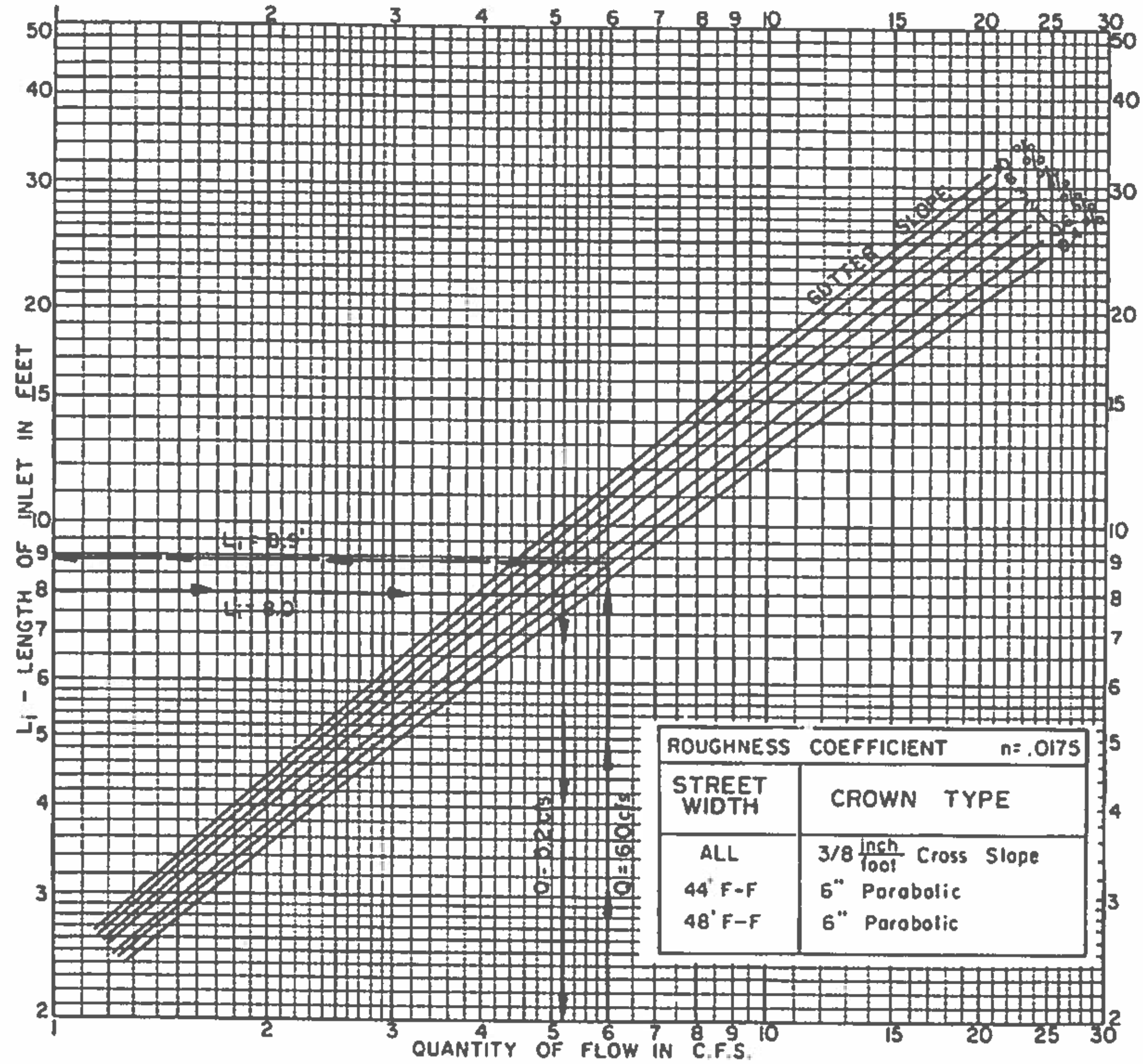
Find:
Length of Inlet Required (L_i)

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)

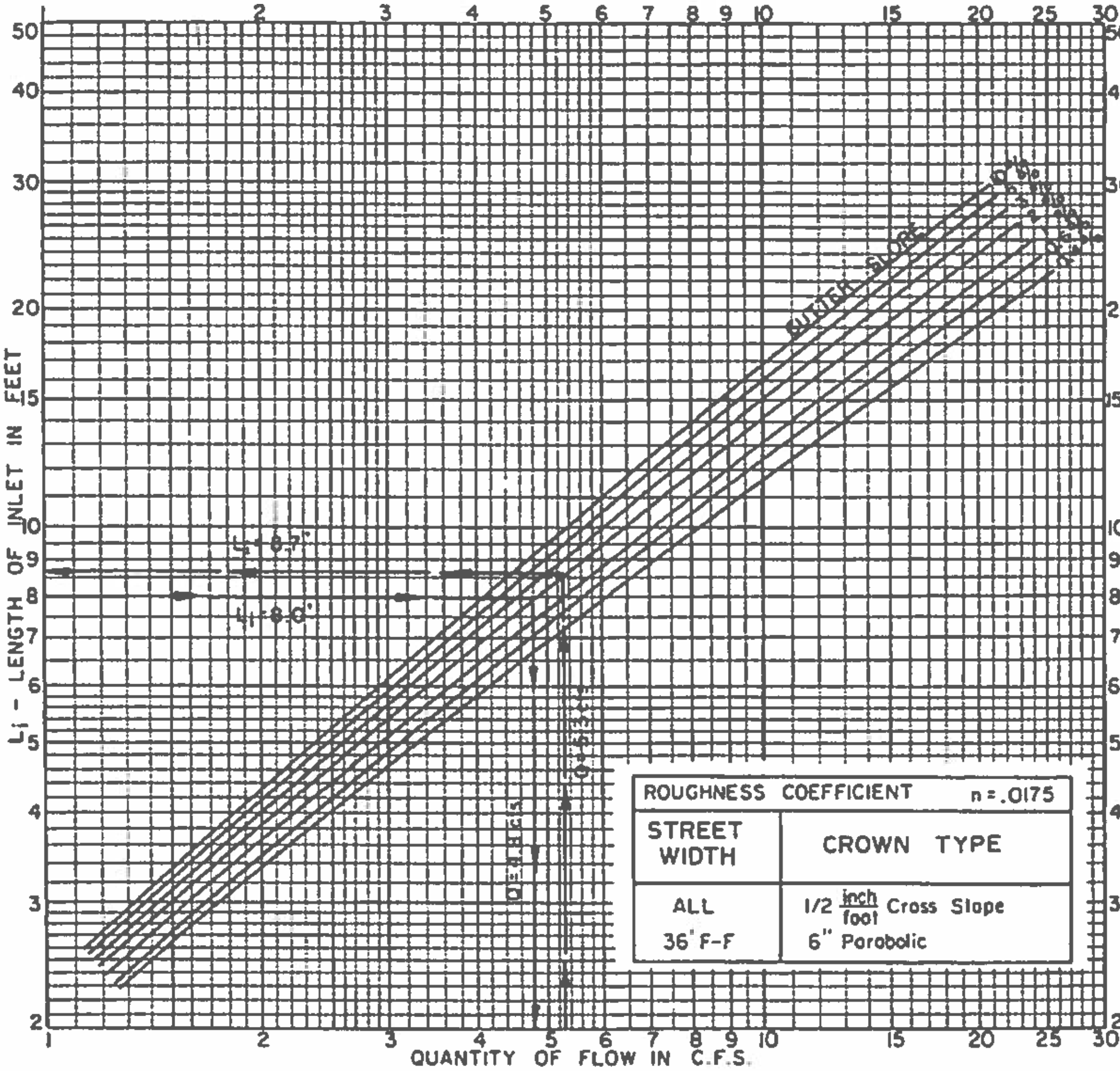
Solution:
- Enter Graph at 6.0 cfs
- Intersect Slope = 0.6 %
- Read L_i = 8.9'

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



EXAMPLE

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

Find:
- Length of Inlet Required (L_i)

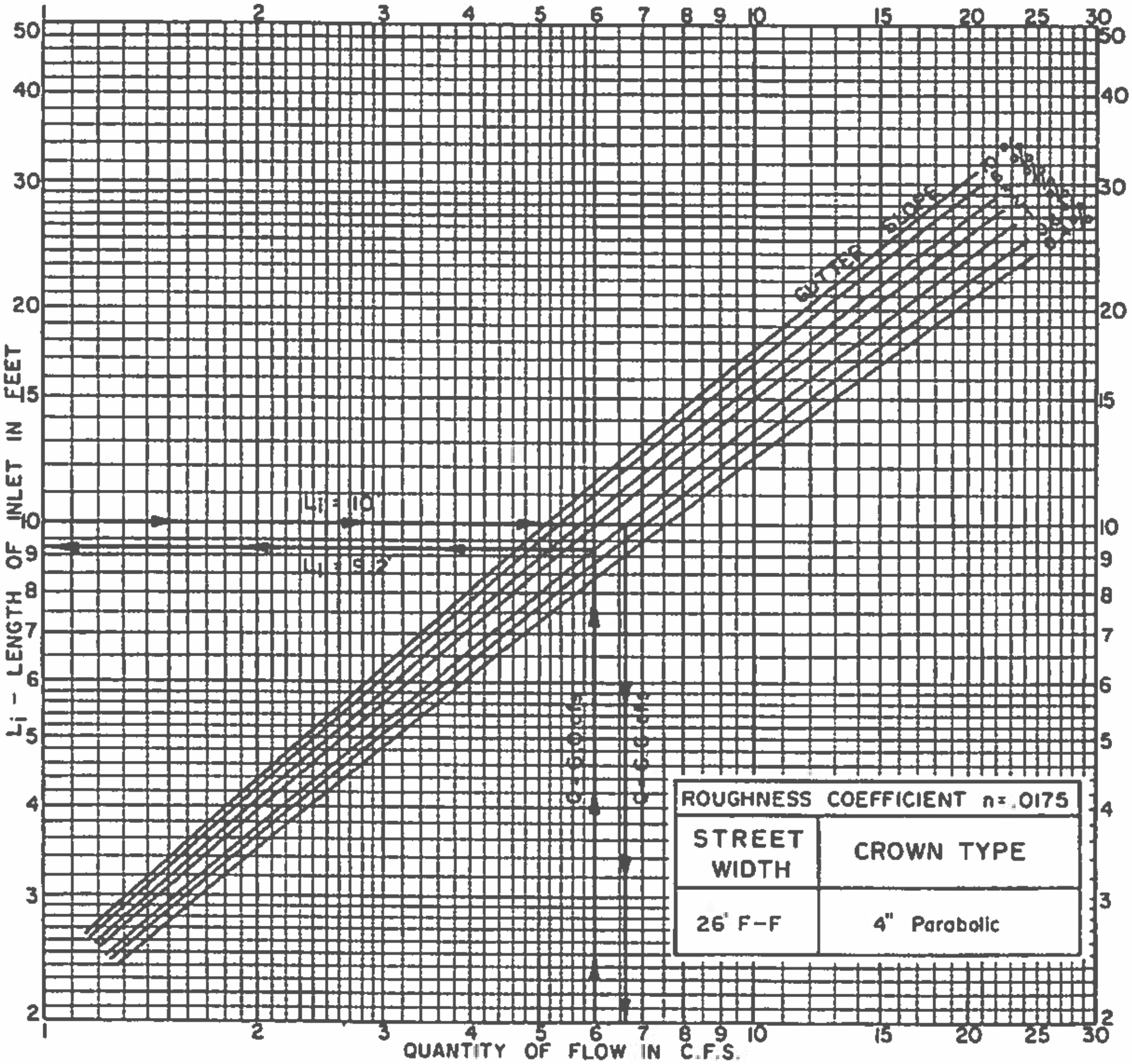
Solution:
- Enter Graph at 5.3 cfs
- Intersect Slope = 2%
- Read L_i = 8.7'

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)

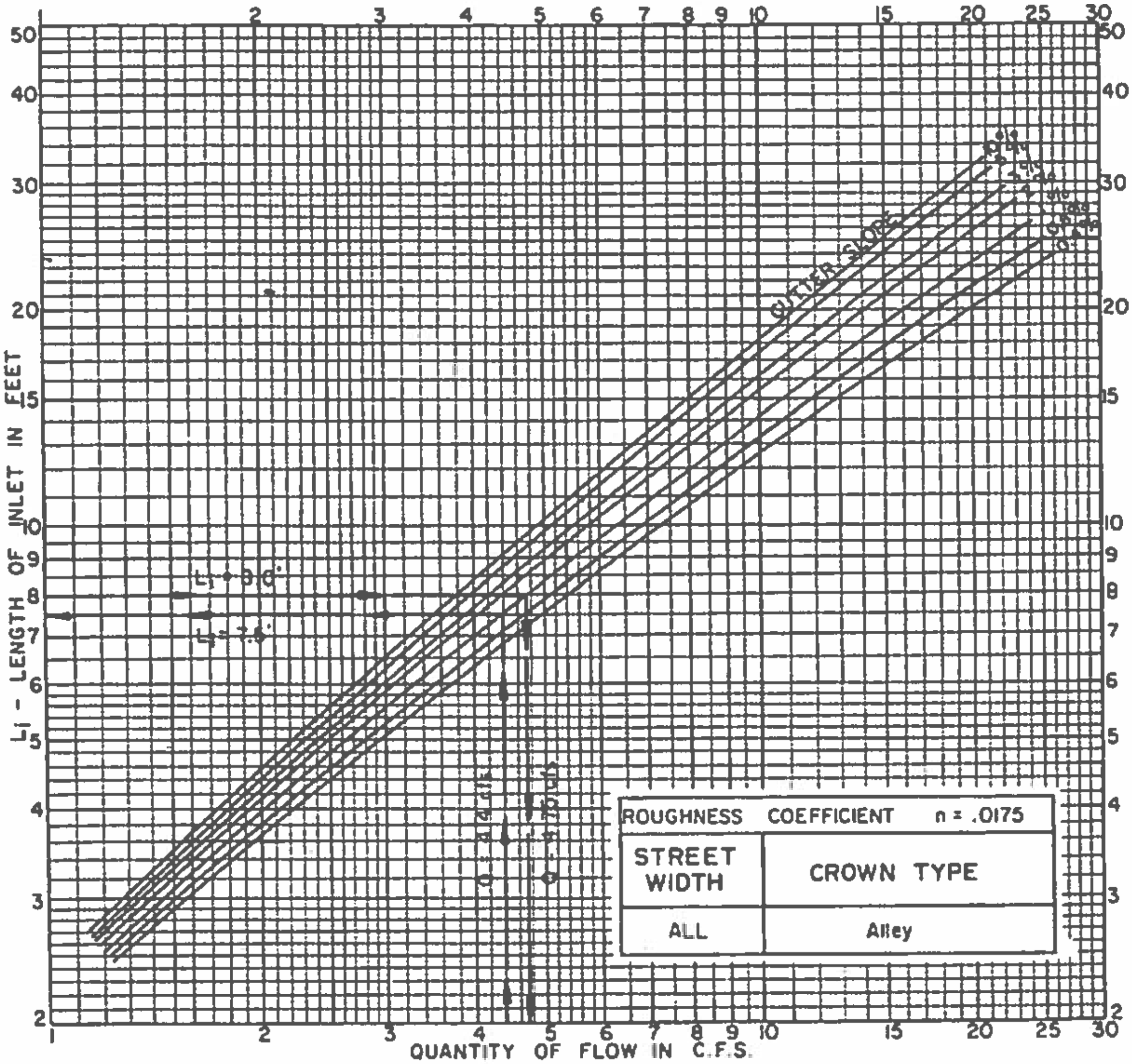
Solution:
- Enter Graph at 6.0 cfs
- Intersect Slope = 1%
- Read L_i = 9.2'

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:

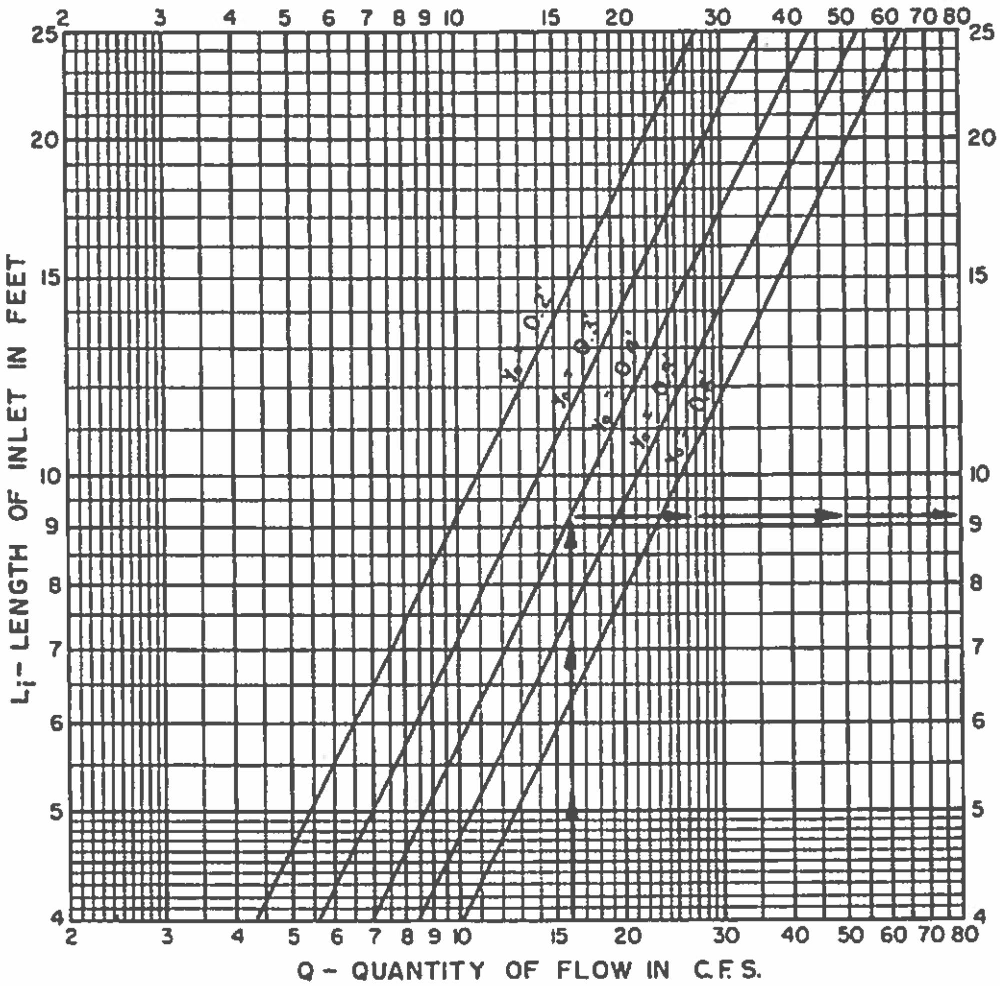
Quantity of Flow = 16.0 c.f.s.
Maximum Depth of Flow Desired in Gutter At Low Point (y_o) = 0.4'

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	Straight and Parabolic

RECESSED AND STANDARD CURB OPENING INLET CAPACITY CURVES AT LOW POINT

FIGURE 13

EXAMPLE

Known:

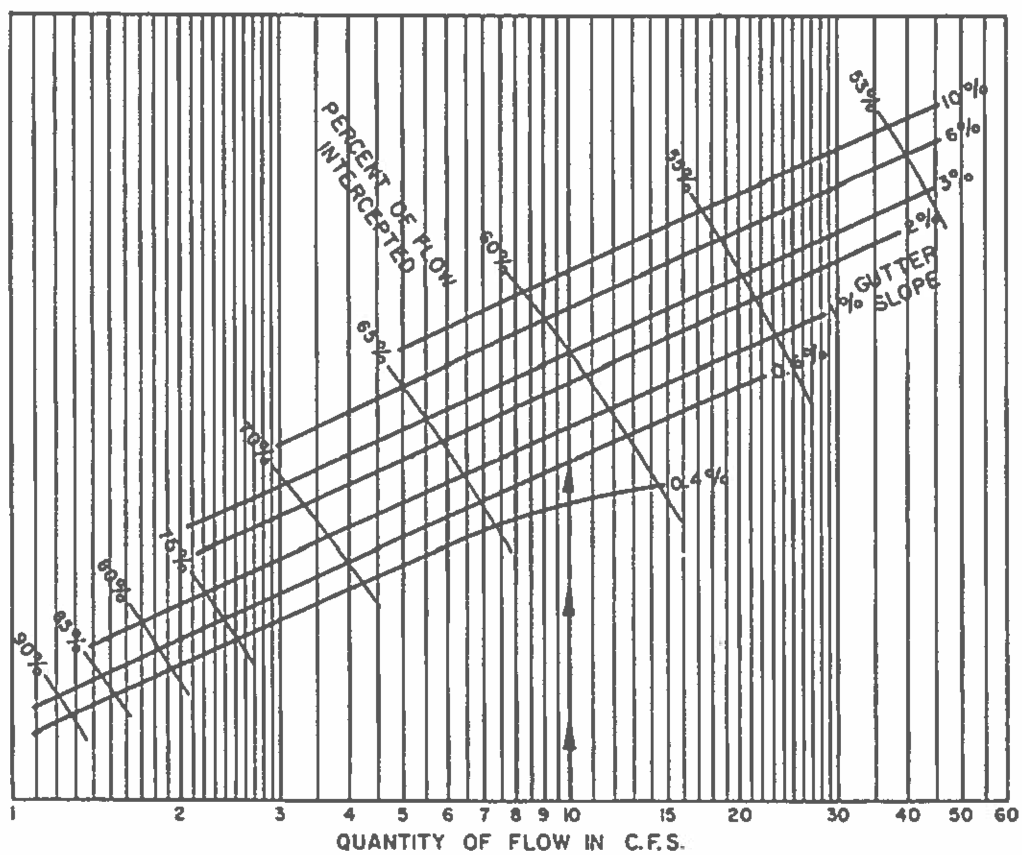
Quantity of Flow = 10.0 c.f.s.
Gutter Slope = 0.6 %

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:

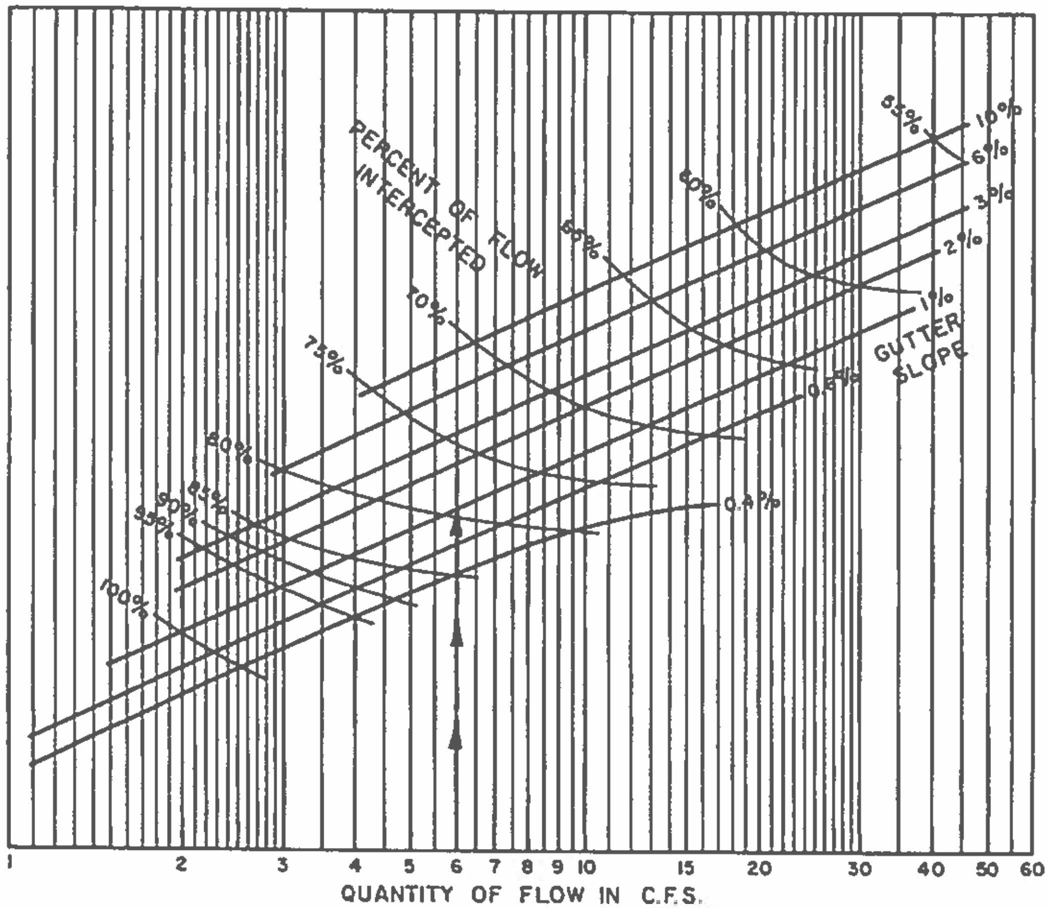
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0 %

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:

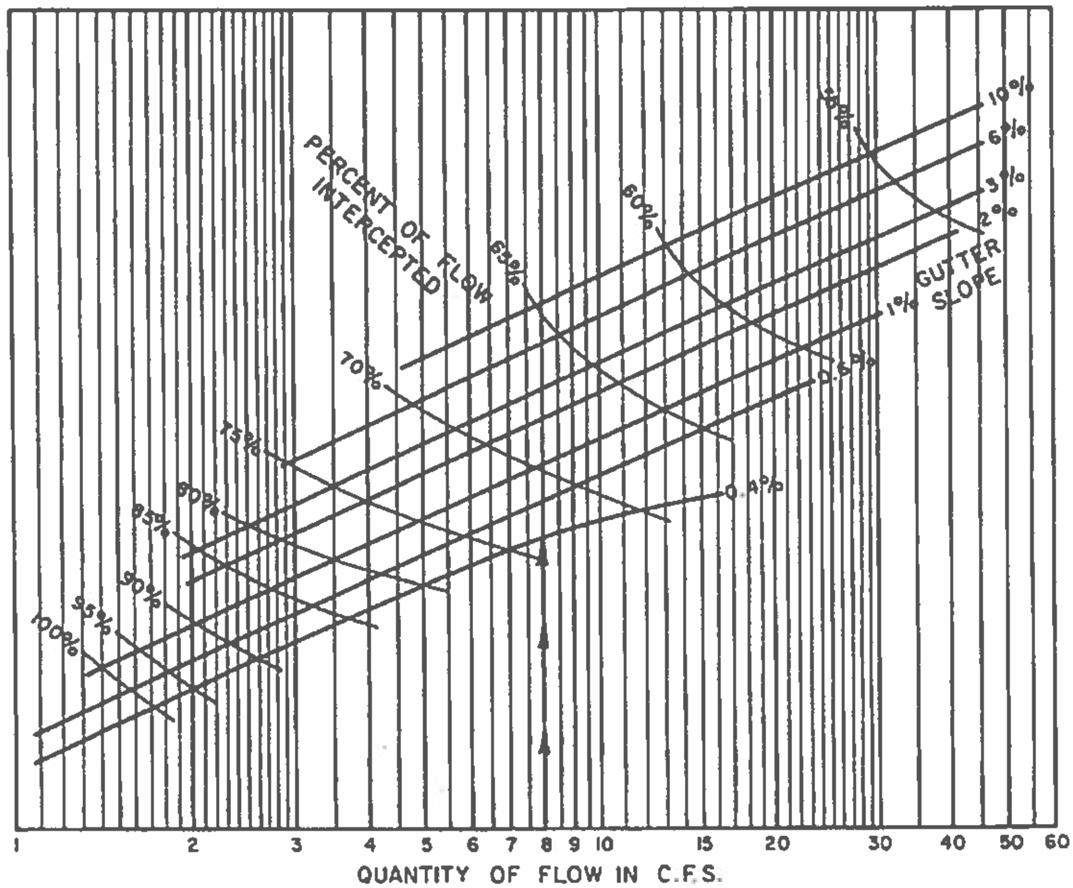
Quantity of Flow = 8.0 c.f.s.
Gutter Slope = 0.4%

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:

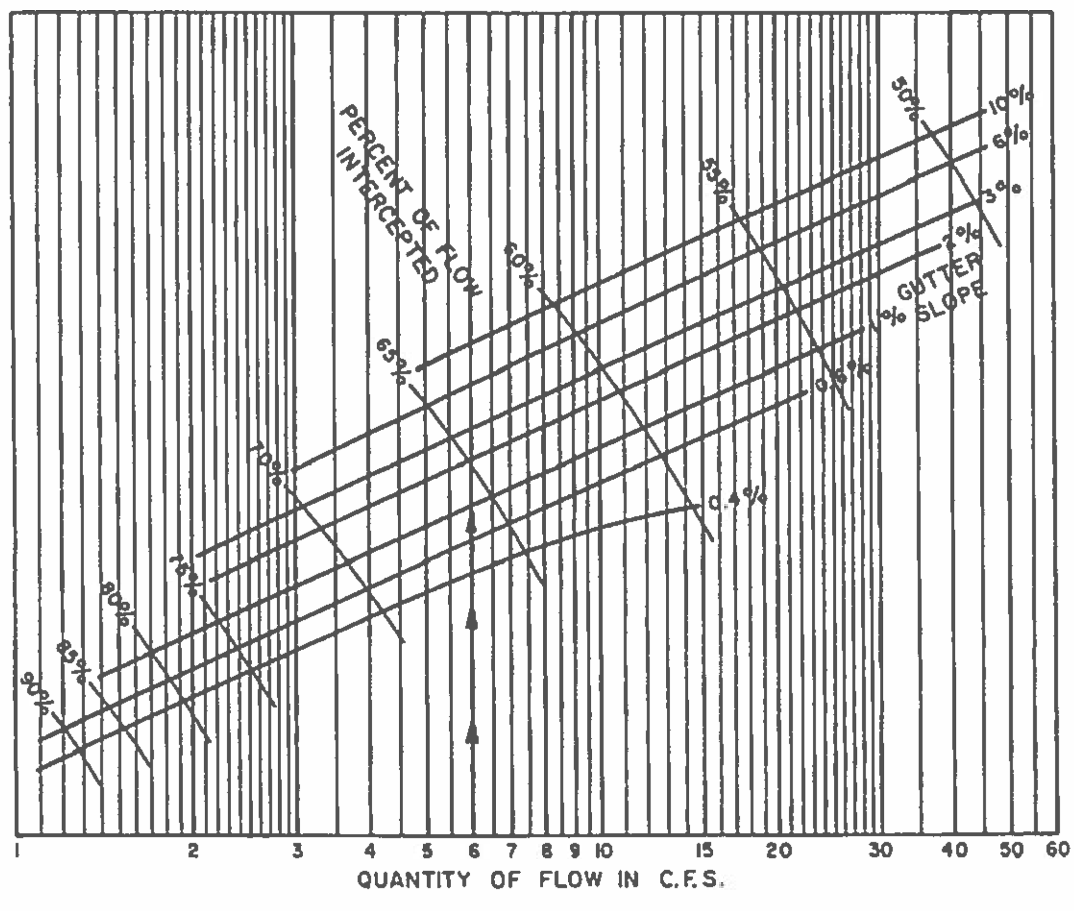
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

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:

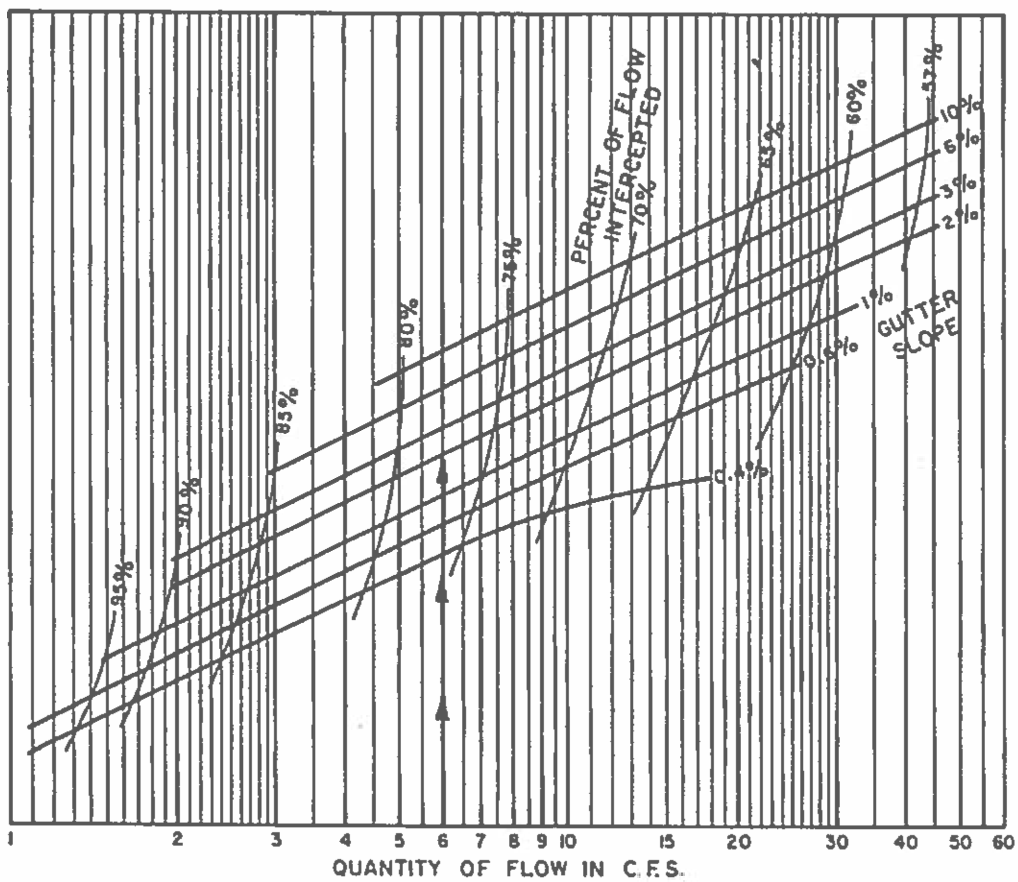
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

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:

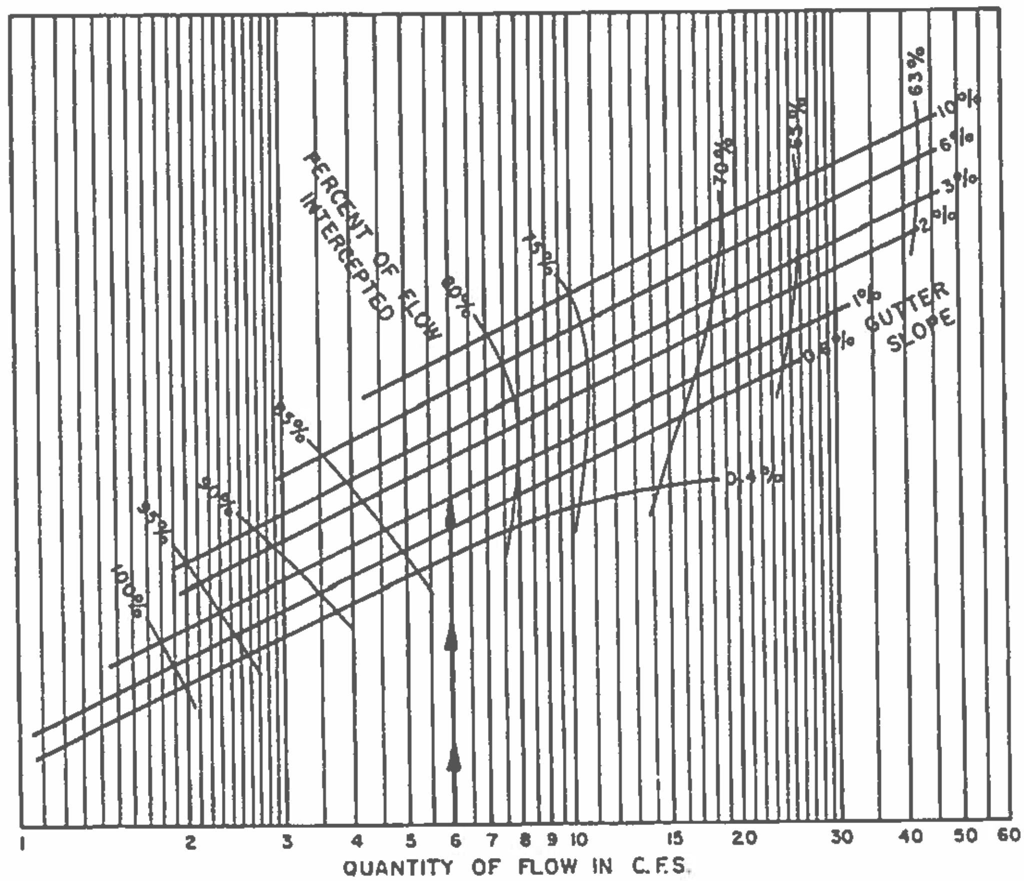
Quantity of Flow = 6.0 c.f.s.
Gutter Slope = 1.0%

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 = 6.0 c.f.s. − 4.9 c.f.s. = 1.1 c.f.s.



SIX GRATE INLET
CAPACITY CURVES
ON GRADE

FIGURE 19

EXAMPLE

Known:

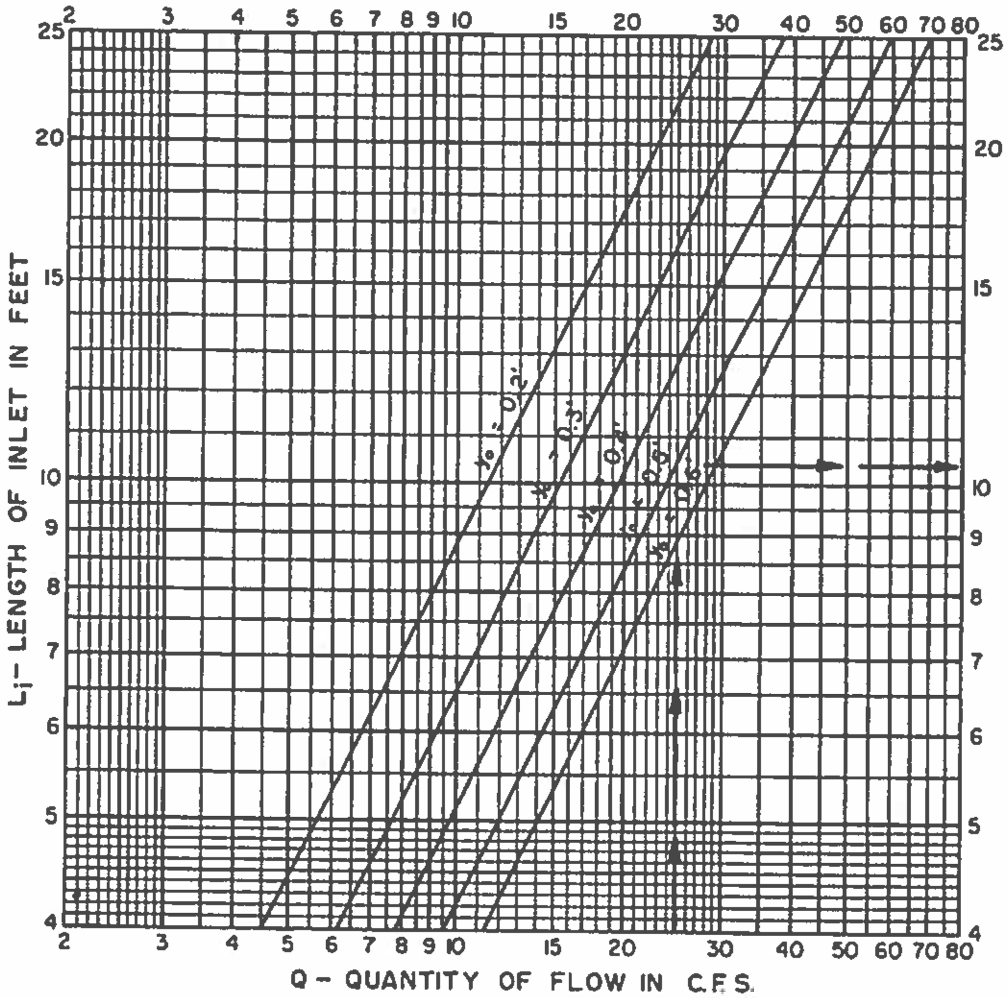
Quantity of Flow = 25.0 c.f.s.
Maximum Depth of Flow Desired
At Low Point (y_o) = 0.5'

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:

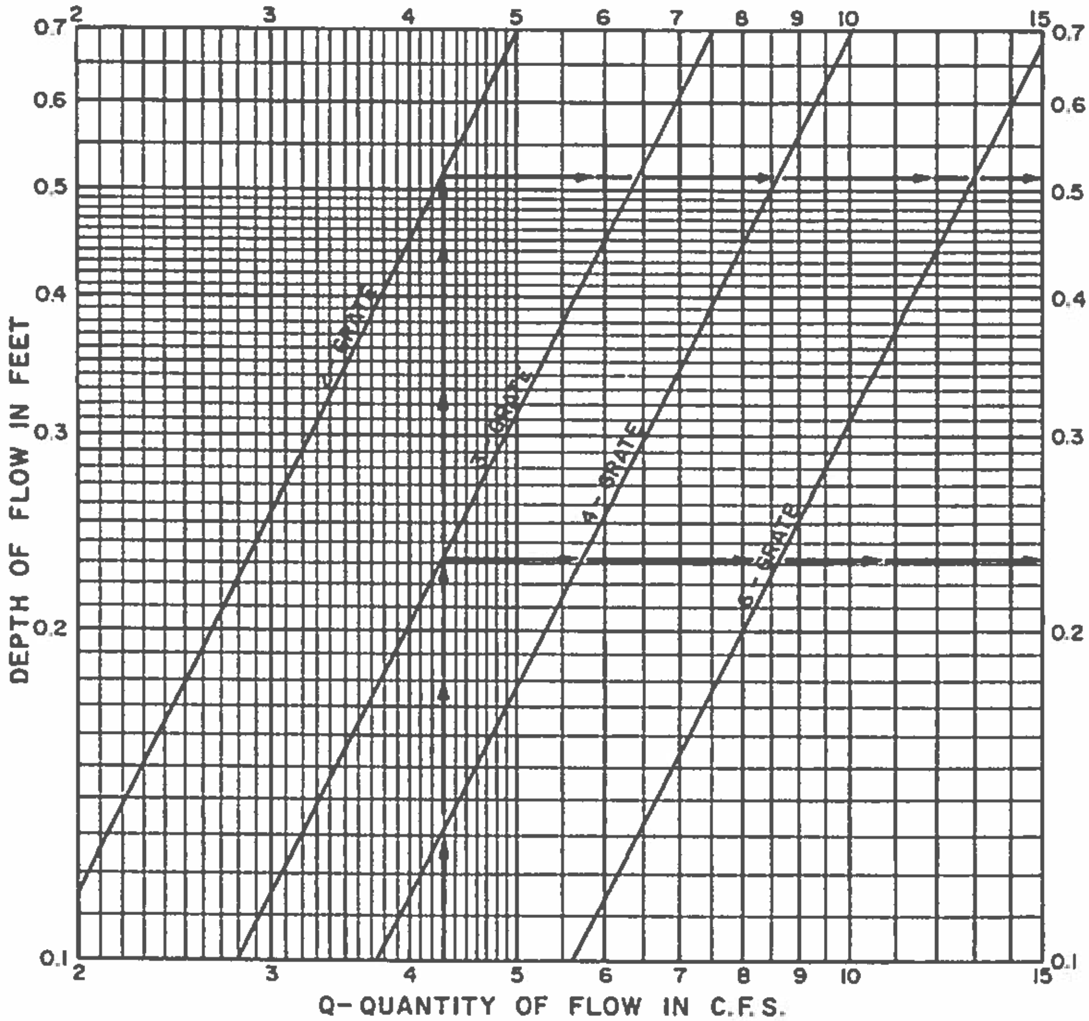
Quantity of Flow = 4.3 c.f.s.
Maximum Depth of Flow Desired at Low Point = 0.3'

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:

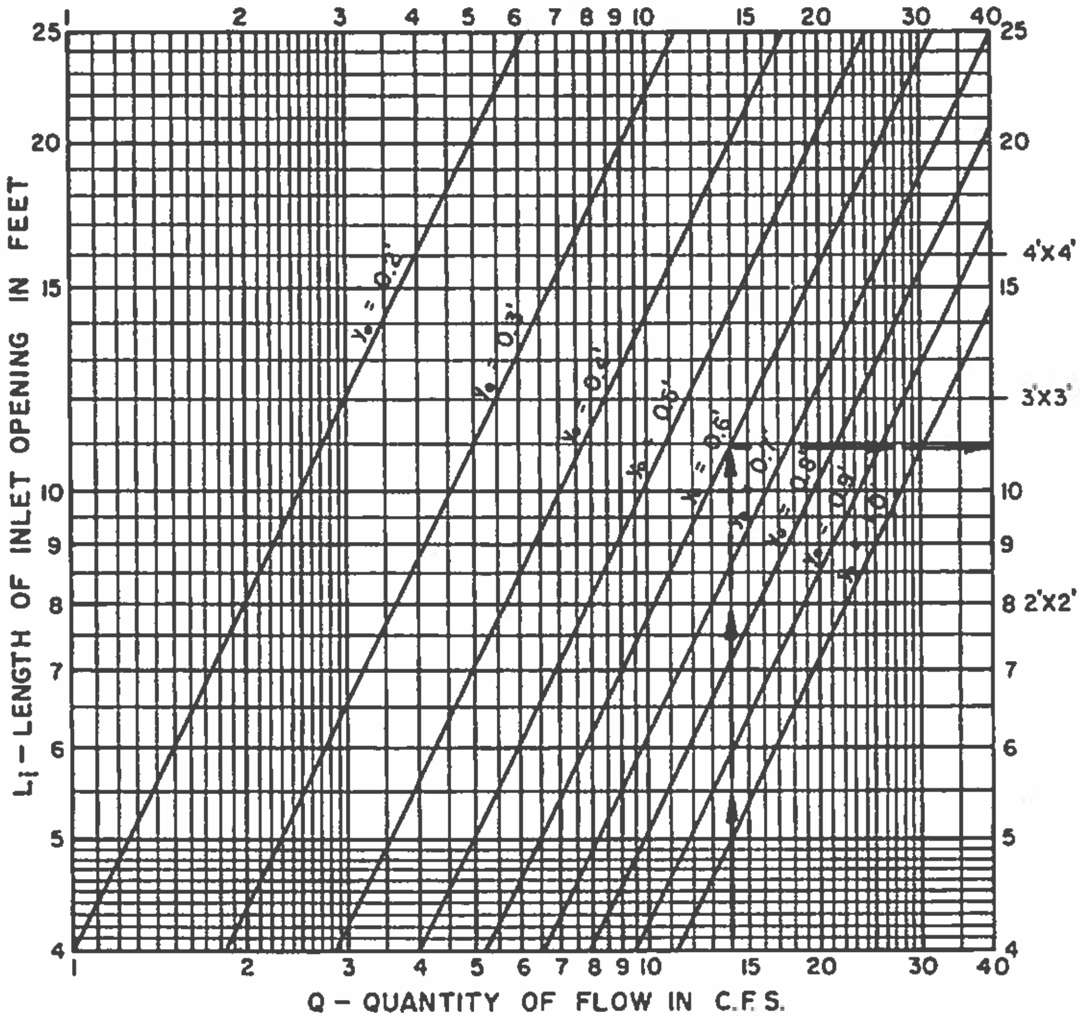
Quantity of Flow = 14.0 c.f.s.
Maximum Depth of Flow Desired (y_o) = 0.6'

Find:

Length of Inlet Opening Required (L_i)

Solution:

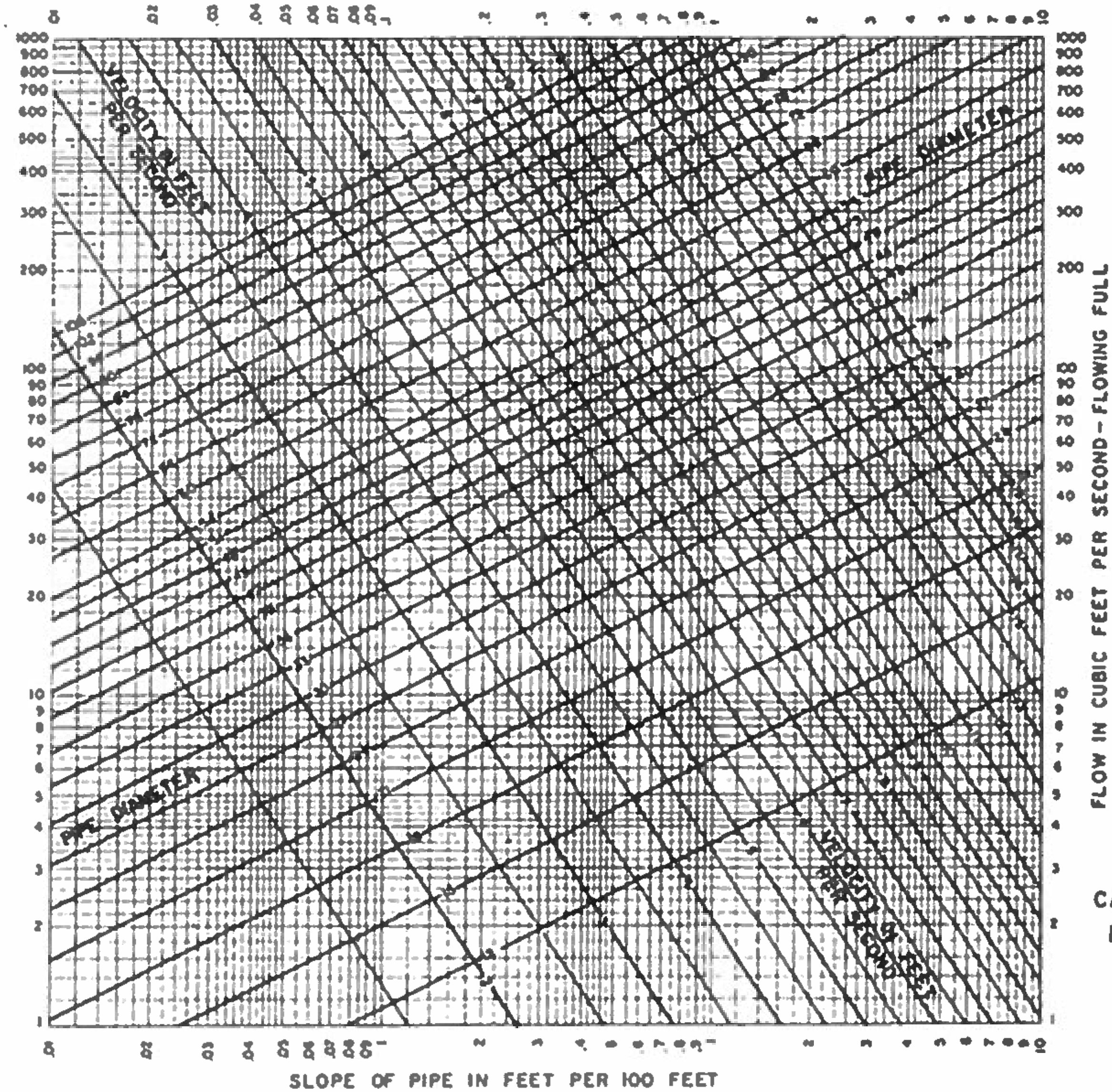
Enter Graph at 14.0 c.f.s.
Intersect y_o = 0.6'
Read L_i = 10.9'
Use 12' of Inlet; 3'X3'



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

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

$n = 0.013$

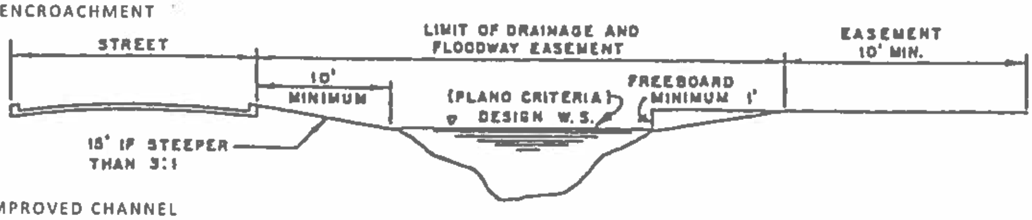
CAPACITY OF CIRCULAR PIPES FLOWING FULL

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

NONENCROACHMENT



UNIMPROVED CHANNEL

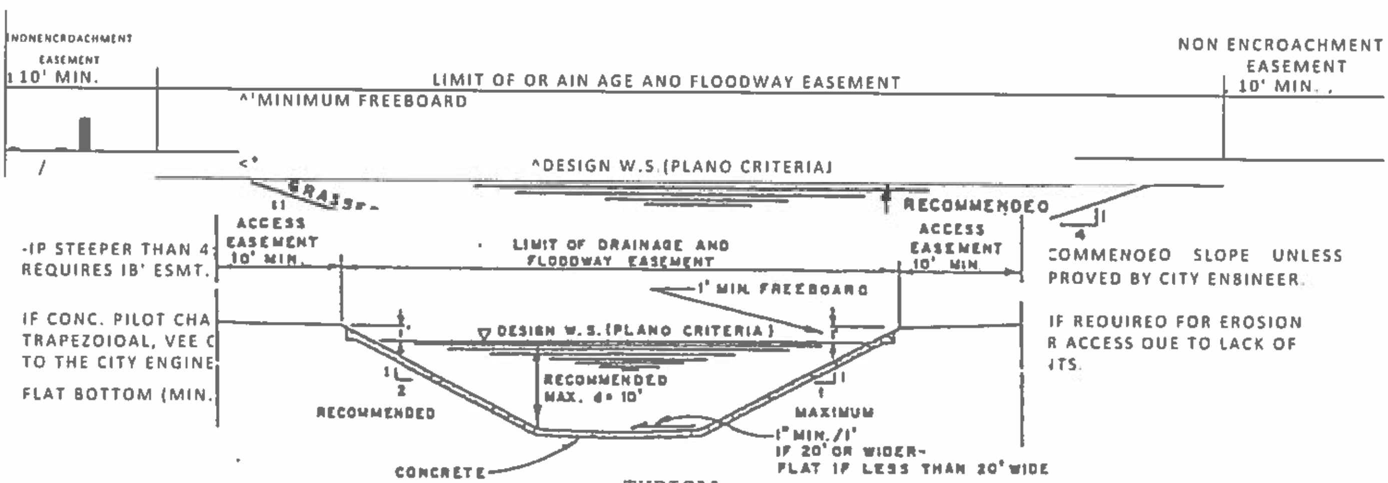
TYPE I - NATURAL

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.

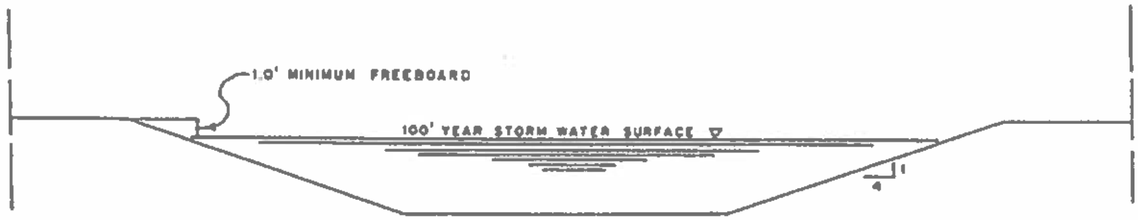


TYPICAL

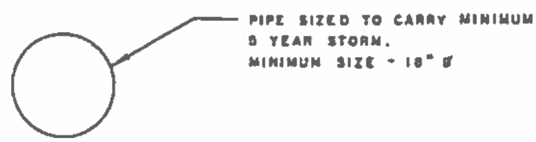
WHEN CHANNEL IS DESIGNED USING PEAK DISCHARGE FLOWS FROM THE <u>FLOOD INSURANCE</u> STUDY, FREEBOARD MAY BE DELETED.

OPEN CHANNEL TYPES

OPEN CHANNEL WITH PILOT PIPE
ALTERNATIVE TYPE II



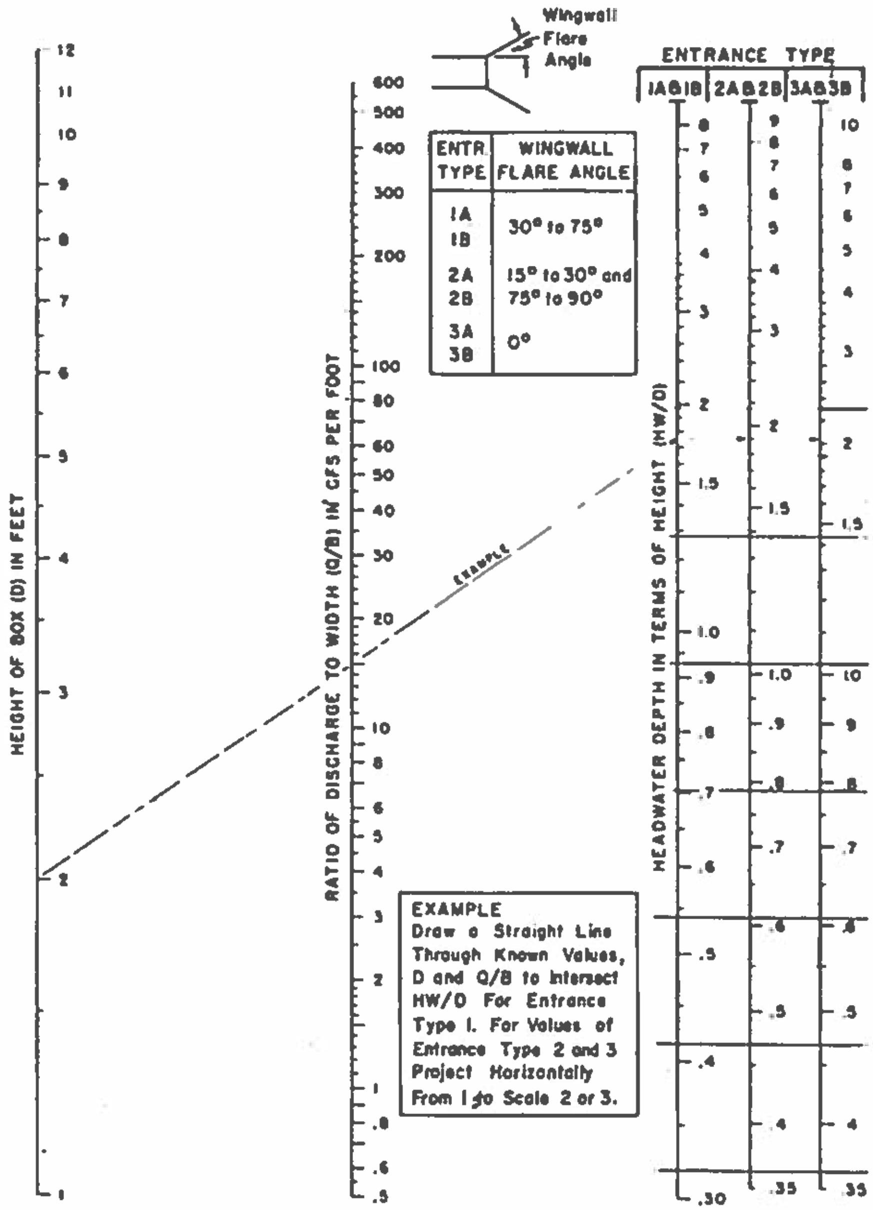
NOTE: Bank slopes and non-encroachment easement requirements same as for Type II.



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

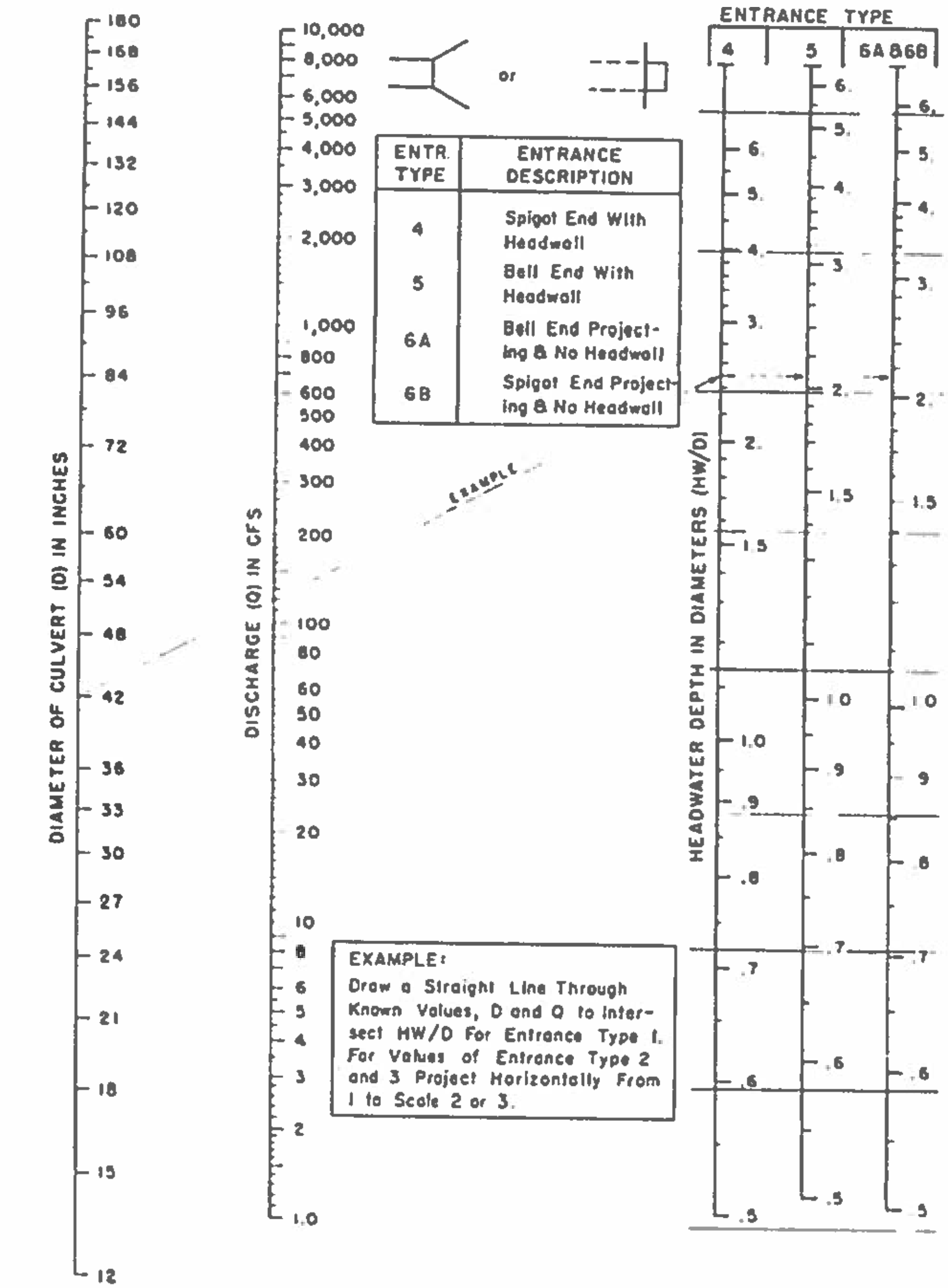
FIGURE 24(B)



BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER DEPTH FOR CONCRETE BOX CULVERT WITH INLET CONTROL

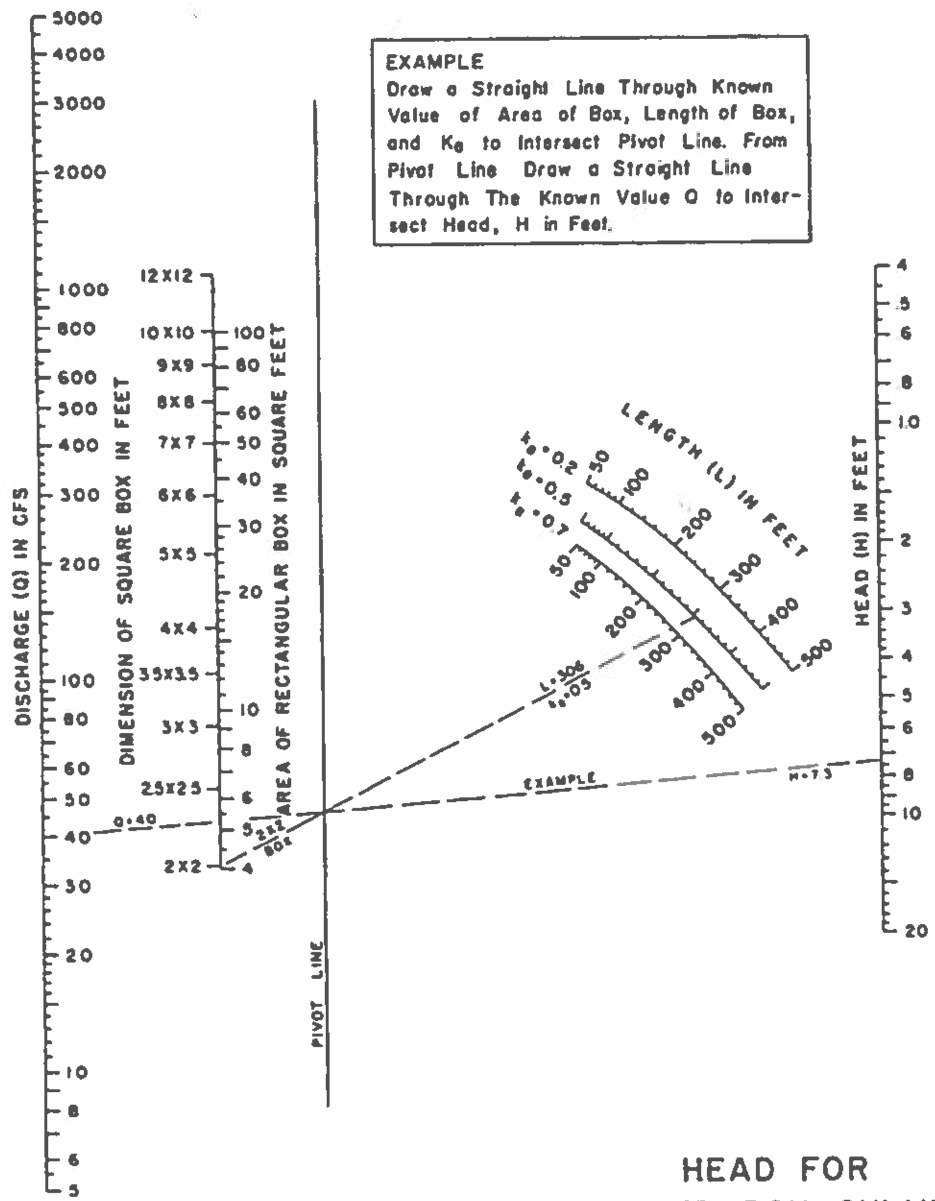
FIGURE 25



BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

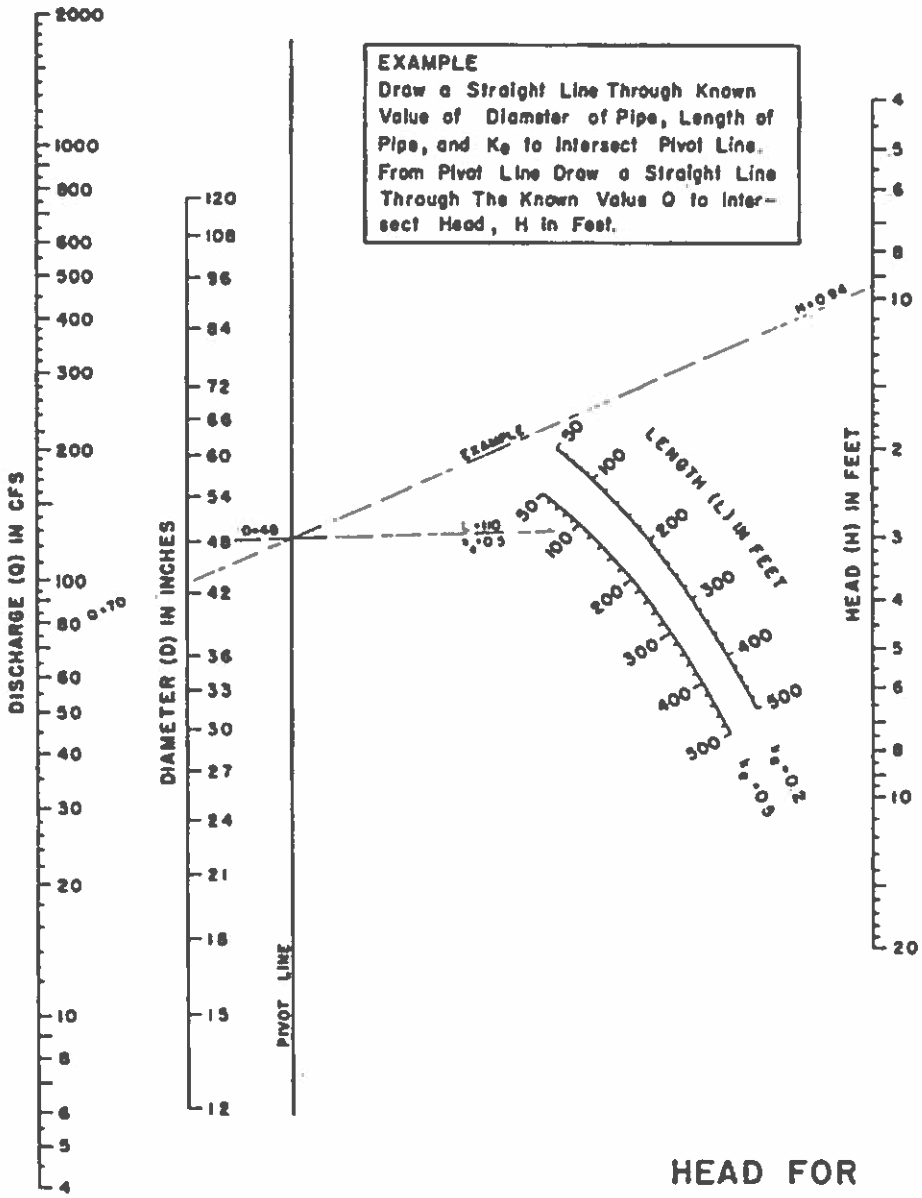
FIGURE 26



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN 1963

FIGURE 27



BUREAU OF PUBLIC ROADS JAN 1963

HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

FIGURE 28

EXAMPLE

Known:

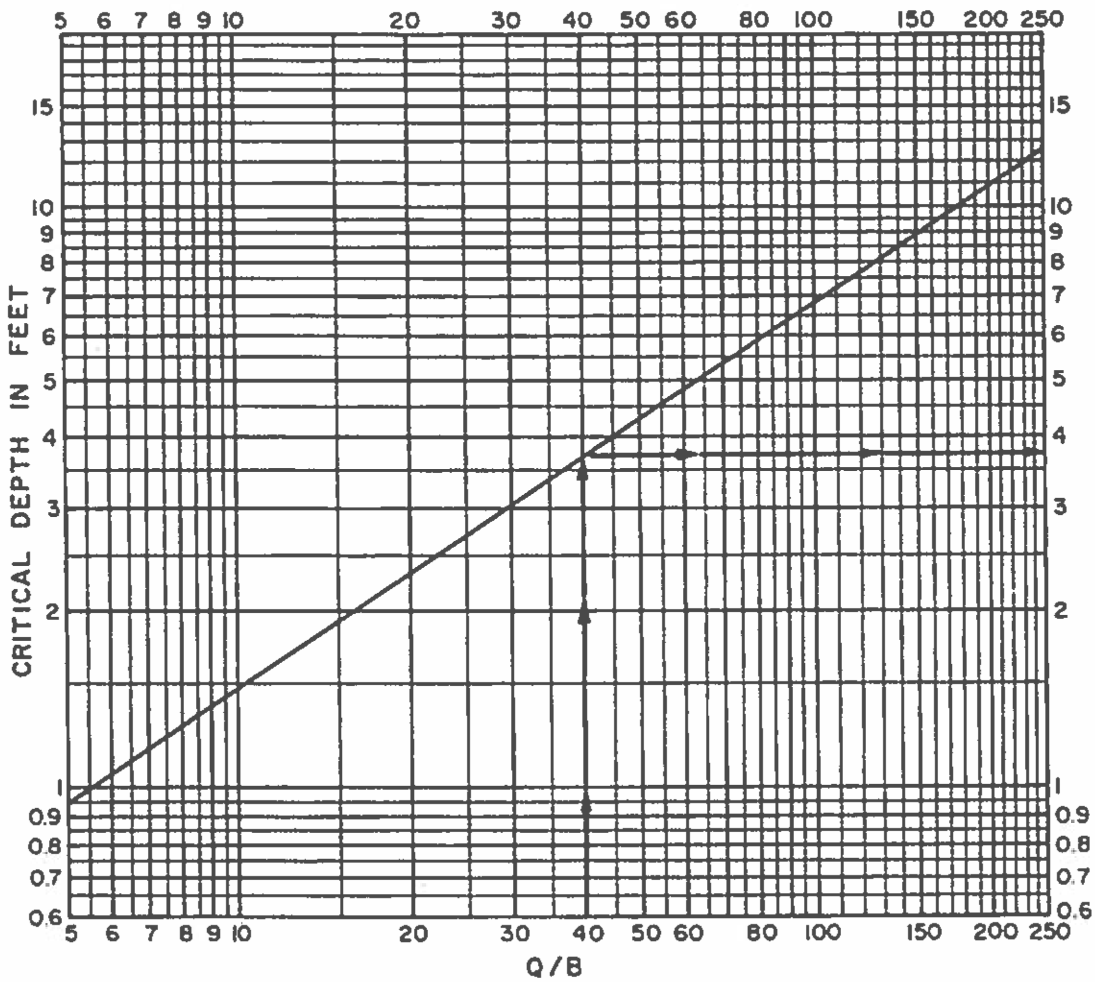
Discharge = 200 c.f.s.
Width of Conduit = 5'
Q/B = 40

Find:

Critical Depth

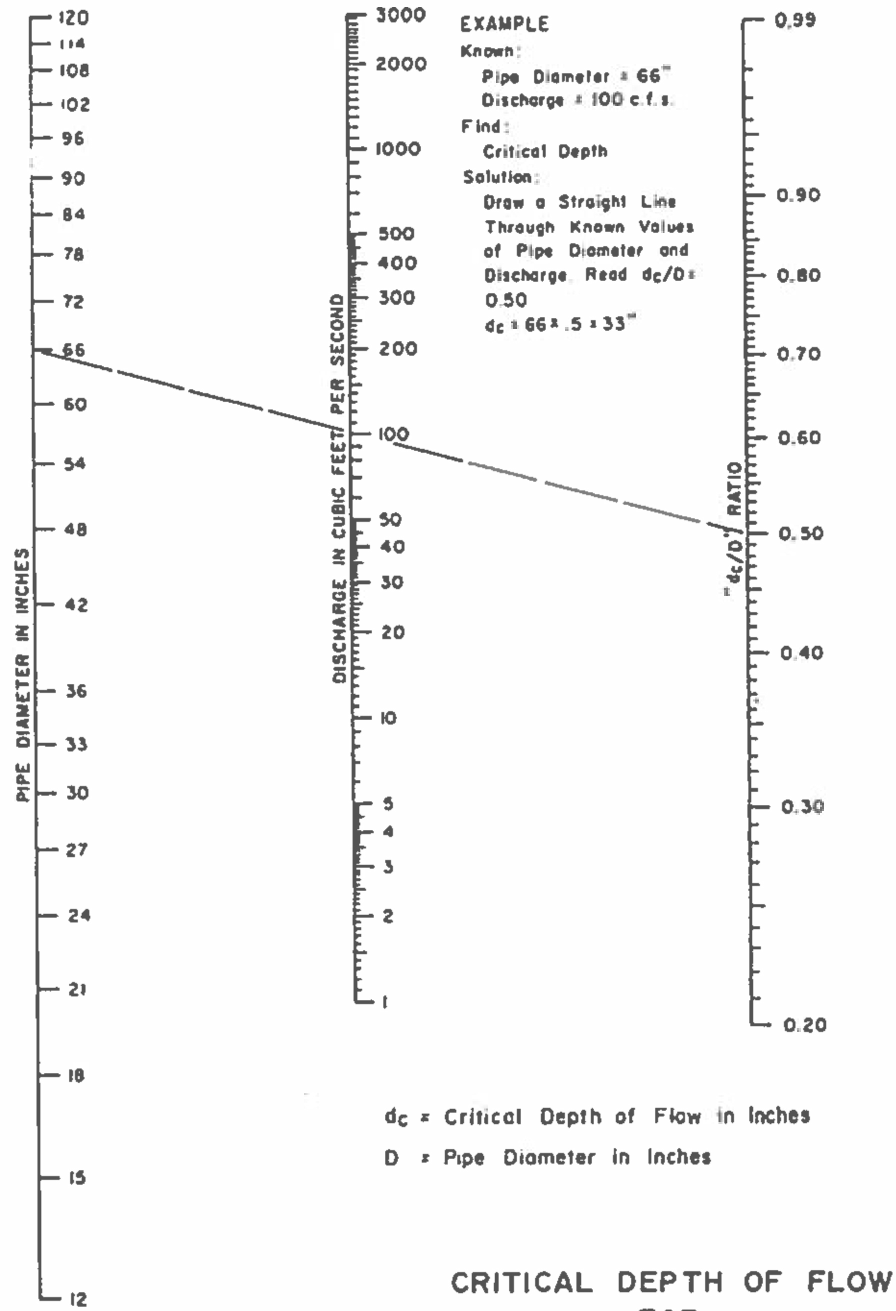
Solution:

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

Form

A. Storm Water Runoff Calculations

B. Inlet Design Calculations

C. Storm Sewer Calculations

D. Water Surface Profile Calculations

E. Open Channel Calculations

F. Hydraulic Design of Culverts

G. Bridge Design Calculations

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.)	Gutter 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)		Distance Between Collection Points "L"	Incremental Drainage Area				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 = $V^2/(2*g)$	Friction Head Loss L*S	Head Loss Coefficient Ki	Velocity Head Loss of Upstream Station (feet)	Flow Time in Sewer = L/(V*60) (minutes)	Time of Downstream Station (minutes)	Remarks
Upstream Station	Downstream Station		Area No.	Drainage Area "A" (Acres)	Runoff Coefficient "C"	Incremental "CA"																			
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

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

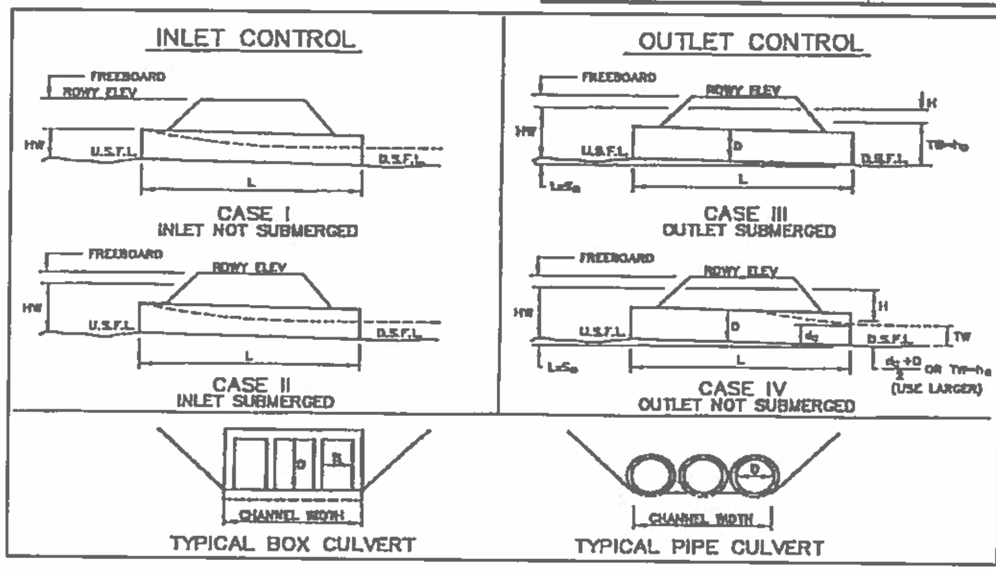
Total Discharge, Q_______________ Design Storm Freq. _______________

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																		
		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_o-L*S, (feet)								
																					$h_o = (d_c+D)/2$ or h_o = TW (use larger)							
Trial Area of Opening T-A = Q/V_max (sq ft)	Channel Width "W" (feet)	(F-V)/W	Allowable Headwater (feet)	Trial Depth "D" (feet)	Number of Culvert Openings	Culvert Width "B" (feet)	Culvert Depth "D" (feet)	Culvert Area "A_c" (sq ft)	Q for Each Opening	Entrance Type	Inlet Control Case	Q/B	HW/D	HW	Entrance Coefficient K	"H" (feet)	"TW" (feet)	L*S_o (feet)	"HW" (feet)	"H" (feet)	d_c (feet)	(d_c+D)/2 (feet)	TW (feet)	h_o (feet)	L*S_o (feet)	"HW" (feet)	Greater Controlling Headwater	SELECTED CONDUIT SIZE
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" = $(K_b \cdot V^2)/(2 \cdot g)$
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. Non-Residential Property or Use

- 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. Apartment. Townhouse' or Cluster Residential Property or Use

- 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.

V - DATA TO BE INCLUDED IN PLANS

A. Sewer Data to be Included on Plan Sheet

1) The plan shall show the existing and proposed water and sewer lines and all appurtenances thereto. The plan should also have the storm sewer system dashed in. All lines shall be numbered, lettered or otherwise designated on both plan and profile sheets. All lines shall show sizes and direction of flow on both the plan and profile sheets. Stationing shall be shown to the nearest 0.1 foot and each new line shall begin at 0+00 at the outlet and increase up the sewer. Station pluses at all junctions of sewers, horizontal P.C.'s, and P.T.'s, bends, angle points, wyes, manholes, the centerlines of all cross streets and railroads, and all crossing utilities, etc., shall be shown on both plan and profile. The degree of angles and horizontal curve data shall be shown on the plan only. Minimum Radius for sanitary sewer mains is 200 feet by pulling pipe not joints. Sewer laterals shall be shown at a location most convenient to serve the property.

2) Sewer laterals will usually be near the center of the lot, either at the street or alley. If the lateral is to be adjacent to the water service, then show the lateral 10 feet downstream. The location shall be designated on the plans.

B. Sewer Data to be Included on the Profile Sheet

1) The data for the profile sheet shall be obtained by running a line of levels along the actual route and by taking any other necessary observations. Profiles shall show the elevations to the nearest 0.1 foot of the ground at the centerline of the sewer, and to the right and left of the centerline of the sewer at the location of the approximate center of the proposed houses or buildings to be served, and the approved street or alley grade. Profiles shall also show the sewer pipe, manholes, etc. The size of the sewer, the direction of the flow, and the grade to the nearest 0.01% shall be indicated just over the "pipe" and the total linear footage of line, size, kind of pipe, and type of embedment or encasement shown below the "pipe". The design flow, pipe capacity and velocity must be shown in the profile. All of the information pertaining to the horizontal data, station pluses, appurtenances to be built, etc., is usually shown just above the ground line, whereas, the flow line (invert) elevations are shown below the pipe. Elevations of crossing and parallel utilities shall be shown. All invert elevations shall be shown to the nearest 0.01-foot. Invert elevations shall be recorded at all junctions (all lines-in and out), at grade breaks, the ends of lines, or other points as requested by the City

Engineer. Benchmarks used shall also be clearly shown, giving the descriptive locations and elevations. Elevations must be from sea level datum, not assumed. Bench level circuits should begin at a USGS monument and benchmark of second order accuracy established at least every one-half mile through the project. All existing water, sewer, gas, storm sewer, telephone, power, and other utilities parallel to or crossing the proposed sewer or water line shall be adequately designated as to size, type, and location.

C. Data to be Included for Water Plan and Profile

1) Indicate the location of any existing valves required for shutdown purposes and of any tees, ends, etc., to be tied into. Indicate clearly the sizes of the lines to be installed, and all proposed valves, fire hydrants, tees, bends, reducers, plugs, sleeves, wet connections, tap connections, creek, railroad or highway crossings, tunnels, meter boxes, valve vaults, and other appurtenances at each intersection or as required. Where the pipe is to be laid around a curve, the curve data must be provided. The size and type of services and the material, type of joint, and class of pipe may be indicated by adequate notation in the lower left- or right-hand corners of the plan sheet. Water services and meter boxes shall be indicated and shall be located at or near the center of the front of each lot. Waterline profiles are required on lines 12-inches and larger, follow the general procedures as outlined for sewers, except that the grades and elevations of the proposed water line usually need not be shown closer than the nearest 0.1-foot except at P.V.I.'s where the elevation shall be shown to the nearest 0.01-foot for field calculation purposes.

APPENDIX "A"

SANITARY SEWER DAILY FLOW CALCULATIONS

Apartment Sanitary Sewer Flow

95 gal. x .75 = 71.25 gal. per day per person
22 units per acre with 3 persons per unit
Calculations (71.25) (22) (3) = 4,702 or 4,700 gallons per day per acre.

Office Sanitary Sewer Flow

3100 parking spaces for 34.7 acres
One person per parking space
20 gallons per person per day
3100 = 89.33 persons per acre (20 gal) = 1,786.7 or 1,790 gallons per day per acre.
34.7 acres

Residential Sanitary Sewer Flow

95 gallons per person per day
4 units per acre
3.5 persons per unit
(95) (4) (3.5) = 1330 gallons per acre per day

Nursing Home Sanitary Sewer Flow

150 beds -heritage Manor
90 gallons per day per bed
90 x 150 = 13,500 gallons per day

Patio Home Sanitary Sewer Flow

95 gallons per person per day
10 units per acre
3.5 persons per unit
(95) (10) (3.5) = 3,325 gallons per day/acre

Add 500 gallon per acre per day for inflow and infiltration. Peaking factor shall be applied to daily flow calculations but not to inflow and infiltration. Peak factors shall be in accordance with ASCE Manual and Reports on Engineering Practice No. 60/WPCF Manual of Practice No. FD-5. Generally, the following factors applies:

Acres	Peaking Factor
0-65	5
70	4.9
80	4.8
85	4.78
90	4.72
100	4.66
110	4.62
120	4.50
130	4.35
140	4.25
150	4.20